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DR. AKHILESH DAS GUPTA INSTITUTE OF TECHNOLOGY & MANAGEMENT
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BBD GROUP

INTERNATIONAL E-CONFERENCE ON ADVANCES IN MECHANICAL ENGINEERING

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Conference Proceedings

F-26 Shastri Park New Delhi 110053

Mrs. Alka Das Gupta

Chairperson

BBD Group of Education

Message from Chairperson

The Department of Mechanical Engineering has always been the gem of the Dr. Akhilesh Das Gupta Institute of Technology and Management. The perennial zeal of the Department has never left the achievements stagnant. The Department not only gives students the exposure to the regular engineering curriculum but also to the aspirations of today's corporate world, thus inculcating a professional aptitude in them. The dedication of the faculty members has strengthened the learning process ensuring an environment of collaboration, experimentation, imagination, and creativity. It is such a prodigious delight in watching the student's cutting edge in technical exploration, enhancing their analytical skills and brushing themselves up for the rapidly changing sector, and establishing themselves as entrepreneurs and engineers.

The Department has always reached new heights and I am looking forward to more wonders and achievements. I wish the very best to the Department of ME for the publication of the proceeding of International E – Conference on Advances in Mechanical Engineering. The proceeding beautifully provides an overview ofoutcome of research done by faculty members and students.

Mr. Viraj Sagar Das Gupta

President, BBD Group

Message from President

I am extremely happy to witness the shaping up of the International E – Conference on Advances in Mechanical Engineering

A special mention to the Editorial Board, who were able to capture the noteworthy proceedings of the ME Department of Dr. Akhilesh Das Gupta Institute of Technology and Management and were also able to present it in an alluring manner. I thoroughly enjoyed myselfgoing through the pages of this conference.

This issue of the technical magazine is an insight to what campus life truly means, the surfeit events together represent the opportunities that one can take and augment their personalities upto the brim and be glorious predominantly.

I hope students and faculty members find this Edition as sound as I did. I congratulate the Department and the Editorial Board for this achievement.

Sh. S.N. Garg
Chief Executive Officer

Message from CEO

Even after so many batches passing under my supervision, the joy and happiness remain constant. ADGITM is exemplary both from the point of view of merit as well as from the placement perspective. Our students have been placed in the best organizations of the country and we strive to maintain such decorum by which the students are benefited the most. Withan aim to remain quality conscious ADGITM has put in efforts for providing the best industrial exposure along with a professionally ethical environment, where one can develop himself / herself on multiple levels. As technology is advancing at a very rapid rate, we have an experienced and well-qualified faculty panel to adjust to the market requirements and guide the students as and when required. The only way to become technically stimulated is by receiving the proper exposure to the world and that is what we inculcate in our students. Our institution is technology-friendly and we don't restrain students from experimenting new technologies and work styles that is how we inculcate self-reliance and tech-savvy mind.

Prof. (Dr.) Sanjay Kumar

Director, ADGITM

Message from Director

"Engineering is not only the study of the technical subjects, but it is about living an intellectual life."

As the Director of Dr. Akhilesh Das Gupta Institute of Technology and Management, I strongly believe that education is not only about imparting knowledge but more about opening the individual's mind to self-expression. I have been personally encouraging students to develop an overall sensibility and awareness. Encouraging them to, not try, but make it happen. I saw an overwhelming response by the students in not only technical domain but also in the branch of sports, art, dance, photography, music and a lot more. Students are our partners in our mission to set a new benchmark in the field of engineering. I am confident that with such a positive and progressive attitude they would be able to justify the credibility of the Department as well as the college by bringing laurels and what not.

I am immensely proud to observe a team of such enthusiasts. The proceeding of International E - Conference on Advances in Mechanical Engineering of the Department of Mechanical Engineering has been able to make a count of all the achievements, hard work and dedication of the faculty members and students alike. I wish them luck.

Dr. Yamini S.

Principal, ADGITM

Message from Principal

When it comes to the real world, everybody needs to be a go-getter. The onus of our institution is to enable the students not only to adapt to changes for the betterment of the society but also be the catalyst to make it more equitable. Dr. Akhilesh Das Gupta Institute of Technology and Management believes in this maxim and the institution has always worked to provide quality education.

We believe that the best way to learn something is actually by doing it, therefore practical education is of utmost importance to us which makes the students well-fortified with contemporary techniques and innovative practices. Our staff is highly committed and dedicated to provide an environment where one can freely think and burgeon their persona andalso to help them encourage others to bloom.

The ADGITM family will stay united to bring glory to the institution and serve for the betterment of the society. One of my beliefs is a very famous quote by Albert Einstein that still motivates brilliance, "Never regard study as a duty, but as the enviable opportunity to learn".

Vision of the Institute

To produce globally competent and socially responsible technocrats and entrepreneurs who can develop innovative solutions to meet the challenges of 21st century.

Mission of the Institute

1. To provide value-based education through multi grade teaching methodologies and modern education facilities.

2. To sustain an active partnership program with industry and other academic institutes with an aim to promote knowledge and resource sharing.

3. To conduct value-added training programme to enhance employability.

4. To provide conducive environment for development of ethical and socially responsible technocrats, managers and entrepreneurs.

Vision of Department of Mechanical Engineering

To produce competent mechanical engineers having distinct employability skills, involving innovative ideas to fulfill societal needs.

Mission of Department of Mechanical Engineering

M1. To provide resourceful education through training and skill upgradation.

M2. To inspire the young dynamic minds towards innovation and research to meet the societal needs and responsibilities.

M3. To strengthen the industry-academia interface for better employability.

Program Educational Objectives (PEOs)

PEO1. Graduates shall excel in their career through participation in multidisciplinary fields.

PEO2. Graduates shall develop cost effective innovative technologies and methodologies to solve engineering problems and contribute to sustainable development.

PEO3. Graduates shall have a successful career in academia, industries or as an entrepreneur to serve societal needs.

Improvement in Mechanical Properties of Aluminum Metal Matrix Composite- A Review

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***Abstract*—The current study deals with Aluminum Metal Matrix Composite reinforced with graphene or Boron Carbide (B_4C). A wide range of B_4C and Graphene content has been used in the manufacturing of aluminum matrix composite (AMC). The AMC has a wide application in various fields like aerospace, automotive industries due to high tensile and yield strength, high resistance to wear, high hardness, etc. Fabrication is done through powder metallurgy and various machining techniques have been seen. Authors try to focus on different types of reinforcements that were used with Aluminum MMC for this purpose several reputed publications were studied. This study will tell us simply about the different types of reinforcement that are used with Aluminum MMC while seeing its effects on the various properties of the composite formed.**

Keywords— ***Aluminum MMC, Powder metallurgy, Boron Carbide, Graphene, Composite.***

I. INTRODUCTION

The metal matrix composite (MMC) is a combination of two or more different materials. If three materials are present, then it's called a hybrid composite [1]. Due to exceptional properties of these MMCs a lot of work has been done over fabrication and characteristics of these composites and they are widely used in industrial technologies [2]. The metal matrix composite being an advanced material with incomparable properties, is also used in the sectors of aerospace, automobile, defense, power plants, electronics, bio-medical etc. [3]. These Al composites are mainly formed by using hard materials like graphene, B_4C, silicon carbide (SiC), alumina (Al_2O_3), graphene oxide (GO), aluminum nitride (AlN) etc. and also sometimes organic materials like fly ash or cow dung [4]. These reinforcements can improve the properties of the composites formed over the base metal alloy. This includes betterment of thermal conductivity, high toughness, increase in tensile and yield strength, durability, improved machinability [5] resistance, lower density, higher fatigue endurance, increased strength-to-weight ratio and dimensional stability [6]. The Additions of high strength high modulus refractory particle to a ductile matrix which generates a material which has the mechanical properties lying between matrix alloy and ceramics reinforcement metals simply have a combination of various properties such as high strength, high temperature resistance and ductility and strong though brittle[7].The objective of this study is to observe the characteristic behaviour of graphene and boron carbide reinforced aluminum metal matrix composite on tensile strength, hardness and other properties on different composition of composites.

II. LITERATURE REVIEW

A. Graphene Reinforced Aluminum Metal Matrix

1. Bartolucci et al [8]: Studied composites of graphene platelets and powdered aluminum these were prepared through ball milling, hot isostatic pressing and extrusion. Comparison was done between pure aluminum and multiwalled carbon nanotube composite. The aim was to analyze microstructure study the hardness and tensile strength. The results showed that the graphene reinforced aluminum matrix showed a decrease in strength and hardness because graphene is prone to forming aluminum carbide while processing. But if we used multiwalled carbon nanotubes the tensile strength increased by 12%.
2. Wang et al [9]: Simply worked on Graphene, Aluminum Composite, Graphene Nanosheets (GNS 0.3wt%). The process involved were Powder metallurgy, Sintering followed by Hot Extrusion (Ratio 20:1). The result was tensile strength of

249MPA was achieved in Aluminum composite reinforced in 0.3wt% GNSs which is 62% more over unreinforced Aluminum matrix.

3. Gao et al [10]: Used pure Al, graphene and its oxide, GO (Graphene oxide)-Al powder. The processing involved Stir casting. And the results were that hardness was increased up to 25% (at 0.3%) graphene, coefficient of friction is least for the same.
4. Raj et al [11]: Al7075, graphene (0,0.25.0,50,0.75,1% wt.) was used the fabrication process involved for microstructures-mechanical milling, ball milline, wet milling. The results showed that hardness was better for nano-composites (around double), coefficient of friction was lower for nanocomposite using 75% for best result (beyond this brittleness increases affecting wear)
5. Kumar et al [12]: The paper investigates graphene reinforced Aluminum Alloy MMC with a varying wt.% (5&10% graphene) of reinforcement SEM was used to study the distribution of particles. The hardness, tensile strength, impact factor was studied. The results were for 10wt% graphene tensile strength and impact strength increased from 25 to 60%. The value of tensile strength was 168.3 for 10% graphene reinforcement.
6. Sharma et al [13]: Pure Al powder and graphene powders with 2.5,5,7.5% wt. were used processing involved ball milling, compaction followed by sintering, friction surfacing on the specimen. Then maximum hardness (nearly 1.05 GPa) was found in material containing 5%wt graphene. Hardness tests were also carried for specimens produced at two different speeds (550 and 1120 rpm). Hardness was found max in the 550-rpm specimen for 2.5% wt. graphene.
7. Dasari et al [14]: The materials involved were Aluminum (Al) matrix composite reinforced with Graphene Oxide (GO). Finite element modelling (FEM) was used to predict the estimated effect and mechanical properties the numerical results from FEM were compared to the Voigt model. It turned out load bearing capacity of Aluminum matrix increased with the addition of Graphene Oxide but Young's Modulus of Al/GO composite decreased with increase in number of layers from mono to 5 layers. And it was concluded that the current approach can help in predicting overall properties of composites.
8. Mokhalingam [15]: The Experiment involved Aluminum reinforced graphene the experiment was performed to study its effect on corrosion behaviour. Al-5% GNP (Graphene Nanoplatelets), Al-10%GNP, Al-15%GNP were produced and studied. The fabrication method involved ball milling, compaction and sintering. The results showed the presence of graphene and its increased amount increases the corrosion rate while decreasing the polarization resistance of aluminum. SEM (Scanning electron microscopy) / EDS (Energy dispersive spectrometer) showed graphene in MMC encouraged Aluminum to corrode more due to galvanic corrosion phenomena.
9. Kumar el al [16]: Experimentally analyzed Aluminum Alloy 7075 with Graphene as reinforcement(0.5wt%,1wt%). The processing involved Stir casting, heat treatment, Quenching and ageing. The results showed for 1wt% graphene there was a decrease in wear loss by 37.6 % and there was an increase in hardness by 34.88% when it was compared to cast aluminum alloy. The application involved manufacturing of automobile parts, bicycle frames, electrical fittings and marine.
10. Naynur et al [17]: Numerical method such as Finite element (FE) and mean field homogenization (MFH) were used in predicting the properties of Aluminum/rGO (reduced graphene oxide) composite. For creating Al/rGO MSC Digi mat were used and software Abaqus were used for analysis purpose. The results were compared with the MFH method from MSC Digi mat software; it showed the experimental data and simulation data were validated. The conclusion was 0.3wt% & 0.5wt% addition of rGO led to increase in thermal conductivity by 15% and decrease in thermal expansion by 12%.
11. Garg et al [18]: Studied Aluminum metal matrix reinforced with graphene the aluminum metal matrix was prepared through powder metallurgy. The objective of the study was to observe the internal structure, hardness, density, microstructure. The results showed density and hardness were dependent on sintering temperature while compressive strength was dependent on the concentration of graphene. The addition of graphene to aluminum metal matrix increases the strength of aluminum and also increases the strength of composite.

Table 1- Depicting the value of sintering temperature, green density, sintered density and value of hardness of Aluminum metal matrix reinforced with graphene. [18].

Sample Code	Aluminum Weight (in gram)	Graphene (% by wt.)	Sintering temperature (in ℃)	Green density (g/cm^3)	Sintered density (g/cm^3)	Hardness Value (HV 5)
A1G 550	15	0.1	550	2.262	2.287	27.7
A1G 600	15	0.1	600	2.320	2.350	27.8
A1G 650	15	0.1	650	2.352	2.352	28.4

A3G 550	15	0.3	550	2.266	2.282	27.8
A3G 600	15	0.3	600	2.302	2.338	28.1
A3G 650	15	0.3	650	2.304	2.341	28.3
A5G 550	15	0.5	550	2.260	2.278	27.7
A5G 600	15	0.5	600	2.330	2.370	27.8
A5G 650	15	0.5	650	2.328	2.369	28.3

B. Boron Carbide Reinforced Aluminum Metal Matrix

1. Topcu et al [19]: The materials that were used simply were Aluminum reinforced with Al_2O_3, Sic, B_4C with concentration as B_4C(5,10,15,20wt%) the processing simply involved were Fabrication through Powder metallurgy, sintering (temperature 600℃,625℃&640℃), Grinding. The results obtained were quite noticeable there was an increase in hardness because of sintering temperature increases and B_4C wt.% (impact resistance decreases). Effect of sintering temperature over 625℃ is lost after 15%wt of B_4C. Further addition of B_4C increases strength. The application of aluminum has been in many industries like aerospace and army weapons are built but can also be used in bicycle frame and disc brake, B_4C melts at high temperature and has a high mechanical property.

2. Zheng et al [20]: Al-2024 matrix composite was involved fabrication by mechanical milling of matrix and reinforcement by Hot Extrusion it was found that for MMC(A) Hardness is 260 and Fracture Strength is 950Mpa. And it was found there was a better combination of Strength and Ductility

3. Ramnath et al [21]: The experiment involved Aluminum Alloy, Alumina (Al_2O_3) and boron Carbide metal matrix composition. It included 3 samples whose composition was Sample 1(Al alloy-95%, Alumina-3%, Boron carbide-2%), Sample 2 (Al alloy-95%, Alumina-2%, Boron carbide-3%) Sample 3 Aluminum Alloy. Fabrication method involves Stir casting and internal structure is observed by scanning electron microscopes (SEM). After finding the results it was concluded that Tensile strength of sample 3 is greater than other 2 samples (because of Aluminum content), Flexural strength of sample 3 is greater than other two samples, Impact value of sample 2 is greater than sample 1 and the observations where Aluminum is the metal matrix having properties like light weight, high strength and ease of machinability. Alumina has a better wear strength, high strength, hardness & boron carbide has excellent hardness and fracture toughness.

4. Alizadeh et al [22]: Al5083, CNT (Carbon Nanotube), B_4C were involved with their composition as 5% and 10% B_4C and 5% CNT (Carbon Nanotube). The processing involved ball milling and hot pressing. The Results showed that hardness is doubled for 5% CNT and 10% B_4C, decrease in wear and coefficient of friction.

5. Gallardo et al [23]: The paper involved the following materials Aluminum 2024 and B_4C (0,0.5,1,1.5,2,2.5 wt.%) these materials were mixed using high-energy milling apparatus. The milling time taken was 1 hour and 2 hours. After material preparation, they were artificially aged (T6 temper) for 6 hours and 191℃. The results showed that the B_4C particles were well mixed with the aluminum matrix as a result of the high-energy milling process (It was seen that micro hardness increased up to 68% for 2%B_4C, yield strength max for 2%.). Hardness, yield strength was higher for the sample processed for 2 hours in comparison for 1 hour & monolithic 2024 alloy.

6. Pang et al [24]: Al6061, B_4C and Al_2O_3, powders of 12% B_4C particles, 85.5wt.% 6061Al powders and 2.5wt.% N-Al2O3 particles. Powder metallurgy was used for synthesis, milling, thermal degassing and hot isostatic pressing were also used. The tensile strength increased to 67.4% and 111.4% increase in yield strength.

7. Shoroword et al [25] - The authors used three Aluminum metal matrix composites containing the reinforcement particles of B_4C, Al_2O_3 & Sic (0-20%) which were processed by Stir casting followed by extrusion. There was a clear interfacial reaction product found at Al-Sic interface which was held for long processing time (>30 minutes). There was no reaction observed at Al-B_4C and Al-Al_2O_3. Two secondary phases (alumina and another phase containing Aluminum, Boron and Carbon) were found in the Aluminum matrix away from the interface in Al-B_4C composite. When the fracture surface analysis was done B_4C reinforced Aluminum composite exhibited a better interfacial bonding as compared to the other two composites.

8. Auradi et al [26]: .6061 Al alloy composite reinforced with 11% B_4C was used, the processing involved melt stirring using 2 step editions rather than one. Characterization of prepared composite was done through SEM/EDX studies. The results showed there was a uniform distribution of B_4C and there was improvement in the mechanical properties of base alloy.

9. Raja T & Sahu O.P [27]: The reinforcement % of B_4C (5,10,15,20%) used particle reinforced

composite was formed by powder metallurgy. Powder blend was prepared the other processing methods were pot milling, cold compaction, sintering in an electric muffle furnace. The results Microstructure distribution and bonding observation revealed good reinforcement of particles.

Table 2- Showing Various composition of Al and B_4C and the value of hardness for it [27]

S. No	Sample concentration	Hardness (HV)
1	Sample 1(Al-95%, B_4C-5%)	15
2	Sample 2(Al-90%, B_4C-10%)	17.4
3	Sample 3(Al-85%, B_4C-15%)	19.6
4	Sample 4(Al-80%, B_4C-20%)	21

10. Kumar et al [28]: Aluminum reinforced with graphene and Boron carbide were studied and its effect on mechanical testing and wear behaviour were studied. Graphite had a constant 2% value while B_4C was 2.5%, 5%, 7.5% volume fraction. The composite was created by Stir casting. The results simply showed with 7.5% reinforcement of B_4C particles the hardness, compression strength was higher and the results of the wear test demonstrated an increase in wear resistance with increase in B_4C reinforcement

Table 3- Value of hardness for various Cast MMC.[28]

S. No	Cast MMC	Hardness (HV)
1.	Aluminum-Graphene-2.5%Boron Carbide	28.125
2	Aluminum-Graphene-5%Boron Carbide	41.625
3.	Aluminum-Graphene-7.5%Boron Carbide	46.550

11. S. Gopal Kannan et al [29]: The study of MMC of Al 7075 reinforced with 10wt% of B_4C particles were prepared by stir casting. The objective of the showed that the value of hardness increased gradually with increase in % of reinforcement. The maximum hardness was for sample 4.

experiment was to simply identify the significant process parameter output characteristic developed by metal removal rate, surface roughness, electrode wear ratio. The results showed that the metal removal rate affected pulse current, pulse on time MRR first increased and then decreased with the increase in pulse time.

12. Uvaraja et al [30]: Investigated the influence of operating parameters of 6061 Al with SiC and B_4C reinforcement. In order to achieve a good binding matrix 1% Magnesium should be added. The value of hardness was 72.25HV.

13. Ibrahim et al [31]: The microstructure and mechanical properties of Aluminum 10wt% B_4C MMC were studied and these were produced by mechanical milling and powder metallurgy. The results showed with increased milling time there is a decrease in density hardness and yield strength. The increase in sintering temperature leads to positive effects like increase in density, hardness and yield strength.

14. K. Kiran et al [32]: The sample involved 2%,4%,6%,8% graphite and B_4C. Stir casting method was used the results reflected that tensile strength increased to 21% compared to base alloy (at 6%B_4C and 4% graphite, hardness up to 19% and 4.2% increase in elongation).

III. RESULT

So, in the present review paper, the AMC were casted using powder metallurgy and various other fabrication techniques were also used. The variation in the properties like yield strength, tensile strength and hardness were studied based on the varying content of graphene and B_4C.

1. With the increase in content of Boron Carbide, there is an increase in the various properties of the base grade aluminum.
2. It was observed that in some cases with the increase in amount of graphene the corrosion rate increases while decrease in polarization resistance of base Aluminum this means graphene MMC encourages Aluminum to corrode more.
3. It was also noted that Graphene is prone to forming Aluminum Carbide while its processing which leads to decreased strength and hardness to counter this problem multi walled carbon nanotubes should be used.
4. If we keep the percentage of Graphene in the MMC less than 1% then there is no problem of formation of Aluminum Carbide.
5. It was also observed that the hardness and density are dependent upon the sintering temperature and the compressive strength is dependent on the concentration of reinforcement.

6. The most important aspect of this Al-B_4C/ graphene MMC is in the aerospace industry because of its strength-to-weight ratio which is up to three times that of mild steel.

IV. CONCLUSION

1. The review from various sources shows that much research has been done on AMC, but titanium, magnesium and copper MMC still have a large scope of research to be done.
2. From this review, it can also be seen that finite element modeling can also be used to predict the mechanical properties of composites. This is going to be very useful in the future because we can predict the properties of composites before making them which can save a lot of time and it can also save the cost of making them.
3. Note that: In the following time, we will try to fuse both Graphene and B_4C together in a single AMC and try to produce aluminum MMC which shows the combined properties of both the individual composites.

V. ACKNOWLEDGEMENT

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3D Printing with AI Monitoring

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***Abstract*—The paper proposes to use image processing to monitor the working of a 3D printer. To manage this goal, we feed a few pictures related to the areas of interest into the neural network. In the learning step, each neural unit is tuned to a particular failure image prototype and failure recognition is performed by a probabilistic decision rule. This scheme offers extremely encouraging outcomes for face recognizable, facial postures, and demeanors. A Self-Organizing Map (SOM) is used for face acknowledgment because it has been particularly successful in various pattern recognition tasks involving very noisy signals. One creates sensible cortical designs when given approximations of the visual environment as info, and is a successful method to show the improvement of face acknowledgment ability. Here we used collected images of failure and good print images and trained the model for a loss of 0.95 for 100 image data paper proposes to use image processing to monitor the working of a 3D printer.**

Keywords—3D printing, SOM, PCA, AI.

I. INTRODUCTION

In today's world, technology is so developed that we can produce or develop various things with a high level of accuracy, precision, minimal wastage, and at an extreme speed. One such innovation is 3D printing which can easily make any part. 3D printing has many pros as well as cons like it is very slow and has a high chance of failure if it is not set up properly. There is always a need for someone who can keep an eye on this machine so we can stop it if any error comes up. This is where the need for an Artificial Intelligence (AI) or Computer vision comes in [1]. By using computer vision we are going to run some image recognition where we first feed some sample images to an object detection model, By using these sample images, the computer first learns to recognize the part which is needed to be found in the picture then test itself with the test images. This whole process is based on the SOM model which is an algorithm specially developed for object detection and computer vision [2].

This ability persists even through the passage of time, changes in appearance, and partial occlusion. Certainly, if such a complicated process as the identification of a human individual based on a method as non-invasive as face recognition could be electronically achieved then fields such as bank and airport security could be vastly improved, identity theft could be further reduced and private sector security could be enhanced. As a result of this noteworthy ability to create close wonderful positive IDs, significant consideration has been paid to techniques by which successful face recognition can be recreated on an electronic level. Surely, if the identification of human individuals on non-invasive electronically accomplished then fields, such as bank and air terminal security could be immensely improved, data fraud could be additionally diminished and private area security could be upgraded [3].

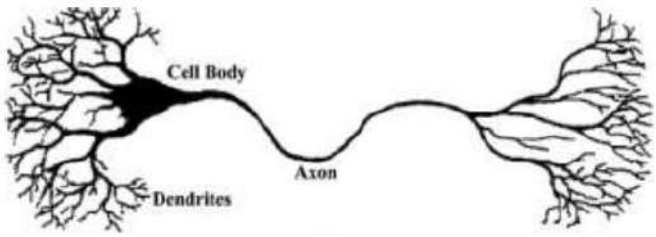

Fig. 1 Neuron cell[4]

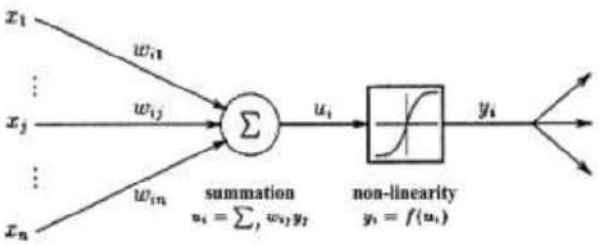

Fig. 2 Neuron model.[4]

II. CHALLENGES IN IMAGE RECOGNITION

Illumination, Wrong detection, Image condition

A. Classification of Error Detecction

Error detection scenarios can be classified into two types' complete fail (Hairy looking mess created) and bad surface finish. Fig.3 shows how they actually look.

The complete failure type of error is easy to detect as it is easily identified. AI can detect it easily because it has a hairy-looking appearance with a very bad surface finish. During training, AI can easily learn to detect them.

The bad surface error detection is completely dependent on image quality coming from the camera and how well the model is trained from the images. Surface quality detection is hard because it is a property of a printed part; such things require the use of Convolution Neural Network (CNN) which helps to detect integral features of any part [5].

The identification process is a "closed" test, which means the sensor takes an observation of the printing in progress that is known to be in the database. The normalized features are compared in the system's database and a score is made on each comparison. The similarity scores are then numerically ranked in descending order. The highest similarity score is the correct match and is referred to as the "top match score". Based on the score received, the model tells that the given scenario is a good print or print failure.

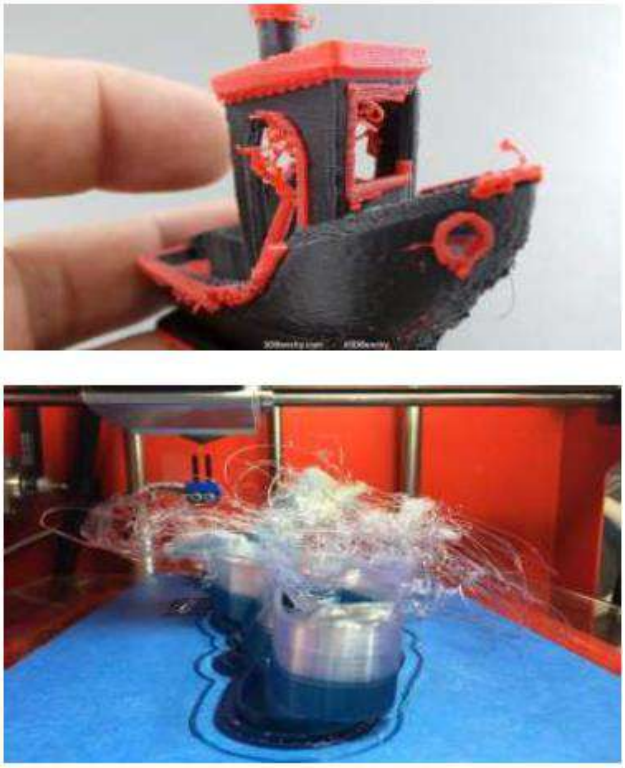

Fig. 3 Print fail with bad surface finish

III. REQUIREMENT ANALYSIS

A. Hardware Requirement

The hardware requirements for the experiment have been shown in table1.

Table 1 Hardware Requirements.

S. No.	Hardware	
1.	P-4 Computer System	Intel CPU @ 2.93 GHz Core 2 Dual/D2C
2.	RAM	2GB DDR2
3.	Motherboard	G41 Gigabit
4.	On Board Soundcard Card & AGP Card	60GB HDD
5.	Cabinet with SMPS loaded with OS	Windows XP / Vista / 7
6.	Webcam	

B. Software Requirement

Open-source software, namely " Jupyter Notebook" has been utilized. It permits live coding, visualization, data cleaning and transformation, statistical modelling, simulation, machine learning, and far more. Open source computer vision

library can be utilized for programming and real-time computer vision. The library is cross-platform and free to be used under the open-source Apache 2 License [6]. The software's used in the experiment have been shown in table2.

Table 2 Software Requirements.

S. No.	Software
1.	Open CV
2	Jupyter Notebook
3.	Python 3
4.	Tensor flow

IV. SOM ALGORITHM AND FLOWCHART

A. *Algorithm Steps*

Steps 1 – Initialising the weights

Step 2– Obtain Best Matching Unit

Step 3 – Scale Neighbours:

a) Determining Neighbours b) Training

Step 4– Mapping determining the quality of SOM.

B. *Flowchart*

Flow chart consistency of two steps: - A) Training B) Testing Training. The flow chart for face recognition is shown in Fig.4.

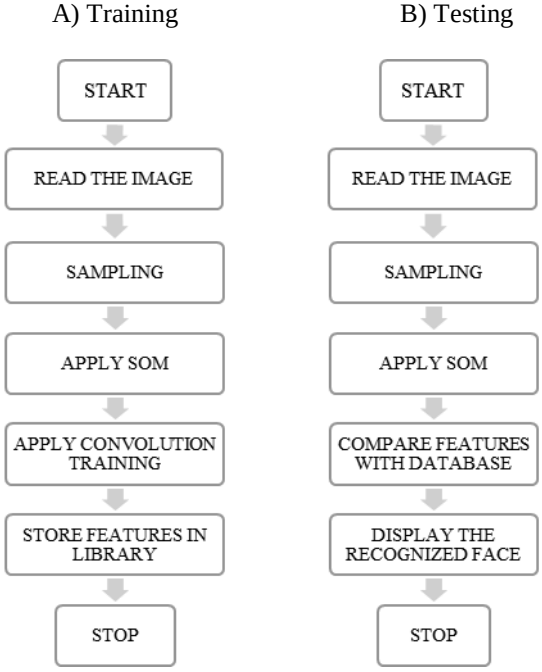

Fig. 4. Flow chart for face recognition [4]

V. EXPERIMENTAL DATA

Images of various sorts of print fail have been collected from the internet alongside some images of excellent prints. There are a total of 160 images, half of them are failed images, and the spouse is good prints. 70% of each half employed as training images and the remaining 30% will be utilized in testing the pictures from the internet are big in dimension and therefore the point of interest is little, so it's needed to label the image. Labelling may be a process during which we mark the part of the image where there's some extent of interest. Here the point of interest is that the green square which shows the print fail. The labelling of image is shown in Fig. 5.

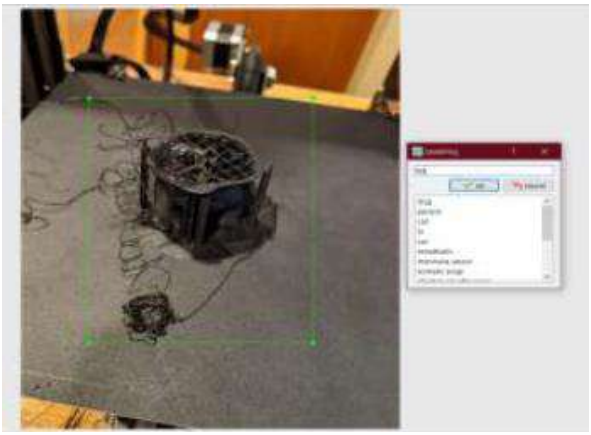

Fig. 5. Labelling of image

VI. EXPERIMENTAL RESULT AND DISCUSSION

The computational efficiency of the SOM method is shown in Fig. 6. This graph shows a plot of Loss vs Step Count. Here, the loss function has been utilized in the training data for determining the deviation amount of anticipated values to the particular values. Lower the loss, better be the prediction. In the present, we get the lowest loss value of 0.107 after the 20k+ step.

The advantage of getting AI monitoring over 3D printers is that it's getting to reduce wastage of filament and save the time of the user. This may get to work with no need for cooperation. The setup is going to be very easy that any new user also can ready to use it and may take advantage. After its completion, it can notify the user when any print fails happens and may even stop it remotely if you're not any nearer to the printer.

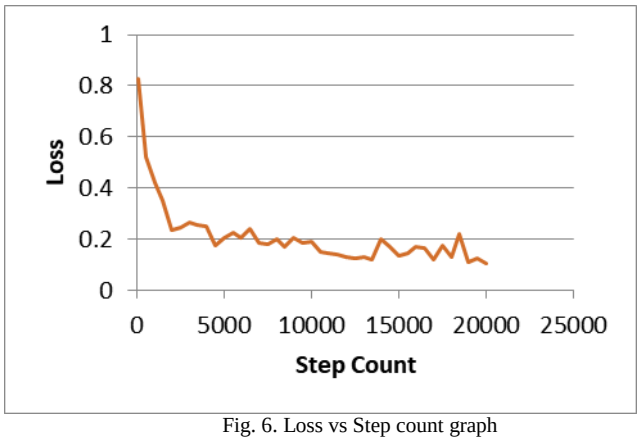

Fig. 6. Loss vs Step count graph

VII. Conclusions

The SOM method for failure detection in a 3D printer has been utilized. It is a sheet-like artificial neural network that reduces dimensions and displays similarities [4]. The very best average recognition rate achieved using the single algorithm is twenty-two, obtained from a dataset of 60 images used for testing. Thus using the SOM method we built an AI model to watch the working of a 3D printer:

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A study of an eco-friendly refrigeration system using domestic LPG

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Abstract—This paper researches the world today is concerned about saving the environment, everywhere measures have been taken up to reduce pollution. Investigates the result of an experimental study carried out to determine the LPG is locally available which comprises of 24.4% propane, 56.4% butane, and 17.2% isobutane which is varied from company.[5] The LPG is cheaper and possesses an environment friendly nature with no Ozone Depletion Potential (ODP) and no Global Warming Potential (GDP).[4] We have design and analyzed a refrigerator using LPG as refrigerant. As the high-pressure LPG stored in cylinder. Pressurized LPG is passed through the small internal diameter of capillary tube. The result is decreasing the pressure of LPG due to expansion and phase of LPG occurs in an isenthalpic process. The latent heat of evaporation gained by the liquid refrigerant in evaporator and temperature decrease of surrounding. That is the way the LPG can produce refrigerating effect.[5] Performance parameters investigated is the refrigeration effect in certain time. The refrigerator worked efficiently when LPG was used as a refrigerant instead of any other refrigerant. From the experiment which done in atmospheric condition, we can predict the optimum value of cooling effect with the suitable operating condition of regulating valve and capillary tube of the system and the evaporator temperature goes down to the 0.5 ˚C. In the final result we have found that the COP of an LPG Refrigerator is higher than a domestic refrigerator. [6]

Keywords—LPG Refrigerant, Domestic Refrigerator, Expansion, Refrigerating Effect, Cooling Effect, COP.

1. INTRODUCTION

Domestic refrigerators consume approximately 17,500 metric tons of traditional refrigerants such as chlorofluorocarbon (CFC) and hydro fluorocarbon (HFC) every year which contribute to very high ozone depletion potential (ODP)and global warming potential (GWP). There are very remote areas in India where electricity is not available; hence LPG as a refrigerant for refrigeration can be a better alternative. [6]

Although government agencies are not able to continuously supply a major portion of electricity in both the urban as well as in rural areas.[5] Still the people in these regions require refrigeration for a variety of socially relevant purposes such as cold storage or storing medical supplies and domestic kitchens this project has the novelty of using LPG instead of electricity for refrigeration. This solution is convenient for refrigeration in regions having scares in electricity. It works on the principle that during the conversion of LPG into gaseous form, expansion of LPG takes place. Due to this expansion, there is a pressure drop and increase in volume of LPG that results in the drop of temperature and a refrigerating effect is produced. This refrigerating effect can be used for cooling purposes. So, this work provides refrigeration for socially relevant needs as well as replaces global warming creator refrigerants. While going through the literature review in LPG refrigeration system, Conventional VCR (Vapor Compression Refrigeration System) uses LPG as refrigerant and produced the refrigerating effect. But in our proposed very simple type of refrigeration system in which the high-pressure LPG is passing through a capillary tube and expands. After expansion the phase of LPG is changed and converted from liquid to gas and then it passes through the evaporator where it absorbs the heat and produces the refrigerating effect. After evaporator it passes through the gas burner where it burns.[2]

2. PROPERTIES OF LPG

• Liquid petroleum gases have no any colour.

• LPG is odourless but it's normal to odorize LPG by adding an odorant prior to supply to the user, for detection of any leaks.

• It is highly flammable.

• Heavier than air.

• Nontoxic but can cause asphyxiation.

• A good mixture of LPG is mainly Propane (C3H8), Butane (C 4H10) or a mixture of Propane/Butane.

• LPG's boiling point ranges from -42 ˚C to 0 ˚C depending on its mixture percentage of Butane and Propane.

3. OBJECTIVES

• Use liquid LPG as a refrigerant.

• Run LPG refrigerator without electricity by eliminate the compressor and condenser.

• To produce the eco-friendly refrigerator.
• To determine the COP of the refrigerator using LPG as a refrigerant.

4. WORKING COMPONENTS & FABRICATION

A. WORKING PRINCIPLE

This work replaces the conventional refrigerant by LPG as a cooling medium in a refrigerator. It works on the principle that during the change of LPG from liquid into gaseous form, expansion of LPG takes place. Due to this expansion pressure drop occurs and increase in volume of LPG. It results in the drop of temperature and a refrigerating effect is produced and it is used for cooling purposes. In this refrigeration system the high-pressure LPG is passed through capillary tube and it expands, after expansion the phase change occurs and it convert from liquid to gas. Then it passes through the evaporator where it absorbs the latent heat of the stored product and produces the refrigerating effect.[6]

B. WORKING OF LPG REFRIGERATION

The LPG Refrigerator uses evaporation of LPG to absorb heat. LPG is stored high pressure in cylinders and working pressure at about 70 psi. We lowering this pressure to atmospheric pressure so that the heat absorbed adiabatically from refrigeration box and cooling is obtained on surrounding. LPG is stored in the LPG cylinder under High pressure. When the gas tank of regulators is opened then high-pressure LPG passes in gas pipe. This LPG passed to capillary tube at high pressure. High pressure LPG is converted in low pressure at capillary tube with enthalpy remains constant. [5]
Low pressure LPG is passed through evaporator. LPG is converted into low pressure and temperature. Vapour from passing through the evaporator which absorbs heat from the refrigeration box. Thus, the refrigeration box becomes cool down. Thus, we can achieve cooling effect in refrigerator. LPG from evaporator is then passed through pipe to the burner. [1]

C. CONSTRUCTION

The LPG refrigerator is shown in the figure. We make the one box of the Thermo-coal sheet. The thermo-coal sheet size is 15mm used for the LPG refrigerator. The size of the evaporator is 355*254*152 mm^3. We kept the thermo-coal sheet because the cold air cannot transfer from inside to outside of refrigerator. And the evaporator is wrapped totally with aluminum tape. The schematically diagram of the LPG refrigeration system is shown in below diagram. The gas cylinder is connected to high pressure regulator, which is connected to high pressure pipes. To the other end of the high-pressure pipes pressure gauge is connected. To another end a copper tube is connected which is connected to the capillary tube. The capillary tube is fitted with evaporator. The evaporator coil end is connected to the stove by another high-pressure pipe. One pressure gauge is put between capillary tube and cylinder and another is put at the end of the evaporator.

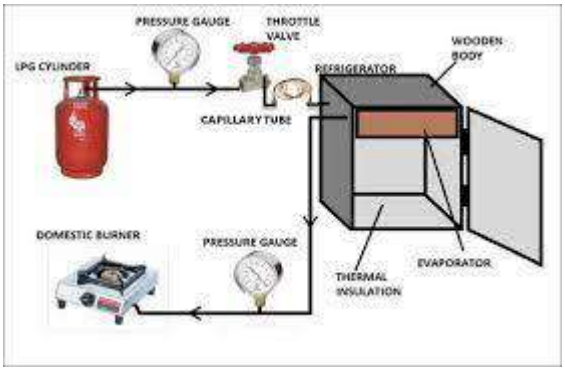

FIG.4.1. SCHEMATIC DIAGRAM

D. COMPONENTS

a) LPG CYLINDER

LPG is Liquefied Petroleum Gas. This is general description of Propane (C3H8) and Butane (C4H10), either stored separately or together as a mix. This is because these gases can be application of a liquefied at a normal temperature by moderate pressure increases or at normal pressure by application of LPG using refrigeration. LPG is used as a fuel for domestic, drying can industrial, LPG be horticultural, to agricultural, another cooking, heating fuel or as LPG processes.


FIG.4.2 LPG CYLINDER

b) CAPILLARY

The capillary tube is a copper tube of very small internal diameter. It is of very long length and it is coiled to several turns so that it would occupy less space. The internal diameter of the capillary tube used for the refrigeration applications varies from 0.5 to 2.28 mm (0.020 to 0.09 inch). The capillary tube is shown in picture. The decrease in pressure of the refrigerant through the capillary depends on the diameter of capillary and the length of capillary. Smaller is the diameter and more is the length of capillary more is the drop in pressure of the refrigerant as it passes through the capillary tube.

FIG.4.3 CAPILLARY TUBE

c) EVAPORATORS

The evaporators are another important part of the refrigeration systems. It through the evaporators that the cooling effect is produced in the refrigeration system. It is in the evaporators when the actual cooling effect takes place in the refrigeration systems. For many people the evaporator is the main part of the refrigeration system, consider other part as less useful. The evaporators are heat exchanger surface that transfer the heat from the substance to be cooled to the refrigerant, evaporators' refrigeration thus removing the heat from the are used for wide variety in and hence the available from of the substance. The diverse application in wide variety of shape, sizes and they are also classified in different manner depending on the method of feeding the refrigerant, construction of the evaporator, direction of air circulation around the evaporator, application and also the refrigerant control. In the domestic refrigerators the evaporators are commonly known as freezers since the ice is made in these compartments. In the evaporators the refrigerant enters at very low pressure and temperature after passing through the capillary tube. This refrigerant absorbs the heat from the substance that is to be cooled so the refrigerant gets heated while the substance gets cooled. Even after cooling the substance the temperature of the refrigerant leaving the evaporator is less than the substance. In the large refrigeration plants the evaporator is used for chilling water. In such cases shell and tube type of heat exchanger are used as the evaporators.

FIG.4.4 EVAPORATOR

d) PRESSURE GAUGE

The most commonly used mechanical gauge is Bourdon type pressure gauge. It is a stiff, flattened metal tube bent into a circular shape. The fluid whose pressure is to be measured is inside the tube. One end of the tube is fixed and another end is free to move inward or outward. The inward and outward movement of free end moves a pointer, through a linkage and gear arrangement, a dial graduated in pressure unit i.e., bar. Pressure gauge records the gauge records the gauge pressure which is the difference between fluid pressure and outside atmospheric pressure.

FIG.4.5 PRESSURE GAUGE

e) HIGH PRESSURE PIPES

The range of high-pressure pipes covers most steel ball fitted these to both application where there is a nipple press thus sealing requirement to transfer gas at high pressure. They consist of a steel pipe with an end. Two swiveling connection balls against the seating of the connecting hole and against gas leakage. Wide range of pipes. All pipes are pressure tested to 100 M Pa (14,500 psi) over recommended working pressure.

FIG.4.6 COPPER PIPE

f) HIGH PRESSURE REGULATOR

This type of regulator is used to send high pressure gas from the cylinders. These are mainly used in functions to industrial purpose.

FIG.4.7 HIGH PRESSURE REGULATOR

g) ACCUMULATOR

Copper accumulator is used for liquid storage, liquid / gas separation, impurity filtering, and refrigerant cushion.

FIG.4.8 ACCUMULATOR

5. EXPERIMENTAL READING

The setup experiment of this project readings was taken at 10 minute's intervals, for 1 hour which is as shown in table 1 below:

LOADING CONDITION (1.25 L WATER BOTTLE)				
INLET PRESSURE (bar)	OUTLET PRESSURE (bar)	TIME (min)	EVAPORATOR TEMP. (˚C)	WATER TEMP. (˚C)
4.82	1	0	29.0	29.5
4.82	1	10	13.5	24.0
4.82	1	20	8.5	21.5
4.82	1	30	5.5	18.0
4.82	1	40	3.5	14.0
4.82	1	50	2.0	10.0
4.82	1	60	0.5	8.4

TABLE: -1 EXPERIMENTAL READINGS OF LOADING CONDITION

Graphical representation of water and evaporator temperature as per the experimental readings of the table: -1 is shown in chart.1 as follow below:

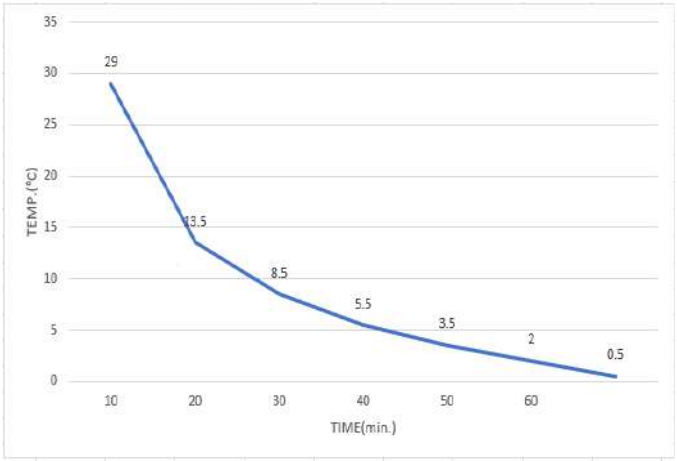

CHART.1 WATER VS EVAPORATOR

The setup experiment of this project readings were taken at 10 minute's intervals, for 1 hour which is as shown in table 2 below:

UNLOAD CONDITION			
INLET PRESSURE (bar)	OUTLET PRESSURE (bar)	TIME (min)	EVAPORATOR TEMP (˚C)
4.82	1	0	27.6
4.82	1	10	7.1
4.82	1	20	3.0
4.82	1	30	1.6
4.82	1	40	-0.3
4.82	1	50	-1.5
4.82	1	60	-2.2

TABLE: -2 EXPERIMENTAL REDINGS OF UNLOADING CONDITION

6. APPLICATION OF RIFREDGERATION

• It can play an important role in restaurants where continuously cooling and heating is required.

• It can be useful in remote parts where electricity is not available.

• It can be used in refineries where consumption of LPG is high.

• It can be used in automobiles running on LPG or other Gaseous fuels for air conditioning

• It can be used for zero cost air-conditioning of spaces like airports, shopping malls, etc. which have their own gas turbine power-plants.

7. CONCLUSIONS

From the experiment we have conclude that the high-pressure LPG gas stored in a cylinder at 12.41 bar with the weight of 14.5 kg equipped with a high-pressure regulator. when LPG gas released the pressure drop occurs and the weight decrease. With the help of capillary tube, the pressure will drop down to the 1 bar from the operational pressure 4.82 bar. Due to the pressure drop the refrigerating effect occurs in an evaporator. The refrigerating effect changes the properties of LPG before and after evaporator. Therefor a conclusion we can use LPG as a refrigerant in a refrigeration. LPG will not harm the environment and the eco system. The potential of ozone layer depletion and global warming will be reduced due to usage of current refrigerant in a domestic refrigerator.

As per the experimental readings (table: -1) we conclude that the evaporator temperature reduces 29.1 ˚c to 13.4 ˚c at loading condition in just 10 mins. And as per the experimental readings (table: -2) the Evaporator temperature reduces 27.8 ˚C to 7.3 ˚C at unloading condition in just 10 min.

As per the above paragraph the cooling effect of LPG refrigeration varies with the load and pressure. So that the design of the refrigerator is different cooling load under the different pressure.

From this temperature drop we can say that the refrigerating effect is higher than the other domestic refrigerator. Eliminates the Compressor and condenser we can conclude that the COP is higher than the other domestic refrigerator.

8. FUTURE SCOPE OF LPG REFRIGERATOR

An introduction of new product in the field of refrigeration is expected and to give out positive result with this normal product. The main aim is to focus on restaurant and community program hall, mid-day meal of school so to preserve food products like vegetables, milk etc. Also, at small snack stores by increasing the probability of refrigerator by reducing its weight, removing compressor totally as well as maximum cost reduction due to no cost of refrigeration. The system can further be improved and implementing in air conditioning of vehicles where LPG is used a fuel.

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Braking System Of Aircraft

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Abstract- *A brake is a device for slowing or stopping the motion of a moving vehicle, or restraining it from starting to move again. Aircraft brakes, for land-based aircraft, are almost exclusively located on the bogie wheels. Operation of the brakes has evolved from a single lever applying all brakes symmetrically, to heel operated pedals, to toe operated brake controls incorporated into the rudder pedals. With the foot-operated controls came the ability to apply left or right brakes independently allowing the use of differential braking to steer the aircraft during ground operations and to maintain directional control during that portion of the takeoff or landing roll when the airspeed is too low for the aerodynamic controls to be effective. In small aircraft, the system can be powered by a master cylinder and does not need hydraulic pumps. In larger aircraft, pumps are required to provide the necessary hydraulic fluid pressure and volume. In the continuing quest to develop lighter, more efficient aircraft, electrically activated brakes are starting to come into service on some of the newest generation passenger aircraft.*

Keywords- *Hydraulics, speed, Bernoulli's principle, wings, reverse thrust, certification, temperature.*

I. INTRODUCTION

To begin with, in layman terms brake is a mechanical device used for slowing or stopping a moving vehicle, typically by applying pressure to the wheels. To retard the motion of a 975,000 lb aircraft during its landing is necessary to have the best braking system to avoid any incident which may cost loss of lives and lethal damage to aircraft. There are different stages of braking and different ways to decrease the speed of aircraft after landing.

II. PRINCIPLES OF FLIGHT

How is it that today's aeroplanes, some of which have a maximum take-off weight of a million pounds or more, can get off the ground in the first place, let alone fly between continents? Surprisingly, with today's technological advances, aeroplanes use the same principles of aerodynamics used by the Wright brothers in 1903.

A. THE FORCES OF THE FLIGHT

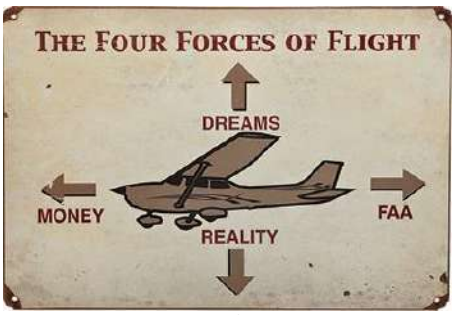

Figure 1: Forces acting on flight

At any given time, four forces are acting upon an aircraft. These forces are lift, weight (or gravity), drag and thrust. Lift is the key aerodynamic force that keeps objects in the air. It is the force that opposes weight thus, lift helps to keep an aircraft in the air. Weight is the force that works vertically by pulling all objects, including aircraft, toward the centre of the Earth. To fly an aircraft, something (lift) needs to press it in the opposite direction of gravity. Drag is a mechanical force generated by the interaction and contract of a solid body, such as an aeroplane, with a fluid (liquid or gas). Finally, the thrust is the force that is generated by the engines of an aircraft for the aircraft to move forward.

B. NEWTON'SSLAWSOFSMOTION

Another essential that applies to understanding how aeroplanes fly are the laws of motion described by Sir Isaac Newton. Newton's first and third laws of motion are especially helpful in explaining the phenomenon of flight. The first law states that an object at rest remains at rest while an object in motion remains in motion unless acted upon by an external force. Newton's second law states that force is equal to the change in momentum per change in time. For a constant mass, force equals mass times acceleration or **F=m*a.** Newton's third law states that for every action, there is an equal and opposite reaction.

C. BERNOULLI'S PRINCIPLE

Bernoulli built his work off of that of Newton. In 1738, he published "Hydrodynamica", his study in fluid dynamics, or the study of how fluids behave when they are in motion. Air, like water, is a fluid; however, unlike water, which is a liquid, the air is a gaseous substance. Air is considered a fluid because it flows and can take on different shapes. Bernoulli asserted in "Hydrodynamica" that as a fluid moves faster, it produces less pressure, and conversely, slower-moving fluids produce greater pressure.

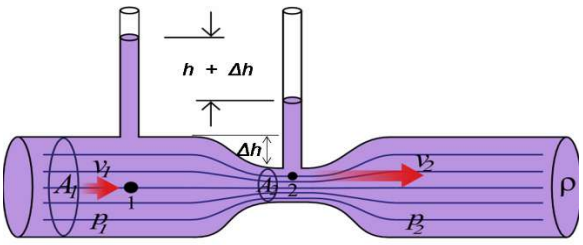

Figure 2: Bernouilli's experiment.

Then because of the shape of an aeroplane's wing, called an airfoil, the air into which the aeroplane flies is split at the wing's leading edge, passing above and below the wing at different speeds so that the air will reach the same endpoint along the trailing edge of the wing at the same time. the wing's upper surface is curved so that the air rushing over the top of the wing speeds up and stretches out, which decreases the air pressure above the wing. Since high pressure always moves toward low pressure, the air below the wing pushes upward toward the air above the wing. The wing, in the middle, is then "lifted" by the force of the air perpendicular to the wing. The faster an aeroplane moves, the more lift there is.

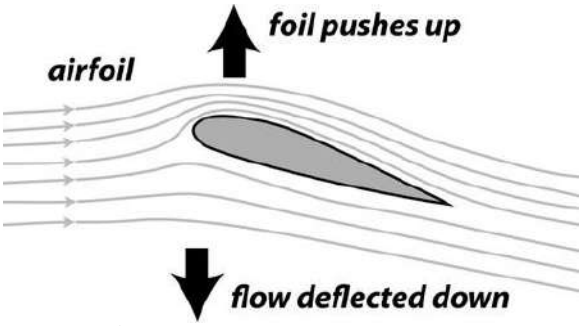

Figure 3: Airfoil.

III. BRAKING SYSTEM

A. What is the braking system?

As previously discussed a braking system is a mechanical process in which a motion of a body is decreased gradually or stops it. Similarly, we need a system to retard the motion of an aircraft whether it's and commercial, private, freight aircraft or fighter jets. To decrease such high speeds aircraft need various systems to be deployed as soon touchdown occurs because the braking system present in wheels is not sufficient to stop. After all, the heat generated during braking is tremendous and will damage the wheel resulting in a tyre burst.

B. Types of the braking system

As discussed above, the only braking system is not sufficient to stop a huge machine as soon it touches the ground, because the landing speed which is 200 knots can not be decreased just by using mechanical brakes. So, there are additional features that are deployed during landing which makes the slow approach and helps in smooth landing without any jerk. Other systems that are employed in aircraft are:

1. Flaps
2. Spoiler
3. Reverse Thrust
4. Wheel Brakes

So, above mentioned are other systems that contribute to the slow down of an aircraft. A brief discussion of these systems will be discussed ahead.

1. Flaps

The flap is placed on the outside edge of an aeroplane's wing. You can find it between the fuselage and ailerons. Large jetliners have as many as three parts to their flaps; these are extended in sections on takeoff and landing, as needed. Flaps help to either increase or decrease the camber, or surface area, of the aeroplane wing. Camber includes how convex the upper part of the wing is, as well as the concavity of the lower half. Wing flaps are a significant part of the takeoff and landing process. When the aeroplane is taking off, the flaps help to produce more lift. Conversely, flaps allow for a steep but controllable angle during landing. During both, efficient use of flaps helps to shorten the amount of runway length needed for takeoff and landing. There are 0 to 4 levels of flaps where:

0= Flaps idle

1= Initial

1+ = Positioning of flaps and slats for take-off for maximum lift

2= At Approach and Landing

3= At final approach and landing

4= During landing (not recommended because of high fuel consumption)

Figure 4: Aircraft flaps

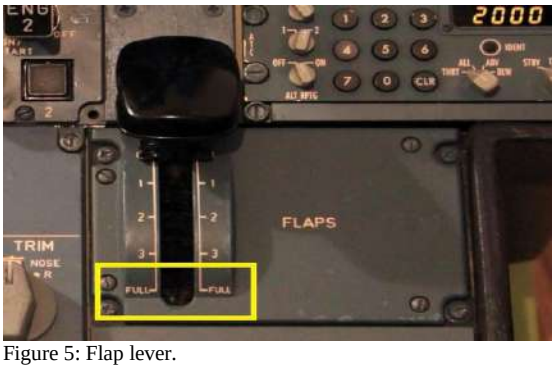

Figure 5: Flap lever.

2. Spoilers

Spoilers are hinged, rectangular plate-like structures installed flush along the top of an aircraft wing, just forward of the flaps. When the pilot activates the spoilers, the plates pivot upon their centre hinge fittings into the airstream. As the name suggests, the airflow over the wing is disturbed (spoiled) and lift is decreased. Maximum deployment of the spoiler would be about 50° from the flush position.

The spoiler is a multifunctional flight control surface with three main functions:

1. In-flight air braking for speed reduction
2. In-flight roll control (to augment the ailerons in turning)
3. And air braking on the ground, during lift dumping.

The latter dispels the remaining lift as an aircraft touches down on a runway. ***This increases the efficiency of the wheel brakes*** by applying the full weight of the aircraft on the wheels.

In the deployment of spoilers there are 5 levels which are:

A(ARMED)= In position before landing.

0= Idle.

1= Initial.

2= Partial deployment.

3= Fully active.

Figure 6: Spoilers.

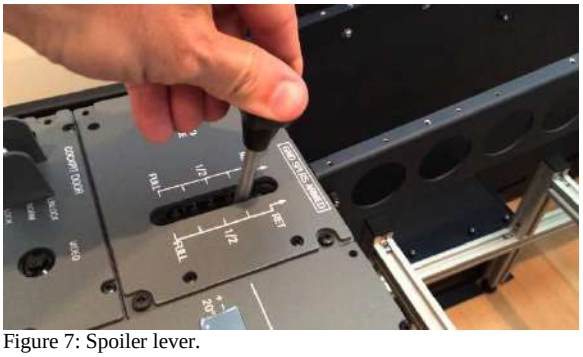
Figure 7: Spoiler lever.

3. Reverse Thrust

Although most modern aircraft brakes are sufficient during normal conditions, when runways become icy or snow-covered, an additional method of bringing the aircraft to stop is needed. A simple and effective way to reduce the landing distance of an aircraft is to reverse the direction of the exhaust gas stream. Thrust reversal has been used to reduce airspeed in flight but is not common in modern vehicles. Many high by-pass ratio engines reverse thrust by changing the direction of the fan airflow. Since a majority of the thrust is derived from the fan, it is unnecessary to reverse the exhaust gas flow.

When an aircraft is in operation, its engines provide forward thrust by blasting out the air in the opposite direction to the plane's travel direction. With enough thrust, the aircraft generates lift, which allows it to take off and remain airborne. Reverse thrust does exactly what its name would suggest reversing the direction of airflow to provide an opposing, decelerating force on the plane's direction of travel.


Figure 8: Reverse thrust lever.

There are various types of reverse thrust that varies from aircraft to aircraft and manufacture to manufacture. Their types are as follows:

3.1 Cascade Reverser

A cascade reverser incorporates radially arranged openings near the aft edge of the fan cowl of a turbofan engine. Within each of the openings is mounted a cascade set of airflow turning vanes. A blocking door and its associated actuating system are positioned flush with the inner wall of the fan cowl adjacent to each opening.

The outer surface of the cascade sets is covered by a "sleeve-like" translating (or sliding) section of the cowl. When the reversers are activated, the actuating system causes the translating cowl to move aft uncovering the cascades. The linkage between the translating cowl and the blocking doors move the doors into the bypass airstream blocking its normal path and diverting it out through the cascades which redirect it forward to help slow the aircraft.


Figure 9: B777 cascade type reverse thrust.

3.2 Clamshell Reverser

The clamshell thrust reversal system is operated pneumatically because the doors rotate to open ducts and close the normal exhaust, which redirects the thrust forward. Commonly used on turbofan engines. On turbojets, it would be less efficient than the commonly used target system, since it only uses the fan's airflow and doesn't affect the engine's core, which is still producing thrust.


Figure 10: A330 clamshell reverse thrust.

3.3 Target Type Reverser

A target reverser is a hydraulically actuated system that uses bucket type doors to reverse the flow of the engine hot gas stream. Whilst in forward thrust, the bucket doors form the final tailpipe nozzle of the engine. When reverse thrust is selected by the pilot, actuators close the buckets over the hot gas stream deflecting it forward. A mechanical lock holds the buckets in their extended position to allow thrust to be increased without the associated risk of an uncommanded, asymmetric retraction of the buckets.

Figure 11: B737-200 Target type reverser.

4. Wheel Brakes

Essentially, the purpose of brakes is to cause the aircraft to slow down. Following this development, the surface of runways has been changed to a much smoother and shorter surface. These new surfaces assisted in providing a softer landing and a more comfortable ride as well as smoother take-off which was crucial specifically as planes moved into passenger transport when travel across the world increased. Therefore brakes have ultimately allowed travelling on an aircraft to become safer and more comfortable as a result of their ability to stop and control ground speed.

Not only is it beneficial to provide passengers with a comfortable ride, but braking systems ultimately allow an increase in travel due to the number of flights taking place. The increase in departures is possible because of braking systems as the time and space it takes to stop has decreased, therefore airlines can take advantage of the clear space once a quick sharp landing has taken place.

Braking redundancy in most large passenger aircraft today is achieved by multiple, independent hydraulic systems backed up by accumulators. These systems allow for several layers of failure without resulting in total loss of braking capability.

Figure 12: Hydraulic brake assembly of A320.

These wheel brakes also have several stages and are used according to requirement. The stages of these brakes are as follows:

P(PARKING)= When aircraft is at aerobridge or is parked at remote area.

1= Minor (used during taxi sometimes)

2=Medium

3= Fully applied (used during landing)

M(MAXIMUM)= Extreme level (used after landing for quick stop gradually)

Figure 13: Wheel brakes control lever.

Figure 14: Parking Brakes.

4.1 Certification

The certification process must be done with all brakes worn to near their service limit (nominally 10% remaining life) and the brake and wheel heat sink must be robust enough that no intervention in terms of fire fighting or artificial cooling is required for 5 minutes after the aircraft has been stopped.

C. Which type of brake is efficient?

The answer depends on factors like the bypass ratio of the engine and the design of the thrust reverser, e.g. bucket doors at the back of the engine or vanes to deflect the bypass airflow from the fan. By the OP's proposed measurement (reverse thrust / forward thrust), the efficiency is also strongly dependent on the engine speed. At maximum thrust, the reverser maybe 50% or 60% efficient, but at lower power levels it may be less than 10%.

Reverse thrust is much more effective at high aeroplane speed than at low aeroplane speeds for two reasons, the net amount of reverse thrust increases with speed and the power produced is higher at higher speeds because of the increased rate of doing work. In other words, the kinetic energy of the aeroplane is being destroyed at a higher rate at higher speeds. To get maximum efficiency from reverse thrust, therefore, it should be used as soon as is prudent after touchdown.

IV. CONCLUSION

Each of these brakes has its purpose for example spoilers may be used during descending from high altitudes in an emergency or flap level 2 to achieve suitable landing speed during wind days or storm. The aircraft brake is dependent on the situation of the aircraft industry and influenced by the development of aerospace technology. Aeroplanes continue to use these four main systems as braking mechanisms as they are the best and most efficient at doing so. The rotors of wheel brake assembly are most commonly made from iron or steel but in the last 20 years, more and more aircraft have been equipped with carbon fibre brakes. There are multiple reasons for this evolution but the two most compelling ones are weight reduction and efficiency. Efficiency is particularly critical, for as aircraft get larger and their weight increases, the brakes must be capable of dissipating more energy. The kinetic energy of an aborted takeoff or a landing is largely converted to heat by the wheel brakes. Carbon brakes are still fully functional and retain the ability to absorb energy and slow the aircraft at and well beyond temperatures at which steel brakes have lost their efficiency and have started to fade.

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GEAR HOUSING AND GEAR DESIGN

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- **Abstract—** ***Analysis of gear housing and spur gear design using finite element analysis (FEA).***

II. IN THIS WE ARE DESIGNING A SELF -LUBRICATING GEAR HOUSING AND GEAR DESIGN. WE ARE REDUCING THE SPEED IN THE GEAR RATIO 3:1, THAT WE RANDOMLY SELECTED, GEAR RATIO CAN BE VARIED. BY REDUCING THE SPEED MEANS WE ARE REDUCING THE RPM I.E. IF WE ARE GIVING 300 RPM THEN THE OUTPUT IS SIMPLY 100 RPM.

III. IT HAS TO BE NOTED THAT BY REDUCING THE SPEED WE ARE INCREASING THE TORQUE THAT LEADS TO INCREASE IN STRESS.

IV. HEAT IS PRODUCED THAT VARIES WITH FRICTION SO WE ARE DESIGNING A GEAR HOUSING THAT IS MADE UP OF SELF -LUBRICATING PLASTICS.

V. THIS PROJECT IS DONE TO DEMONSTRATE THE EFFECT OF TORQUE IN DIFFERENT ANALYSIS LIKE STATIC STRUCTURAL, THERMAL ANALYSIS, MODAL AND SHAPE OPTIMIZATION.

VI. WE ARE USING SPUR GEARS FOR THE SAKE OF SIMPLICITY AND THE INPUT SHAFT AND OUTPUT SHAFT ARE CONCENTRIC IN ORIENTATION AND TO PROVIDE A FACTOR OF SAFETY GREATER THAN OR EQUAL TO 4.

VII. **THE HOUSING IS MADE UP OF SELF-LUBRICATING PLASTIC,**

Keywords—FEA, Self-lubricating plastics, Gear housing and gear design.

1.INTRODUCTION

Computer-aided design (CAD) involves creating computer models defined by geometrical parameters. These models typically appear on a computer monitor as a three-dimensional representation of a part or a system of parts, which can be readily altered by changing relevant parameters. CAD systems enable designers to view objects under a wide variety of representations and to test these objects by simulating real-world conditions.

finite element method (FEM) is a widely used method for numerically solving equations arising in engineering and mathematical modeling. The FEM is a general numerical method for solving partial differential equations in two or three space variables (i.e., some boundary value problems). To solve a problem, the FEM subdivides a large system into smaller, simpler parts that are called finite elements. The finite element method formulation of a boundary value problem finally results in a system of algebraic equations. The method approximates the unknown function over the domain. [4] UHMW (ultra-high-molecular-weight polyethylene) offers a combination of exceptional properties. This thermoplastic material is tough with superior impact strength. It is corrosion-resistant and exhibits virtually no water absorption. It is also wear-resistant, non-sticking and self-lubricating.

UHMW is an excellent choice for many industrial applications. It reduces noise and vibration, is chemical-resistant and non-toxic and offers excellent mechanical properties even in cryogenic conditions.

- Non-toxic
- Low coefficient of friction
- Corrosion, abrasion, wear and impact resistant
- Extremely low water absorption
- FDA and USDA approved

Applications for UHMW

- Chute linings
- Food processing parts
- Chemical tanks
- Conveyor guides

[1] These plastics are blends of a thermoplastic resin and a small percentage of silicone.

[1]The silicone migrates to the surface of a molded or extruded part, thus generating a polymer film which serves as a boundary, or mixed-film lubricant. such materials are called migratory internally lubricated thermoplastics. They provide lower friction and wear than earlier internally lubricated thermoplastics and they eliminate the run-in period to bring the lubricant to the surface. A further enhancement of wear and friction properties has been achieved by adding both migratory-type polymer lubricants (silicone) and particle-type internal lubricants (such as polytetrafluorocarbon).

[1]As these materials combine at the wear surface, they form a high-temperature grease.The PTFE acts both as a thickener and an extreme-pressure additive, and the silicone lubricant ensures continuous lubricity, both at startup and at high speeds.

2.Equations

[2]Backlash is clearance between mating components, or the amount of lost motion due to clearance or slackness when movement is reversed and contact is re-established. In a pair of gears, backlash is the amount of clearance between mated gear teeth. Backlash value is 0.1.

[2]Pressure angle in relation to gear teeth, also known as the angle of obliquity, is the angle between the tooth face and the gear wheel tangent. The pressure angle is equal to the profile angle at the standard pitch circle and can be termed the "standard" pressure angle at that point. Standard values are 14.5 and 20 degrees. is taken as 20 degree.

[2]Gear module is the measure of gear tooth size which is normally used for metric system gears.

Gear module = diametrical pitch /no. of teeth on gears.

Module = Drive_Gear_Dia/Teeth = 96/48=2

Gear thickness = 8 mm

Gear ratio = Drive_Gear_Teeth/Driven_gear_teeth = 48/16 = 3

Gear ratio can be varied according to number of teeth and diameter size.

3.experimentation

- Using fusion 360 cad and cam software for the simulation i.e. finite element analysis for static, shape optimization, thermal analysis, thermal stress analysis and modal i.e. vibrational Analysis.
- First was material choice that is ultra- high molecular weight polyethylene plastic for gears and gear housing material.
- specifying the constraints like fixed ,pin , rigid ,moment applied.
- Applying the loads force ,moment, , thermal loads , convection
- Applying contact sets which shows the connections between assembly parts
- Generating the mesh (splits the domain into a discrete number of elements for which the solution can be calculated). Refining and manually adjusting the mesh size into smaller size gives more accurate result .
- Last is to check all the conditions and loads applied before solving the study.
- Review the results obtained.

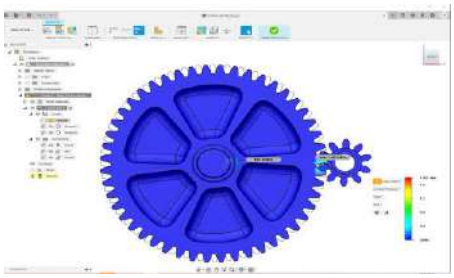

Fig.1Showing contact pressure between teeth of gears

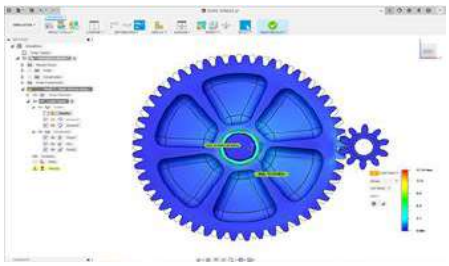

Fig.2 Showing stress between teeth of gears

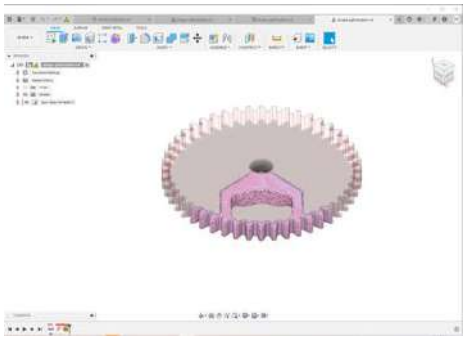

Fig.3 showing meshing of shape optimization

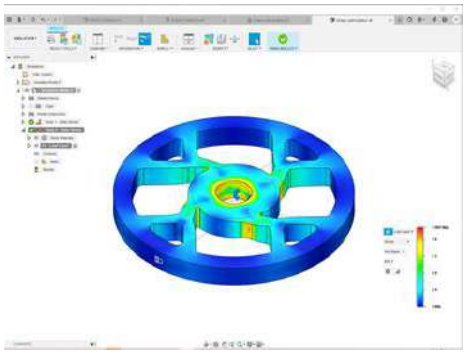

Fig.4 Showing mass and shape reduction during shape optimization

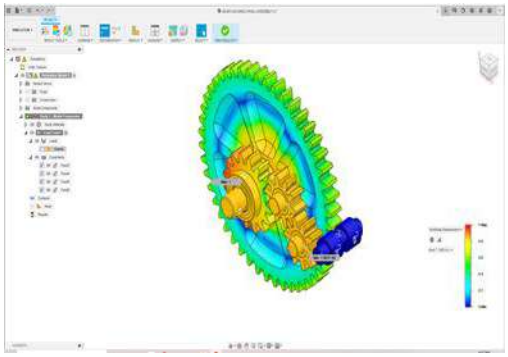

Fig.5 Showing modal effect on gear train assembly

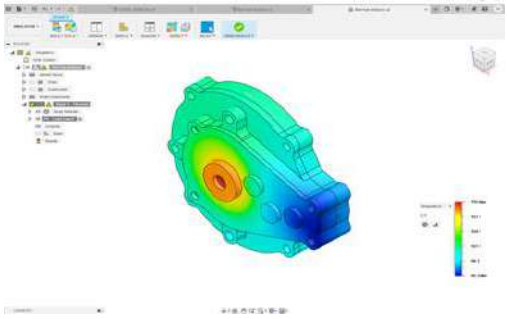

Fig.6 Showing temperature distribution across different section

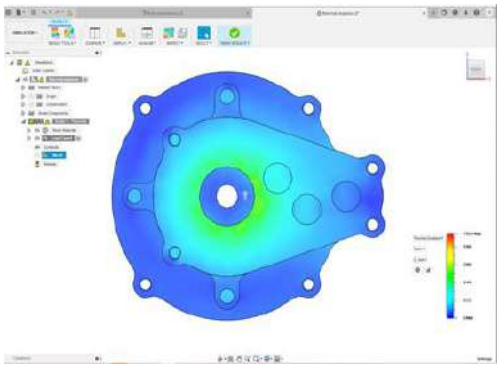

Fig7. Showing heat flux across the gear housing

4.Results and discussion

- Static simulation results

once your simulation has finished solving, you'll automatically be placed into the results toolset. all of our results tools and the results details automatically displays on the right-hand side. We can see what our safety factor targets are. In this case factor of safety maximum value is 15 and min is 2.959 and stress maximum value is 15.54MPa and min value is 4.89E-0.6 MPa. Strain maximum value is 0.03353 and min 7.316E-0.9. contact pressure between teeth is maximum 1.801MPa and min 0 Mpa.

- Shape optimization results
- Taking a look at the results of our shape optimization study. So we have a thin border around the outside where we had our fixed constraint. We have the center section which we defined as our preserved region. Then we have this spoke shape that's in the middle. Now because we did this as a quarter section of the entire gear, this gives us the information that we need in order to make modifications or adjustments to the shape of our gear. This allows us to remove material and still keep the gear relatively strong. This study shows critical load path and the sections which can be removed making the component lighter without affecting the strength.
- Mass target is reduced to 40% and Maximum stress value is 1.866 MPa.
- Modal analysis results.
- Modal analysis is the study of the dynamic properties of systems in the frequency domain.
- In this we have shown the effects of vibration on gears
- Thermal analysis results
- Fins size = length =15mm breadth = 2mm
- steady state thermal analysis calculates effects of constant thermal loads on a model and is used to determine temperatures, heat flow rates, and the heat fluxes in a part. In our case we have taken 110 degree Celsius that is the UHMW maximum temperature and the extreme case with 220 degree Celsius with fins and the result values :
- Temperature = 110 degree Celsius case
- Maximum temperature of housing= 110 degree at the hottest section
- Minimum 95.3 at the coldest section
- Temperature =220 degree Celsius case
- With fins maximum temperature is 240.2 degree and minimum is 205.7 degree
- Temperature = 110 degree Celsius case

- Heat flux without fins : Maximum = 0.1732 W/mm*2 & Minimum = 0W/mm*2
- Temperature =220 degree Celsius case
- Heat flux with fins : Maximum = 0.4322 W/mm*2 & Minimum = 0W/mm*2
- Temperature = 110 degree Celsius case
- Thermal gradient without fins : Maximum = 1.037C/mm & Minimum = 0 C/mm
- Temperature =220 degree Celsius case
- Thermal gradient with fins : Maximum = 8.72C/mm & Minimum = 0 C/mm

Thermal stress analysis

- Thermal stress analysis refers to a static analysis that measures the strains, stresses and deformations that occur with changes in temperature.
- Heat flux : Maximum : 0.006395 W/mm*2 Minimum = 0 W/mm*2
- Thermal gradient : Maximum = 16.03 C/mm Minimum=0 C/mm

Stress : Maximum = 136 Mpa Minimum = 0 MPa

Strain: Maximum = 0.2894 Minimum value =0.

5.Figures and Tables

Specifications

Gear parameters	Driven	Drive	Idle 1 and 2	Idle 3
Module	2	2	2	
Teeth	48	16	10	10
Backlash	0.1	0.1	0.1	0.1
Root Fillet	0.5	0.5	0.5	0.5
Gear Thickness	8	8	8	21
Hole Diameter	12	12	12	12

USER PARAMETERS	VALUE
Drive_Gear_Teeth	48
Driven_Gear_Teeth	16
Idle_Gear_Teeth	10
Gear_Module	2
Drive_Gear_Dia	96
Driven_Gear_Dia	32
Idle_Gear_Dia	20
Mount_Bolts	8
Idle_Gear_Shaft	8
Mount_Bolt_Flange	12
Gear_Clearance_Dia	4

6.CONCLUSION

In this project first we have used the cad and cae tool like fusion 360 and designed the gear housing and gear train with the values mentioned in the specification part. Then experimenting and performing different simulation got us different results. we have tried to show the effect of torque on gears when reducing speed. Using self-lubricating plastics Ultra High Molecular Weight Polyethylene for the gear housing and gear material. As plastic gears are replacing many metal gears for its functionality and costs.

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Designing of Human Powered Vehicle

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***Abstract*— This document provides systematic approach towards designing of an HPV whose main objective is to achieve high speed. It describes the steps that can be followed while designing an HPV. It can serve as a guide for future attempts toward designing fast HPVs.**

***Keywords* — HPV: Human Powered Vehicle**

I. INTRODUCTION

Use of human powered vehicles is the best alternate available with us to reduce the use of fossil fuels. Although for long distance travel this might not prove to be a good option but for short distances, this can prove to be the best. Human powered vehicles are generally perceived to be slow as compared to other options. This paper is an attempt to change this perception and prove that human powered vehicles can also travel at high speeds.

II. OBJECTIVE

To design and analyse a human powered vehicle with an objective to achieve high speed. The rider should be able to maintain the vehicle at its top speed by using her/his pedaling force only. This is an attempt to achieve speed close to the current land speed world record for human powered vehicles (280kmph).

1. To design and analyse a human powered vehicle.
2. To ensure maximum strength of the structure while keeping the weight minimum.
3. To ensure safety of the rider.
4. To achieve speed more than 200kmph.

The HPV thus designed is expected to meet the following indirect objectives:

- Pave way for future development of faster HPVs.
- Promoting the use of HPVs among younger generations by showcasing their capabilities.

III. IMPORTANT CONSIDERATION

The above-mentioned research and past experience in designing and competing in HPV competitions helped in making important decisions about the design and provided valuable inputs.

1. The HPV designed used a 2-wheel frame. This is done to keep the volume of the vehicle minimum to reduce aerodynamic drag acting on the body. Also, this helps in reducing the rolling resistance and weight of the vehicle.
2. An ergonomic semi-recumbent ride position is chosen that helps in streamlining the shape of the vehicle while providing support to the whole of the rider's back. This helps in making the design safer for the rider in case of a front impact. This also allowed us to attach an RPS to the frame.
3. An RPS is attached to the frame that serves as a mounting for the rider's safety harness, keeping the rider attached to the vehicle in case of a fall. It also prevents any part of the rider’s body from coming in contact with ground in case of a fall.
4. 2 similar pipes having 2 bends each join the RPS to the pedal assembly present in the front of the vehicle. Use of two pipes helps in increasing the strength of the joint between the pedal assembly and the pipes. It also helps in increasing the load bearing capacity of the frame.
5. The HPV uses a 4 sprocket-2 chain compound transmission to achieve the necessary gear reduction required. This helps in increasing the transmission ratio, reducing the chain length and improving the transmission efficiency.
6. The front telescopic serves as suspension and steering both. It has some travel to reduce the effect of perturbations on the frame and keeping the vehicle stable.

Since the main objective of the vehicle is to achieve high speed, the turning mechanism loses it’s need,

but still to provide the rider with better control over the vehicle, a steering system similar to the one present in conventional upright bicycles is installed.

7. For ease of management and progress of the project, the design has been broken down into following subsystems:
   - Transmission
   - Frame
   - Fairing

IV. DESIGN

A. Ride Position

The following comparison supports the choice of going with a semi-recumbent rider position for our design.

	Pros	**Cons**
1.Prone	• Good aerodynamics • High speed	• Uncomfortable • Less safe
2.Semi-Recumbent	• Comfortable ride • Good aerodynamics • Good performance and speed • Safe	• Complex design • Difficult to steer • Difficult to ride
3.Upright	• Simple design • Easy to ride • Commanding ride position	• Poor aerodynamics • Less comfortable • Unsafe

B. Transmission

A drivetrain is that subsystem of a vehicle which is responsible for converting the vehicle's energy source into kinetic energy or mot ion. It is a group of components that delivers power to the driving wheels.
A chain-driven system was decided to be used for the HPV. A unique 2-chain transmission system was designed to achieve the desired objectives.

- The pedal assembly is installed at the frontmost part of the vehicle. The sprocket here has 60teeth and the crank length is 0.2m.
- The first chain coming from pedal assembly runs a 12 teeth sprocket. A primary speed multiplication of 5 times is achieved here. The 12teeth sprocket is compounded with a 60teeth sprocket on the other end of the frame. This is connected to another 12teeth sprocket that runs the rear wheel. These two sprockets are connected by a second chain and a secondary speed multiplication of 5 times is achieved again here. Thus, an effective speed multiplication of 25 times is achieved from the pedals to the rear wheel.
- The diameter of the rear wheel decides the distance travelled by the vehicle in one rotation of the wheel. The larger the wheel diameter, more will be the distance travelled by the vehicle per rotation of the pedal, thus, more will be the speed. But with increase in wheel size, strength of wheel spokes, wheel rim and the tyre reduces. This necessitates optimization and compromise between the two contradicting requirements. Market survey suggested that the maximum tyre size available in the market, having the necessary strength is 17" diameter. Therefore, this is the size of the tyre that is chosen for the vehicle.

C. Frame

The frame is the most essential and defining part of the HPV. The goal was to make the frame as sturdy as possible while also minimizing the weight. The two ambitions are contradicting and therefore a balanced settlement was reached.

- An RPS is designed that loops around the rider and acts as mounting for seat, safety harness and rear suspension system. Its dimensions are chosen such that no part of the rider's body comes in contact with ground in case of a sidewards fall or complete rollover. This keeps the rider safe from injuries. The safety harness keeps the rider attached to the RPS which further improves rider's safety.
  The RPS also supports the seat, that provides the necessary support to the rider's body to ensure rider's comfort and help the rider to perform at the best possible level.

- Two similar pipes, having two bends each, run along the length of the vehicle. One end of these pipes is connected to the base of the RPS while the other end goes up to the front pedal assembly. These two pipes support most of the load acting upon the vehicle. The set of idler gear which is used to transfer power from one side of the frame to the other, while also multiplying the speed of transmission, is mounted on a drop-down mounting designed specifically for this.

- A hollow tube is installed through the two parallel pipes. This tube is inclined at an angle equal to the

angle of inclination of the front fork because this tube serves as the mounting for the front fork. The front fork passes through this tube and the steering handle is attached to it at the top. This tube is provided with extra wedge members to provide additional strength and support.

D. *Fairing*

The fairing is the outermost part of the vehicle that comes in contact with air when the vehicle is in motion. The shape of the fairing is of prime importance as it governs the magnitude and direction of aerodynamic drag forces acting on the vehicle.

- The fairing of the vehicle is designed that it covers the whole of the vehicle to ensure minimum drag coefficient. It also acts as an additional layer of safety for the rider by keeping the rider enclosed in a strong, lightweight enclosure.
- The shape of the fairing is optimized to keep it streamlined, while keeping the volume of the vehicle to a minimum. The frontal area of the fairing is minimized to the maximum possible extent as it directly affects the drag force acting on the vehicle.
- The area of the rear end of the fairing is also reduced to the maximum possible extent to reduce the low-pressure wake region developed at the trailing end of the vehicle. This also reduces drawbar pull acting on the vehicle, reducing load on the rider. This also improves the overall vehicle efficiency.

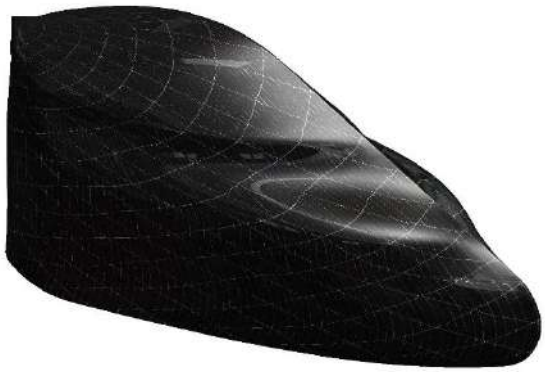

Fig I: Fairing for HPV

E. *Materials*

The strength of the components is governed by the design and the material. The design can be optimized by repeating cycles of design, analysis and modification. For material, we need to choose the right one from the available choices. Going fast requires the vehicle to be very light, while also being exceptionally strong. These two requirements necessitate the choice of very high strength, low weight materials like carbon fiber and titanium. The choice is made between these 2 materials for various parts of the vehicle, depending upon the strength required by each component.

F. *Frame Material*

The frame is made out of Titanium Alloys (Ti-3Al-8V-6Cr-4Mo-4Zr) to give it the necessary strength while keeping the weight to a minimum.

G. *Fairing Material*

The fairing is made out of Hexcel AS4C (3000 Filaments) because of it being lightweight and having good strength. The surface finish of the fairing is improved by polishing to reduce air friction.

Fig II: A view of HPV

H. *Drivetrain Calculation*

Maximum cadence per minute = 100
Total speed multiplication = 25times
Rear Wheel Diameter = 0.4318m
Distance travelled by rear wheel in 1 rotation

= πd = π*(0.4318) = 1.357m
For 1 rotation of the pedal sprocket, the rear wheel rotates 25 times.
Distance travelled at 100 cadences
= 100*25*1.357 = 3392.5m/min = 3.3925km/min
Speed at 100 cadences = 3.3925*60 = 203.550kmph

V. CONCLUSIONS

We designed a human powered vehicle that theoretically crosses the 200kmph mark. The current land speed record for human powered vehicles is 184miles per hour or 296kilometers per hour. These speeds might never come true for commercially available human powered vehicles, but such attempts serve as a great leap for future development projects and keep us aware of our maximum calibre.

The speed achieved by the HPV designed so far is far from the current land speed record for HPVs. But with a few modifications, a long enough track and a generous budget, this design is capable of going beyond the current record.

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Efficiency and Economic Impact of Energy-Saving Transformation of Residential Buildings in Different Climatic Regions of China

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***Abstract*— In China, the transformation of existing buildings is confronted with various problems in aspects ranging from technology to policy and even to economic efficiency, which restrains the pace of existing building transformation. Aiming at these conditions, a building model is established with simulation software in the research herein to deeply analyze the energy-saving effect of building envelope transformation in different climatic regions and its economic efficiency based on regional and national policies. The research results show that any single technology is difficult to completely satisfy the requirements of current energy efficiency standards, and technical measures should be taken according to different climatic regions. For the northern heating area, the building envelope transformation must be carried out simultaneously with the transformation of heat metering. Policy formulation and fund determination for the energy-saving transformation of existing buildings in China should be more flexible based on transformation effect and rely more on social and commercial forces rather than solely on the promotion of government.**

I. INTRODUCTION

Along with the acceleration of the urbanization process in China, the building energy consumption constantly increases. It is revealed by the research results of the Building Energy Research Center, Tsinghua University, that the unit area of buildings is increasing rapidly and the energy consumption intensity of buildings is rising moderately at the same time, both of which lead to the continuing increase of total energy consumption of buildings.

The vast majority of buildings constructed before 2000 are not energy-efficient in China. It is shown by data that, by the end of 2013, the existing floor area in China had exceeded 50 billion m2, including 27 billion m2 of existing urban floor area; however, urban energy-saving buildings merely took up 29.63% in the existing gross floor area, and more than 70% of buildings needed energy-saving transformation in the future. What is more, there is annual increment resulting from emerging urbanization process.

The problems of existing buildings are mainly manifested by the low average thermal insulation level of exterior wall, only 1/3 of that in developed countries at the same latitude in Europe, low efficient systems of heat supply and cooling, lag of heat metering reform, and so on. In order to change such a situation, a series of national and local policies and financial incentives have been implemented to support energy-saving transformation. However, these policies and measures still have various problems that hinder the energy saving transformation of existing buildings. For example, the estimated cost for the energy-saving transformation of building envelope, heat metering, and pipe-network thermal equilibrium is higher than 220 Yuan/m2 , and the need for capital investment will be larger if heat source transformation is added, but current subsidies for energy saving transformation are not enough. For another example, the immature market mechanism impedes the enthusiasms and approaches of enterprises and residents for carrying out energy-saving transformation. Finally, there is no in-depth analysis of the energy-saving transformation and its cost efficiency in different climatic regions or analysis of the impact of transformation results on the end users.

II. RESEARCH METHOD

Aiming at aforementioned conditions, a building model is established with simulation software in the research herein to deeply analyze the energy-saving effect of building envelope transformation in different climatic regions.

In China, civil buildings are majorly classified into two kinds, namely, public buildings and residential ones. Judged from the energy-saving transformation of a single building, the energy-saving transformation of a public building involves broader items and includes not only the improvement of thermal insulation performance of

building envelope but also the energy conservation of heat supply and cooling systems during the life-cycle use process; the comprehensive efficiency of energy-saving transformation is highly dependent upon both . The condition of a residential building is relatively simple, and the energy-saving benefit can be effectively increased to a large extent by improving the thermal insulation performance of building envelope. The research herein does not discuss the transformation of heat supply and cooling systems, so residential building is selected as the object of transformation.

There are five climatic regions for buildings in China. A typical city in each of the four regions among them is selected, respectively, as research object, that is, Harbin in the severe cold region, Beijing in the cold region, Shanghai in the hot summer and cold-winter region, and Guangzhou in the hotsummer and warm-winter region, as shown in Figure 1. No city is selected in the mild region.

To deeply and meticulously analyze the specific effect of building envelope transformation on building energy efficiency in different climatic regions, a model is built in the research with simulation software ENERGYPLUS by taking a 10-floor typical residential building as the prototype, as shown in Figure 2. This building has a total area of 7,836.48 m2, shape coefficient of 0.2, window-wall ratio of 0.15, total area of exterior wall of 3,855.02 m2, total area of exterior window of 208.08 m2, and roof area of 783.65 m2.

In the research, in accordance with the Design Standard for Energy Efficiency of Residential Buildings in Severe Cold and Cold Regions (JGJ26-2010) , Design Standard for Energy Efficiency of Residential Buildings in Hot-Summer and Cold-Winter Region (JGJ134-2010), and Design Standard for Energy Efficiency of Residential Buildings in HotSummer and Warm-Winter Region (JGJ75-2003) [9], parameters related to the thermal performance of ENERGYPLUS model's building envelope are set, respectively, for benchmark building (1980s) and reference building (meeting above specifications) for different climatic regions. Examples of the thermal performance parameters of these two types of buildings are shown in Table 1, and the city shown in the table is Beijing.

I: severe cold zone
II: cold zone
III: hot-summer and cold-winter zone
IV: hot-summer and warm-winter zone
V: temperate zone
VI: severe cold zone VI_C: cold zone
VII: severe cold zone
VII_D: cold zone

Figure 1: Diagram of climatic regions for buildings in China and selected cities. Source: ⟨code for design of civil buildings⟩ (GB 50352-2005)

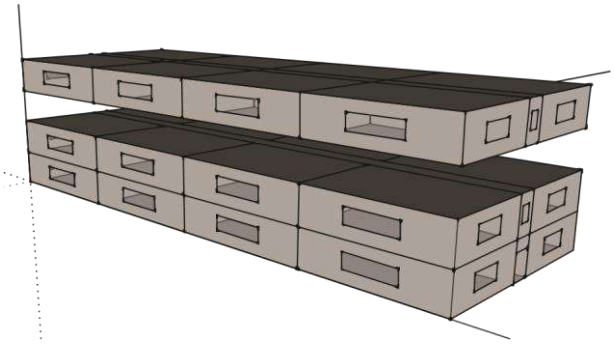
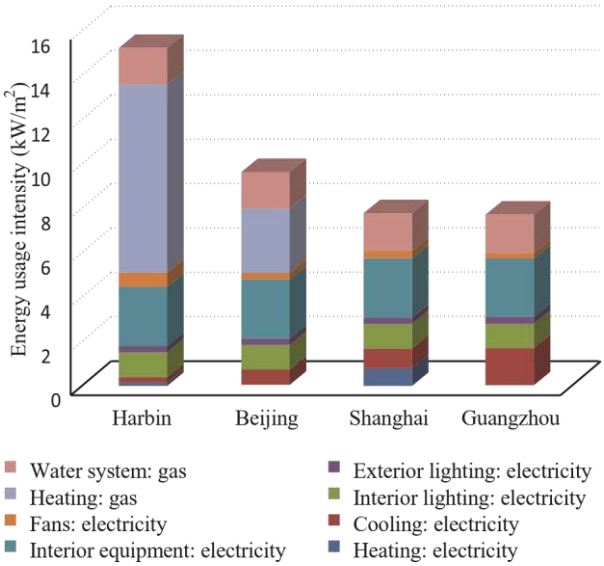


Figure 3: Schematic diagram of energy consumption intensities of benchmark buildings in different climatic regions.



After the establishment of model, various parameters are input into ENERGYPLUS to calculate the energy consumption intensity, respectively, of benchmark building and reference building through simulation, as shown in Figures 3 and 4. It can be observed from the figures that the energy consumption intensity, respectively, in Harbin in the severe cold region and Beijing in the cold region is significantly reduced after the transformation of building envelope, especially by nearly a half in Beijing.

With the aim of making the effects of the transformation of such components as wall, exterior window, and roof in building envelope on the result of energy-saving transformation clear, the thermal performance changes of these three components are simulated separately for in depth comparison and analysis based on the whole process of benchmark building, single component transformation building and reference building.

In the analysis of the energy consumption intensity of heating, it can be seen from Figures 5–7 that the energy

consumption intensity of simulated building will be reduced by improving the thermal performance of any exterior envelope structure in any single component and making it meet the requirement of current energy-saving standard, and when all the items are consistent with the

Table 1: Parameter comparison of thermal performance of prototype buildings in Beijing

Item	Benchmark building (1980)	Reference building (meeting energy efficiency standard)
Wall	□ value of exterior wall: 1.7 W/(m²· K)	□ value of exterior wall: 0.7 W/(m²· K)
Roof	□ value of roof: 1.26 W/(m²· K)	□ value of roof: 0.45 W/(m²· K)
Window	□ value of window: 6.4 W/(m²· K)	□ value of window: 3.1 W/(m²· K)
Air change rate	1.5 times/hour	0.5 times/hour (according to the standard for cold region)
Running time	24/7	24/7
Cooling system	Indoor air conditioner, EER: 3.1	Indoor air conditioner, EER: 3.1
Heat source (central heating)	Natural gas boiler, efficiency: 0.8	Natural gas boiler, efficiency: 0.8
Pump	Constant volume	Constant volume
Heating period	11.15–03.15 (next year)	11.15–03.15 (next year)
Cooling period	06.15–08.31	06.15–08.31

requirements, that is, forming the reference building, the energy consumption will reach the optimum value. For instance, the energy consumption intensity of heating is decreased by 54% in Harbin and more significantly by 70% in Beijing. The impact

analysis of the energy consumption of heating does not include Guangzhou, because it is in the hot-summer and warm-winter region, where the heating period is very short and the energy consumption intensity very low.

It can also be seen from the figures that the thermal performance change of window brings about the best energy saving effect, because such a change in the research is not only reflected in the *U* value of window, but the effect of tightness performance change of window is also taken into consideration. The tightness of doors and windows is relatively poor in the buildings constructed in 1980s in China, so the value of air change rate is set as 1.5 times/hour in the model. The quality of buildings in China has been obviously improved in recent years, and the air change rate is about 0.3–0.5 times/hour in properly constructed residential buildings with high-quality doors and windows. The energy consumption of residential buildings in the south is mainly generated by air conditioners, and air infiltration through doors and windows or ventilation through windows can greatly shorten the running time of air conditioner; therefore the value of air change rate in the severe cold and cold regions is set as 0.5 times/hour and that in hot-summer and cold-winter and hot-summer and warm-winter regions as one/hour.

Figure 6: Schematic diagram of comparison between energy consumption intensities of heating in Beijing.

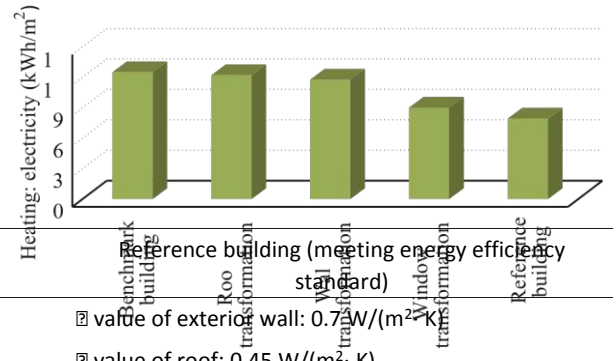


Figure 7: Schematic diagram of comparison between energy consumption intensities of heating in Shanghai.

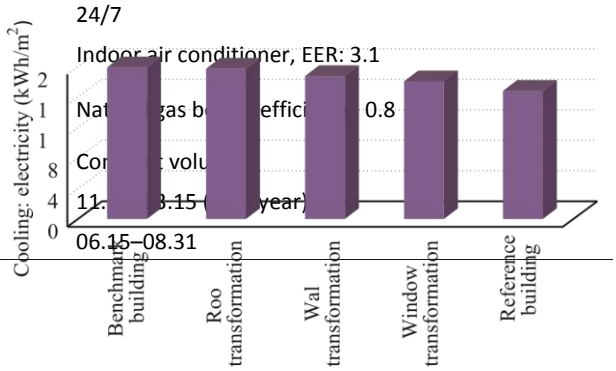


Figure 8: Schematic diagram of comparison between energy consumption intensities of cooling in Guangzhou. Source: self-drawing.

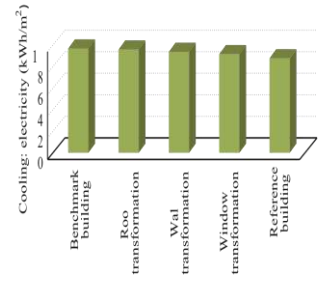


Figure 9: Schematic diagram of comparison between energy consumption intensities of cooling in Shanghai

In the analysis of the energy consumption intensity of cooling, it can be found from Figures 8–11 that the reduction in cooling energy consumption is obviously smaller than that in heating energy consumption by improving the thermal performance of any exterior envelope structure and making it meet the requirement of current energy-saving standard. The comparison diagram of Harbin indicates that the enhancement of tightness of doors and windows even increases the energy consumption intensity of cooling in summer, and the thermal performance improvement of wall results in the most remarkable transformation effect.

It is revealed by the research above that, on the one hand, China should continue expanding the transformed area of existing buildings in that just the thermal performance improvement of envelope alone can be highly effective in the reduction of energy consumption intensity, especially in the north. On the other hand, the energy-saving transformation of exterior envelope structures alone is not

enough to completely meet or surpass the national energy-saving standard unless it is combined with the energy-saving transformation of heat metering and pipe-network thermal equilibrium.

III. Analysis of the Economic Benefit of Energy-Saving Transformation

During the "11th Five-Year Plan" period, the transformation of existing buildings in China had been mainly concentrated in the northern heating area. By the end of 2010, 182 million m^2 of existing residential buildings had been transformed in the aspects of heat metering and energy conservation. In a bid to implement the spirit of the *Notice of the State Council on Printing and Distributing the Comprehensive Work Scheme of Energy Conservation and Emission Reduction* (GF [2007] number 15) and practically boost heat metering and energy saving transformation of existing residential buildings in the northern heating area, the Ministry of Housing and Urban Rural Development and the Ministry of Finance jointly or separately unveiled multiple management and incentive policies, mainly including

(1) Ministry of Finance and Ministry of Housing and Urban-Rural Development: *Interim Measures for Management over the Incentive Funds for Heat Metering and Energy-Saving Transformation of Existing Residential Buildings in the Northern Heating Area* (CJ [2007] number 957),

(2) Ministry of Housing and Urban-Rural Development: *Opinions on Boosting the Implementation of Heat Metering and Energy-Saving Transformation of Existing Residential Buildings in the Northern Heating Area* (JK [2008] number 95),

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(4) Ministry of Housing and Urban-Rural Development: *Acceptance Measures for Projects of Heat Metering and Energy-Saving Transformation of Existing Residential Buildings in the Northern Heating Area* (JK [2009] number 261).

During the "11th Five-Year Plan" period, the transformation of existing buildings in China had been mainly concentrated

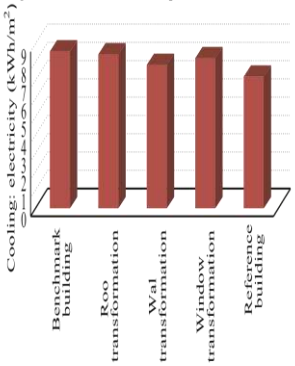

Figure 10: Schematic diagram of comparison between energy consumption intensities of cooling in Beijing. Source: self-drawing.

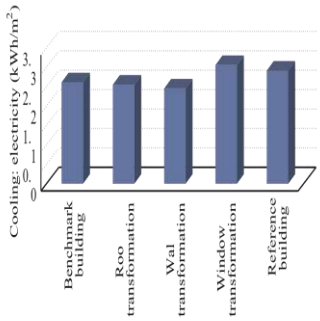

Figure 11: Schematic diagram of comparison between energy consumption intensities of cooling in Harbin.

The implementation of these policies promotes the transformation process of existing residential buildings in the northern heating area to a certain degree. However, under the condition of asymmetric information, there is no way to find out whether the incentive funds meet the transformation requirements, the economic incentive obtained by the existing buildings' owners, their reservation utility, and the economic and environmental benefits after energy-saving transformation and whether the economic incentive obtained by the owners through contract is comparatively low.

According to relevant surveys, 360,000 m2 of existing public and residential buildings had been transformed in Xi'an from 2007 to 2011, among which 320,000 m2 belonged to existing public buildings transformed under the guidance of government. Only the building envelope was transformed, and the cost per square meter was as high as 300 Yuan. The residual 40,000 m2 was transformed by the owners, with the incentive funds issued by the government. The reward for comprehensive transformation of building envelope was 50 Yuan/m2, and that for exterior window transformation alone reached 30 Yuan/m2, higher than the provisions in the Interim Measures for Management over the Incentive Funds for Heat Metering and Energy-Saving Transformation of Existing Residential Buildings in the Northern Heating Area (see the following).

Special fund amount allocable to a place = reward benchmark of the climatic region where it is located × [∑ (area of single transformation item in the region × corresponding single transformation weight) × 70% + area of transformation in the region × coefficient of energy-saving effect × 30%] × progress coefficient, where reward benchmark of the climatic region is classified into two categories: 55 Yuan/m2 for the severe cold region and 45 Yuan/m2 for the cold region.

Single transformation items refer to energy-saving transformation of building envelope, transformation of indoor heat metering and temperature control, and transformation of heat source and heat supply pipe-network thermal equilibrium, and weight coefficients for these three transformations are 60%, 30%, and 10%, respectively.

During the "12th Five-Year Plan" period, to implement the spirit of the Notice of the State Council on Printing and Distributing the

Comprehensive Work Scheme of Energy Conservation and Emission Reduction during the "12th Five-Year Plan" Period (GF [2011] number 26), China has launched the transformation of existing residential buildings in hot summer and cold-winter region and formulated the Interim Measures for Management over the Subsidies for the Energy Saving Transformation of Existing Residential Buildings in the Hot-Summer and Cold-Winter Region (CJ [2012] number 148). No relevant policy has been unveiled for the hot summer and warm-winter region.

In the research, Harbin is taken as an example first of all for the economic analysis of the energy-saving transformation of existing residential buildings. Because Harbin is in the severe cold region, its energy consumption of heating is significantly higher than that of other cities. Hence, the research, with the focus on economic benefit, carries out economic analysis by combining national and local intensive policies to further clarify the actual expenses of transformation and work out the investment payback period.

According to relevant data, different thermal insulation systems of exterior wall have different price (Table 2).

Table 2: Guiding price for different thermal insulation methods of exterior wall.

System description	Price per m^2 (Yuan)	Remarks
EPS board with thin floated coat	84–87	Including labor cost of 15–18 Yuan
Thermal insulating mortar of EPS rubber-power particles	65	Excluding labor cost
Cast-in-place concrete of EPS board (coating, no net)	80	Including labor cost of 15 Yuan
Cast-in-place concrete of EPS board (coating, steel net-supporting board)	59	Excluding labor cost
Mechanically fixed EPS steel net-supporting board	59	Including 2 Yuan's cost for plastering mortar and installation of net-supporting board

Table 3: Energy-saving transformation cost of residential buildings in Harbin.

Transformation cost of Harbin	Roof transformation	Wall transformation	Exterior window transformation	Reference building
Construction cost (Yuan)	76,014.05	335,386.74	52,020	463,420.79
Construction cost/m^2	97	87	250	59.14 (floor area)

Table 4: Comparisons between heating expenses before and after transformation of existing residential buildings in Harbin.

Harbin	Benchmark building (1980)	Roof transformation	Wall transformation	Window transformation	Reference building (meeting energy efficiency standard)
Heating: natural gas (kWh/m^2)	184.83	181.47	166.81	106.55	84.17
Heating expense (Yuan/m^2) Note: with heat metering	45.25	44.78	42.72	34.29	31.15
Actual charge	40.35	40.35	40.35	34.29	31.15
Technical information	= 0.77 = 1.28 = 3.26 Air change rate: 1.5 times/hour	= 0.3	= 0.55	= 2.5 Air change rate: 0.5 times/hour	= 0.3 = 0.55 = 2.5 Air change rate: 0.5 times/hour

As a result, no matter whether it is for the northern heating area or other climatic regions, in-depth economic analysis is necessary, and it is significant for the rationalization and deepening of policy trend to calculate the cost efficiency of energy-saving transformation of building envelope in different climatic regions by combining simulated data with national and local incentive policies and pay attention to the economic and environmental benefits after transformation.

The most commonly used system of EPS board with thin floated coat is selected by the research. The thickness of EPS board is assumed to be 50 mm, and each increase of 10 mm will lead to 2-Yuan increase in the cost. PVC double-glazed window is adopted (thickness of air layer: 16 mm) at the price of 250 Yuan/m2. The transformation cost can be calculated according to the simulated external thermal insulation thickness of exterior wall and roof and the corresponding areas and exterior windows, as shown in Table 3.

According to relevant information, there are two charge standards for the municipal heat supply of Harbin. In case there is no heat metering, the uniform charge is 40.35 Yuan/m2; in case there is heat metering, the heat supply charge = basic heat supply charge (19.37 Yuan/m2) + 0.14 Yuan/kWh. Based on such standards, the comparison between heating expenses before and after transformation of existing residential buildings in Harbin is shown in Table 4.

It can be seen from Table 4 that, in case of charge through heat metering, the heating expense caused by actual heat consumption of existing residential buildings before transformation is higher than the uniform urban charge standard, and the same problem exists if only roof or wall is transformed. This indicates that if energy-saving transformation is not carried out, the city will spend more money on this aspect each year, resulting in negative benefit and loss. As to reference building whose envelope has been comprehensively transformed, in case of charge through heat metering, the user will be able to save 9.2 Yuan/m2, the energy consumption of city in heat supply will be reduced by more than a half, and the expense will decrease accordingly, thus showing a good economic benefit.

According to relevant information, the electricity charge for residential buildings in Harbin is 0.51 Yuan/kWh . Based on this charge standard, the comparison between cooling expenses before and after transformation of existing residential buildings in Harbin is shown in Table 5.

It is demonstrated by Table 5 that the enhancement of tightness of doors and windows even increases the energy consumption intensity of cooling in summer, making the summer cooling expense of reference building that meets energy efficiency standard higher than that of the benchmark one. However, in view of the fact that Harbin is located in the severe cold region, its energy consumption of cooling is far lower than that of heating. On the basis of overall consideration, the reduction of heating energy consumption in winter should be taken as the primary target.

As previously mentioned, in the Interim Measures for Management over the Incentive Funds for Heat Metering and Energy-Saving Transformation of Existing Residential Buildings in the Northern Heating Area, the reward benchmark for the severe cold region is

55 Yuan/m2, among which energy-saving transformation of building envelope, transformation of indoor heat metering and temperature control, and transformation of heat source and heat supply pipe-network thermal equilibrium take up 60%, 30%, and 10%, respectively. Therefore the reward for envelope transformation alone is 33 Yuan/m2. According to the following formula:

Payback period = (Transformation cost − Reward fund), (1)

(Saved heating expense + Saved cooling expense) we can work out that the payback period for the reference building that meets energy efficiency standard is 2.88 years and will be prolonged to 6.5 years in case of no reward fund for transformation and that the reward fund approximately amounts to 44% of the total investment.

Shanghai is taken as another example in the research for the economic analysis of the energy-saving transformation of existing residential buildings. Shanghai is in the hot-summer and cold-winter region where there is no heat supply pipe and network or central heating equipment, so electric heating is mainly adopted for heat supply at low temperature in winter. For this reason, the energy conservation of the city is realized largely by saving electric power. In the Interim Measures for Management over the Subsidies for the Energy Saving Transformation of Existing Residential Buildings in the Hot-Summer and Cold-Winter Region (CJ [2012] number 148) , the hot-summer and cold-winter region is divided into the eastern, middle, and western parts, for which the subsidies are 15, 20, and 25 Yuan/m2, respectively. Then, the subsidy amount allocable to a place = subsidy benchmark of the region where it is located × ∑(area of single transformation item × corresponding single transformation weight). Single transformation items refer to transformation of exterior doors and windows, energy-saving transformation of exterior sunshade, and energy-saving transformation of building roof and exterior wall's thermal insulation, with weight coefficients being 30%, 40%, and 30%, respectively. Shanghai is situated in the

Table 5: Comparisons between cooling expenses before and after transformation of existing residential buildings in Harbin.

Harbin	Benchmark building (1980)	Roof transformation	Wall transformation	Window transformation	Reference building (meeting energy efficiency standard)
Cooling: electric power (kWh/m^2)	2.61	2.55	2.45	3.06	2.91
Cooling expense (Yuan/m^2)	1.33	1.30	1.25	1.56	1.49
Technical information	= 0.77 = 1.28 = 3.26 Air change rate: 1.5 times/hour	= 0.3	= 0.55	= 2.5 Air change rate: 0.5 times/hour	= 0.3 = 0.55 = 2.5 Air change rate: 0.5 times/hour

eastern part of hot-summer and cold-winter region and consequently enjoys the subsidy of 15 Yuan/m2. The electricity charge for residential buildings in Shanghai is 0.61 Yuan/kWh.

The transformation cost of residential buildings in Shanghai can be calculated according to the simulated external thermal insulation thickness of exterior wall and roof and the corresponding areas and exterior windows, as shown in Table 6.

See Table 7 for the comparison between heating and cooling expenses before and after transformation of existing residential buildings in Shanghai.

It can be observed from Table 6 that the heating expense is significantly reduced despite the small value, and the transformation of building envelope is not quite effective in cooling.

Table 6: Energy-saving transformation cost of residential buildings in Shanghai (self-drawing).

Transformation cost of Shanghai	Roof transformation	Wall transformation	Exterior window transformation	Reference building
Construction cost (Yuan)	64,475.65	304,546.58	43,096.8	411,719.03
Construction cost/m²	81	79	210 (PVC single-glazed window)	52.54 (floor area)

Table 7: Comparisons between heating and cooling expenses before and after transformation of existing residential buildings in Shanghai (self-drawing).

Shanghai	Benchmark building (1980)	Roof transformation	Wall transformation	Window transformation	Reference building (meeting energy efficiency standard)
Heating: electric power (kWh/m²)	12.47	12.17	11.73	8.98	7.91
Heating expense (Yuan/m²)	7.60	7.42	7.16	5.48	4.83
Cooling: electric power (kWh/m²)	9.75	9.65	9.44	9.22	8.83
Cooling expense (Yuan/m²)	5.95	5.89	5.76	5.62	5.39
Technical information	= 1.5 = 2 = 6.4 Air change rate: 1.5 times/hour	= 1	= 1.5	= 4.7 Air change rate: once per hour	= 1 = 1.5 = 4.7 Air change rate: once per hour

According to the investment payback formula of energy saving transformation of Harbin:

Payback period =

(Transformation cost − Reward fund) (2)

(Saved heating expense + Saved cooling expense) we can work out that the payback period for the transformation cost of reference building that meets energy efficiency standard is 11.27 years and will be prolonged to 15.78 years in case of no reward fund for transformation and that the reward fund approximately amounts to 29% of the total investment.

IV. Conclusions and Discussions

Through the research, we can reach the following three conclusions:

(1) Any single transformation is difficult to completely satisfy the requirements of current energy efficiency standard. If only roof and wall are transformed, the investment payback period will be too long, and thus the economic benefit is relatively poor. The change in the tightness of doors and windows has a great impact on the result of energy-saving transformation, so it should be taken as the key point in energy-saving transformation. For the existing residential buildings in the northern heating area, the energy-saving transformation of building envelope has a more remarkable effect, and we should continue to vigorously promote such transformation in this region. As to the hot-summer and cold-winter region, besides necessary energy-saving transformation of building envelope, the source for heat supply in winter should also be resolved with great efforts. At present, the development of multiple distributed energy technologies provides more possibilities.

(2) It is revealed by economic analysis that the reward funds for transformation provided by the state cannot satisfy the expenditure of transformation. Because of asymmetric information, users have no idea about their own benefit, lack enthusiasm for transformation, and tend to be unwilling to participate in and spend money on it. However, although the national reward funds are not sufficient for covering the complete energy-saving transformation, the investment payback period will not be very long without the support of such funds. Hence, the EPC (Energy Performance

Contracting) model may be employed for the transformation.

(3) For the northern heating area, the transformations of building envelope and heat metering must be carried out simultaneously. The reason is that as shown by the economic analysis only through heat metering can the managers grasp the specific energy consumption intensity and the users see the practical economic benefit and become active in taking part in the transformation. However, in reality, the management over the transformation of building envelope is presided over by the construction committee, whereas the transformation of heat metering is presided over by the municipal services. The coordination and unification of the two urgently needs to be solved at the level of management.

For China as a country continually accelerating its process of new-type urbanization, digesting the existing energy in efficient buildings is a great challenge while coping with the annual increment brought about by urbanization. For this reason, policy formulation for the energy-saving transformation of existing buildings and the determination of transformation funds should be more flexible based on transformation effect in the future. In addition, the energy-saving transformation should rely more on social and commercial forces rather than solely on the promotion of government.

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FIXED WING UAV RECOVERY SYSTEM USING A LINE SUSPENDED BETWEEN 2 POLES FOR AUTOMATIC MEDICAL DELIVERY SYSTEM

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Abstract— Unmanned Aerial Vehicle (UAV) operations constitute a vital area of studies which permits a large sort of project types. Most of those operations call for an excessive stage of persistence which generally calls for the use of a fixed-wing UAV. Traditionally, an internet placed at the deliver deck is used for convalescing the fixed-wing UAV. However, there are severe demanding situations whilst trying self-sustaining landings in such environments. Waves will see off heave motion, and turbulence close to the deliver will make procedures challenging. In this paper, we gift an idea the use of multirotor UAVs to recuperation operation off the deliver deck. To get better the fixed-wing UAV, an internet is suspended beneath coordinated multirotor UAVs that can synchronize the motion with the fixed-wing UAV. The method trajectory may be optimized with respect to the wind direction, and turbulence as a result of the deliver may be avoided. In addition, the multirotor UAVs can deliver the internet at a positive pace alongside the trajectory of the fixed-wing UAV, hence lowering the relative pace among the internet and fixed-wing UAV to lessen the forces of impact. This paper proves the proposed idea via a simulation have a look at and an initial manage machine architecture.

I. INTRODUCTION

A. Motivation and main idea

Unmanned Aerial vehicles (UAVs) are exceptionally compelling in far off activities. These vehicles have been utilized in a few sorts of uses like reconnaissance [1], search [2], agriculture [3], [4] line watch [5], logical investigations [6], and planning [7]. Correspondence, sensor and control procedures have developed in the course of the last scarcely any decade that has prompted the improvement of a wide scope of UAVs differing fit as a fiddle, size, setup, and attributes. The basic kinds of UAVs are fixed wing UAVs, Quad-rotors and helicopters at various scales (huge UAVs or smaller than expected vehicles or miniature ethereal vehicle). Fixed wing UAVs have a basic construction, fly at high paces, and for a more extended span as looked at to revolving wing UAVs. Nonetheless, a portion of the fixed wing UAVs may require a runway for departure and landing, while those that can be either hand dispatched or through a sling system can be arrived without a runway. On the other hand, rotating wing UAVs enjoy a benefit of floating, which is helpful for checking a few areas of interest. Revolving wing UAVs have deft moving capacity yet simultaneously they have high mechanical intricacy, low speed and short flight range.

B. Landing problem

UAV flight comprises of various stages, to be specific, take off, climb, cruise, descent and finally landing. UAV autopilots have independent take-off system (sling and hand dispatched) and voyage yet restricted independent landing capabilities because of high dangers and unwavering quality issues. The precision of the landing should be high otherwise the aircraft could crash. Autonomous landing is one amongst the foremost difficult a part of the flight. Landing should be done in a restricted quantity of your time and space. Thence precise sensing techniques and correct control is needed throughout this maneuver.

C. Contributions

The drawback of this concept is that it can only be used for fast recapture of the medical delivery UAV, as this system need a full infrastructure to be operated. In this system, we demonstrated. That this system works in a manner that line suspended between 2 poles captures the UAV and bring it back to the ground. And within no time the system is ready to use again

D. Organization

This paper is organized as follow. In SECTION II the concept of maneuver and its advantages are described. SECTION III be describing about control structures and the algorithms. In SECTION IV the simulation platform and the data will be discussed in SECTION V the results will be discussed and presented. SECTION VI will be discussing about the future developments.

II. UAV CATCHING CONCEPT

The idea of fixed-wing UAV recuperation depicted in this paper utilizes a line suspended between two poles. This line will be alluded to as the Recapture line. All together to get the fixed-wing UAV appended to the multirotor line, a different line is delivered from a unit joined to the fixed-wing UAV before the catch. This line will be alluded to as the get line. The catch line has a weight and a snare toward the end fully intent on overloading the line and getting the multirotor line separately. A sketch of this framework is appeared in Figure 1(a). . All together for the catch to occur, the fixed-wing UAV passes under and in the middle the poles to such an extent that the catch line blocks the multirotor line. After the catch, the fixed-wing hangs underneath the poles as found in Figure 1(b) and can be brought down for a fruitful recuperation. The line-get idea is intended for recuperation of fixed wing UAVs where there is a requirement on space which makes it difficult to land a fixed-wing UAV.

A. INTERFARANCE FROM OTHER SYSTEM

This system is developed for only medical delivery system UAV is as they are little heavy from normal UAV so there should be a proper space for this setup. Secondly, we have to always set the path for UAV after it comes from delivery.

B. Effect of wind and turbulance on the operatiom

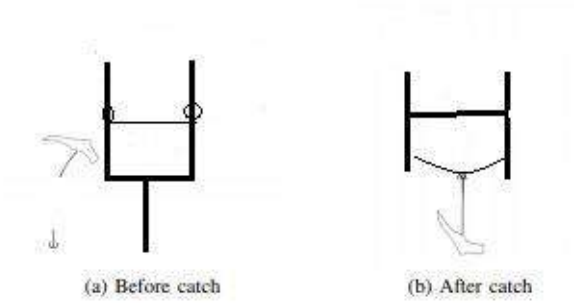
There will be almost no effect of the turbulence and the catching system as tall the system will be attached on ground only the cable can move up and down.

C. Personal safety

The safety of the personnel's around wont effect as UAV won't need to fly nearby.

D. Structural requirements

We need a proper space runway where these can be installed , so the place is an main draw back in this whole technology.



E. The maneuver

This maneuver starts when the UAV is aligned to the virtual runway the flight control send all the data to the auto line controller .The altitude of the UAV is becomes constant the line catcher sets the line accordingly . The UAV reduce its speed and line will catch the UAV . The maneuver will be over

F. The runway , Ref. Frames, and some notations

- The straight line where we catch the UAV is called virtual runway. The runway will be defined as and the center of that path is known as center line its length would be (Lrw)
- The setup is set in that way that the center line is collided with the catch line.
- The frame can be referred as (n)
- The height and width of the frame will be referred as (Hrw) and (Rrw)
- Velocity will be described as (Vc)
- Position vector will be (Pc)

III. CONTROL DESIGN

In this section, we will talk about all the controls that will be used in this section. The basic structure can be seen in figure 2. There are three different control module that will be

discussed in this part .Herewith we will also discuss the part of virtual runway.

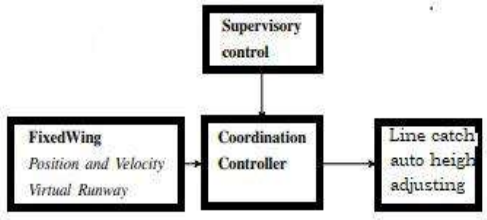


Fig2. This process flow diagram is based on position of the UAV. The supervisory controller starts the process, The UAV intercept the line catcher.

Note :- In this system the position of the line catcher acts as the reference the center of the line catcher will act as the reference as the aircraft has to always line up with the run way.

Here in the process we consider many things as the UAV approach towards the line catcher it should be on the constant flight path . The altitude should between the given range this will be controlled by an On-Board auto pilot system

A. THE RUNWAY

Runway defines the path at with the UAV will run at the time of end of the mission.

Here the path frame always remain constant (P)

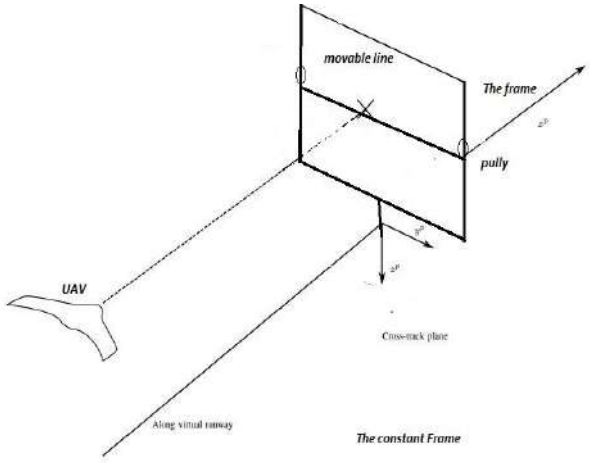


Fig .3 this is the illustration of the frame and virtual runway the frame the pullies that will take the catcher up and down the x is marked where the UAV will intersect with the catcher and the frame here the frame is constant the path of UAV is marked with dotted line .

B. The Supervisor

The supervisor supervise the position and speed of the fixed-wing UAV comparative with the virtual runway to switch between the various modes in the move. Every mode empowers a specific regulator and reference, which gives an ideal speed set point. Fig 4 gives an outline of the various conditions of the director. As can be found in Fig 5, the supervisor likewise controls when to enact the two pieces of the coordination controller.

The supervisor screens the maneuver as it is advancing in the process. In the event that, due to wind or different variables, the fixed-wing UAV misses the line, the supervisor can abort the mission and instantly the catcher will go down. The supervisor will schedule the projected path and try the maneuver again, therefore it can abort the mission any time while recapturing

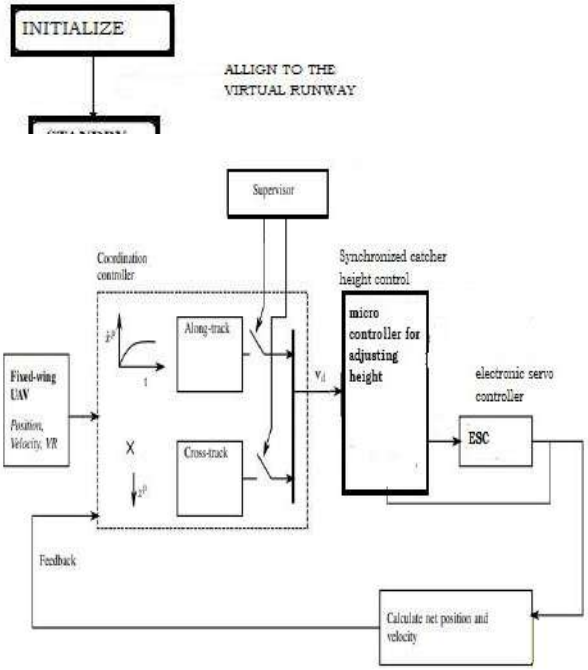


Fig5. Basic illustration of control structure. The fixed wing UAV send its position coordinates to coordinate controller. The along track controller is an open-loop started by the supervisor

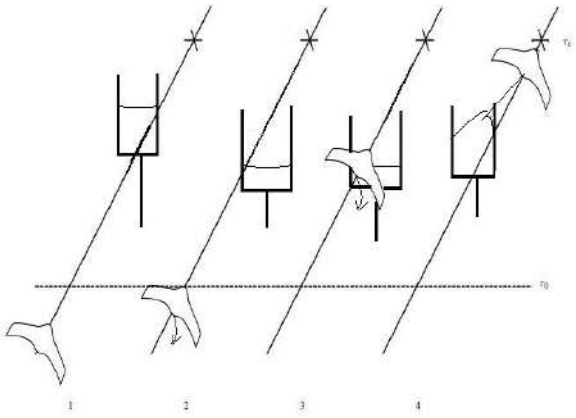
C. Cordination- criss track

The position of the wire is controlled according to the UAV position in the cross track .The line suspended is almost 1.2m from the UAV and the line position itself 0.5m under the coordinates of the UAV.

$$Hlz = Pz - 0.5M$$

D. Cordination- along track

The relative velocity between the net and the UAV is reduced as the UAV enters the Virtual runway by de accelerating. As soon as the UAV hit the catcher wire .The wire will expand till the acceleration become 0 then retract all the wire and bring it to the ground



IV. SIMULATION AND RESULTS

In this section, we present discuss about the numerical simulation using all the type of controller and the model presented in the previous section , In this section we have considered the in this case we are considering the poles on which the pulley is mounted is of 8M height and fixed rigid in the ground . the pulley we considered is of 20cm of diameter . the weight of the UAV is 3kgs and the fixed wing UAV is hovering at 10kmph. Constant speed. Further the UAV has auto piolet that will feed the data we can set the approch height according to the battery that's left in the auto pilot the cross sectional track will always having the cordinate controller the supervisor will provide the end headings if the trajectory of UAV differs .the numerical simulations are conducted in matlab through runga kutta 4 as integrater in the below given fig 6 you can see that catcher successfully catched the UAV . In fig 7 there is the data of tention occored at the line beneth the UAV, after that we in fig 8 we have shown the velocity change of the UAV

The operational data of the UAV used for simulation

Airframe weight	3 kg
Maximum takeoff weight	4.2 kg
Cruise speed	18 m/s
Flight time	45 - 60 minutes
Control Surfaces	Elevons (combined aileron and elevator)
Autpilot	Pixhawk w/ ArduPlane

V. MISCELLANEOUS

A. *Tension force on the UAV(Tension force[N] v/s Time[s])*

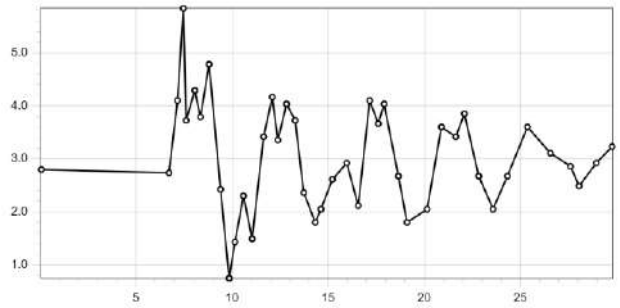


Fig.: x-component of force

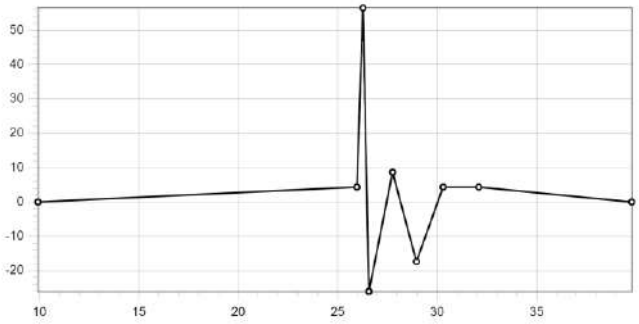


Fig.: y-component of force

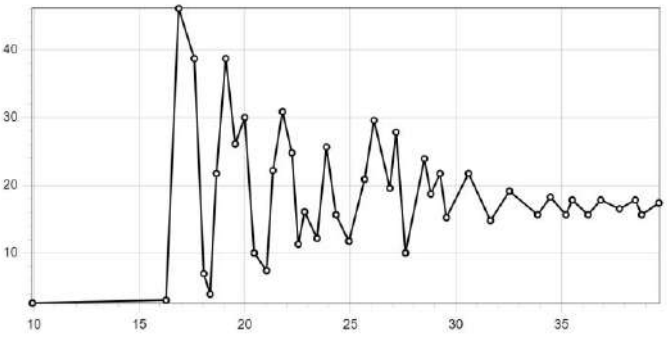


Fig.: z-component of force

B. *Centroid along –track velocity(Along track velocity[m/s] v/s Time[s])*

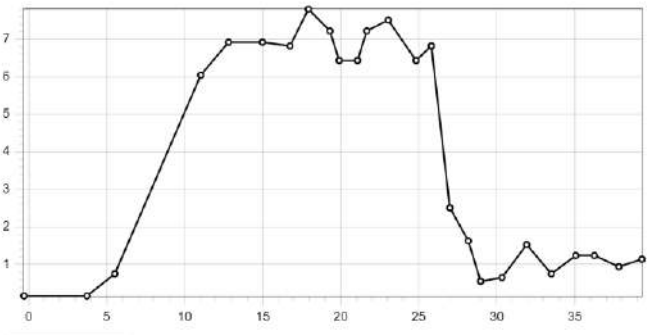


Fig.: Speed

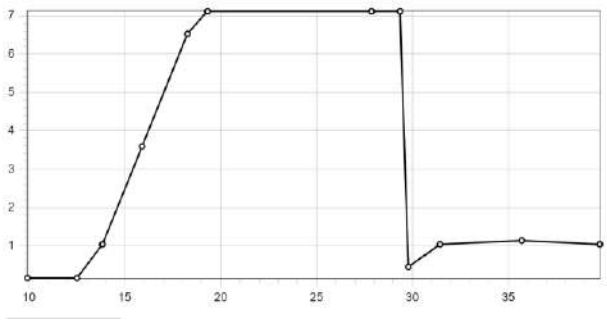


Fig.: Reference

VI. SYSTEM ARCHITECTURE

In this section we will see the overview of the architecture of the system, here we will see all about autopilot, communication links. All the detailed of the system is beneath the table.

A. Airframe

In this research we have utilized the custom made UAV whose data is given above. The custom made UAV is pusher type UAV made of Styrofoam that's light weight its wing span is almost 3 foot and have a capacity of 3 additional. Its GPS and battery connected so that we don't have to make link at the time of emergency

B. Auto pilot

Every UAV in the word almost same hardware for auto pilot we are using pixhawk 2.4 and it is PPE enabled and we configure it with ardupilot.It is widely used because it has the setup of gyroscope , gps, navigation, accelerometer ,by using mission planner we can configure the path altitude of UAV remotely. In addition the hardware is fitted with onboard linus operator that is raspberry pie to remotely command the UAV

C. Navigation, network, and other sendors etc

As told in previous auto pilot have in built navigation system which consist if MEMS based IMU with magnetometer, the vehicle communicate over radio signal of 5.8 HZS that's from Ubiquity Networks that controls constant delays and enabling In the pole we have used an Arduino to control the height it takes coordinates from the coordinate controller and sends the signal to ESC that control the servo motor

VII. SIMULATION IN LOOPS SOFTWARE

As a preparation for tests, the control programming is tried in a Software In the Loop (SIL) recreation strategy. Here, the product is equivalent to when running on the objective vehicle, yet where the elements and reaction are finished by a test system. Our control programming is carried out in C++, and by utilizing DUNE makes it straight forward to run the product in a SIL climate. Further, one of the advantages of utilizing the open-source autopilot ardupilot, is that is has an alternative to run the autopilot code with a vent with test system in SIL also. This makes all the product interfaces and correspondence channels indistinguishable, which makes it a decent trial of the execution. In this test, we explore the presentation of the control programming with the emphasis on the coordination task. While the reenactment introduced in Section V incorporated the total elements of the suspended wire, including the effect powers, there is no net in this test.

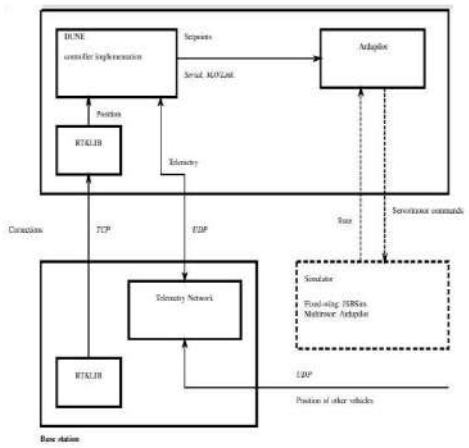


Fig10 this is the overview of different elements used in the networking.

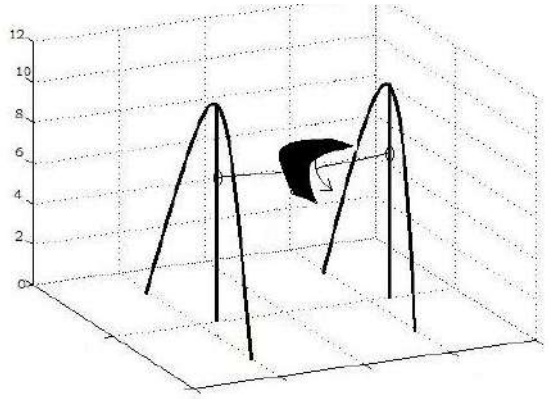


Fig. : Before catch

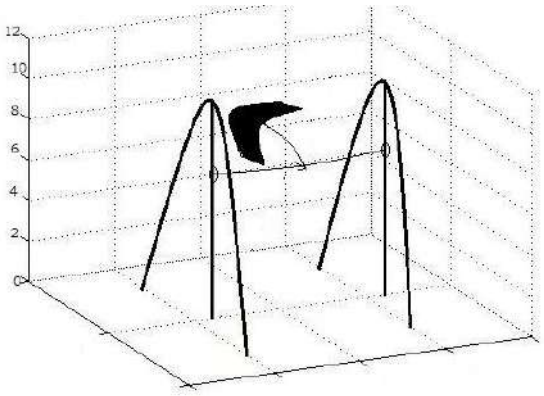


Fig.: UAV catched

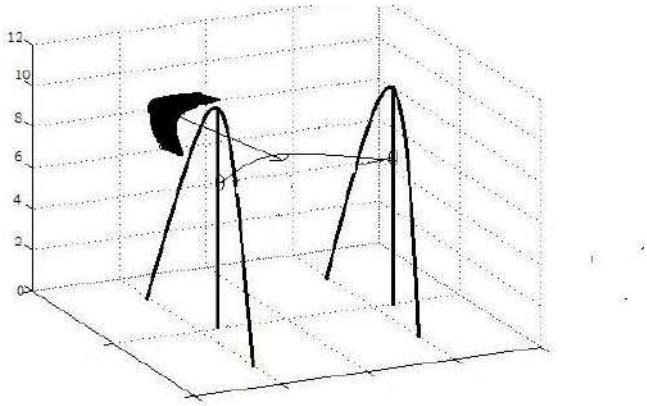


Fig.: UAV comes to a stop

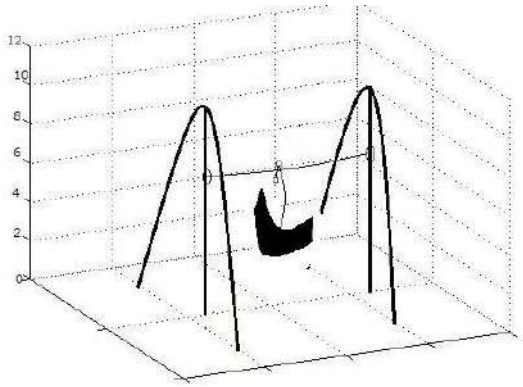


Fig.: UAV recovered

VIII. CONCLUSION

In this paper, we have introduced an idea for recuperation of a fixed-wing UAV between poles. We have proposed a control configuration to conform to the idea. Further, mathematical recreations. Further, we have recommended an execution methodology, and the control framework was carried out and tried in a SIL-arrangement which incorporated the interface to the autopilots.

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Fatigue failure analysis of low pressure steam turbine blade

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ABSTRACT

This work is focused on utilising a technique to assess low cycle fatigue life of steam turbine blade. Fatigue failure in Steam turbine blades is a very common problem faced in steam turbines. There can be many reasons for fatigue in the blades. These blade failures cause inefficiency and time wastage to re install. The research is focused to analyse the life of a steam turbine blade before failure by determining the number of cycles before fatigue failure on the blade. The blade material used in the turbine blade is X10CrNiMoV 12-2-2. FEM analysis is done to determine values of stress and strain on the blade and the distribution of stress and strain. Fatigue life tool is used under boundary conditions to determine the life of the turbine blade without failure and the location of potential failure. The location with the maximum damage can also be determined with the fatigue analysis. By determining the fatigue life of the blades i.e determining the number of cycles before failure, inefficiency can be reduced and turbine failures can be predicted and time wastage can be reduced.

Keywords: low cycle fatigue, LP blade, FEM analysis, fatigue tool

1. INTRODUCTION

The steam turbine has been the major source of power generation worldwide. In India, 60% power is produced by the steam turbine thermal power plants. To meet the desired growth rate of country, most of the power plants in India are running at their full load capacity throughout the year. In operation of turbines is important to know the

behavior of all components and processes in order to avoid such failures and consequently maximize the availability and performance of them [13]. Steam turbine blade are critical components of power plant units and experience failures due to various damage parameters. Blade failures are a common failure in steam turbines. Failure of a blade and re installation can cause high investment of capital and waste of time. More than 90% of all service failures of machine components are caused by fatigue [2]. Blades of the last stage in the LP are the most important components of the turbine in power generation [11]. Therefore, fatigue must be taken into consideration before designing a steam turbine blade because blades are extremely loaded. Since the turbines are required to be more and more efficient, the loading on the blade also increases. Life prediction and reliability evaluation is still a challenging problem despite extensive progress made in the past decades. A comprehensive review of early developments can be found in [14]. In this paper Fatigue analysis is done under the boundary conditions. The data about boundary condition and other data about the turbine blade was are already available. The blade material used in the study is X10CrNiMoVr 12-2-2. Finite element analysis (FEA) was performed to determine the values of stress and strain occurring on the blade. FEA gives us the location of the maximum stress and maximum strain. FEA is done to evaluate stresses in order to suggest the crack initiation, propagation and finally the operating conditions [12]. The maximum stress and strain are developed on the leading edge of the blade. Location of the potential failure is now known to us. Fatigue analysis is performed to determine the number of cycles before the crack initiation. Fatigue tools also tells us the location of the failure due to fatigue.

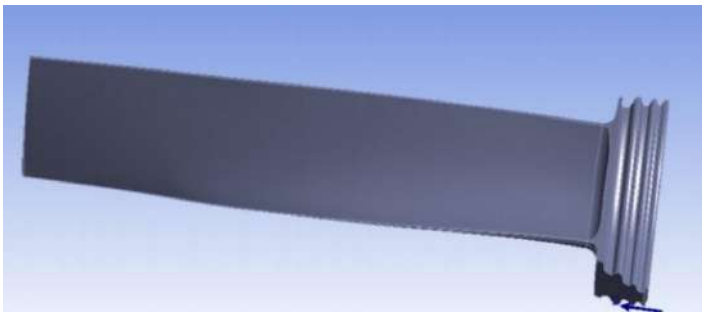


Fig 1. LP steam turbine blade

2. MATERIAL AND METHOD

2.1. Material and mechanical properties

Last stage of LP steam turbine blade were studies in this paper. The blades are made of X10CrNiMoV12-2-2 alloy. Mechanical Properties are given in Table 1.

Table 1

Mechanical properties

Young Modules (MPa)	Ultimate Tensile strength (MPa)	Yeild strength (MPa)	Vickers Hardness (HV)	Density (Kg/m^3)	Poisons ratio
213	1001	843	334	7.85	0.3

2.2 Chemical composition of X10CrNiMoV 12-2-2 alloy

The material tested in this study is a martensitic 10% Cr steel used for low pressure steam turbine blades in power generation. The chemical composition is shown in Table 2.

Table 2

Chemical composition

Element	C	Cr	Ni	Mo	Mn	V	Si
Weight-%	0.117	11.4	2.70	1.64	0.70	0.31	0.23

2.3 Methodology

Turbo machinery blade is analysed on ANSYS software. Symmetric nature of the LP stage is used to reduce the computational time. The geometric model is generated using CAD package. Frictional, rigid and fixed blade supports are assumed Fig 2. Cyclic boundary conditions are applied. The blade is assumed with yield strength 213, density 7.85 and poison's ratio 0.3. of 843MPa, young's modulus

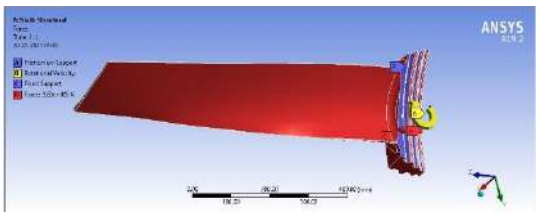


Fig 2. Fixed support

FEA analysis is performed with the boundary conditions to determine the maximum and minimum stress and strains on the blade. Different regions of varying stresses (Fig 3.) and strains (Fig 4.) are obtained. Maximum stress is found out be occurring near the fir-tree of the blade. Strain distribution is obtained and the max stress is also seen near the fir-tree.

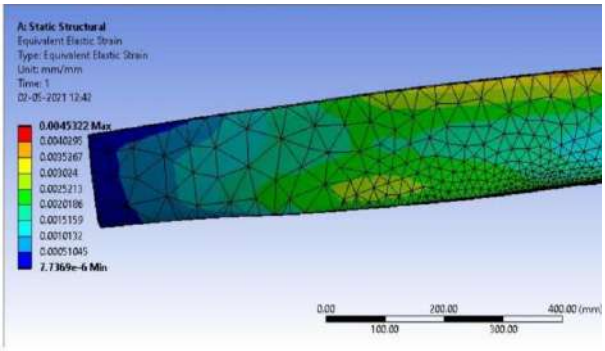


Fig 3. Equivalent von mises stress distribution on blade

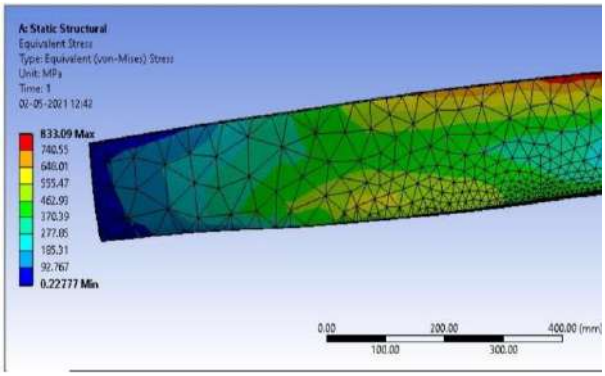
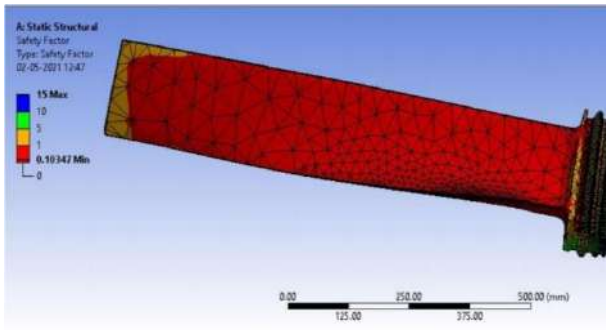


Fig 4. Equivalent strain distribution on blade

3. Safety Factor

Factor of safety is method to analyse if the material will fail or not. If factor of safety is less than 1 then it means the material is likely to fail. After performing, the analysis safety factor comes out to be 0.10347 Fig 5. So the material is likely to fail.



0

Fig 5. Safety factor

4. Results and Discussion

The Finite analysis is performed with the loading conditions. The analysis considered elastic deformation only. The equivalent peak von misses stresses is about 833.09 MPa near the fir-tree of the blade. The equivalent maximum strain is 0.0045322 MPa near the fir-tree root. The damage distribution occurring on the blade is also obtained. The fatigue analysis is then performed to calculate the life cycle of blade before failure. After inserting the fatigue tool, the life of different region are calculated Fig 6. The minimum life cycle of the region material is 382.50 cycles. So the material will fail at 382.50 cycles as it is also the minimum cycle.

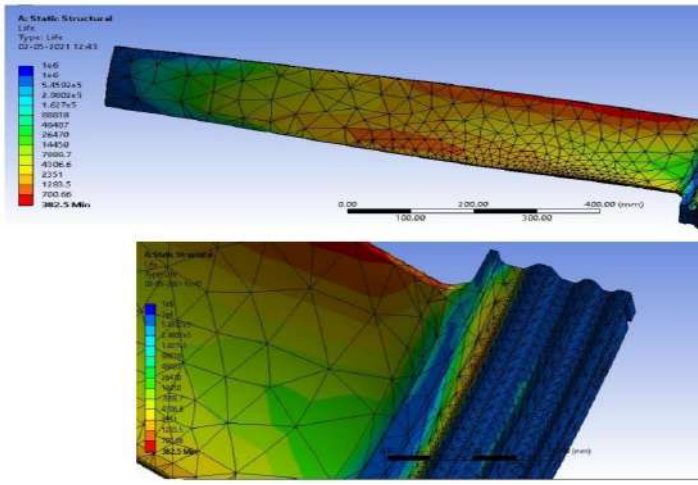


Fig 6. Fatigue life of blade

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Side Stand Alarm System for Two Wheeler

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Abstract

In developing countries like India, two wheelers are arguably the most convenient and affordable means of road travel. Especially in these pandemic struck times where personalized transport is the need of the hour. With ever- rising number of two wheelers on road, the risk of them being involved in road accidents has risen too. While there are numerous reasons leading to accidents, studies have found rider's negligence where they forget to unreleased the side stand before riding, one of the prime reasons. To minimize this negligence, we have come up with an electro-mechanical design which alerts the rider if the side stand is left released.
This design was tested on a model and was found to be working fine.

Keywords: Side stand, alarm, two wheelers, safety

Introduction

We have come a long way in terms of car safety. There are seat belts, air-bags and now even seat belt indicators in most four wheelers. On the flip side, most two wheelers do not come equipped with any safety guard against road accidents. According to a report published by the Ministry of Road Transport and Highways two wheelers took up to 37% of all the road accidents that happened in 2019. A big chunk of this percentage was found to be due to rider negligence where the rider forgot about the dangling side stand. While manufacturers have infused a side stand tell-tale light to alert the rider, this is still not very effective or found on most two wheelers. So, there is a need for a system which is affordable, easy to install, and effective. Hence, we've come up with a side stand alarm system and the idea behind our project is simple; to reduce riders' negligence and increase the safety of people on the road. In literature, Poovendran C.et.al [1] has used a reed switch and a sensor in connection with a buzzer to indicate the rider of the released position of the side stand.

Components

a. A side stand

A side stand is a device on a motorcycle that

(figure 1)

allows the bike to stay upright without leaning against another object or the aid of a person. A side stand is usually a piece of metal that flips down from the frame and makes contact with the ground (as shown in figure 1). It can lock in place, either up or down, by several means. Two most common ones are:

- A spring that is stretched when the side stand is partway deployed and less stretched when it is stowed or all the way deployed.
- A detent mechanism, which usually also employs its own spring.

b. Limit switch

(figure 2)

A limit switch is an electromechanical device operated by a physical force applied to it by an object. Limit switches are used to detect the presence or absence of an object. These switches were originally used to define the limit of travel of an object in this case the side stand.

There are 4 types of limit switches:

- Whisker
- Roller
- Lever
- Plunger

In the project we have used a lever type limit microswitch of 250V and 16A (as shown in figure 2).

c. Relay

(figure 3)

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. Relays are the switches which aim at closing and opening the circuits electronically as well as electromechanically. We have used a main relay of 12V and 7A in conjunction with a flasher relay of 12V and 1A (as shown in figure 3).

It controls the opening and closing of the circuit contacts of an electronic circuit. When the relay contact is open (NO), the relay isn't energized with the open contact. However, if it is closed (NC), the relay isn't energized given the closed contact.

d. Buzzer and Indicator

(figure 4)

A buzzer or beeper is an audio signalling device, which may be mechanical, electromechanical, or piezoelectric(as shown in figure 4).
Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.

(figure 5)

An indicator light is mainly used on the circuit or mechanical equipment to monitor and alarm the operation status of the equipment (as shown in figure 5). In this project the indicator light has been used to alert the rider visually regarding the released position of the side stand.

Working

When the rider unlocks the handle of the two wheeler with the kill switch in ON position, power flows through the relay and through the buzzer & indicator. This alerts the rider about the released position of the side stand. If the kill switch is in OFF position, the relay does not dissipate any power to the buzzer & indicator and thus they remain OFF. This is the idle state of the two wheeler.

When the kill switch is in ON position, power flows through the relay, consequently sounding the buzzer and flashing the indicator alerting the rider of the released position of the side stand. If in this situation the rider decides to put the two wheeler in ignition mode, no power will be drawn from the battery and the two wheeler will not start. This is an added safety measure since if the side stand is released, the two-wheeler won't start, even if the buzzer and light malfunction.

When the side stand is put back into the unreleased position, it pushes back on the lever of the limit micro switch. This completes the circuit, therefore enabling the ignition of the two wheeler.

Conclusion

The model made on the basis of the mechanism reported in earlier sections is working one. According to a study conducted for 2012-2015 it was reported that ignorance towards lifting the side stand resulted in 36% of two wheeler road accidents. With this model we aim to reduce the rider's negligence about the unreleased side stand and hope to minimize road accidents.

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Analysis of Compression Ignition Engine's outputs, along with environmental and economic implications of Petrol, Diesel and major alternative fuels

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***Abstract*—The rationale behind every technological development in any domain possible is to obtain the best outputs that benefit the consumers, producers, and the environment, which is always in conjunction. Internal combustion engines that were once a revolution to a sluggishly-moving world are now a threat to the environment because of their increased amount of harmful emissions that degrade the quality of air. To compensate for this environmental harm, many researchers have tried to use alternative fuels or improvised conventional Petroleum fuels with an eclectic range of different additive materials. But by doing so, the performance and efficiency of the engine have been negotiated or have been economically infeasible. Thus, there is a need for a technology or a plan that can satisfy all, the environmental concerns, performance requirements, and economic feasibility. To contribute to this research topic, I have collected comparative data on Petrol and Diesel engines along with data of biofuels in general. The data collected is divided into three parallels: based on the major factors that contribute to engine performance, based on environmental impacts caused by the fuel, and based on expenditure. This study answers a major question regarding the choice of engines among CI and SI engines. The choice is based on the requirements of routine drivers in terms of performance, emissions, and costs and by considering the current market designs of these engines. Moreover, this research focuses on postulating limitations that persist in our choices and suggests major areas of research that are still in progress to curb the underlying issues.**

Keywords—alternate fuels, biodiesel, aftertreatment processes, vehicular economics, performance outputs

I. INTRODUCTION

Vehicles are major contributors to air pollution. A polluted air includes harmful components such as Particulate Matter (PM), Volatile Organic Compounds (VOC's), Nitrogen oxides (NO_X), Carbon monoxide (CO), Sulphur dioxide (SO_2), and some other greenhouse gases. Repercussions of polluted air are numerous. Statistics show that the major contributor to pollution in the national capital city of India, Delhi, which is one of the world's most polluted cities, are private vehicles. In 2016 a 'Comprehensive Study on Air Pollution and Green House Gases in Delhi' by a team of IIT Kanpur researchers pointed out that "the two most consistent sources for PM 10 and PM 2.5" in the region are vehicles [1]. According to the study, the vehicle output comprised of 36 per cent of nitrogen oxide emissions and 83 per cent of carbon oxide emissions of the total of these emissions. About 40% of the total pollutant emissions are attributed to vehicular emissions [1].

The major reasons, why many organisations put their feet forward are air pollution and the extensive utilization of already depleted non-renewable fuels. In turn, new designs of the engine, piston rings, cylinder wall, electronics, exhaust systems, new combustion technologies etc., are proposed to alter the situation. Sometimes, new technologies such as electric or hybrid drive trains are introduced altogether and expected to revolutionise the transportation system. Such changes can indeed show us the future, but their adoption is and would be very slow because of factors such as economic constraints, affected consumer demands, lack of supply, and lack of technical user knowledge. Demand is affected because the supply of vehicles guided by these technologies would be low due to high production and labour cost as well as high production time. This would result in inflated prices of these engines due to cost-push inflation, consequently leading to inaccessibility for the middle-class consumers and thus, degradation of the overall economy. Moreover, solutions like the implementation of innovative combustion processes such as HCCI (Homogeneous Charge Compression Ignition) [7], has the potential to reduce both PM and NO_X emissions and to maintain high thermal efficiency. Although it has a positive impact in the environment, especially when applied with alternative biofuels, and produces output at par with that produced by conventional processes, this and many such technologies are not laid down in the catalogues of commercial vehicles. The major challenges that prevent commercial use of HCCI engines are the control of the auto-ignition and the combustion phasing. These examples bolster the need to do research to facilitate temporary improvements on the existing designs and technologies as well, rather than just focusing on new technologies.

Thus, there is a need to work in two parallels. First, is to look for alternative-temporary approaches by working on the existing designs and technology for the time being. Secondly, there is a need to deploy more research facility and labour towards such future potential technologies, with the aim to increase future demands by reducing production costs and time. The need of the hour is neither to switch irrationally to an electric vehicle transportation system completely nor to just improve and work upon what is already there single-handedly, but rather to have a workable trade-off between both these categories of research. This is because, if we are stagnant enough to rely just on the existing technologies, then an efficient and eco-friendly transportation system will just far-fetched dream. On the other hand, working completely towards new technologies or designs would have economic implications and consumer satisfaction might get hampered.

Moreover, if transportation is switched completely into electric then the government's revenue receipts will drastically come down and thus will affect the overall GDP. This is because on the complete arrival of electric vehicles, demand for domestic and international Petroleum consumption will come down resulting in fewer taxes levied and decreased consumption of Petroleum products. According to studies, the natural gas and Petroleum sector contribute about 15% to India's GDP. Exports from the Petroleum industry are about 17% of the total exports of the nation. Revenue from taxes levied on Petroleum products from both central and state governments has a major proportion in indirect tax collection. According to a study 'Estimation and Projection of Petroleum Demand and Tax Collection from Petroleum Sector in India' by Sacchidananda Mukherjee in 2019 [2], at an average, 45 per cent of Union taxes were collected from the Petroleum sector. These facts show that how much the state and central financial budget will be affected and how much the total GDP will get declined, if the engine technology that runs on Petroleum is impulsively transformed into new inexperienced designs or new technologies, resulting in a complete collapse of current bureaucracy and oil market.

This research is disposed towards the former part, i.e. working towards the existing engine designs and technology. Using appropriate blends of fuels, i.e. Petroleum and major alternative fuels, in the existing engines can be a game-changer in maintaining performance and efficiency, not effecting environment horrendously and being economically pragmatic. This study displays a comparative analysis of Diesel and Petrol engine and then try to put forward various limitations in the choice made. Compressed Ignition engine (C.I engine) has been chosen as a better engine considering regular-road and heavy-duty purpose requirements.

II. WHY DIESEL ENGINE OVER PETROL ENGINE?

Diesel engines are compressed ignition engines, in which intake gas is compressed to very high pressure and then Diesel fuel is injected with a fuel injector, which results in a thrust onto the piston face due to combustion reaction. As this engine has a high compression ratio, it is designed to have thicker walls than a SI engine. Thus, it is comparatively heavier and thus requires more torque to overcome load in the form of weight of the engine itself.

As we are talking about the economy and environment, it is practical to consider regular commercial vehicles than sports engine vehicles or rally cars. Private vehicles are the major contributors to pollution. Moreover, the performance requirement for a private vehicle is not to have a competitive speed and power but to be efficient, economical and eco-friendly, in complete contrast to sports vehicles or concept cars. High speed characteristics are remarkable but is not an immediate requirement for a vehicle on city roads. Regular private or public vehicles need to be efficient, and thus should have a higher thermal efficiency. They need to have higher low-speed torque, to have capabilities to travel on off-road terrains, such that in desserts or gradient slopes and for heavy duty purposes. They should have low specific fuel consumption and the fuel used should have a lower market price to be economically feasible. It must have low NO_X, CO_2, and Particulate Matter (PM) emissions to be eco-friendly.

Most of these characteristics that are desirable for a regular-road vehicle are accomplished by using Diesel engines over Petrol engines (If we are to compare these two engines). The analysis of both these engines based on our three parallels of performance, environmental impacts and economics is as follows.

A. Performance

Practical experiences and consumer surveys have shown that the performance characteristics desired by owners of private vehicles and drivers of public vehicles include high pick-up velocities, better overtaking capabilities on highway roads, and better control on off-road terrains. All these characteristics are achieved by having an engine output producing high low-speed-torques. For a single revolution, Torque is given by:

$\tau = \frac{MEP * V_d}{2\pi n}$, (thus, $\tau \propto V_d$) where MEP is the mean effective pressure inside the engine cylinder, V_d is displacement volume, i.e. the volume swept by the piston between Top Dead Centre (TDC) and the Bottom Dead Centre (BDC) of the cylinder, and n is the number of revolutions of crank per cycle. As, $V_d = \frac{(\pi * D^2)}{4} * L$, where D = Bore diameter and L = stroke length and $\tau \propto V_d$, thus $\tau \propto L$. Thus we will generally have higher torque outputs if stroke length is more. Compression ratio (r_c) is given by $\frac{V_{BDC}}{V_{TDC}}$. Also, Higher V_d relates to higher r_c. Now as the Diesel engine has higher r_c, it will have higher V_d and L and thus higher torque output. Thus, a Diesel engine produces higher engine torque. Conversely, a Petrol engine having lower r_c, and thus lower V_d and L produces lower torque output. Both the parameters of torque and power, to measure performance, are biased due to engine size and engine speed respectively. Thus, the choice of the engine, out of C.I and S.I, is completely relative to the consumer demands and requirements.

As this research is devoted to picking an engine that might serve routine consumers, higher torque output requirement is considered and thus C.I or Diesel engine is picked. Audi 2.0 TFSI engine and Toyota 2.0 D-4D engine of comparable configurations are compared to obtain torque power, rpm ratings at full load.

Table 1: Audi 2.0 TFSI vs. Toyota 2.0 D-4D [16]

Name	Engine capacity [cm^3]	Fuel injection	Air intake	Valve timing	Fuel
Audi 2.0 TFSI engine	1994	Direct	Turbocharged	Fixed	Gasoline (SI, Petrol)
Toyota 2.0 D-4D engine	1998	Direct	Turbocharged	Fixed	Diesel (CI)

Chart 1 [16]

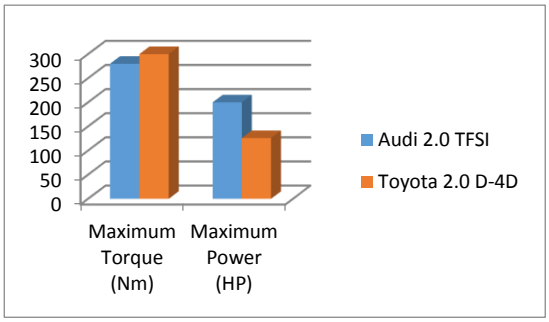
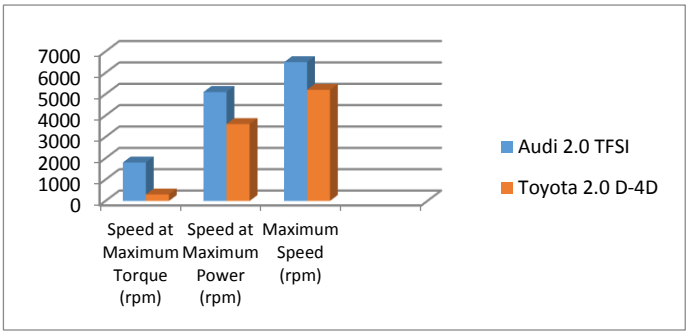


Chart 2 [16]



Thermal efficiency is an excellent indicator that tells how well an engine performs its output in the presence of heat input. Diesel engines are much more efficient than Petrol engines as Thermodynamics puts Diesel engines above Petrol engines. This is as follows:

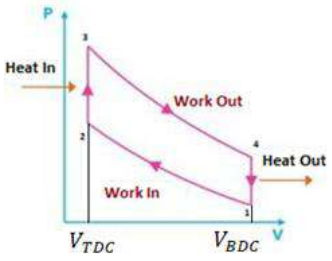


Figure 1: Otto Cycle

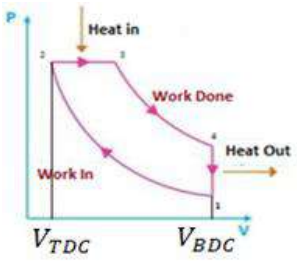


Figure 2: Diesel Cycle

The thermal efficiency of an Otto cycle is given by:

$$\eta_{otto} = 1 - \left(\frac{1}{(r_c)^{\gamma-1}}\right)$$

Equation (1), Where r_c = compression ratio, and γ= Adiabatic Constant.

The thermal efficiency of a Diesel cycle is given by:

$$\eta_{diesel} = 1 - \left(\frac{K}{(r_c)^{\gamma-1}}\right)$$

Equation (2), Where, K is a constant equivalent $\frac{(\beta^{\gamma}-1)}{\gamma\cdot(\beta-1)}$), where β= Cut-off ratio.

As r_c of Diesel engine is more than a Petrol engine, this makes the second term of η_{diesel} smaller than the second term of η_{otto}. Subtracting smaller term from 1, results in higher efficiency value. Thus, $\eta_{diesel} > \eta_{otto}$.

Note: If the r_c is assumed to be same for both types of engines then result would be the opposite, i.e. $\eta_{otto} > \eta_{diesel}$. This is because then the second term of η_{diesel} become greater than the second term of η_{otto} (as K > 1). Thus, theoretically the most ideal engine is a C.I engine having constant volume combustion stroke. 'C.I engine' because it has higher r_c and 'constant volume combustion', because $\eta_{otto} > \eta_{diesel}$, for engines having same r_c. We can't get both these ideal conditions in a single engine in real practice, though a Russian-German engineer Gustav Trinkler developed a cycle (Dual cycle) that stipulated an appropriate trade-off between higher r_c and constant volume combustion. The dual cycle is being adopted by C.I engines (as they have higher r_c). To achieve this there is a change made in the engine fuel injection system. Fuel gets injected nearly 20 degrees before reaching TDC at the end of the compression stroke, due to which the first faction of the fuel gets burnt completely at TDC and till here the process is constant volume combustion. Then, the rest of the combustion process takes place in constant pressure conditions, till the piston reaches a small volume ahead of TDC while reaching BDC. The initial stage constant volume combustion process increases the thermal efficiency of the C.I engine.

B. Economic Aspects

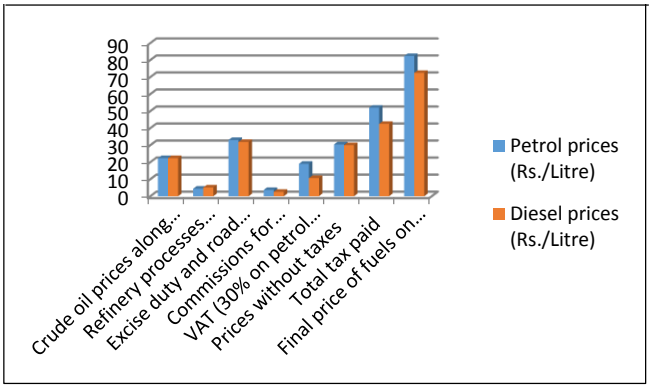
As the calorific value of Diesel fuel is lower than Petrol fuel it might appears that Petrol should be cheaper than Diesel. But the opposite is true. Market prices of these fuels are available in the units of money/litre. As Diesel is denser and more viscous than Petrol, more volume of Diesel can be bought for the same amount of price paid for relatively less quantity of Petrol. Consequently, Diesel produces 15% more energy by volume than Petrol (i.e. more heat energy per unit volume). Energy density along with thermal efficiency gives the ratio of total output to the total input. This is known as overall efficiency. Considering the difference in energy densities of Petrol and Diesel fuels, along with their thermal efficiencies, Diesel engines have 20% more overall efficiency than the Petrol engine, despite Diesel being much denser and heavier than Petrol fuel.

Overall Prices of Petrol fuel is higher than Diesel. Although, both the fuels are by-products of the refining process of crude oil, the difference in prices is due to taxes levied on them. Nearly 60% of the prices we pay at the fuel booth are in the form of taxes. Below is the cost comparison of Petrol and Diesel in Delhi for different stages of production, transportation, and incurred indirect-taxes on 1st of December 2020 [15].

Table 2: Petrol and Diesel costs incurred in various stages [15]

	Petrol prices (Rs./Litre)	**Diesel prices (Rs./Litre)**
Crude oil prices along with freight costs	22.32	22.32
Refinery processes and logistics costs	4.39	5.1
Excise duty and road cess charged	32.98	31.83
Commissions for pump dealers	3.65	2.53
VAT (30% on Petrol and 16.75% on Diesel)	19	10.64
Prices without taxes	30.36	29.95
Total tax paid	51.98 (63%)	42.47 (58%)
Final price of fuels on 1st of December 2020	82.34	72.42

Chart 3 [15]



This shows that production costs for both Diesel and Petrol are almost similar, i.e. nearly Rs.30/Litre [15] (The slight difference in their production costs is because of the higher commission costs of pump dealers on Petrol. If these costs are kept aside, then the production costs would be relatively higher for Diesel than Petrol because of its higher logistics and transportation costs due to its heavier nature.) But the taxes levied on Petrol is higher than that of Diesel, because of which Petrol is generally more expensive. Excise duty and the VAT are the taxes that are charged on Petroleum products (Petroleum products were not included in the GST list that was introduced on 1st of July 2017).

Generally, VAT is much higher for Petrol than for Diesel, but an exceptional situation happened after the global pandemic hit the economy. Indian Oil Corp.'s chairman Sanjiv Singh said that the demand for fuel reduced drastically due to the aftermaths of lockdowns, sending the prices of oils to multi-year-low [14]. After the lockdown was withdrawn form the nation, to regain the losses incurred, the state and central government increased the VAT dramatically on Diesel and it so happened that the price of Diesel, for the first time in living memory, crossed the price of Petrol on 24th June 2020 in Delhi, India.

But in general, taxes on Petrol have always been higher, due to numerous political and economic factors, consequently, resulting in higher prices for the same quantity of Diesel. India is the third-largest importer of crude oil in the world and imports around 84% of its oil consumption. The oil refineries must have to pay a lot of varying custom duties, which in turn reflects in the final prices of its Petroleum products. Middle–East countries are the major source of crude oil for India and many other consumer countries. Thus, the highly volatile demand and supply figures of crude oil also affect the final prices of Petroleum. (Although according to US Energy Information Administration, Indian has second largest reserves of oil in the whole Asia-pacific region, but unfortunately, the production is done only in 5 Indian regions. If India manages to increase the production in more such potential regions, then oil prices can be significantly lowered). It is also true, that Diesel cars are more expensive than Petrol cars of similar configurations. This is because of the more efficient engine (C.I) employed in Diesel cars. But this higher cost is compensated for the lower cost of Diesel fuel used to run this engine.

There is another type of efficiency that enables us to choose a better fuel and engine, in terms of fuel expenditure at the disposal of humans to the power output produced. This is known as specific fuel consumption. It is given by:

$SFC = \frac{\dot{m}_f}{P}$, where SFC is specific fuel consumption factor in Kilograms/joules, $\dot{m}_f$ is the mass flow rate in Kilogram /Seconds, and P is the power output in Watts.

Lower the value of SFC, higher the efficiency of the engine is. At an average, CI engines have a BSFC (Brake Specific Fuel Consumption) value of 200 g/kWh and SI engines have the BSFC value of around 250 g/kWh [13]. This again justifies the efficiency of a CI engine. This means that lower SFC, i.e., lower consumption of fuel, produces better efficiency. Thus, Diesel engines produce better efficiency at lower costs.

NOTE: Volumetric Efficiency also play a role in engine efficiencies. Maximum efficiency is when you have enough air to burn all the fuel. After a certain high rpm, the engine doesn't breathe with max efficiency i.e., volumetric efficiency decreases because complete combustion doesn't take place. Perhaps, If the driver of a car running on Petrol changes gears at optimal intervals, according to the engine torque and power requirements, and another driver of a car running on Diesel, irrationally changes gears without having any account of the engine speed and load requirements, then most probably this Diesel car would be less efficient than the former Petrol car. Changing of gears, in Petrol or in a Diesel car, should be mapped according to the 'Power Band'. The engine speed (rpm) range between 'peak-torque' rpm and 'max-horse power' rpm is known as 'Power-Band'. It is the range in which fuel efficiency is the highest.

C. Environmental Concerns

It has been a hot and debatable topic, that which engine is environmentally more deleterious. CI engines produce less CO_2 and other Greenhouse gas emission than SI engines. This is due to the reason that CI engines are more efficient than Petrol engines. Having higher fuel efficiency means that less fuel is required to produce the same amount of power and torque outputs, and thus producing less exhaust gas emissions in general. Though, fuel efficiency or the overall efficiency is dependent on many factors. Type of injection system is one such factor. Although, now the conventional use of Carburetors, as the inlet of fuel-air mixture into the cylinder, has been replaced by much more efficient fuel-injection technologies like GDI (Gasoline Direct Injection) and MPFI (Multi-Point Fuel Injection) in SI engines, Diesel engines are still higher in fuel efficiency because of its fuel characteristics and a higher compression ratio of the engine, consequently producing less greenhouse gas emissions.

Only greenhouse gas emissions do not determine the amount of pollution that vehicles create. Two more sources of pollution should be taken into account to have a holistic analogy for the environmental effects. These are noise pollution and the emissions of fine-particles. If we consider both these sources, Diesel turns out to be more deleterious. Generally, Diesel engines produce more sound while in running state and emits a huge quantity of fine particles that includes- CO (Carbon monoxide), HC (Hydrocarbons), NO_X (nitrogen oxides), SO_2 (Sulfur dioxide), and PM (Particulate matter). As the air-fuel ratio is comparatively higher for Diesel engines, the higher intake of air results in increased chemical reactions after combustion. This lean burning characteristic of Diesel engines results in the formation of these fine particles (especially NO_X) that comprises of just nearly 1% of the total exhaust product. As, since few years, improved injection systems (GDI, MPFI) have been a core part of the Petrol engines as well, amount of fine particle emissions have increased in SI engines as well due to the same reason of increased air-fuel ratio. Although pollutants from SI engines are increasing as the engine technology is getting advanced, CI engines are more responsible for the dangers associated with the environment. Moreover, as we know that engines that run on Diesel are much more efficient and are employed for regular use and heavy-duty purposes, they are utilized more than a Petrol engine. If a person owns both, Petrol and a Diesel car, then he is much likely to use his Diesel car more frequently. This eventually results in more overall emissions by the Diesel car. So ultimately, this gives us a holistic view that Diesel engines produce more pollution than Petrol engines.

Manufacturers of the car exhaust system have since then installed different particulate filters to deal with this underlying problem, which has, in turn, resulted in curbing pollutants outlet by more than 90%, but it is not enough. Despite filtering out a huge fraction of these fine particles, these filters are not competent enough to curb the finest particles, which are the most deleterious ones. Plus, due to clogging of particles, these particulate filters can produce even more nitrogen dioxide, the major component among these toxic fine particles. Moreover, many European reports have shown that these filters have very less effect on NO_X emissions which are the greatest threats imposed by Diesel engines. Therefore, better ways are being proposed by the engine researchers, to curb these fine particles emissions.

Diesel fuel primarily consists of carbon and hydrogen. Thus, ideal thermodynamic combustion of a Diesel engine would yield just carbon dioxide (CO_2) and water (H_2O) as combustion products. But as the process is not thermodynamic and is mechanical and due to the influence of various factors including engine inlet pressure, atmospheric pressure, quality of fuel, injection system, valve-timing, air-fuel ratio etc., other combustion products are also generated. These are as follows:

Table 3: Combustion products proportions [3]

Combustion products	**As percentage of the whole product (%)**
N_2 (Nitrogen gas)	67
CO_2 (Carbon dioxide)	12
H_2O (Water)	11
O_2 (Oxygen gas)	9
CO, HC, $S0_2$, NO_X, PM (Fine particles)	1

N_2 and O_2 are produced due to the presence of non-utilized air in the combustion process. The highest percentage is of nitrogen gas as it has the major proportion of the environmental air in general. The presence of the fine particles is less than 1% of the total product (exhaust gas). NO_X is the major contributor to the combustion product comprising nearly 50% of the fine particles. The second-largest contributors are the PM (Particulate matter) particles. There is a modicum amount of $S0_2$ that is also present in the exhaust gas outlet. NO_X is produced due to the high combustion temperatures, particularly more than 1600 degree Celsius. That's one of the reasons that justifies why Diesel engines emit a higher quantity of NO_X emissions. High combustion temperatures develop within the CI engines due to high compression ratio inside the engine cylinder. CO and HC are produced due to the incomplete combustion of fuels. PM particles are present because of the agglomeration of unburnt or partially-burnt fuel particles, partially burnt lubrication oil, ash content, Sulphates in fuel etc.

Aftertreatment methods are considered as the most effective methods to combat finest particle emissions that are not covered by the conventional particulate filters. It is a method consisting of various catalytic converters that clean the exhaust gases coming out form the exhaust manifold of an engine to meet the emission level requirements laid down by various administrations. According to a review by a researcher I.A. Resitog˘lu in 'the pollutant emissions from Diesel-engine vehicles and exhaust Aftertreatment systems', the most potential after treatment methods for Diesel engines are DOC, DPF, and SCR [3]. They are sometimes employed independently or in combinations.

Presence of $S0_2$ in the exhaust gas can't be kept under control by these Aftertreatment procedures, as such a method has still not invented in theory or practice. So, Sulphur contents are kept under control by using various blends of alternative fuels with Diesel or by using ultra-low Sulphur Diesel (ULSD) as the fuel. Rest all fine particles (including CO, HC, NO_X and PM) can be curbed by Aftertreatment procedures. For Diesel engines, major expectations from these processes are to curb NO_X effectively. NO and NO_2 are the primary nitrogen oxides that are usually found in the engine outlet. Selective catalytic reduction (SCR), is the most potential technology among the Aftertreatment methods to curb NO_X emissions. In this method, NH_3 is used as a reductant and is injected on exhaust gas to convert NO_X emissions into N_2 form. NH_3 is provided by injecting a urea solution from a pump through an injector. This effectively reduces nitrogen gas emissions and converts them into inert nitrogen gas and water.

Diesel oxidation catalyst (DOC) is a method used to oxidize and thus to limit HC and CO emissions. Besides that, DOC plays a role in decreasing the mass of Diesel particulate emissions by oxidizing some of the hydrocarbons, which is generated due to unburnt fuel. In this way, the unburnt hydrocarbons are converted into Carbon dioxide and water. Since the arrival of DOC in the 1970s, this method has resulted in the reduction of HC and CO emissions by around 60-90% as compared to their past statistics. It is used as a catalytic heater, as the processes happen due to the inlet of heat into the DOC. DOC may also be used in conjunction with SCR catalysts to oxidize NO into NO_2 and thus increasing the concentration of NO_2. The most commonly used catalysts for DOC and SCR methods are Pt and Pd based catalysts.

Diesel particulate filter (DPF) is another Aftertreatment method used for removing PM content from the exhaust gas emission. It involves physical filtration of PM particles, which is usually made up of either Cordierite ($2MgO–2Al_2O_3–5SiO_2$) or Silicon Carbide (SiC). When DOC is used in conjugation with DPF, it facilitates the emission reduction process. DOC is placed in the upstream of the exhaust manifold that helps in increasing the ratio of NO_2 by NO, and decreasing the temperature of PM particles.

These methods are necessary to meet the emission control requirements proposed by individual administration boards. An organization such as EU (European Union) for Europe and Central Pollution Control Board for India have been formulating rules for protecting the environment for several decades. These organizations ensures proper emission standards considering advancements in time (as time proceeds, development of goods increases, which in turn increases the possibility of causing harm to the environment). Applicable since 1st April of 2020, Bharat Stage 6 norms are currently the 6th version of The Bharat Stage Emissions Standards (BSES), to limit Indian vehicular fine particles emissions. These norms have been set by the Central Pollution Control Board under the Ministry of Environment and Climate Change of India. It lays down limits on retrieval of individual emission product from the engine cylinder to the surrounding environment. BS-4 was the set of norms that preceded BS-6. It was in practice for three and a half years until the 1st of April 2020. BS-4 norms give a clear difference

between the emissions out from Petrol and Diesel engines. This is because of the emission-limits imposed on these engines. These norms are engine specific. These limits are as follows:

Table 4: BS-4 limit for Petrol engines [12]

Exhaust gas product (in mg/km)	BS-4 limit (Petrol engines)
CO	1000
HC	100
NO_X	80
PM	(no limit)

Chart 4 [12]

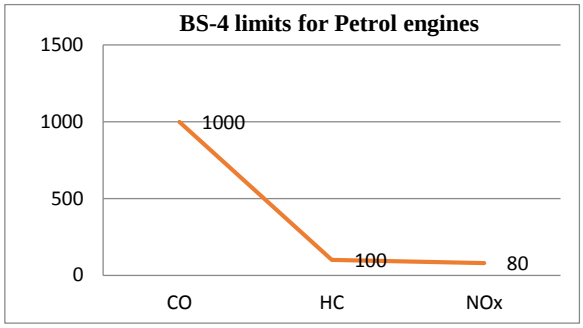
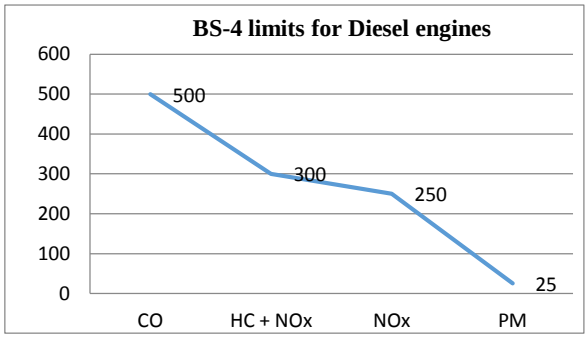


Table 5: BS-4 limit for Diesel engines [12]

Exhaust gas product (in mg/km)	BS-4 limit (Diesel engines)
CO	500
HC + NO_X	300
NO_X	250
PM	25

Chart 5 [12]



These graphical trends show that BS-4 displays a sharp contrast in Petrol and Diesel engine emission limits. Moreover, it justifies that the pollution caused by Diesel engines is more than that by Petrol. But due to the arrival of BS-6 norms, that are currently getting into practice, this difference between Diesel and Petrol limits have been significantly eliminated. BS-6 limits are as follows:

Table 6: BS-6 limit for Petrol engines [12]

Exhaust gas product (in mg/km)	BS-6 limit (Petrol engines)
CO	1000
HC	100
NO_X	60
PM	4.5

Chart 6 [12]

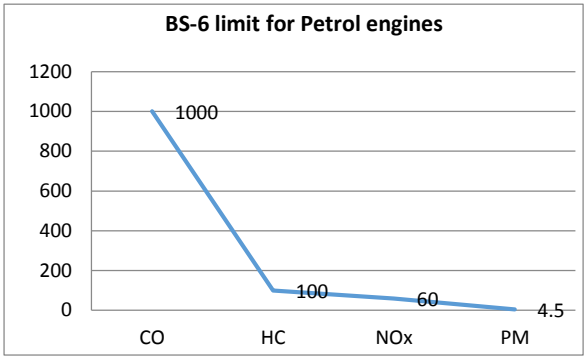
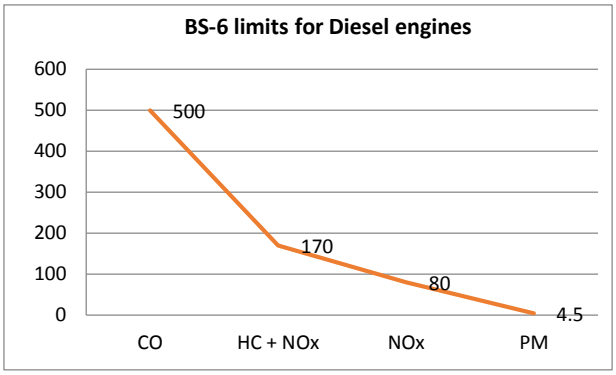


Table 7: BS-6 limit for Diesel engines [12]

Exhaust gas product (in mg/km)	BS-6 limit (Diesel engines)
CO	500
HC + NO_X	170
NO_X	80
PM	4.5

Chart 7 [12]



These trends observed from the BS-6 norms emission levels justify that Diesel and Petrol engines are now considered almost similar pollution causing machines. (Note: CO content shows a drastic difference between Petrol and Diesel limits. This is because of the difference in their combustion processes. A Diesel engine operates in lean fuel-air composition, because of which CO production is relatively low.) These limits have been achieved by the BS-6 norms. These include physical changes such as an enhanced combustion chamber and fuel injector design that results in an efficient combustion process and finer atomization of fuel, respectively. Plus, systems such as OBD (On-board Diagnostics), RDE (Real Driving Emission), and Aftertreatment procedures of exhaust gas (DPF and SCR), also contributed to achieving such relatively modicum

pollutant limits. RDE measures vehicles' emissions in real-world conditions against simulated conditions. For the first time, the use of DPF and SCR are introduced by the BS-6 norms that have contributed significantly to reducing nitrogen oxide and PM particle contents.

Thus, all this gives us an impression that even if Diesel fuels have proved to be more deleterious to the environment, the current improvisations, mostly physical, has lead Diesel/CI engines to match their pollutant emission standards with Petrol/SI engines.

III. NEED FOR ALTERNATIVE FUELS

It seems that CI engine is a better engine out of both the engines, there are many reasons for not choosing Diesel as the only fuel for the CI engine.

A. Persisting Performance Issues.

Whenever there is a certain kind of leakage of Diesel within the engine, the engine oil gets contaminated. This is because unlike Petrol, Diesel has low volatility due to which it does not get evaporated after getting mixed with the engine oil. This contaminates the lubrication system, consequently resulting in engine wear. This eventually results in lowering the engine performance output. Moreover, if the fuel is not properly filtered, then it might result in the clogging up of fuel injector. This is because of the inadvertent presence of water and impurities in the fuel and due to the presence of high-pressure environment at combustion stroke. Moreover, Aftertreatment techniques that are employed to reduce emissions of pollutants from the exhaust, also produces back pressure on the engine resulting in a net decrease in output. For example, the regeneration process is performed for the combustion of NO_X or particulate particles, which gets trapped in various filters, using the engine fuel and thus causing back pressure. As a certain amount of the input fuel is utilized for secondary purposes, the net energy or output generated by the engines reduces. Reduction of Sulphur in the BS-6 fuel has resulted in lower performance and efficiency. This is because Sulphur is used to reduce the resistance within the engine, which eventually reduces frictional losses. Reduction in Sulphur content has resulted in higher frictional losses, especially in Diesel engines, resulting in damages caused to the fuel injector and lower overall performance.

B. Economic Burdens

Although many companies and automakers have tried to combat these issues by improving engine technologies, either the costs cross the maximum limits or increased performance negotiates with our environmental. The maintenance costs of a Diesel engine are pretty high to achieve the required performance. These costs include, refinement of the contaminated lubrication system, cleaning of the clogged-up fuel injector nozzle, improvement of engine drive terrains to compensate for the efficiency loss due reduction of Sulphur content (as done by Mahindra and Tata), regeneration methods applied to burn the trapped NO_X or particulate particles and many more.

India, to match up there emission control norms with the US and European equivalent norms, has skipped a transition of emission control, that is, after the arrival of BS-4 engines there was a direct jump to BS-6 engines after three and a half years. This has resulted in drastic differences in the pollutant emission limits imposed on the BS-6 engines as compared to BS-4 engines. Both automobiles as well as oil companies have been drastically affected. Their work has been doubled to make new engines that are compatible with the new norms. This has resulted in many models and powertrains being phased out and thus have incurred a lot of losses to the automobile business sector including major automakers.

Low workforce during the series of lockdown and the additional costs of the development of newer engines to make their emission limits synonymous to those of BS-6 norms has led to an increase in vehicular costs of production. At an average, Petrol car prices have gone up by Rs.10,000 to Rs.20,000, while Diesel cars have gone up by Rs.80,000 to Rs.1,00,000. BS-6 vehicles are slowly getting introduced in the market, but there are still a large number of BS-4 engine vehicles repleted in the streets of India. Thus, BS-4 fuel is still being supplied by the Petroleum pumps in abundance. The issue is that if this fuel is used to run BS-6 engines, then the maintenance cost will eventually run out of hands. This is because due to the relatively high Sulphur content in the BS-4 fuels, the particulate filters and other Aftertreatment filters in the exhaust system will get clogged up and would need replacement earlier than its actual life. This further causes efficiency loss and lower fuel economy resulting in higher maintenance and lower outputs. Moreover, if the BS-6 fuel is used in BS-4 cars, then the engine injector valve will wear out. This is because the Sulphur content in BS-6 fuel is very low and BS-4 engines are designed in a manner that they require a higher quantity of Sulphur to reduce frictional losses. Due to the lower availability of Sulphur for the BS-4 engines, the engine cylinder, especially the fuel injector valve gets worn out due to excessive friction. These problems of mismatching of the fuels are major with Diesel engines and not significantly with Petrol engines. The variability in the availability of these fuels, with their corresponding engines, has made this process of transformation from BS-4 engines to BS-6 engines slow. Moreover, such a compromise might result in depreciated performance. Diesel engines have therefore a need to consider some permanent changes in the fuel blends for the engine.

C. Environmental Concerns Relating To the Aftertreatment Processes in Diesel Engines.

- Limitations of using DOC

Catalysts used in DOC converts the $S0_2$ and SO_3 into harmful Sulphate and Sulphuric acid emissions. This further can cause damaging of the Aftertreatment processes, health issues, and serious implications to the environment. Although many physical changes have been suggested and implemented, nothing had the potential to eradicate the underlying issue.

- Limitations of using DPF

The exhaust gases when passes through the DPF filters, they form a saturated layer of soot particles over the filter having optimum porosity. Although this layer provides an effective surface filtration, excessive saturation must be prevented as this causes back pressure on the engine resulting in poor fuel economy and lower performance. This is because the PM particle gets trapped in the filters. Regeneration processes are used to avoid this, i.e., burning off the trapped PM. There are two types of regeneration processes commonly referred to as active regeneration and passive regeneration. Active regeneration is periodically applied to DPFs in which trapped soot is removed by oxidizing it with O_2 at 550 degree Celsius or higher. This is done by providing heat through heat sources such as an electric heater or a flame-based burner. Passive

regenerative processes use a combination of few regenerative. Regenerative temperature higher than the melting point of the filter might fail DPFs. Moreover, too much dependence on outside heat sources for DPFs, might increase the cost of production.

- Limitations of using SCR

The Sulphur content in the fuel is a great hazard for Aftertreatment technologies. Sulphur lowers the catalytic activity. Desulphurisation can be done by high heat inputs. But a problem, similar to DPFs, i.e. due to high temperatures and production costs persists. Thus, there is a need for alternative fuels or fuel additives having lower or no Sulphur content.

According to the researches that have been carried out, Biodiesel has been the most potential alternative fuel for Diesel engines to improve these Aftertreatment processes.

IV. BIODIESEL

Biodiesel is considered as a major eco-friendly, non-toxic, biodegradable, Sulphur-free, economical and renewable fuel.

A. Emission Characteristics

Sulphur content in these fuels is very less, and probably zero in vegetable-derived methyl esters and extremely small in animal-based ones.

PM, HC and CO emissions decreases and NO_X emissions increases as the proportion of Biodiesel increases in a Diesel and Biodiesel blend. The increase in NO_X is not due to a particular component in the fuel blend, but due to the combination of various factors.

B. Performance and Economic Characteristics

Cetane number is higher for such fuels. Higher the Cetane number, lower the ignition delay, because of which better is the timing of the combustion process which thereby increases performance and efficiency.

Octane number is also higher. More the octane number, lesser the fuel is likely to self-ignite which consecutively reduces the tendency of knocking and detonation. In other words, this means Biodiesel have higher flashpoints. Thus, they are safer than Diesel.

They are even denser than Diesel, therefore more mass of Biodiesel is injected by the same volume of fuel in comparison to the conventional Diesel fuel.

Brake specific fuel consumption (BSFC) of Biodiesels is similar to that of conventional Diesel fuels.

C. Downsides of Using Existing Biodiesel Options

Quantity of oxygen is 10-12% by weight due to which energy density is low resulting in the use of a higher mass quantity of Biodiesel fuels to produce outputs synonymous to that of conventional Diesel fuels. Thus, the heating value is relatively low in Biodiesels.

As Biodiesels are even denser than Diesel fuel, they have very high viscosity. Due to high viscosity, the performance of fuel injector is majorly affected. Consequently, resulting in improper atomization of fuel, increase in mean diameter and breakup time of the fuel droplets etc.

NO_X emissions increases as the proportion of Biodiesel increases in a Diesel and Biodiesel blend.

D. How can Biodiesels be Made Fit for Vehicular Consumption?

Factors that make the full-time use of Biodiesel skeptical include high NO_X emissions, high viscosity, high specific fuel consumption and high cost of production.

- How NO_X emissions can be controlled?

NO_X emissions in Biodiesel are high because of the presence of oxygen and due to high Cetane number rating. High Cetane number means lower ignition delay, which causes the fuel mixture and initial combustion products to have a longer residence time at elevated temperature, thereby increasing NO_X formation. Moreover, the oxygenated combustion of Biodiesel favours the formation of NO_X particles. Better ignition techniques can curb high NO_X emissions. Retarding the injection to post-TDC (Top Dead Center) lowers the peak heat release, which in turn causes low-temperature combustion, consequently reducing NO_X emissions. Potential ignition methods to curb underlying issues include Homogeneous Charge Compression Ignition (HCCI) or Premixed Charge Compression Ignition (PCCI) [7].

- How to solve high viscosity problem of Biodiesels?

Transesterification is the most effective method of producing Biodiesels out of Triglycerides [5]. Triglycerides are normal plant and animal (sometimes edible) oils composed of the Glycerin ester of three fatty acids. This process is carried out by reacting a particular Triglyceride oil with alcohol (Methanol or Ethanol) using a catalyst($KOH, NaOH$). This process creates Methyl or Ethyl ester with free fatty acids and Glycerol as a by-product. Several modifications in this Transesterification process can prevent the development of high viscous Biodiesel fuels. For instance, using catalysts like Sodium Methoxides (CH_3ONa) can produce lower viscous Biodiesels. Moreover, better injection systems can compensate for the presence of high viscous Biodiesels.

- Analysis of the high cost of Biodiesels.

Price of Biodiesel can be out of scope for regular car owners. This is because of the technology involved to produce such a new environmental-friendly alternative. Moreover, since 2018, taxes on Biodiesel have gone up from 6% excise duty to 18% GST, after the introduction of GST in India [10]. And as the cost of production is skyrocketing, it is very difficult for Biodiesels to take place its position as the most favourable vehicle fuel. A study by Prabodh Illukpitiya in the paper titled 'Economics of Small-Scale Biodiesel Production' in 2014, demonstrates the general cost of production of the Biodiesel [6]. According to the study and money value in 2014, the total cost of production (which includes feedstock cost, alcohol and catalysts cost for Transesterification process and electricity cost) was \$5.53-\$6.38 per gallon [6]. This was even higher than the cost of producing conventional Diesel fuel at that time.

But the seed meal produced by oilseed pressing also has a certain value through which production costs decreases by a great amount. If one takes into account the value of the seed meal produced [6], it comes out to be approximately \$3.03 per gallon. This value was subtracted from the total cost of production and the net production cost came out to be \$2.50-\$3.35 per gallon [6]. At that time, 1 Dollar was equivalent to 60 Rupees, so this gives the range of Biodiesel cost as just 150-201 Rupees. The above report was evaluated under

several different ownership scenarios namely individual, subsidized, shared ownership. This ownership status affected the costs substantially. This is as follows:

TABLE: Profitability of biodiesel production under various ownership scenarios.

Ownership	Total Processing Costs ($/gallon)	Total Production Costs ($/gallon)[a]	Total Production Costs with Meal Value ($/gallon)[b]
Individual	$3.27	$5.92	$2.89
Subsidized (25%)	$2.82	$5.47	$2.44
5 farmers	$1.79	$4.44	$1.41
10 farmers	$1.64	$4.29	$1.26

Note: The above estimation is based on the biodiesel production under medium processor speed with annual production of 1,500 gallons, feedstock cost of $2.65/ gallon biodiesel produced, seed meal value of $3.03/gallon biodiesel produced.

[a] Total production cost includes processing cost plus feedstock cost.

[b] Total production cost per gallon of biodiesel = Total production costs/gallon – value of seed meal in terms of gallon of biodiesel produced.

Figure 3 - By Bioenergy [6]

Thus, farmers can reduce their production costs of Biodiesels effectively under shared ownership [6]. The government should assist the production units and people who make their livelihood by producing various Biodiesels from plant and animal-based oils.

- *How can the high specific heat consumption of Biodiesels be less bothersome?*

This can be curtailed by adding suitable additives in the fuels or using a proper proportional blend of Diesel-Biodiesel fuel. Nano additives is a potential additive to increase the capabilities of Biodiesel, at par with Diesel fuel [9]. Nanoparticles have a large surface area which increases the number of reaction sites. This facilitates the combustion process by generating much more heat energy. Moreover, Reduction in production costs, by practicing shared ownership, can compensate for the higher Specific fuel consumption rates of Biodiesels.

V. CONCLUSION

Currently 99.8% of vehicles run on internal combustion engines and liquid Petroleum comprises of 95% of their energy sources [4]. Although, researches on better engine design and new drive train technologies are going on, even by 2040 there will be 85-90% [4] of vehicles that will run on conventional liquid fuels. Thus, there is a need to reflect on the existing designs and look optimistically towards potential alternative fuels. Diesel engines produce better efficiency at lower costs. After the advent of Aftertreatment methods, the emissions are also synonymous to that of Petrol engines. Still, a litany of limitations persists, such as cost issues, Aftertreatment methods limitations, and various other issues concerning engine performance. Thus, numerous researches have been going on separately to demonstrate the best Biodiesel or Biofuel in general. Some potential biofuels include Jatropha Curcas, Cashew nut, algae oil, Pongamia Biodiesel, hydrogen and many more [8]. Currently, the most common proportions of Biodiesel in Diesel fuel blends are B5 (up to 5% Biodiesel) and B20 (6% to 20% Biodiesel) [11]. If the above measures are seriously considered by production units and governance, then we are not far from a day when Biodiesel would be the most favourable fuel for heavy-duty, regular-road vehicles.

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Social Robotics and HRI

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***Abstract* - One of the most fascinating trends in recent technology is "Social Robots", born out of human intelligence. Soft Robots will soon become a vital organ of Human civilization. Social robots are robots that are designed in such a way that they can interact with other living organisms. The detailed study of interactions between a Social robotic system and humans is crucial in developing this technology. With the progress in this field, social robots are becoming more and more intelligent. Social robots are widely used in the healthcare sector, Disease diagnosis, and many other customer services. To better understand this field of Soft Robots and HRI, we decided to summarise both of these concepts. In this paper, we bisected the topic into two parts. In the First part, we tried to explain the basic definition of "Social Robots", elaborated their architecture, perceptions about them, then we discussed few of the recent and famous Social robots of our time with specifications, it's benefits and potential risks, and the future of Social robots. In the second part, we attempted to explain HRI and its current status, it's supervisory control, teleoperations, automated vehicles, social interactions and discussed various human factors that are required to overcome few challenges in this field. Along with that, we discussed the future scope for HRI.**

Keywords: Social robots, Architecture, human interaction, supervisory control, teleoperator, telerobot

I. INTRODUCTION

"Social robots" is a subfield within the vast field of robotics. Robots are the autonomous machines that work under the supervision of human through a set of programs which is also created by humans, social robots are those robots which are designed in such a way through Artificial Intelligence commonly known as "AI", that they can communicate with humans and other living beings as well. Social robots are gaining rapid popularity, because of their ability to socialize with humans. Many social robots are already in the use. Many companies like Hanson Robotics and Boston Dynamics are leading the research in the vanguard. Soft robots are embedded with features similar to that of humans or any other living being. Eyes, nose, mouth with lips everything is attached to it to normalize its appearance. They are designed in such a way that they can recognize their former users and learn from their past experiences. They is proven to be very effective especially in the field of Healthcare, but while they make our life easier they contain some drawbacks as well. This brings us to our second part of this paper "HRI" a short form used for Human-Robot Interactions. HRI is another challenging field, which is very diverse and extremely extensive. HRI is constantly improving and is becoming more and more advance. Our main aim in this paper is to give a brief overview of the concepts involved in this rather new yet fascinating field.

II. SOCIAL ROBOT

A machine that has implanted elements of computational intelligence that allows them to behave independently for a long period of time with human control or supervision is called robots. Social robots are a kind of robot that are usually humanoids and animaloid, that is they have human and animal-like features. They have physical features like "eyes", "nose" and "facial hair". And they embedded with actuators that support expressions to make them more social. In another word, Social robots are AI-assisted robots that can interact with humans and other humans and can perform jobs like butlers and therapists. In the homes, social robots can be designed perfectly enough to become part of the family and can be developed with programs to engage with family members. A social robot may be remotely controlled, perhaps serving as a telepresence representative at a business meeting or in the home or as a companion in a healthcare facility. In other words, social robots are AI-assisted robots capable enough to communicate with people and things in the environment. Autonomous robots of these kinds are known as Smart robots, Smart robots are those robots that can copy the functioning of the human brain through data mining, pattern recognition, and natural language processing (NLP) The social interactions in soft robots are more cooperative, but the definition is not limited to this situation. But robots can also interact with minimal or no communication. The social robots must interact within the framework of social rules assigned to them. Many restaurants are in India and

all over the world have started using robots are butlers, their performance is very good. Social robots must communicate with humans in an understandable natural manner and follow contextually appropriate norms [1]. Apart from spoken language processing, they must produce human-like features like smiles or frowns, whereas sound, posture, color, prosody, and movement can also enhance the quality of communication [1]. Despite facial features, the most important part of human nature is "emotions", which is why more significant efforts have been made to develop "emotionally responsive robots" [1]. The field of social robotics is able to grasp much broader developments in AI (Artificial intelligence) and robotics, including robot control, natural language processing, improvements in machine learning, and computer perception. Various new techniques like cloud computing are used to produce a more intensive form of computations, this will enhance its capabilities. Social robots are also able to access resources such as databases and off-board sensors that will permit them to provide more difficult social support. Hence, rather than emulating forms of human-to-human interaction, we can hope that Human-robot interaction will be different than the previous one. The key elements in the pursuit of the social robot:

• Physical: Physical robots exposed to the physical environment
• Reflexive: they are of two types Fast reactive and reflexive nature to unforeseen or unanticipated events
• Deliberative: Computational machinery required in order to realize defined complex goals
• Social: It is the ability of the robots to interact with other robots for achieving future goals.

III. THE ARCHITECTURE OF SOCIAL ROBOT

The Social Robot Architecture facilitates the development of teams of robots that may not be homogenous, both in terms of behavior and hardware. Behavioral heterogeneity is achieved by developing BDI agents of various capabilities through Agent factory, e.g., commitment adoption strategies, knowledge resources, planning facilities, etc. The use of a standard interface among the reactive layer and deliberative component (i.e., the agent-events and commands) signify that robots with sensors of different fields and actuators can be submerged into the system. For the purpose of interaction, the use of a standard interface that is the ACL Teanga, permit non-homogenous agents to co-ordinate and communicate [2].

The architecture is made of four different layers: physical, reactive, deliberative, and social:

1. Physical: Robots take the form of a physical thing or being
2. Reactive: A series of fundamental reflex behaviors are used at this level. The sensory information is worked upon and transformed resulting in clear agent-events and interacted to the deliberative level. Agent-commands are received from the deliberative layer.
3. Deliberative: This comprises of a Belief-Desire-Intention (BDI) architecture developed through Agent Factory [Col96] [OCC+98]. The process of perception deals with the transformation of agent events into belief and adding them to the belief set providing the agent with an up-to-date model of its current perceived situation and results in the agents' commitments are updated as per the process [2]. Commitments that were already existed are checked and those pertaining to the current time frame changed resulting in either a communicative act being sent to the social level or a physical act being delivered to the actuators through the reactive level.
4. Social: agents communicate through an Agent Communication Language (ACL), called Teanga1.

IV. PERCEPTIONS REGARDING SOCIAL ROBOTS WITH RESPECTIVE CONCERNS

Generally, people possess positive perceptions regarding Social robots and are interested to engage with them, but the development in the field of social robotics have generated several concerns on the societal and ethical challenge they raise. The behavior and exterior of the robots resemble us and many representations in cultural artifacts such as film and literature may contribute to feelings of unease, and perhaps triggering anxieties about our own human nature. They may come as a threat to human dominance and may later de-humanize the world. That is why Robots are seen as a matter of concern about the broader impact of AI. A major portion of the debate on the ethics of social robots revolves around the contrast between their physical and ontological status [1]. Physical due to their ability to behavioral manifestation which can only be seen in living organisms, this leads humans to place them near boundaries of Human sociality and culture. But ontologically they belong to the family of the designed machines. But in the case of social robots, we may categorize them with machines and tools, still, we communicate with them as if they have psychological capacities similar to us. So rather than categorizing Social robots in any of the above, they should be seen as a new ontological class.

V. FAMOUS SOCIAL ROBOTS OF OUR TIME

A. PEPPER

Created by Softbank's robotics, it first came into the limelight when it was introduced in Tokyo on June 5, 2014, the type of this robot is "Humanoid". Pepper became popular in a very short period of time; more than 12000 pieces of this robot are already sold in Europe (Fig. 1(a)). Pepper is currently used as reception in several offices, is able to identify visitors with the use of facial recognition,

send alerts for meeting organizers and arrange for drinks to be made. In Japan, it is widely used in households, banks, and restaurants. Pepper can successfully interact with humans can propose games and menus in restaurants. The robot has embedded with 4 microphones, 1 HD camera in the mouth and another in the forehead, and a 3D depth sensor which is located behind its eyes. Touch sensors are located in the head and hands. 6 lasers, 2 sonars, 3 bumper sensors, and a gyroscope are located in the gyroscope. The height of this robot is 4ft, depth of 17 inches, es, and a width of 19 inches. And weight is approximately 28 kilograms and used Lithium-ion battery and size of the display is 10.1 inch. It uses the platform of NAO iq OS.

B. NAO

Nao is a human-based or humanoid robot of compact size, due to sensors embed in it is able to perform human operations and can sense or recognize human faces (Fig. 1(b)). It also created Softbank's robotics. Nao is an autonomous, programmable, medium-sized humanoid robot. of which the architecture of control and the software is customizable. NAO can walk at different speeds and at different directions including the speed of small children. The robot has the capability of performing a rich panel of movements with smoothness and precision, and a certain degree of interactive autonomy. NAO is modular, referring to actuator modules that can be used for different joints. The head of NAO can be unplugged and replaced by a more specialized one. Hands and forearms can also be changed. Nao's lower part has 11 DOF (Pelvis and legs), 25 Degrees of Freedom, upper part (Arms, trunk, and head) has 14 DOF. 2 DOFs are located at the ankles in each leg, the knee had 1 and hip have 2. The pelvis is made of 2 coupled joints mechanisms at each hip. The rotation axis of these two joints is tilted at 45◦ towards the body. It is a very fine replacement for a classical set of 3 active rotary joints. The rotation of the trunk along the vertical axis (YAW ROTATION) is prevented by the coupling of pelvis joints when support is provided to both legs. This is a major advantage as now only 1 motor is required to drive the pelvis instead of 3 like before, which will be cost-effective and saving space in the lower part of the trunk. The structure helps to better distribute the power between the hip roll joint and the pelvis joint and confers a specific motion style to the NAO humanoid. 2 DOFs are located on the shoulder, 1 at the wrist, 2 at the elbow, and for hand's grasping 1 additional DOF is provided. The head is able to rotate about yaw and pitch axes. Custom-designed integrated circuits based on Microchip 16-bit ds PICs microcontrollers is embed in it. The main function is able to control bus control, sensor management, power converters, and servo control. MREs are attached with actuators.

C. ATLAS

Developed by American Company Boston Dynamics and U.S. Défense Advanced Research Projects Agency (DARPA) is a bipedal humanoid robot. Atlas is designed to operate both outdoors and inside buildings and has whole-body dynamic balancing. Atlas is able to sense obstacles run over rough terrain autonomously or through teleoperation (Fig. 1(c)). The robot is electrically powered and hydraulically actuated. The Applications of Humanoid have basically two types of Stage control problem. One is a Behavior level controller that produces outputs of high-level commands and another one is a low-level controller that generates the joint commands. The low-level controller is composed of dynamics and full-body kinematics in order to use the workspace and robust the external perturbations. Inverse kinematics via stiff joint position tracking is another way of controlling humanoid robots. Whereas inverse dynamics-based approach method has gained drastically increasing acceptance by providing compliant motions and robustness to external perturbations. The inverse Kinematic method is easier as it only needs Kinematic models which are easier to generate, whereas the previous method is highly dependent on Dynamic models of high quality. As per DARPA Robotics Challenge, ATLAS was tested on the proposed full-body controller. It has a total of 28 hydraulic actuators, back joints have 3, neck pitch has 1 and each leg and arm have 6. Their major function is to perform various functions like ladder climbing, through full-body manipulation. Atlas is capable enough to perform all eight tasks as follows:

1. Drive a utility vehicle at the site.
2. Travel dismounted across the rubble.
3. Remove debris blocking an entryway.
4. Open a door and enter a building.
5. Climbing the industrial ladder and traverse an industrial walkway.
6. Breaking concrete panel through a tool.
7. Locate then close a valve near a leaking pipe.
8. Connect a fire hose and standpipe then turn on a valve.

D. SOPHIA

Developed by Hong Kong-based Hanson Robotics Sophia is one of the most developed social robots. Sophia is the first robot ever to be granted citizenship of any nation, As of October 25, Sophia is the first robot in history to be a full citizen of a country (Fig. 1(d)). Sophia has a female face, she has 2 cameras embedded in her eyes, cameras are programmed to detect faces and greet users by their names. The material used for making her skin is a special variety of silicone (Frubbet). This material is flexible enough to perform 62 facial expressions like anger, joy, sadness, amazement, annoyance, fear, etc. She possesses an electronic synthetic voice that

allows her to speak. The most human-like feature of this robot is that it gains from her previous experiences and uses them for the future. Sophia becomes more and more familiar with the cultures, customs, feelings, emotions, and linguistic styles of her interlocutors.

(a)


(b)


(c)


(d)

Fig. 1: Some famous Social Robots of our time; (a)Pepper, (b)Nao, (c)Atlas and (d)Sofia

VI. BENEFITS WITH SOCIAL ROBOTS

The benefits of social robots should always be placed before negative aspects. One major benefit is comfort. Comforts can later be again classified into two parts, Emotional and physical. Various studies have proved that the role of social robots in providing physical comfort has been demonstrated in studies that compare interventions with social robots with controls using a tablet-based avatar of the same robot. Children always interact with robots with great interest even more than living being such as dogs. The increasing work on Human-robot interaction also understands the value of physical contact with artificial companions in providing comfort [1]. Many robots like Sony Aibo and Miro-e can also provide emotional support to people by reducing social isolation and the experience of loneliness (Fig. 2(a), (b)) [1]. Interactions with robots will also result in a positive consequence especially in the case of older adults and therapies.

VII. RISKS WITH SOCIAL ROBOTS

Social robots will be essential members of human society in the upcoming days. But everything has some negative consequences as well so do social robots. One of the major demerits of the social robot is cost, the cost of the robots like NAO, Atlas, and Sophia are very high. The main areas where social robots will be used are with children suffering from autism, parents, schools, or therapies, and might not have enough capital for purchasing social robots. Though cheaper versions of robots are available they won't be that effective. Children with autism would be missing out on a great opportunity. The second is that children with autism might form emotional bonds with social robots which can have serious consequences. Especially children, because children become very emotional with the thing they play. The third and the most important aspect is job loss, social robots will take over many jobs in the future and will create a few and limited for skilled people only. Jobs like therapists, Butlers, and receptionists might be human-free in the future.


(a) (b)

Fig. 2: (a)Sony Aibo and (b)Miro-e

VIII. FUTURE OF SOCIAL ROBOTS

With the future, robots are becoming an integral part of the future. Automation and robots go hand in hand. Many companies like Softbank's and Boston dynamics are tiring to make new robots that are more affordable and versatile. Many Restaurants and hospitals are using social robots as butlers and receptionists. Many Hotels are using robots as the staff. But it may pose challenges to humans' jobs.

Researchers are developing more refined hardware and software, with their integration with artificial intelligence in social robots are making things more and more versatile. Many philosophers are exploring the morality of human-robot relationships. Social ecologists and social

psychologists study the dynamics of relationships and examine their impact on the quality of life.

Major challenges that still remains are:
1. consider the positive and negative potential impacts of social robots.
2. identify potential outcomes that are plausible.
3. develop strategies to promote positive impacts and discourage negative ones.
4. Affordability of robots among people.

IX. HUMAN-ROBOT INTERACTION

Human-Robot Interaction or HRI is a multidisciplinary field of study dedicated to learning, designing and evaluating artificial robotic systems to work for humans or with humans. It is presently an extensive field of research and experimentation. Interestingly, the roots of this field originated when it was presented by 20th century author *Isaac Asimov* in his novel *I, Robot* as a distinct in problem in 1941. In his work, he postulates the three laws of robotics as:

1. *A robot may not harm a person or, through inactivity, allow the person to be injured.*
2. A robot must obey the commands given to it by its human supervisor, except if the commands would lead to injuring the supervisor hence contradicting the first law.
3. A robot must safeguard itself inasmuch it does not contradict its function to not harm a human and by extension it should not contradict the first and second rules.

Although the actual concepts of HRI were much more complicated requiring years of research work, these fictional laws provided a framework for engineers and researchers to build upon. Also, HRI gives more priority to safety of humans dealing with potentially dangerous robotic systems. The solution to this problem involves approaches ranging from philosophical to practical. *Lidar* is as example where safety zones are created based on detection of human/obstacle presence in the robot's proximity to impede any contact between the machine and its operator. At first, human involvement was necessary for the operation of HRI but since the early 2000s, fully autonomous have become more common as a consequence of persistent and continuing research in this field. Such systems include simultaneous localization and mapping, natural language processing and natural language generation which all contribute to smart motion and natural communication with humans [3].

The studies in this field are expanding rapidly through various publications annually and by different research societies dedicated to technical disciplines of mechanical and electrical engineering, computer and control science, artificial intelligence and deep learning. The demands for observations on human interaction and robotic cooperation are huge. Ergonomics professional should work with engineers and scientists to better understand robot dynamics and control which will further research, design and evaluation in HRI. Study has shown that interaction between robots and humans is mostly dependent on their proximity. One such type of interaction is *Remote interaction* where the robot-human pairs are not in the same location, but are separated by space or time (for example: space rovers). The other type is *Proximate interaction* in which both are in the same location. With these two important distinctions, we can categorize the different types of robots according to the application.

HRI encompasses around four regions of application,

A. SUPERVISORY CONTROL: It is a proximate interaction involving mobile robotics. In such applications, the robot is used to perform routine functions under human supervision and have limited automation. Such robots are used in the process of manufacturing where parts need to be put in sequence on an assembly line, delivery of components to different places etc. These robots are called *Telerobots*. Telerobots are operated by humans using computer programs and designed to sense their environment and component trajectories. In case there are changes, the robots report back to the supervisor/human operator and the necessary updates in the computer program are be made.

B. TELEOPERATION: Here, remote interaction with mobile robots is involved. The robots operate in sequestered and potentially dangerous environments like in space exploration, aviation or in underwater scenarios. They perform non-routine exercises in a remote physical surrounding in accordance with continuous instructions from a remote human who control the robot's motion. These machines are called *Teleoperators*.

C. AUTOMATED VEHICLE: This kind of robotics deals with human passengers in automatic automobiles, automatic rail travel or automatic aircraft travel.

D. SOCIAL INTERACTION: It includes the societal, perceptional and emotional aspects of human-robot interaction. In social interaction, humans and robots treat each other as companions or associates. Such an interaction is seen as proximate rather than remote. These robots are used for human aid applications like entertainment, education, Autism intervention, injury rehabilitation etc.

The current research and challenges in all of these areas is discussed in this paper. The human

factors and the basic tough problems facing HRI are also discussed in the following sections.

X. SUPERVISORY CONTROL

Many types of robots are involved in performing fabrication work (Fig. 3(a)). Nowadays, many manufacturing industries use artificial aid in assembly and other wide variety of works. The human component in the interactions taking place in such an environment is in a supervisory role where humans instruct the robots what function to perform, what repairs need to be made etc. In other words, telerobots are used here. One such robot is the Baxter robot developed by Rethink Robotics [6]. This robot was built in such a way so as to allow safe proximate interaction with humans (Fig. 3(b)). It is compliant, humanoid structure. It has been provided with a set of eyes not for sight but to intimate to the humans what task it is presently performing.

In 2011 and 2015, some researchers in HRI were trying to enhance the interactions between human-robot pairs in industrial conditions and have shown methods in surveying people carrying out supervision of artificial agents. The survey was carried out by demarcating the limbs of the robot manipulating operators using computer vision. The data is used to deduce a strategy for close-knit cooperation with the robot where it relieves the operator of some duties which it can do better. It was found the operators preferred the robot to predict their actions rather than them having to guide the robot through the task step by step. Also, the human participants concluded that this method was better instead of a knowledgeable operator having to program the robots to do certain tasks.

Present HRI challenges in this category include industrial performance, medicinal supply systems, agriculture etc. Safety continues to be a major concern.

XI. TELEOPERATION

In the early days of robotics, the demand of robots began when highly radioactive substances needed to be manipulated without putting the Human operators in danger of exposure to these toxic substances. Master-slave robotic systems which held and moved objects in all six degrees of freedom were made. In the beginning, mechanical tapes were used for controlling this mechanism which later transitioned to electromechanical servomechanisms having a feedback force. Since then, the research and experiments have led to the development of more remote robots which can be used in hazardous scenarios like space rovers (Fig. 4(a)), underwater robots, drones (Unmanned aerial vehicle or UAVs) (Fig. 4(b)) [6].

Further research and innovation are required in order to improve display and control in these robots. The robots need to be incorporated with complete circular observation at the site to which they are sent to. In faraway regions like in space research communication between the remote operator and the robot needs to be improved in order to eliminate the long delays in relaying messages or instructions. These robots are also used in surveillance, search and rescue, military strikes via drones etc. In the medical industry, telerobots are being used in some minimally evasive surgery and they provide a greater range of accuracy of the hand movements performed during the surgery. Patients with missing or amputated limps have greater control and are able to achieve motion and manipulation with the artificial counterparts. The research in this field is important for the rehabilitation of disabled people as it will help them overcome their neurological or muscular or any other type of artificially improvable deficiency.

XII. AUTOMATED VEHICLES

Automobile manufacturers are upgrading their technologies in order to enhance the human driving experience. Some of these improvements include radar augmented cruise control, run-of-the road alarms, and vehicle to vehicle communication in order to promote driver safety in case of accident scenarios. However, it is difficult for an artificial system to understand the complex social cues involved in driving in traffic like hand-eye signals between drivers while driving. Making an artificial intelligence-based automobile will require further research on how to train AI to understand traffic behavior and to what extent can the automobile incorporated with AI within safe limits. Present day urban planners are mulling over automated rail and highway systems but are limited in their capacity to make it a reality (Fig. 5).

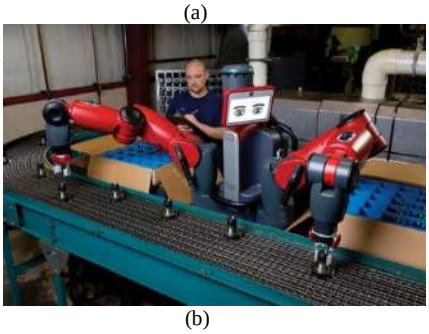
Artificial commercial aircrafts are included here since they are telerobots operated by supervisory pilots by utilizing the flight machinery for giving commands, changing direction and mapping locations. Similar to the human motor skills like driving, closed-loop system can be used to achieve pitch, yaw and roll on an aircraft. Speed, altitude and heading all combine to give guidance to the aircraft in order maintain a particular flight path which is like humans needing traffic lights and traffic signs for travelling from one place to another. Now, like people review weather and other conditions in order to determine their travel schedule, artificial aircrafts use map memory, knowledge of weather conditions and air traffic to navigate to a particular airport destination. Human in-loop simulations must be tested along with digital communication methods in human factors research of commercial aerial vehicles [8].

XIII. SOCIAL INTERACTIONS

The Massachusetts Institute of Technology (MIT), contributed significantly to social robotics research in the late 1990s with its Kismet robot head. It can understand and create facial gestures pertaining to emotion (Figure 6(a)). It uses the computer processed face and voice of a human subject and makes the suitable facial signals in return. Although we can ask how it counts as social intelligence, it is a step forward to further intellectual debates regarding its nature. Evidence shows that robots like kismet interact with young children efficiently but questions can be raised on whether they lessen or increase imagination in children.

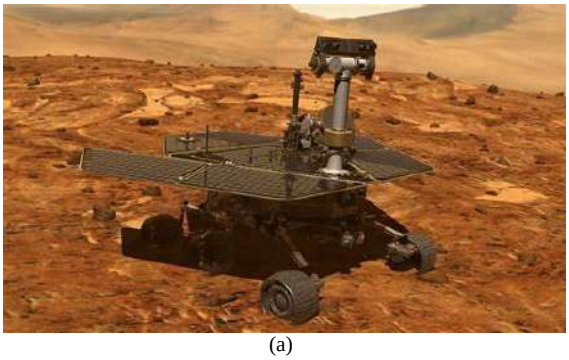
Interactive toys with artificial speech recognition and decision-making capabilities are being produced by toy manufacturers. One example of this type of robots is the barbie doll designed by Mattel. It is capable of making regular interesting conversation with children owing to its speech and language recognition and it's to the internet via the server. Interactive robots are especially useful in healthcare of autism afflicted children and elderly people (Figure 6(b)) [8]. Here, a major dilemma is whether the patients will fully trust a robot to aid their rehabilitation process. Much work is still required in human factors research to integrate social robots into the healthcare industry.

(a)



(b)

Fig. 3: (a)An industrial robot (b)A Baxter Assembly line robot.



(a)

(b)

Fig 4: (a)NASA's mars exploration rover (b) A US army Drone (UAV)

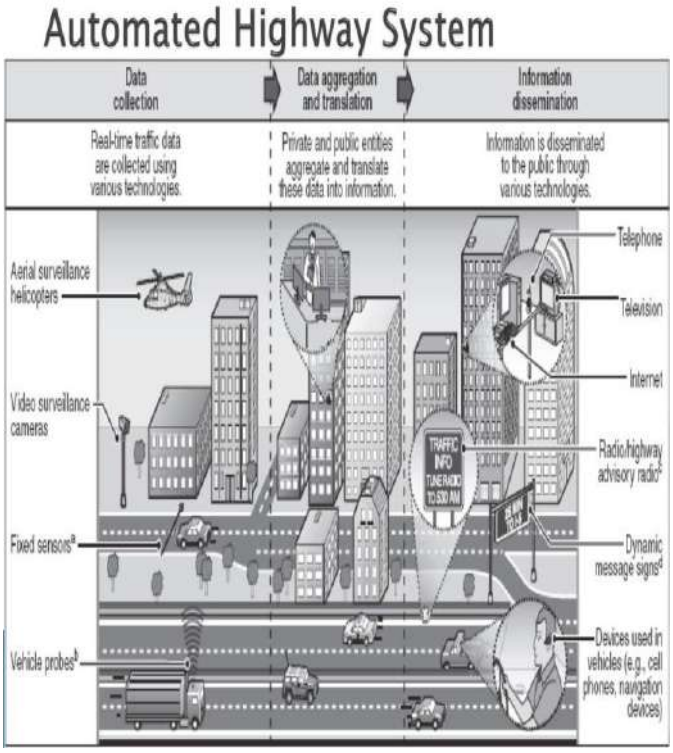
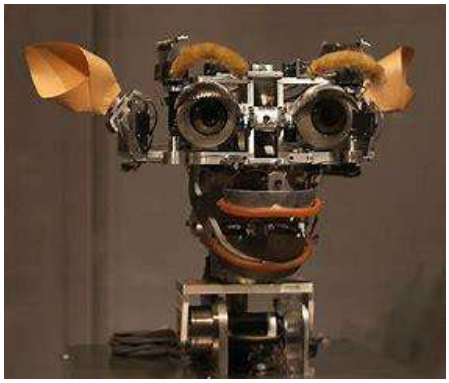
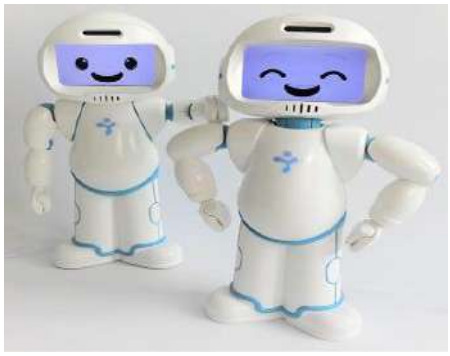


Fig. 5: A computer generated model of an Automated Highway system.



(a)



(b)

Figure 6: (a) MIT's Kismet (b)QTROBOT - An interactive social robot for children affected by autism

XIV. HUMAN FACTORS RESEARCH REUIREMENTS TO COMBAT THE COMPLEX PROBLEMS OF HUMAN ROBOT INTETACTION

A. FUNCTION ANALYSIS

One important attribute of human factors research is the differentiation of tasks between humans and robots. The study on what tasks a human or a machine can perform best individually was established but needs more work. Small sensors, AI, deep learning and high frequency communication have led to the progress of social machines. From an Ergonomics point of view if one takes the example of aiding the elderly and handicapped people, human caretakers injure their backs while doing this work while robots may be designed to lead the patients safely and gently from place to place. However, challenges do arise in task planning and modelling of such machines in duration, spaciousness, impetus, energy and price [16]. Also, previous tests show the corporeal form of the robot is best decided by what task it will perform rather than trying to make it more humanoid which does not make proper sense.

B. TRAINING MACHINES AND PREVENTING INVOLUNTARY OUTCOMES

Human operators can instruct an artificial hand to move but to guide its movement, at what time to move, avoid of certain movements etc., one has to use symbols rather than communication in analog form. Huge leaps in computerized speech recognition (e.g., Amazon's Alexa) has made it easier to instruct machines to do tasks but this creates a prospect for involuntary outcomes. One can use real- time virtual simulations to combat this hazard since it provides a way to visualize what the machine might do when given the said command before getting on with the task. Essentially, one can "look ahead" by extrapolating the ongoing process and create model simulations [16].

C. INTERFACING

There has been the idea of intelligent machines and people having intellectual models for each other for quite some time. Computer algorithms can see human activity, save this data as models, and perform analysis and forecasting. Serious challenges are encountered while interfacing the human-robot internal models when attempts are made to elicit human visualizations on purpose of robots and integrating them with the artificial robotic model of organization and prevention of contradictions. Experimentation in the areas of visual, speech and language recognition has implied that AI can replicate the initial 90% of human abilities but replicating the remaining part is extremely difficult since the human consciousness is made up of vastly different and wide variety of life experiences [16]. Robotics research has always been about ultimately about creating an artificial organism in our image. Now, if it can be realized or not is yet to be see.

D. EDUCATION

Till date learning has been through texts or attending lectures at schools or colleges which can be tiresome for those who have lack of interest in such education or for people with learning disabilities. Communicating with physically present teachers has always increases the efficacy of education. Robots will revolutionize the teaching profession and learning in the coming time by enhancing the joy in education, using live physical demonstrations of concepts for deeper understanding or by giving appropriate responses in the form of remarks on students' works and opinions. The research on Humans and robots teaching each other is fascinating. The challenge here is to determine at what rate can humans consume information form robot teachers across different ages, different disabilities or different cultures. Artificial learning in the whole world should not be centralized since people arise from many different regions in the world with varying backgrounds. Local researchers must focus on the needs of their particular region and collaborate with researchers from all the other different regions to carry this field forward.

E. LIFE, CONCERNS AND HUMAN PRINCIPLES

In popular culture, robots have been shown to be antagonistic machines trying to combat the human race at all costs. Movies like the *2001: A Space Odyssey*, *Terminator* series, *Ex-Machina* etc., depict the dangers of artificial intelligence. The idea of autonomous robots seems to scare people and these fictional scenarios are depicted widely in society. Although these are for entertainment, such scenarios are not entirely realistic. With the invention of any technology, there are pros and cons that arrive with them. In case of robots there are many public concerns like will they serve us or will we serve them, will they make us unemployed, will they instead of spying for us go rogue, will they kill us instead of our enemies and so on. This is why creators of such technologies and human factors scientists are more aware of the falsities and possibilities than general society. They can think rationally, come to proper conclusions about the technology being safe for humanity or not and only then will they sanction the use of such devices. Results of experimentation should steer public debate and discussion nor unwarranted fears elicited by fictional scenarios. The crux of the discussion is this: if we could potentially automate anything, which facets of human society should we do it to and to which it should not be done to.

XIV. CONCLUSION

Social Robots will soon become an integral part of our future society. Social robots can interact with then people very easily this the main reason they are becoming trendy in the healthcare and Education sector although the research and studies show that social robots can help people across the lifespan but they have a few potential risks as well. HRI is a rapidly evolving field. Robots under human controls have proven successful in the field of medical and hazardous situations. The field of this "social robotics" is a rather new field. It investigates unconventional materials and morphologies of autonomous systems for social robots. The field of social robotics is new, and it holds great potential but also challenges many of the assumptions, models, materials, tools, and techniques used in traditional robotics for decades. The traditional processes of design and manufacturing cannot be used when we seek to create machines with and mechanical properties and complexities that human features. New design processes, new material concepts, and new simulation algorithms are required to overcome these challenges. However, with time and advancement in technologies, we are overcoming these challenges. Revealing a new world of robotic systems far richer than today.

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A review on 3D printing technology (2015-2020)

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***Abstract*— This paper presents a review, analysis and classification about 3D printing. It emphasizes on the potential of 3d printing with the the help of various articles of high degree of relevance published between the years 2015 and 2020. Each of these articles was classified by means of 9 categories: study types, affiliation, approach, origin of the study, geographic scope, unit of analysis, scope, benefits and negative points. Through the results obtained, it was verified that the number of articles on 3D printing is increasing every year, which indicates its importance and popularity. Most of the time, scientific research is conducted and led by people connected to universities in Europe, Asia and the Americas. And finally, the number of citations related to the benefits of 3D printing are greater than the number of citations on the negative points ofthe process.**

Keywords*—*3D printing, additive manufacturing, literature review.

INTRODUCTION

The competition between companies of any industrial sector grows more and more each year. In this way, companies seek to reduce costs and deadlines and, at the same time, are pressured to develop and deliver products of high quality and performance. This competition generates the need to launch a new product in the market with a greater frequency and, consequently, the demand for new projects and development of new products grows. It is at this stage that 3D printing stands out (LOPES, 2016).

Popularly known as 3D printing, this process has many other names such as rapid prototyping (RP), additive manufacturing (AM) additive techniques, additive processes, among others (LOPES, 2016).

Within a few minutes or hours, this manufacturing process allows to produce complete products from a CADsoftware, using the most diverse raw materials and without a great human intervention. 3D printing has as its characteristic to construct three-dimensional pieces by means of the addition of successive thin layers, one on top of the other, until the formation of the desired product (ABREU, 2015; LOPES, 2016).

As mentioned earlier, additive manufacturing is an important technology in the development phase of the product. Its benefits are (LOPES, 2016): less time in the product development phase, lower costs, possibility of performing several tests and prototypes, increase product complexity without increasing deadline, decrease in project delivery time.

HISTORY

The first known 3D printer was invented and patented by Charles W. Hull in 1986. In his patent he describes a method where it is possible to fabricate objects by solidifying layers of a photo polymer (resin). This process was called stereolithography (ABREU, 2015, AGUIAR, 2014). Three years later, in 1989, Scott Crump patented another 3D printing equipment that uses a different method than the Charles Hull printer, called Fused Deposition Modelling (FDM). Through the ability to move along three axes, the nozzle of the printer deposits a molten material, and layer by layer the final object is produced. (AGUIAR, 2014). However, the rapid prototyping process became better known and accessible in the early 2000s. With the e xpirat ion of FDM patents, Adrian Bowyer created the RepRap (Replicating Rapid Prototyper), where the software of the equipment is free, its source code is open and 57% of the mechanical 3D printer components are manufactured through the additive manufacturing process (concept of self-replicating machine). In this way, in 2004 the first low-cost 3D printer appeared (ABREU, 2015). By having an open system, many people were interested in developing and enhancing Adrian Bowyer's original design, and thus, the 3D printer has become cheaper, more accessible and more efficient (ABREU, 2015).

DIFFERENT TYPES OF 3D PRINTING

Over the years, the evolution of technology has had a major impact on the development of other 3D printing processes. The following are the most applied processes.

Stereolithography (SLA)

As previously mentioned, stereolithography was the first 3D printing process created and, according to Abreu (2015), is the most used type of additive manufacture.

By means of the incidence of an ultraviolet laser, a layer of liquid resin is solidified. After this step, the platform where the solidified resin layer is located is moved slightly downward, causing a layer of liquid resin to be added. Again, the laser solidifies the resin creating a second layer. This process is repeated until the object is completely constructed (ABREU, 2015; LOPES, 2016; BIKAS et al., 2016).

Fused Deposition Modelling (FDM)

As exp lained earlier, the FDM process was the second type of additive manufacture created and is one of the most used processes because of its low cost.

In this process, thermoplastic filaments are heated in the

extruder and deposited on the construction platform by means of the extrusion nozzle. The construction platform has a lower temperature than the deposited thermoplastic, causing it to solidify rapidly. The platform moves down, and the nozzle of the e xt ruder deposits the second layer of material. This process is repeated until the object is created. (*ABREU*, 2015; LOPES, 2016; BIKAS et al., 2016).

3DP

Unlike the processes mentioned above, the 3DP uses as a raw material a ceramic powder and a liquid binding agent. In the first step, a layer of ceramic powder is evenly distributed on the building surface. Subsequently, the liquid binding agent is applied over the desired area by means of a jet. In the third step, a piston recedes, causing the object's construction surface to move downwards. Thereafter, a new layer of ceramic powder is added, followed by the liquid binder. This procedure is repeated until the piece reaches its final shape. The piece is removed from the machine and a jet of compressed air is applied in order to remove uncoated powder from the model. The prototypes manufactured using the 3DP method are fragile, and to make them more rigid it isnecessary to subject them to a process of infiltration of resins (ABREU, 2015; BIKAS et al., 2016).

Selective Laser Sintering (SLS)

Like the 3DP process, selective laser sintering also uses a powder (usually thermoplastic, nylon or metal) as the raw material. This material is arranged in a homogeneous layer and a laser is applied to melt its particles, and thus solidify the material. This procedure is performed many times until the part is ready (LOPES, 2016; BIKAS et al., 2016).

Laminated Object Manufacturing (LOM)

This process can use different types of raw material, such as paper, plastic or metal. The material is laminated by a heated roller and glued to the bottom layer. Thereafter, it is cut by means of a laser (LOPES, 2016; BIKAS et al., 2016).

STEPS OF 3D PRINTING

To develop a project via 3D printing, you need to perform the following steps (AZEVEDO, 2013; OLIVEIRA, 2016):

- Develop a project of the desired object in 3D CAD software, such as SolidWorks, Inventor, AutoCAD, among others;
- Convert the project to STL (Standard Tecelation

Language) format. This format describes surfaces of an object through a set of triangles of different dimensions. The more triangles there are, the greater the project accuracy;

- The next step is to choose a reference plane from the STL file, and so the object will be divided into layers parallel to the chosen reference plane. The smaller the size of the layer, the more accurate the print will be;
- Each of these layers is described by a file called GCODE. This code has the numerical commands for the manufacture of each of the layers, possessing information of temperature, trajectory, speed, positioning, among others;
- Finally, printing is done using the GCODE code, which directs the printer to obtain the desired object.

APPLICATIONS

Today, rapid prototyping has a very broad reach. It can be used in the most different industries, institutions of education from the fundamental level up to the higher level and for private use (individuals).

Aerospace Industry

It was one of the first areas to use the benefits of 3D printing to create prototypes quickly. The components of the aviation industry have a complex geometry and use advanced materials (advanced metal alloys such as:

titanium, nickel superalloys and special steels), which makes additive manufacturing a viable option (LOPES, 2016; BAHNINI et al.,2018).

Car Industry

The automotive industry was also one of the first to use 3D printing for the rapid development of prototypes / products and then began using the technology to manufacture the parts used in cars. Braking systems, drive shafts and gearbox parts are some e xa mples of parts that are manufactured through additive manufacture (LOPES, 2016; BAHNINI et al.,2018).

Medicine and Dentistry

Like the two sectors mentioned above, the health area was also one of the first to use the technology. 3D printing is a great way to manufacture prostheses and implants, as these products require a high degree of customization due to the

different morphological characteristics of each patient (LOPES, 2016; BAHNINI et al.,2018).

The ne xt step in 3D printing that will revolutionize the medical world is 3D bioprinting, where the goal is to create bones, tissues and living organs (LOPES, 2016; BAHNINI et al.,2018).

Art and Fashion

Artistic class and fashion also surrendered to the benefits of 3D printing. Plastic artists have found an easier and more direct way of bringing their ideas to life, while fashion designers use technology to create a variety of different accessories, such as: luggage, shoes, glasses and hats (LOPES, 2016).

OBJECTIVE

The objective of this work is to review, analyse and classify the research carried out on 3D printing between the years 2014 and 2018. Thus, it is expected to understand in what way the researches are being carriedout and what are the results achieved on the subject in recent years.

ARTICLES SELECTION

The 124 selected articles were classified into 9 categories: study types, affiliation, approach, study origin, geographic coverage, unit of analysis, scope, benefits and negative points.

The category "types of study" refers to the way in which research is approached. Following the classification of Miguel (2007), the main types of research approach are:

- Conceptual theorist: new theories are developed

through discussions of the existing literature;

- Case study: it is a more detailed analysis of one or more subjects or objects, aiming at their greater knowledge;
- Survey: Through a survey, you get information about a problem or object. Subsequently, an analysis of the collected data is made, in order to find a solution to the problem;
- Modelling and simulation: mathematical techniques or computer software are used to better understand a system;
- Action research: it is an empirical research where the researchers and interviewees seek to solve a given problem together;
- Literature review: study on a certain area of existing literature whose objective is to know and follow its development;
- Experimental research: it is the study about a system or object, where the researcher has control of one or more variables, manipulating them to observe what happens.

The second category, "affiliation", aims to the same thingsn show what kind of institution is behind the research: university, research center or industry. The "approach" category analyses the data format used in the research: quantitative or qualitative. Next, the categories "origin of the study" and "geographic scope" are analysed, where they cover, respectively, in which continent the research was carried out and the scope of this study (regional, national or international).

The sixth category is the "unit of analysis", where the area in which the study was carried out is classified:

Application in companies or academic projects in the areas of costs, design, production or product quality; study of theoretical model; social impact; equipment (hardware, software or process).

The seventh category, "scope", contemplates the subject studied by the article, while the last two categories classify the "benefits" and "negative points" found by the researchers.

JOURNALS SELECTION

Through the CAPES Sucupira platform, a first search was made about periodicals from Engineering III (which is composed of Mechanical, Production, Aerospace and Naval). The other criterion used in the search was the relevance index, where we searched for the best articles in this question (in this case, the best articles are classified with the inde xes A1, A2, B1 or B2). In this way, 21 journals were selected that had articles on Production and Manufacturing Engineering.

Using the keywords "3d printing" and "Project", searches were carried out in the 21 selected journals from 2014 to 2018. Thus, articles were found in 8 newspapers.

After analysing the selected articles, it was verified that some of them contained only brief quotations on the subject of rapid prototyping and therefore were discarded. Thus, the final selection is shown in Table 1 in result section.

RESULT AND DISCUSSION

In this chapter the results obtained will be shown and analysed in the last section of the chapter. Firstly, the data of the publication numbers of the articles selected between the years 2014 and 2018 will be shown. After that, the data of each of the 9 categories mentioned in the methodology will be shown. In the final item, the results will be discussed.

Number of Article Publications about 3D Printing

Fig. 1 shows the percentage of articles published in the selected journals between the years 2014 and 2018. The small number of art icles on rapid prototyping in the years 2014 and 2015 can be perceived, with the increase of these numbers in the following years, year of 2018, with 41.79% of articles released. The word data is plural not singular and the subscript for the permeability of vaccum andstudy about a systemor object where the researcher has the control over all the variables. This figure shoes the number of articles published in selected journals between year 2014 and 2020.

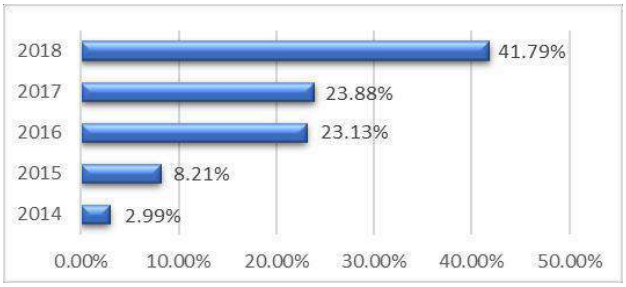


Fig.1 : Percentage distribution of articles published per year

Types of study

Fig. 2 shows the distribution of the types of studies performed. It was verified that the research study of the case was the most accomplished, with 61.3%. It is followed by far by e xperimental research, with 22.6%. Literature review, action research, modelling and simulation, survey and conceptual theorist obtained less than 10%, and action research was not performed once**.**

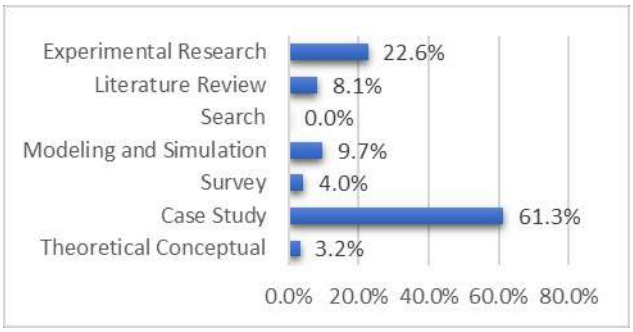


Fig.2 ; Classification by types of study performed

Affiliation

In order to carry out this classification, only the main author of each article was considered. Thus, although there were contributions from individuals linked to private industries and research centers, it was considered that 100% of the articles were carried out through universities, due to the fact that all the leaders of the articles are linked to institutions of teaching.

Approach

Fig. 3 shows the type of approach performed in the selected works, being it quantitative or qualitative. According to the figure below, 79.8% of the cases adopted are quantitative.

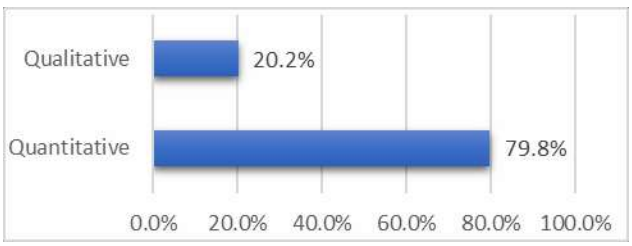


fig.3: Classification by approach

Origin of study

Fig. 4 classifies the origin of the art icles. Asia and Europe lead the number of publications with 32.3% each. While the countries of the Americas (the only countries cited were the United States and Canada) published 25.8%. Oceania and Africa reached 4.8% and 2.4%, respectively, while Brazil also published 2.4% of the articles.

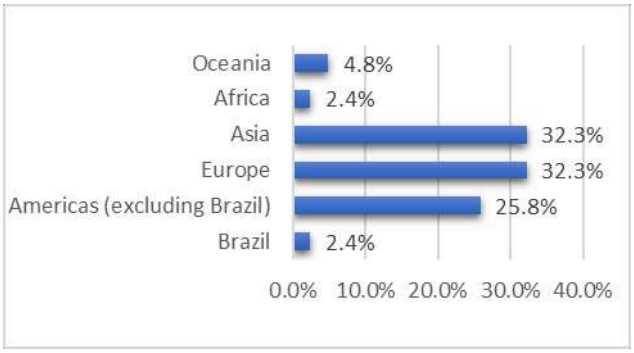


Fig.4: Classification by origin

Geographical scope

Fig. 5 classifies the articles by means of the geographical scope of the art icles, that is, what territory was taken into account in their research (regional, national or international level). Only 11 of the 124 selected articles were found, and in 63.6% of these 11 art icles, they were classified as international coverage and the other 36.6% as a nationalcoverage.

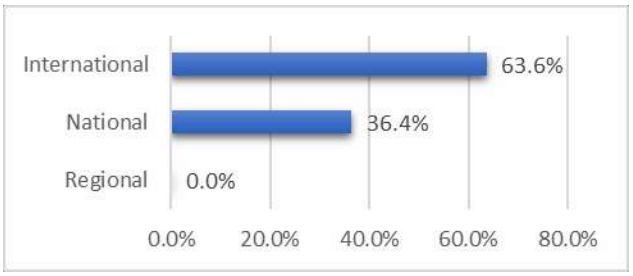


Fig. 5: Classification by geographical scope

Unit of analysis

Fig. 6 shows the unit of analysis data, that is, the area in which the search was performed. They were classified into 5 main groups, 4 of which have subgroups:

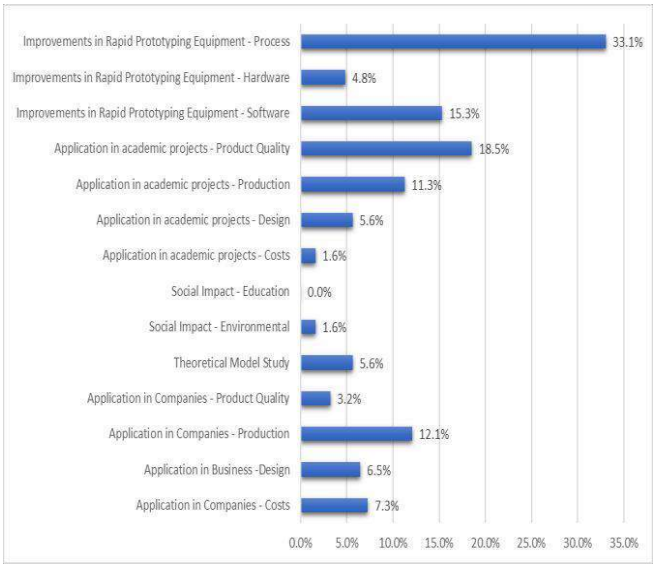
- Improvement in fast prototyping equipment (53.2%), being subdivided into process (33.1%), hardware (4.8%) and software (15.3%);
- Application in academic projects (37%), being subdivided into product quality (18.5%), production (11.3%), design (5.6%) and costs (1.6%);
- Application in companies (29.1%), being subdivided into product quality (3.2%), production (12.1%), design (6.5%) and costs (7.3%);

• Social Impact (1.6%), being subdivided into

education (0%) and environmental (1.6%);

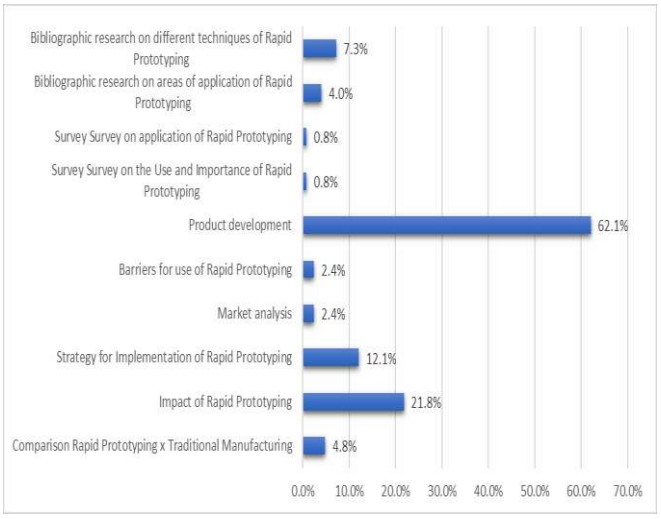
• Study of theoreticalmodel (5.3%).

Fig. 6 : Classification by unit of analysis



Scope

Fig. 7: Scope classification



CONCLUSION

Through the data analysed it can be analysed that 3D printing is increasingly being studied,which indicates the importance and popularity of the theme.Of all the articles selected 2.99% of them were published in the year 2014, 8.21% in 2016, 23.14% in 2017, 31.41% in 2018, 41.79% in 2019. Taking into account the category affiliation all articles were classified as uni--versity students that is the research was led by professionals linked to higher institutions. Taking in to account the origin of articles produced, it was

In article scope the product development was the mostly Cited (62.1%). Finally the catagories of benefits and negativities of 3D printing, the highlights were t5he higher Cost and lack of capacity for high scale production, with 30.8% for each of the items.

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THERMO-MECHANICAL ANALYSIS OF FUNCTIONALLY GRADED MATERIAL ROTATING DISK

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ABSTRACT-The analysis of thermos-elastic functional graded hollow circular rotating disc is made. Material properties are varying along the radial path. A finite element technique is offered to study the thermal stress in functionally graded hollow annulus rotating at constant angular velocity. Thermal stresses and radial deformation are obtained by finite element method by using software called ANSYS-APDL. A comparison is made for special power law between finite element method and analytical method to verify the correction of finite element method. Numerical outcomes are plotted to display the variation of different parameter

INTRODUCTION

Rotating disks are circular element in which rotational motion (i.e. angular velocity) is subjected. It may be of thin or thick type and solid or hollow type. Due to the subjection of angular velocity, it develops the body forces ($\rho r\omega^2$ per unit volume) due to centrifugal force, which correspondingly give rise to various types of stresses, strain, displacement. Disks are among the basic element which are frequently used in structural system.

1.1 FGM Rotating Disk

FGM rotating disks are one in which the material charater (i.e. youngs's modulus, density, poisson's ratio, thermal conductivity, and coefficient of thermal expansion) may vary in along the radius. Variation in properties in FGM is modeled by various functions, such as sigmoid, exponential, parabolic, power etc., in order to characterize FGM bodies. However, exponential and power function are widely used as they can cover a wide range of variation by changing the index of the function.

1.2 Functionally Graded Material (FGM)

A functionally graded material (FGM) is a combination of two elements characterized by a compositional gradient from one component to second component. As compare to customary composites are homogenous blends, therefore include a balance among the beneficial character of the component material. Because essential proportion of a FGM comprise the unadulterated form of both component, the requirement for balance is removed. The properties of both the component can be completely used. For example, the stiffness of metal could be coupled with the refractoriness of a ceramic, without any balance in the toughness of metal part or the refractoriness of the ceramic part.

Functionally graded materials are a new generation of engineered material which are a non- homogenous mixture of two or more distinct material phase, such as different ceramics or ceramics and metals. The key distinguishing feature of these material is that the composition, or in other word, the material distribution of each constituent material. Continuously vary with space variable. This continuously varying material distribution induces chemical, material, and microstructural gradient, and makes it different in behavior from homogenous material and traditional composite, material [1,2]. It is noted that a traditional composite is homogenous from the view point of the macroscopic study and does not have gradient in microstructure. The concept of a typical FGM consist of two different materials A and B illustrated in Fig. 1.1. The left surface of the FGM plate shown in Fig. 1.1(a) has 100% material A while right surface of plate has 100% material. In between these two surfaces, the material distribution(composition) denoted by the volume fractions VA and VB of the constituent A and B respectively, continuously changes as shown in Fig. (b). The material distribution shown in Fig.(b) may vary linearly, exponentially, or following any power function depending on the desire properties and application of FGMs.

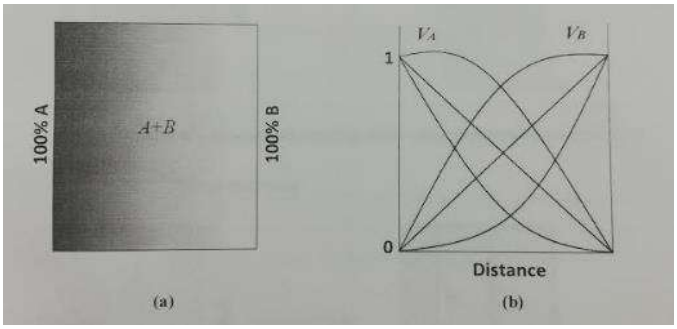


Fig.1 Material distribution in the FGM plate

The concept of FGM was first invented in japan in 1984 during a spaceplane project, in the form of a proposed thermal barrier material capable of bearing a surface temperature of 2000 kelvin and a temperature gradient of 1000 kelvin across a cross section<10mm [1]. There is no single uniform material of bi-material endurable to such an adverse condition of temperature. For example, if a uniform/homogenous material is subjected to the above mentioned thermal gradient, it will bend excessively as shown in Fig. 1.2 due to mismatch in thermal expansion, which leads to the failure of structure. Another alternate solution to deal with this adverse situation might be bi-material having lower coefficient of thermal expansion (CTE) at higher temperature side and higher CTE at the lower temperature side. However, in this case again, mismatch in thermal expansion at the interface between two materials cause delamination or disbanding at the interface depicted in Fig.1.3. To get rid of these two fold problems, the japanese scientist realized that necessity of the third alternate material that would neither bend nor experience the problem of delamination under the above adverse condition of temperature. Consequently, the concept of FGM was originated.

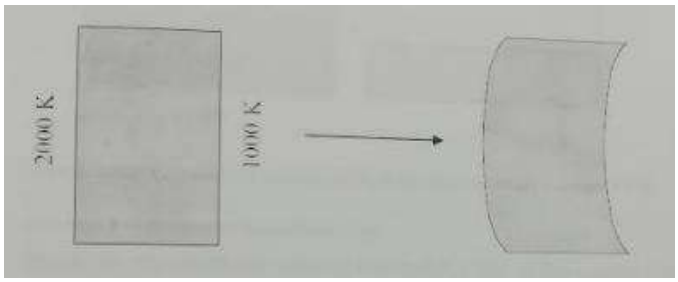


Fig.2 Bending of a homogenous material under a large temperature gradient

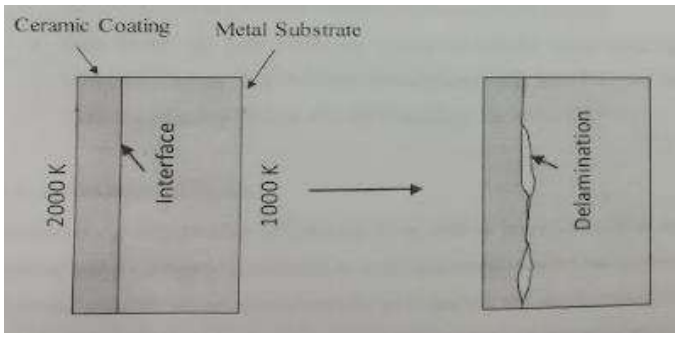


Fig.3 Delamination of bi-metal under a large temperature gradient.

1.3 Type of FGM

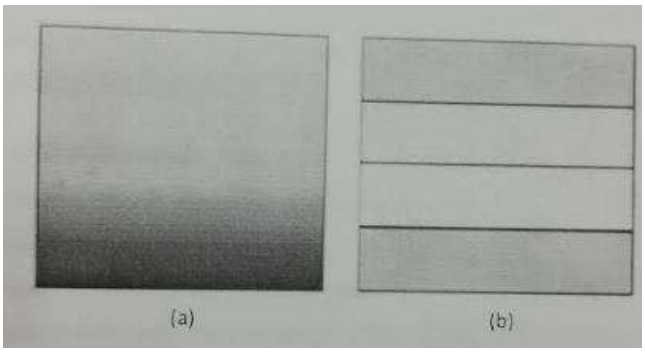
FGM are classified according to different criteria like,

1.4 According to the structure:

Continuously structured FGM: In continuously structured FGM properties of materials varies gradually.

Discontinuous (layered) FGM: In discontinuous (layered) FGM properties of materials varies abruptly.

Difference is clarified by the figure:



(a) Continuously structured FGM, (b) Discontinuous (Layered) FGM
Fig.4 Types of FGM

1.5 According to process of manufacturing:

Thin FGM: Thin FGM are relatively thin section or thin surface coating. This type of FGM are made by plasma spraying, self-propagating high temperature synthesis (SHS), physical or chemical vapor deposition (PVD/CVD) [3].

Bulk FGM: The bulk FGM are volume of material which need more labor intensive process. Bulk FGM are manufactured using solid freeform technology, centrifugal casting method, powder metallurgy technique [3].

1.6 1.4 Advantages of FGMs

Functionally graded material is being used as interfacial zone to enhance the bonding power of layered composites, to decrease the residual and thermal stress in bonded dissimilar materials and as wear resistant layer in machine and engine components. One of the advantage of FGM over laminates is that, because of continuous material property variation so that there is no stress concentration at sharp material boundaries thus reducing potential structural integrity issue that is delamination.

The following noticeable advantage are as follow:

- Gives multi functionality.
- Gives opportunity to control deformation, dynamic response, wear, corrosion, etc. and ability to design for different complex environment.
- Gives ability to eliminate stress concentration.
- Gives opportunities to take the benefits o different material system [e.g. ceramics and metals such as resistance to oxidation (rust), toughness, machinability, and bonding capability]

1.7 Applications

1.8 Aeronautics: Spaceplane body, rocket engine component, etc.

- **Biomaterials:** Artificial bones, joints and teeth.
- **Defense:** Bullet proof vest, armor plate.
- **Industrial materials:** Heat exchanger tubes, forming tools, wear resistant lining for handling large heavy abrasive ore particles etc.
- **Energy materials:** Thermo-eletric materials for optoeletric conversion and sun energy laser conversion etc.
- **Optoelectronics:** Optical fibers.

1.9 Objective of Study

The objectives of present study are stated as follows:

- To formulate the problem of a hollow FGM disc rotating at particular angular velocity.
- To investigate the effect of material distribution on stress distribution in the FGM (Ni/Zro2) circular disk.
- To investigate the effect of rotating speed with different boundary condition of the FGM circular disk.
- To verify the the present finite element model by comparing the results obtained for a simplified model of the problem with those found by journal.
- To determine the temperature distribution corresponding to the prescribed material distribution in the disk.
- To verify the validity of the temperature distribution model by a finite element package.
- To examine the effect of temperature distribution on stress distribution in the FGM (Ni/Zro2) circular disc.

Literature Review

FGM have now been promising candidates for various structural components such as FGM beam, plates, shells and cylinders, which have been rigorously studied under various thermal and mechanical loading conditions.

2.1 Brief History

Suresh and Mortensen [3]: Defined FGMs are the materials in which the volume fraction of two or more materials is varied continuously along certain dimensions of the structure.

Teymur et al. (1996) [4]: Defined functionally graded materials (FGM) as a new generation of composite material in which the microstructural details are spatially.

Ben-Oumrane et al. [5]: An elastic, rectangular, and simply supported, sigmoid functionally graded material (S-FGM) beam subjected to uniformly distributed transverse loading has been investigated.

You et al. [6]: Worked on the stresses and deformation in elastic plastic rotating disk with new created numerical method by changing thickness and density. The governing equation was obtained by Runga-Kutta method. Stress function was to develop the governing equation from equilibrium equation. Finite element method was used to compare the result computed by existing technique.

Eraslan and Orcan [7]: Investigated elastic plastic deformation of an exponentially varying thickness of disk. The investigation was carried out using Tresca-yield criteria. It was analyzed that when the thickness of disk decrease with increasing the value of the parameter(n) then angular velocity also increased. By allowing elastic plastic deformation and by choosing appropriate choice of the thickness parameter efficient and economic design is achieved.

Yongdong et el. [8] and Zhong and Yu [9]: Worked on beams of rectangular cross-section for analyzing the stress due to mechanical loads.

Singh and Ray [10]: Investigation on the creep behavior of a rotating disk made of isotropic functionally graded material. The disk under investigation was made of a composite contains silicon carbide particle in a matrix of a pure aluminum. The steady state creep behavior had been described by Nortons's law. The conclusion is made that in an isotropic rotating FGM disk with linearly decreasing particle content from the inner radius to the outer radius, the steady-state creep response is remarkably superior compared to that is a disk with the same particle content distributed uniformly.

Zhao et al. [11]: Investigation has been made on the mechanical and thermal buckling analysis of FG ceramic-metal plates using the first-order shear deformation plate theory, in combination with the Ritz method.

Kim et al. [12]: Investigated geometrically nonlinear analysis of FGM plates and shells in which material properties are varying in the thickness direction which follows sigmoid function.

Bayat et al. [13]: A axisymmetric disc which is made of FGM and is rotating with some angular velocity is to be examined and the elastic solution is obtained. The thickness of the disc is varying from inner to outer radius. The characteristics of material and thickness of disc contour were varying according to distribution of power rule. For hollow disc, the analytical and semi-analytical solution was given for both the boundary condition that is fixed-fixed or fixed free. Only semi-analytical solution was obtained for the disc. The outcome of material classifying catalogue and the geometry of the disc on the stress and displacement was examined. The stress and displacement obtained in the disc whose thickness was varying were less as compared to the disc which had constant thickness. It was witnessed for the functionally graded solid disc with parabolic thickness profile that the extreme radial stresses were not at the middle similar to uniform thickness disc. Result of this research suggested that a disc which is rotating at particular angular velocity with parabolic concave and hyperbolic convergent thickness profile could be further designed than the one with even thickness.

Bayat et al. 14]: Presented thermos elastic solution in a rotating FG disk whose thickness is varying under a steady temperature field.

Bayat et al. [15]: Offered a piece of work which was related to the magneto-thermomechanical behavior of a FGMM with variable thickness of rotating disc. The material characteristics of disc fluctuate along the radius according the power law. The disc put under the thermal load that are hyperbolic in nature and the thickness profile of the disk positioned in a constant magnetic field.

Chen et al. [16]: Presented 3-D study of a simply supported FGM cylinder in which a grouping of state space and matrix transfer technique was used to find natural frequencies of the structure.

Ootao and Tanigawa[17]: They had Presented the hypothetical conduct of a transitory thermos-elastic problem comprising a FGM thick stripe due to a non-uniform temperature source in the width direction. They had obtained the precise answer for the 2-D temperature variation in temporary state, and thermal stress of simply supported stripe under the state of plane strain.

Zenkour [18]: He had Considered two amalgamated structures of FGM solid disc. An accurate analytical solution was presented for the rotating structure subjected to different boundary condition at the outer surface of disc. The composite structure was made up of three layers sandwich solid disk with face composed of different isotropic materials and core made up of FGM. The stress and displacement distribution were smooth through the radial direction of the composite disk. The peripheral stress for some structures of the clamped and free FG disk had an interior extreme.

Kordkheili and Naghdabadi [19]: They had given a semi-analytical thermos-elastic solution for hollow and solid rotating axisymmetric disk made of FGMs.

Afsar and Go [20]: They had Presented the finite element analysis of thermos-elastic field in a thin circular functionally graded material disc exposed to thermal stimulus and an inertial force due to rotation of disc. Due to evenness, the FGM disc was supposed to have exponential variant of material character in radial path only. Based on the 2-D thermos-elastic theories, the axisymmetric problem was being framed in terms of a second order ordinary differential equation which was being answered by finite element method.

Obata and Noda [22]: They had Studied the FGM circular cylinder and hollow sphere to perform the analysis of thermal stresses.

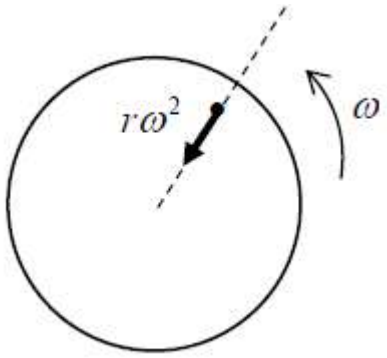
Sharma et al. [23]: They had Investigated a functionally graded thermos elastic disk by finite element method to find stress and strain. Conclusion obtained from this research that the stress, strain and deformation of FGM circular disc designed for immovable angular velocity get remarkably changed due to continuous temperature variant, logarithmic thermal variation and non-heat isotropic conditions. We can model and improve the field in FGM disc by controlling the thermal variation, radial thickness and temperature difference at inner radius and outer surface of the disk.

Fukui and Yamanaka [24]: They had presented the effect of the gradation of works on the deformation or strength of thick walled FGM pipes under mechanical stimulus such as inner pressure with plain strain situations.

Fukui et al. [25]: Stretched their former work by considering a thick-walled FGM pipe under unvarying thermal stimuli. They studied the result of graded components on remaining stresses.

3.1 BASIC CONCEPT OF ROTATING DISK

Consider a disc whose thickness is negligible and rotating at a constant angular velocity ω. Due to rotation of disc all the particles are subjected to centripetal acceleration $a_r = -r\omega^2$. The notation r denotes an acceleration in the radial direction and the negative sign denotes that the particles are accelerating in the direction of center of the disc.



Due to this acceleration a force is generated (per unit volume) $F_a = -\rho r\omega^2$ due to which stresses are generated in the disc. So, that inertial force is axisymmetric "loading" and so this problem is axisymmetric. The equilibrium equation of an axisymmetric problem is given by. The corresponding equation of motion is obtained by Adding in the acceleration term:

$$\frac{d\sigma_r}{dr} + \frac{1}{r}(\sigma_r - \sigma_\theta) = -\rho r\omega^2 \quad (1)$$

This equation can be expressed as

$$\frac{d\sigma_r}{dr} + \frac{1}{r}(\sigma_r - \sigma_\theta) + b_r = 0 \quad (2)$$

where $b_r = \rho r\omega^2$

Therefor the problem of dynamic rotating disc has been converted into a problem of an equivalent static problem of a disc that is subjected to a known body force.

$$\sigma_r = \frac{E}{1-\vartheta^2}\left[\frac{du}{dr} + \vartheta\frac{u}{r}\right] \quad (3)$$

$$\sigma_\theta = \frac{E}{1-\vartheta^2}\left[\frac{u}{r} + \vartheta\frac{du}{dr}\right] \quad (4)$$

$$\epsilon_r = \frac{du}{dr}, \qquad \epsilon_\theta = \frac{u}{r} \quad (5)$$

By using the plane stress Hooke's law and strain-displacement relationships 3,4and 5 which leads to the differential equation

$$\frac{d^2u}{dr^2} + \frac{1}{r}\frac{du}{dr} - \frac{1}{r^2}u = -\frac{1-\vartheta^2}{E}\rho r\omega^2 \quad (6)$$

By integrating 6 we have

$$u = C_1 r + C_2 \frac{1}{r} - \frac{1}{8}\frac{1-\vartheta^2}{E}\rho r^3 \omega^2$$

7

From 3&7 we have

$$\sigma_r = -\frac{3+\vartheta}{8}\rho\omega^2 r^2 + \frac{E}{1-\vartheta^2}\left\{C_1(1+\vartheta) - \frac{C_2}{r^2}(1-\vartheta)\right\}$$

8

For hollow disk:

By applying boundary conditions:

At r=a $\sigma_r = 0$

At r=b $\sigma_r = 0$

$$C_2 = \frac{3+\vartheta}{8}\frac{1+\vartheta}{E}\rho\omega^2 a^2 b^2$$

$$C_1 = \frac{3+\vartheta}{8}\frac{1-\vartheta}{E}\rho\omega^2(a^2+b^2)$$

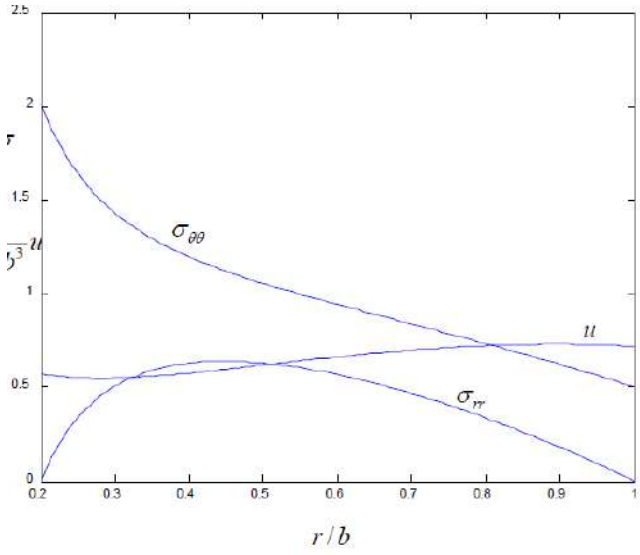
By putting C_1 and C_2 in equation 8 we have:

$$\sigma_r = \frac{3+\vartheta}{8}\rho\omega^2\left[a^2 + b^2 - r^2 - \frac{a^2 b^2}{r^2}\right]$$

9

$$\sigma_\theta = \frac{3+\vartheta}{8}\rho\omega^2\left[a^2 + b^2 + \frac{a^2 b^2}{r^2} - \frac{1+3\vartheta}{3+\vartheta}r^2\right]$$

10



Variation of radial, tangential stress and radial displacement

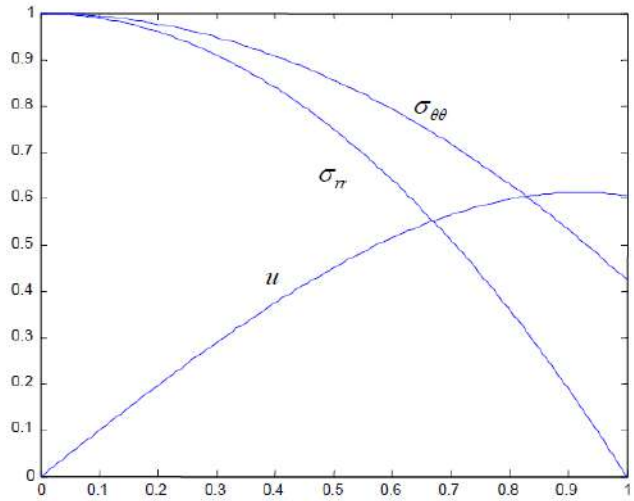
For solid disk (a=0)

$$\sigma_r = \frac{3+\vartheta}{8}\rho\omega^2[b^2 - r^2]$$

11

$$\sigma_\theta = \frac{3+\vartheta}{8}\rho\omega^2\left[b^2 - \frac{1+3\vartheta}{3+\vartheta}r^2\right]$$

12



Variation of radial, tangential stress and radial displacement

FORMULATION OF FINITE ELEMENT METHOD (FEM)

The FEM is a numerical technique that can be very useful to obtain approximate solution to many applications in engineering. There are many methods to analyze the problem such as steady, transient, linear, or nonlinear problem in stress analysis, heat transfer, fluid flow and electromagnetism. R. Courant, who developed the Ritz method of numerical analysis and variational calculus to find approximate solution to vibration system in 1943. This was the initialization of the finite element analysis(FEA).

In the early 70s, the use of FEA was limited and very expensive, mainly in the field of automotive, defense, aeronautic and nuclear industries. Due to rapid growth of the computer manufacturer of company the cost of the computers decreases. Then computer became to use in every field. Due to increase in the power of computer, current FEA models have commonly much more number of element and it improved accuracy. Present day supercomputers are able to calculate more perfect result in very small amount of time. Structural analysis is carried out to anticipate the variation of stresses, strains and deformation. The material character such as youngs modulus, density, conductivity(thermal), thermal expansion coefficient are varying along the radial direction linearly.

METHODOLOGY IN ANSYS-APDL

STEP-1: Defining the material properties

Since the material properties are varying according to power rule along in the path of radius except Poisson's ratio which is

constant through the radius, so new technique was utilized for assigning the properties. Also there are many techniques available in ANSYS-APDL for assigning the material definition. Here simple method is utilized to assign material properties. Analogous to foll- owing equation

$$Y(r) = Y_a \left[\left(\frac{r}{a} \right)^{\beta} \right]$$

$$\beta = \frac{\ln \left(\frac{Y_a}{Y_b} \right)}{ln \left(\frac{a}{b} \right)}$$

Y_i and Y_o are the material properties at inner and outer radius respectively. Where β is the inhomogeneity parameter. A numerous number of data are generated and imported to ANSYS.

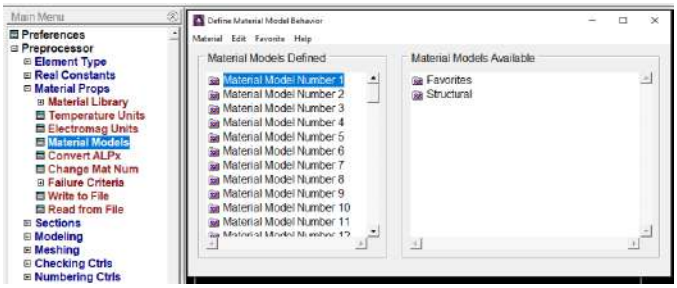


Fig.5 Assignment of material properties

STEP-2: Modeling of Part Geometry

A half cross-sectional area of disk is plotted at a distance from Y-axis equal to inner radius (40 mm) of disk in modeling section of APDL. The area is divided in to number of parts (80 parts) exactly equal to the number of properties previously defined.

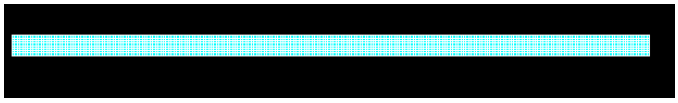


Fig.6 Modeling of cross-section Area

STEP-3: Meshing

For each division of area material properties were assigned separately and then meshing was done.

For structural analysis, structural analysis filter was selected. Selection of the element type depends on the specific problem as it may be planer 2D element or solid 3D. "quad 8 nodes 183" is selected as the element type. Since this is an axisymmetric problem, element behavior has to be set as axisymmetric.

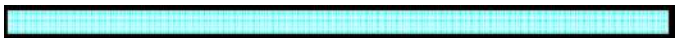


Fig.7 Meshed View

RESULTS AND DISCUSSION

The finite element model developed in the study is demonstrated for an Ni/Zr FGM disk with nickel at inner radius and Zirconium at outer radius and between inner and outer radius properties varies linearly.

Material Properties

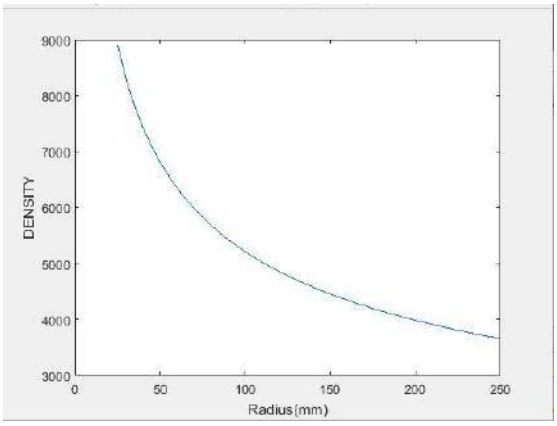
	Zirconia	Nickel
E(Gpa)	116.4	199.5
ϑ	0.3	0.3
$\alpha(10^{-6}/°C)$	3.0	13.0
K(w/m°C)	2.0	90.0
$\rho(kg/m^3)$	3657.0	8900.0

The material properties vary in accordance to the following equation:

$$Y(r) = Y_a \left[\left(\frac{r}{a} \right)^{\beta} \right]$$

$$\beta = \frac{\ln \left(\frac{Y_a}{Y_b} \right)}{ln \left(\frac{a}{b} \right)}$$

$Y_i$and Y_o are the material character at inner and outer radius respectively. Where β is the inhomogeneity parameter. In this simulation β taken is unity i.e. material properties are varying linearly along the radius according to power law.



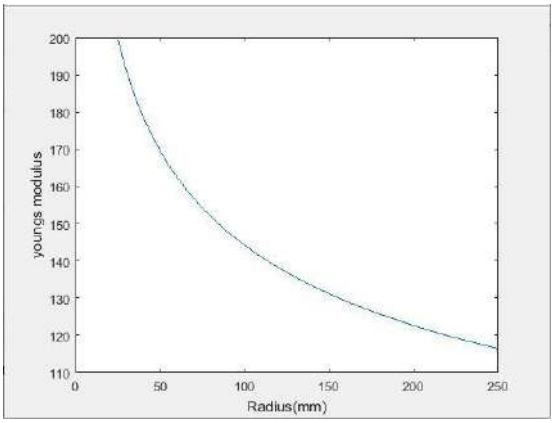
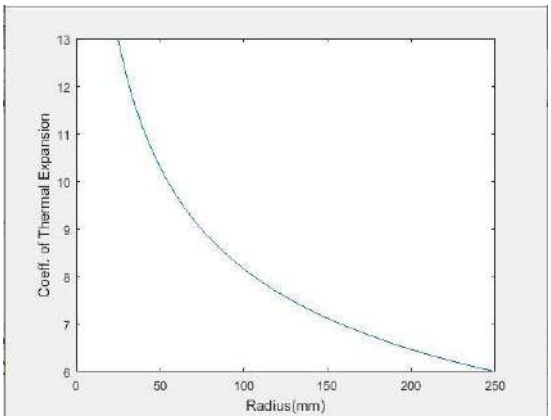


Fig.8 Variation of Density along the radius
Fig.9 Variation of Young's Modulu



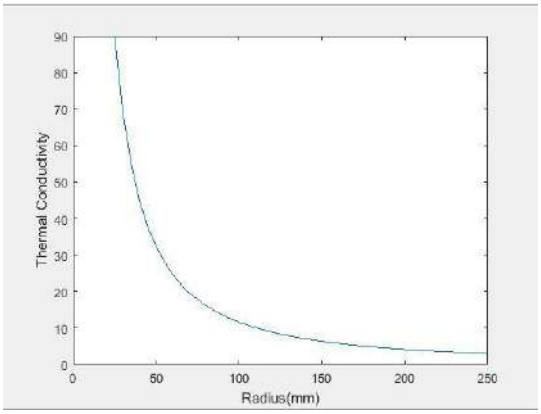


Fig.10 Variation of coeff. Of Thermal Expansion
Fig.11 Variation of Thermal Conductivity

For the above mentioned properties, numerical result for stress, strain, and displacement are computed in ANSYS-APDL. The results are presented in the form of graph and analyzed to investigate the effect of material distribution profile, speed of rotation. The result obtained in analytical analyses are compared with the result obtained from the ANSYS-APDL modeling for particular boundary condition as mentioned in analytical method.

Comments

As we can see from the plots of different-different parameters i.e radial displacement, radial and hoops stress. The results of finite element method which in done on the software called ansys-apdl matching closely enough to the analytical solution. So, we can say our method is correct and we can apply this method to obtain above mention parameter for thermal loading also.

CONCLUSION

- As according to the boundary condition of freely rotating disc there is no stress at inner and outer radius of disc it increases from inner to outer radius and has a maximum value in between inner and outer radius.
- For the second boundary condition extreme radial stress arises at the inner radius and drops as we move away from the inner radius to outer radius.
- If the disc is rotating freely maximum hoops stress arises at the inner radius and it drops from inner to outer radius.
- And for the disc whose inner radius is fixed has a certain value at inner radius and as we move along the radius it increases at first attains an extreme value and then decreases. It has an extreme value in between the inner and outer radius, more precisely near the inner radius.
- Radial displacement is minimum at the inner radius and maximum at the outer radius.
- Each and every parameters ie. Stress and deformation increases as we increase the angular velocity. Which means stress values are higher for higher angular velocities and lower for lower angular velocities.

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360 DEGREE FLEXIBLE DRILLING MACHINE

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Abstract

Nowadays, the drilling machine is developing very fast with more uses and application. In basic drilling machine, the machine work in particular direction which is the limitation in this machine. And there is more problem like space between the drill and job is very less. In this project we are working on the flexible drilling machine which can work in any direction and can be adjust as per choice. And drilling machine work automatically that can make work easier and can done more accurately. It is mounted on the flat surface as like table which can rotate in any direction, move up and down. It will reduce the setting time and capital for the operation. And in this drilling machine, we use permanent magnetic chuck which is attached to drilling machine.

Introduction

Drill machine is one of the machines which is important and it is the heart of every industry. Drilling is a cutting and removal of material process in which a holes are made or expand with the help of a multipoint sharp end cutting tool. By power, when the drill is made to rotate on the workpiece, thus the unwanted material is withdrawn in the form of chips by moving along the shank. The purpose of our project is to rotate 360 degrees and make it more convenient to use. This machine minimize the manufacturing cycle time, the clamping of workpiece is also eliminated: once the workpiece is clamped on magnetic base plate, there is no need for moving workpiece at different location for drill at different positions, the number of machines required are also minimum, human errors are also rectified. With the contrast of this machine we can drill in any direction at a particular time with less effort. The machine is mounted on a flat surface like a table or wall. In this drilling machine we were using rack and pinion to move the drill, so the machine can be work in less space with accuracy. This drilling machine is works automatically, the whole machine is controlled by only one box. The machine is very simple to operate. The weight of the machine is not as heavy as we assumed, so anyone can use it easily without any uncomfortable experiences. In this we are using a rack and pinion mechanism over the arms to make it a telescopic arm for increasing and decreasing the length of the arm. A magnetic base plate is also introduced for a clamping work-piece.
The machine can move from one place to another very easily. This machine can be easily transported as it light weight for easy movement. The overall space required for the setup of this machine is less. It precedes our expectations and performs pretty well, further improvement can be done through the experimental hypothesis.

History

The unique transferable drill, assembled in 1916, is in the National Museum of DC's Electric Drill in Washington. Before the 1916 DC electric drill was in procedure, but it was a huge, constant machine used in industrial and built-up facilities. Black Decker was the first work out when electric spices came as a lightweight portable tool.

In 1910, S. Duncan Black and Alonzo Decker well- known a machine shop in the Baltimore

warehouse Gun manufacturers were in sculpture clients. According to the 1992 Baltimore Sun article Black and Decker were allowing for the design of electric drills, which they were increasing and how they were able to find the best tools and organize drilling work. A close to pistol was a weapon to motivate his pistol and trigger a new drill.

360 Degree Flexible Drilling Machine Construction

The basic parts of a drilling machine are its base, supporting arms, drill head and chuck. The base made of cast iron or other hard material may rest on a bench, floor depending upon the design. Larger and heavy duty machines are grounded on the floor. The arms are mounted on base with the help of hinge to rotate about it. It is accurately machined and the arms can move up, down and rotate about x-axis. The drill chuck, an electric motor and the mechanism meant for driving the chuck at different speeds are mounted on the top of the upper arm. Power is transmitted from the electric motor to the drill chuck.

Working principle

The working principle of this flexible drilling machine is initially started from the D.C. motor through full wave rectifier. In which there is one power sources, received from the rectifier. Then the arm rotates at 360 degree and moves anywhere when drilling is required up to its maximum arm length. With the help of my project we can drill in complicated parts accurately.

Components:-

1. DC Motor

An electric motor operated by DC (direct current) is known as a DC (unlike an induction motor that operates via an alternating current). A DC motor converts DC electrical energy into mechanical energy.

It is an electrical device which converts electrical energy to mechanical energy. It rotates shaft which support by bush in it when power is supply through rectifier. This shaft connect with drill bit through chuck to rotate drill bit and make hole on work piece when it is required. Is of high torque capable which required for drilling. An electric motor is an electrical machine that converts electrical energy into mechanical energy. The reverse of this is the conversion of mechanical energy into electrical energy and is done by an electric generator, which has much in common with a motor. Most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force. In certain applications, such as in regenerative braking with traction motors in the transportation industry, electric motors can also be used in reverse as generators to convert mechanical energy into electric power.

1.1. Principle of DC Motor

When a current-carrying conductor is placed in a magnetic field, it experiences a torque and has a tendency to move.
In other words, when a magnetic field and an electric field interact, a mechanical force is produced. The **DC motor** or **direct current motor** works on that principle. This is known as motoring action.
The direction of rotation of this motor is given by Fleming's left hand rule, which states that if the index finger, middle finger, and thumb of your left hand are extended mutually perpendicular to each other and if the index finger represents the direction of the magnetic field, middle finger indicates the direction of the current, then the thumb represents the direction in which force is experienced by the shaft of the **DC motor.**

2. CONNECTING ARM

Connecting arm is used to connects the two objects to each other for support between them to help to move as desired. It connects two solid objects with the help of a hinge, this allows us to move at different angles of rotation between bodies. Two objects are rotated about a fixed axis of rotations connected by an ideal hinge,

all other translations or rotational motion are being prevented and thus a hinge has a single degree of freedom. In this we are using a rack and pinion mechanism over the arms to make it a telescopic arm compromising of the outer arm and inner arm for increasing and decreasing the length of the arm. The pinion is attached to the outer arm and the rack is attached to the inner arm which together makes motion between the arms.

3. HINGES

It support frames and connecting rods to each other by joints together. It used to constraint one axis movement.
It is of two types –
1) Vertical Hinge – It helps by fixing y-axis movement of Arm.
2) Horizontal Hinge – It helps by fixing x-axis movement of Arm.

4. FRAMES

It is of metal sheets of material G.I. (galvanized iron). It supports the arm by help of hinges. Its thickness is of about 0.5mm (approx.). This are of two different sizes one is support by vertical hinge and other is support by horizontal hinge.

5. SCREWS

Single degree of movement kinematic pair used in mechanisms of screw joints. Screw joints facilitate single axis translation motion by the employ of the threads of the screws. This type of joint is used primarily on linear actuators. A screw joint is considered as a segregated form of joint but it is actually a contrast of bolted joint.

6. DRILL BIT

The tools which are required to remove material in order to create holes or enlarge them, mostly of form of circular shape. Drill bits are available in variable sizes and shapes and can create different kinds of holes as required for operation in many different materials. It is made up of carbon steel. In our model we are assumed to use a drill bit of diameter of 2mm. These bits are used to make drill holes on wood, plastic, light metals, etc.

METHODOLOGY

In 360 Degree flexible drilling machine drill can be done at any desired orientation and angle without using any king of clamping or using different machine for drilling. This machine also reduces the clamping time and increases productivity time. 360 drilling machine is already invented but in our model we are using rack and pinion mechanism over the arms for making it telescopic arm whose length can increase or decrease as required. A permanent magnet chuck is also introduced which clamp the workpiece with its magnetic field without using any physical clamping device. This model is far better than our conventional drilling machines.

MERITS

- ✓ The setup of the machine is simple and compact.
- ✓ Machine is easy to handle.
- ✓ The machine can drill in any direction automatically.
- ✓ It can drill in congested and difficult place.
- ✓ This method can reduce the setting time of operation.
- ✓ The handling cost of machine will be reduce.

FUTURE SCOPE

- ➢ The complete automation can be achieve.
- ➢ This machine can be used in every industry.
- ➢ It will be more flexible and easy to adjust.

- The method of rotation of arm and drill can be used in machining operation.
- The portability of a machine can be increase.
- Locking of the base with the flat surface can be improved.
- This mechanism can also improvise in other machinery for easy movement and increase the productivity

Application

- ✓ To put holes with high precision on engine heads, blocks and cylindrical shell.
- ✓ Used in furniture making.

Conclusion

This project is an efficient operation and competitive cost. Since a number of operation and hole can be performed in a simple unit. It is efficient and economical. Considering its uses and cost of project, it becomes relatively cheap when compared to other units.

Evolution in Mars Rover

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ABSTRACT

Mars has been the ultimate goal for human space exploration and surface of mars consist lots of recent particles that has not been introduced to humans straight away. To go looking and to satisfy new substances rovers has been used. This paper will combine research objectives relevant to a mars rover, how the rovers evolving, it's working, operations and also the importance of rovers on mars. A rover can drive around to different areas, studying the various chemicals in each rock. The most source of power for every rover comes from a multi-panel solar battery. They appear almost like "wings," but their purpose is to supply energy, not fly. As we all know that sojourner was the primary robotic rover which was operated on mars. It had been landed on Fourth of July 1997 that point it's two cameras and it had been first vehicle that's drove on another planet. But, there are certain areas where rovers can't go because of steep route, rocks and height. But, then comes the evolution brought by ingenuity rover which features a helicopter and it's the primary aircraft on mars. Now, the rover scans visit those areas which weren't covered by the previous rovers. This evolution ends up in solve plenty of mysteries that was uncovered previously. This paper consists about the technologies that were used previously within the rovers and also the technology is employed in the upcoming time which can be effective within the exploration of mars.

KEYWORDS

Mars, Martian, Exploration, Evolution, Science, Rover, Sol, Lander.

INTRODUCTION

Mars Rover is additionally a vehicle that has ability to travels across the full mars and helps within the exploration of recent things. Mars remains a mystery for us and its lots and much of things which could bring an oversized evolution within the globe. To explore Mars we wish some reasonably automobile as human life isn't possible on mars currently. But, Mars Rover is that the

key for us as we are able to operate it as we wish to and it can work the utmost amount as we would like. Mars Rover contains a camera in it which shows everything and makes the research easy. It's one in every of the key advantage is it can advance the roughest surfaces of mars effortlessly thanks to its build structure and mechanism. The cruise stage had two antennas that were accustomed communicate with the planet. When the rover speaks on to Earth, it sends messages via its high-gain antenna (HGA). Mars Rover is operated on electric batteries and thus the pliability source is termed a "Multi-Mission Radioisotope Thermoelectric Generator" or MMRTG for brief. The MMRTG converts heat from the natural disintegration of plutonium into electricity. This facility charges the rover's two primary batteries. The rover's radioisotope thermoelectric generator makes electricity from the warmth given off by its plutonium fuel. The foremost source of power for every rover comes from a multi-panel device. They appear almost like "wings," but their purpose is to produce energy, not fly. When the rovers are fully illuminated, they will generate about 140 watts of power which last up to four hours per sol (a Martian day). For highly steeped areas rover can fly to understand their destinations as they contains strap wrapped on their belly which leads the rover fly which they works reasonably barely helicopter.

HOW TO OPERATE MARS ROVER

Generally there are two systems for the navigation on Earth today, first is by using maps/compass, and other one is by using GPS satellites. It seems unlikely there'll be a full constellation of GPS satellites before the primary humans landing on Mars. Additionally, Mars doesn't have a magnetic flux like Earth, so a compass is out. When NASA wants to manage the Mars Rover, they boot up a game that mixes high-tech software, 3D glasses, and video games. By this way, the researchers can "walk" on the surface of Mars with the help of game images, by marking the waypoints of their upcoming path, and by uploading the maps they created for their way which helps in operating the rover a bit easier on the surface of mars. From there, generally the Mars Curiosity rover moves ahead, takes photos, and also picks up some important surface samples essentially by reproducing the driver's virtual movements on the surface of Mars. This technology can even be a solution to NASA's problem of distance. Mars is over 100 miles away, so it takes around half-hour for the signals to induce there and back to Earth. Plotting the Rover's course with game prevents a $2.5 billion device from worsening an unseen ledge. It starts with JPL's part Network, a platform of antennas it's stationed in Goldstone, California, Madrid, Spain, and Canberra, Australia. Placing dishes round the Earth allows scientists to "talk" with its robotic spacecraft 24 hours daily. All this imagery produces a similitude of what an astronaut would see if he or she were standing on Mars. The maps have only gotten better, especially with the Mars Reconnaissance Orbiter spacecraft sending back many photos. For the foremost part, all drivers must do is search around and plan a route. While Curiosity probably won't be driving off any cliffs, it could still grind to a halt or run into some rocks the thrust didn't see within the virtual world. Fortunately, Razze says it's hazard avoidance software in-built.

HOW MARS ROVER WORKS

The rovers are designed in a way that they can trek up to 100 meters across the surface of the mars at each Martian day, though they need gone much farther and doing really well. While a whole Martian day (called a sol) is about 24 hours and 40 minutes long (or 24 hours 37.5 minutes if you prefer), the Sun can only provide enough power for driving during a four-hour window around midday. Meaning the rovers must be able to move quickly and effectively. It is difficult sometimes for rover moving safely from place to place and from one location to another as the communication time between Earth and Mars delays, which is about 20 minutes on the average, but the operators works in such a way that rover got no problem on the surface of mars. Unlike a foreign controlled car, the drivers of rovers on Mars cannot instantly see what's happening to a rover at any given moment and that they cannot send quick commands to stop the rover from running into a rock or drop-off of a cliff. During surface operations on Mars, each rover receives a replacement set of instructions at the start of every sol. The command sequence of the rover tells it what targets to travel and what science experiments to perform on the surface of Mars which is sent by the scientists and engineers present on the earth. The rover is predicted to maneuver over a given distance, precisely position itself with relevance a target, and deploy its instruments to require close-up pictures and analyse the minerals or elements of rocks and soil.

PREVIOUS TECHNOLOGIES

The first spacecraft that was transport mars was pathfinder in December 1996 and it absolutely was landed in July 1997. The technologies used at that point are as under:

- Imager for *Mars Pathfinder* (IMP), it also includes magnetometer and anemometer.
- Atmospheric and meteorological sensors (ASI/MET)
- Imaging system (three cameras: front B&W stereo,[13] 1 rear color)
- Laser striper hazard detection system
- Alpha Proton X-raySpectrometer (APXS)
- Wheel Abrasion Experiment
- Materials Adherence Experiment
- Accelerometers

PRESENT TECHNOLOGIES

Each Mars mission could even be a component of a seamless chain of innovation. Everything relies on the past missions that has been done or proven technologies and it also provides its own contributions to the upcoming missions that will be done in the future. This approach allows NASA to push the boundaries of what's currently possible, while still looking forward to past developments. Much of Perseverance's rover design, including its entry, descent, and landing system are directly inherited from the previous Curiosity rover as it's technology makes all the combination perfect, whereas curiosity rover landed on Mars in 2012. Perseverance also carries new technology demonstrations and now it has an improvised entry, descent, and landing technologies, which could help pave the way for the upcoming technology in robotics and human missions to the Mars and Moon.

The Perseverance rover carries two technology demonstrations to Mars and that are:

Moxie

The MOXIE instrument, located inside the body of the rover, will test technology that converts CO2 within the Martian

atmosphere into oxygen. Using local resources found on the world are going to be important for future human missions to Mars.

Ingenuity Mars Helicopter

Stowed beneath the rover is that the Ingenuity Mars Helicopter: a tiny low, autonomous rotorcraft designed to check — for the primary time — powered flight within the thin Martian atmosphere.

The Mars 2020 rover mission has used various types of new technologies for it's basic three things entry, descent, and landing:

- Range Trigger - for precise timing of the parachute.
- Terrain-Relative Navigation - to assist avoid hazardous terrain.
- Advanced aeroshell sensor package - to record what the spacecraft experiences during landing and the way it performs.

In addition to all of these technologies, the Perseverance rover also carrying a new suite of descent cameras this time which works a bit good then the previous ones and a microphone for the documentation of the sights and it also catch the sounds while landing.

PARTS AND THEIR FUNCTIONS

A rover consists of various parts and those are as under:

BODY: The rover body is termed the good and comfy electronics box, or "WEB" for brief. Quite a car body, the rover body can be a strong, outer layer that protects the rover's computer and electronics (which are basically the equivalent of the rover's brains and heart). The rover body encompasses an even bigger area because it keeps the vital organs of rover protected and it's going to also control the temperature. The great and cozy electronics box is closed on the simplest by a little amount called the Rover Equipment Deck (RED). The Rover Equipment Deck makes the rover kind of a convertible car, allowing a section for the rover mast and cameras to want a seat are available the Martian air, taking pictures and clearly observing the Martian terrain because it travels

BRAIN: Unlike humans and animals, the brains of the rover are placed in its body, rather than its head. There is a module called Rover Compute Element (RCE) which is present inside the rover body is the rover computer (its "brains").The communication interface that enables the main computer to exchange data with the rover's instruments and sensors is called a "bus." This bus is an industry standard interface bus it is required to communicate and to control all of the motors of rover, it's science instruments, and communication functions.

EYES AND OTHER SENSES: Each rover consists of nine "eyes" with Six engineering cameras aid in rover navigation and the other three cameras performs science investigations

ROVER TEMPERATURE CONTROL:

Under excessively hot and cold temperatures the mars exploration rover cannot function well. So on survive during all of the assorted mission phases, the rover's "vital organs" must not exceed extreme temperatures of -40° Celsius to +40° Celsius (-40° Fahrenheit to 104° Fahrenheit). The rover's essentials, rather a bit like the batteries, electronics, and computer, which are basically the rover's heart and brains, stay safe inside a Warm Electronics Box (WEB), commonly called the "rover body." Heaters are packed inside the rover body, and kind of a warm coat, the net walls help keep heat in when the night temperatures on Mars can drop upto -96° Celsius (-140° Fahrenheit) which is very less and in this type of situation rovers are needed to control their temperature. While

an athlete sweats to release heat after an intense workout, the rover's body may release excess heat through its radiators, almost like ones utilized in car engines.

NECK AND HEAD: What feels like the rover "neck and head" is named the Pancam Mast Assembly. It stands from the bottom of the rover wheel 1.4 meters tall (about 5 feet). This height is chosen as it gives the cameras a perfect "human geologist's" perspective and wide field of view to observe the surroundings.

1) To act as a periscope for the Mini-TES science instrument that is placed inside the body of the rover for thermal stability.

2) To provide height and a far better point of view for the Pancams and also the Navcams.

ARMS: The rover arm (also called the instrument deployment device or IDD) holds and maneuvers the instruments that help scientists get up-close and private with Martian rocks and soil. Very like a person's arm, the robotic arm has flexibility through three joints: the rover's shoulder, elbow, and wrist. The arm enables a tool belt of scientists' instruments to increase, bend, and angle precisely against a rock to figure as an individual's geologist would: grinding away layers, taking microscopic images, and analyzing the basic composition of the rocks and soil.

WHEELS: The Mars Exploration Rover consists of six wheels; every wheel consists of its own individual motor. The 2 front and two rear wheels even have individual steering motors (1 each). This steering capability allows the vehicle to show in situ, a full 360 degrees. The 4-wheel steering has a ability that it also allows the rover to swerve and curve, making arching turns which is very helpful on the surfaces of mars.

ENERGY: The rover requires power to control. If there is no power supply it cannot even move, it uses science instruments, or communicates with Earth. The most source of power for every rover comes from a multi-panel electrical device. They appear almost like "wings," but their purpose is to supply energy, not fly. When the rover is fully illuminated, the solar arrays of rover can generate a power of about 140 watts which has a good durability and it can lasts up to four hours per sol (a Martian day). The rover needs about 100 watts (equivalent to a typical light bulb in an exceedingly home) to drive. Comparatively, the solar arrays of Sojourner rover provided Pathfinder mission in 1997 with supply of around 16 watts of power on Mars at noon. That´s resembling the ability employed by an oven light. This extra power that is generated will potentially enable the rovers to conduct more science.

COMMUNICATION: The rover has both a low-gain and high-gain antenna that function both its "voice" and its "ears". they're located on the rover equipment deck (its "back"). The low-gain antenna sends and receives information in every direction; that's, it's "Omni-directional." The antenna transmits radio waves at an occasional rate to the part Network (DSN) antennas on Earth. The high-gain antenna can send a "beam" of knowledge in an exceedingly specific direction and it's steerable, therefore the antenna can move to point itself on to any antenna on Earth. The advantage of having a steerable antenna is that the whole rover doesn´t necessarily must change positions to speak to Earth. Like turning your neck to speak to someone beside you instead of turning your entire body, the rover can save energy by moving only the antenna.

STRUCTURE OF ROVER

The spacecraft lander is kind of protective "shell" that protects the rover and houses it,

together with the airbags, from the forces of impact, as the exerted force is too high therefore, the shell must be heavy. The shell of spacecraft in which rover is sent can be of approx 190 kilograms. The lander may be a strong, lightweight structure, consisting of a base and three sides "petals" within the shape of a tetrahedron (pyramid-shaped). The Lander structure consists of beams and sheets that are made up of a "composite" material. Composites like fiberglass are made from strong fibers or fabrics that are stiffened with a glue, or "matrix". Carbon-based layers of graphite fiber is used to built the lander beams when woven into a cloth, creating a fabric that's lighter than aluminum and more rigid than steel this combination makes it pre-eminent. Titanium fittings are bonded (glued and fitted) onto the lander beams to permit it to be bolted together. The Rover is held inside the lander in which a lot of extra tools are also placed which dismantle later with the help of small explosives after landing. The three petals are connected to the bottom of the tetrahedron with hinges. Every petal hinge includes a powerful motor, the motor is so strong that it can lift the burden of the whole lander and there are no chances of failure as they are built precisely (The Rover and the Lander weighs about 530 kilograms, which might weigh almost 1,200 pounds on Earth but the gravity is less on mars if we compare therefore it weighs only 437 pounds on Mars. The actual weight of Rover is 170 kilograms, which weighs 375 pounds on Earth and 140 pounds on Mars due to gravity). Having a motor on every petal ensures that the lander can place the rover in an upright position irrespective of which side the lander involves rest on after the landing subsides on the surface of Mars.

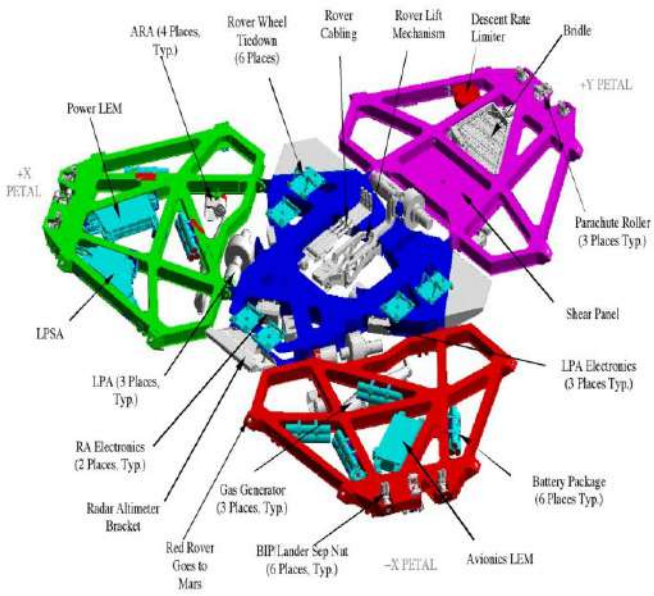

Figure 1: structure of a rover
(source: mars.nasa.gov)

MICROCONTROLLERS

The current microcontroller used in Mars Rover is Arduino Mega. We use TTL serial to link to the varied subsystems. The drives generally controlled by six motors in which 2x25A Sabertooth motor is used and for steering servos a Maestro servo controller is used. The NASA-style, six-wheel rocker-bogie suspension, which is that the thing we're most happy with on this robot, is made of aluminum tubes, channels, brackets, machine screws, and other components. When the Mars Rover has to turn, the Arduino tells the servos at the corner wheels to rotate 45 degrees then drives all six motors, causing the robot to rotate which makes the movement of the rover happens. When the robot receives commands it transmits the signal status using an Xbee radio. So on avoid running into Mars rocks and exhibit walls, the robot is equipped eight XL-Maxsonar-EZ4 ultrasonic sensors, two on each corner wheel assembly. Temperature and infrared detection is one

altogether the key elements of the exhibit, therefore the robot includes a thermopile array sensor so on detect the temperature of what's before of it by which it detects all the hurdles that are coming in it's path, it also consists of a green line-generating laser (to point out visually where the temperature array is pointed), and also consists of a high-resolution infrared-detecting Wi-Fi camera. The robot is additionally equipped with a voltage sensor to appear at the battery charge. Our first Mars Rover robot drew power from four Spark Fun solar panels, but because this particular robot is being operated in an interior exhibit we run it on a 10,000mAh 7.4v LIPO battery. LIPOs will be used further once we built our first quadrotors, but for now LIPOs is being used in every robot we make.

APPLICATIONS

- It can search for a variety of soils and different types of rocks that hold clues to find if there was any certainty about past water activity. Particularly, the samples that sought also include those things that have minerals deposited by any kind of water-related processes.
- Determine the distribution and composition of minerals, rocks, and soils.
- Determines how geologic processes have influenced the modern chemistry and shaped the local terrain.
- Performs all the calibration and it also validates surface observations done by instruments of Mars Reconnaissance Orbiter. This will help in determining the accuracy and effectiveness of various types of instruments that surveys the Martian geology from the orbit.
- Search for minerals which contain iron, it also identifies and quantifies the relative amount of specific minerals that contain water or were formed in water.
- Characterize the textures of rocks, mineralogy and soils to look out the processes that created them.
- Search for geological clues and conditions that existed when water was present.
- Scrutinize whether the environments is able to create a life.

DISCUSSION

Rovers are the machines that are hope to create a glimpse of life on mars and it seems to have extensive applications in variousareas of automotives. It can bring out some new simple or complex particles that are not introduced to the world now. As we know that mars consist wide variety of materials which may leads to the new life on Mars. This technology makes the job of exploration on mars easier with minimum side efforts. Rovers are send on mars in a spacecraft which consists of a lot of resources and if NASA is spending this much of resources on mars then there will be some hope that life is possible on mars and if we have to find things out, mars exploration is must which can be only done with the help of rovers. The evolution in rovers is also necessary as new technologies brings new ideas in exploring and if we can find any kind of existence on mars with the help of rovers it will be a huge discovery and exploration on mars is only possible with the help of rovers.Evolution in rovers can bring out by changing its structure and technology has potential to make lightweight durable, and geometrically complex objects. There is an improvement in the quality of parts and efficiently solve the problem in the manufacturing of spare parts. Thus lowering the manufacturing cost and improving cooperation between engineer and the machine.

CONCLUSION

Research shows that the tip result is a comprehensive understanding of how humans can live and work on Mars in future if the exploration works like this only, likewise as of variety of the doubtless valuable Martian resources which is able to be utilized within the context of a permanent human presence. This status shows continuously increasing research work undertaken by the rovers. There are some rovers that are still present and currently acting on mars to explore all of the possibilities to go looking out something new. Rovers have several advantages over stationary landers as they examine more territory, they'll be directed to interesting features, they'll place themselves in sunny positions to weather winter months, which they'll advance the knowledge of the thanks to perform very remote robotic vehicle control. Rovers are helping us in understanding the surface of the mars and also the evolution of the planet for future human exploration on mars. Understanding whether life existed elsewhere within the Universe beyond Earth might be a fundamental question of humankind. This research leads us on a conclusion that how useful rovers are in understanding the surface, whether, ecosystem and life on mars. As soon because the rovers gets evolved we are visiting cause a more robust exploration which we are going to come more attract finding some suspicious substances too whose existence isn't present in today's world.

CONFLICT OF INTEREST

We conform that the submission is original and is not being submitted for publishing elsewhere.

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Recovering waste heat from internal combustion engine to produce refrigeration using TEGs

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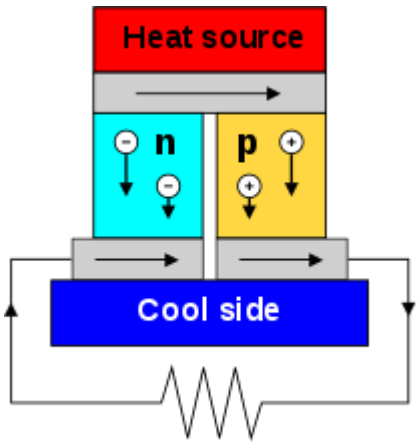
***Abstract*- Eco friendly energy is the centre of research for last few decades and TEGs provide a great opportunity to use heat energy which is generally wasted. Here we discuss various aspects of how waste heat can be utilized to produce electricity. The effective use of peltier modules is also discussed to produce refrigeration effects. Using peltier modules directly decreases emission of various gases released by compressors in refrigeration systems.**

I. INTRODUCTION

Thermo electric generators are devices which uses the principle of Seebeck effect to convert heat into electricity. Seebeck effect is observed when two dissimilar metal wires are joined end to end and a temperature gradient is applied which further results in a small electric voltage. The electricity produced can be used to produce refrigeration effects. Nowadays semiconductors are used in TEGs to produce electricity from heat as they have high electrical conductivity and relatively high seebeck coefficient. These devices are made up of N-P type elements connected electrically in series and thermally in parallel as shown in the figure below:



The most common TEG material available is Bismuth Telluride whose efficiency generally peaks around 5-5.5%. This paper discusses the prospects of producing electricity from the waste heat of the engine using TEGs and further using that energy to produce refrigeration effects using peltier effect efficiently.

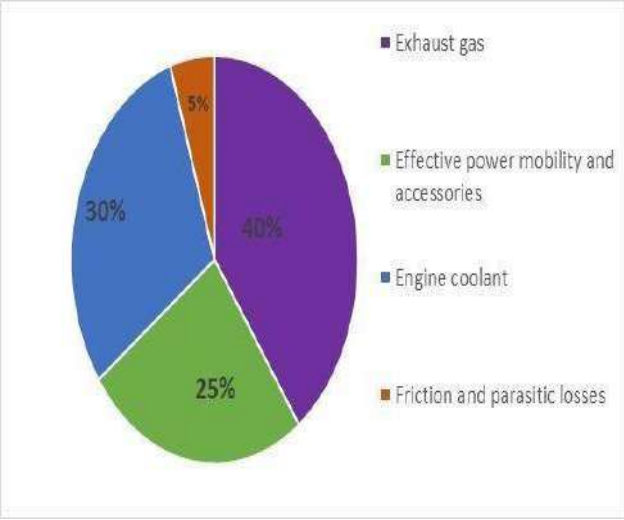
II. OBJECTIVE

The objective of our research article is to analyze the waste heat emission in an automobile and how it can be used to produce refrigeration effects.

III. WASTE HEAT ANALYSIS

The Lawrence National Laboratory Livemore of the energy used by the United States in 2014 shows the following significant values (the unit used is the Quad, which is about 293 million MW.h.): production of 12.4 Quads of electricity for residential, commercial and industrial consumes approximately 38.4 Quads of primary energy (mainly fossil fuels or nuclear). 25.8 quads of waste heat are released into the air. The transportation sector consumes 27.1 quads of primary energy and 21.4 quads are released. These results show the margin for progress via waste energy recovery. The transportation industry is probably the most attractive sector for use of TEGs to recover lost heat. Until now, there have been few solutions to recover waste heat from the exhaust gas of engines. The most active area for energy recovery is the automotive sector where competition towards ever-cleaner cars is very dynamic and encouraged by governments. The aeronautics sector is also looking into the use of hot gases from the engines of airplanes or helicopters. Maritime transport offers interesting prospects due to the presence of a free cold sink (fresh water, sea water).

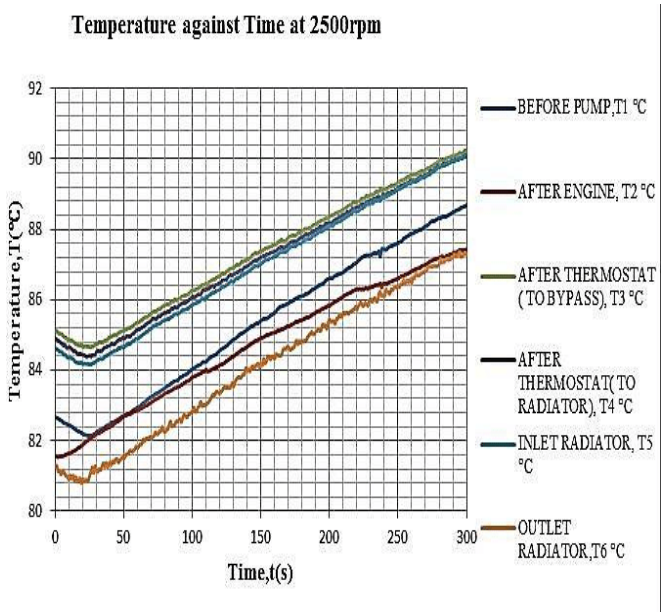
The pie chart below shows the distribution of the energy in an IC engine.



IV. SPEED DEPENDENCE OF TEG

Seebeck effect entirely depends on temperature gradient to produce electricity. As the speed of an automobile increases there is a significant amount of heat generation which automatically results in the increase of temperature. The efficiency and power of a TEG remarkably depends on the temperature. Given figure shows the temperature of inlet and outlet when the engine is operated between 2500 rpm to 3400 rpm. As the engine speed increases, the temperature difference between the surfaces of TEM increases rapidly, hence the output power also increases. It was found that there is a possibility of generating 1.4 kW of electricity from the heat recovery system in the exhaust of the car if the power produced by the engine is 150 kW and also found that it is possible to produce electricity of 5.9 MW by a waste heat energy recovery system of 500 MW of gas turbine power plant.

The graph below represents how the temperature inside the engine varies with rpm:



V. CASE STUDY: AUTOMOBILE

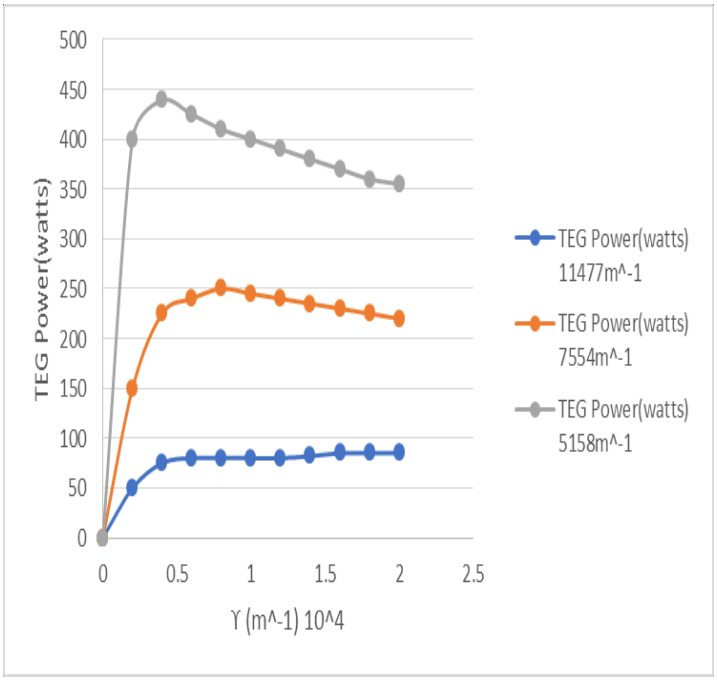
Typically, the energy used in gasoline combustion engines break down into 25% for mobility, 30% in coolant, 5% in other parasitic losses and 40% in exhaust gas. For diesel light-duty trucks using 100 kW of fuel power,

this represents 30 kW of heat loss in exhaust gases. Converting this lost energy into electricity, even with efficiency of 3%, could represent 900 W of electricity. According to the Fiat Research Centre, 800–1000 Wel means a reduction of 12–14 g/km CO2. Looking at the economic context, for example in Europe, the new CO2 emission performance standard set by the European Commission justifies the research efforts of manufacturers: CO2 emissions for passenger vehicles stood at 130 g/km in 2012 and are to be drastically reduced to 95 g/km by 2021 (which corresponds to a consumption of about 4 L/100 km). In the case of light-duty trucks, emissions were 175 g/km in 2014 and must drop to 135 g/km by 2020. Car manufacturers will have to pay heavy fines for vehicles exceeding the CO2 limits of the European Union. From 2012, the penalty is €20 per excess gram and this value will rise to €95 per gram from 2021. The economic incentive has therefore become very significant. The Fiat Research Centre presented the following performance calculations. Electricity generation by an alternator is as follows: chemical (fuel) energy conversion into mechanical energy has efficiency of around 25–27%, mechanical energy conversion (alternator) into electricity is about 60%. This means that the efficiency of transformation of chemical energy into electrical energy is around 15–16%. The installation of a TEG on a vehicle must meet the following conditions. The TEG should not change the operating point of the engine; the acceptable pressure losses are very limited (around a few tens of mill bars). The maximum temperature of TE materials must be respected and at the same time, in order to have a significant temperature difference, the TEG should be operated near its limits. It is therefore necessary to add control command (sensors and actuators) to bypass part or all the hot gas. The materials must be recycled and environmentally friendly. The economic cost must be competitive.

Many manufacturers are working on such subjects. Gentherm (formerly Amerigon and BSST) is conducting studies on specific geometry modules for BMW and Ford. The Ford group has been conducting research in partnership with the Department of Energy (DOE) of the United States. The research program was based on the installation of a TEG on a Ford Fusion equipped with a 3.0 L V6 engine. The objective was to produce 500 W for a vehicle travelling at about 100 km/h. The results presented by Maranville at the 3rd Thermo electrics Applications Workshop in March 2012 showed generated power of about 250 W. A bypass was installed on the exhaust system to protect the generator and cooling was by means of 14 liquid and a pump.

The RENOTER project concluded that a TEG with Mg2SiMnSi materials can generate up to 130 W for a passenger car diesel exhaust in highway conditions, which remains low.

However, power may rise to 250 W for gasoline passenger car exhaust and 350 W for a truck exhaust gas recirculation cooler by improving parasitic electrical resistance (contact and connections) and by improving the performance of the p-doped material. This program is being continued with the RENOTER 2 Project which started in 2013. This new program targets hybrid gasoline vehicles and industrial vehicle exhaust gas recirculation systems. Valeo plans to produce magnesium silicide TEGs for 10,000 vehicles in 2018. More recently, FIAT and Chrysler presented a light commercial vehicle equipped with a TEG. The project financed by the European Union was called HEATRECAR (Reduced energy consumption by massive thermoelectric waste heat recovery in light-duty trucks). Work has been done on the heat exchanger and on the size of the TE modules which have been reduced (16 16 mm2) in order to decrease contact resistance. The performances achieved by the TEG are encouraging: a 3.9% fuel economy improvement (6.7 g CO2/km reduction) over the worldwide harmonized light vehicles test procedure (abbreviated WLTP) cycle. This TEG used Bi2Te3 modules with limited operating temperatures.

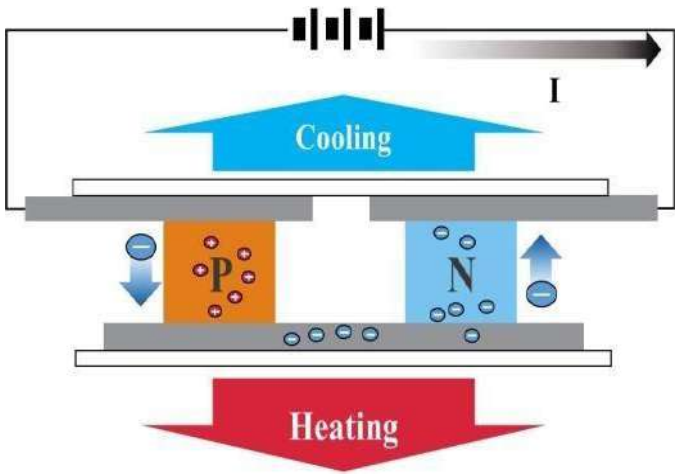


High-temperature material should be used in future applications to take full advantage of TEG power generation. A cost analysis of the prototype gives a current specific cost per watt of electricity produced of around €8.4/W. The cost breakdown analysis shows that 20% of the cost is due to material cost (Bi2Te3) and up to 73% of cost is due to TE module manufacturing. The maximum cost accepted by the automaker in terms of €/W has been estimated as follows: – private conventional car or gasoline hybrid taxi: €0.5/W, – light duty truck or freightliner in USA: €0.7/W, – diesel light-duty truck or freightliner: €1.5/W, – conventional diesel taxi: €3/W. Scania and TitanX exhibited a heavy-duty truck at the 34th Annual International Conference on Thermoelectric (ICT2015) with an engine equipped with an exhaust gas recirculation system. Two TEGs were present on the truck: one in the exhaust gas recirculation system path and one in the exhaust gas path located after the treatment system (ATS). The target for the sum of both TEGs using today's commercially-available modules was 1 kW. The measurement showed that for low engine load, most of the electric power was produced by the TEG located after the treatment system but that for heavy engine load, the TEG located on the recirculation system, produced almost the same power. This study showed the interest of combining the two systems. The measured electric power reached 775 W for an engine speed of 1300 rpm and 100% load.

VI. REFRIGERATION USING ELECTRICITY

Compressor less refrigeration can be easily achieved by using peltier modules. It works on the principle known as "Peltier effect" which is sometimes referred as the reverse seebeck effect. The **Peltier elements**, which are also called **thermoelectric modules** or TEC, are an electrically operated heat pump. Here, energy in the form of heat is transferred from one side of the module to the other side and has to be dissipated there. The Peltier module is based on the so-called **Peltier effect** which describes the quasi-inverse of the Seebeck effect. The Peltier effect states that energy can be transported in the form of heat by a current flow in a semiconductor, which creates a temperature difference. The Seebeck effect means that a current flow is obtained when a temperature difference is applied to a semiconductor. The Seebeck effect is used to measure temperature or to harvest electrical energy.

The Peltier element is a heat pump, which is based on the transport of electric current in a semiconductor.



VII. CONCLUSION

In this review of thermoelectric applications, new thermoelectric modules with improved ZT, larger operating range allowing their uses with higher temperature differences and made with low-cost materials that counteract the negative effect of low efficiency of thermoelectric generators, have been presented. Starting points to system design have been described. For years, the development of TEGs has been limited to Space and hard access areas where reliability is critical. These extreme environment applications have very high added value but they are niche applications for which the market is very limited. In these applications, TEGs have proven their extreme reliability. Studies conducted by the space research agencies resulted in the discovery and development of most of the TE materials. These materials are or will be used in the industry today and in the future.

However, it is very important to note that in these cases, the heat sources do not vary significantly and the materials are therefore not subject to high thermal stress. It is quite different for others applications presented in this review where the temperatures of heat sources are changing and where the materials often experience very severe temperature cycles.

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DESIGN OF CORONAVIRUS STERILIZER BOX

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***ABSTRACT*- In the beginning era of the twenty-first century, many viral infections have attacked the human body. Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS) are few examples of these infections. Nowadays, COVID-19 pandemic has appeared in existence till December 2019. Though the mortality rate due to SARS-CoV-2 is less, the transmission capability is very high compared to the other viruses. Till the end of April, 2020, three millions people have been infected across the world due to this rapidly growing pandemic. Research works have been reported to reduce the transmission of infection in various dimensions. But there is no alternative rather than handling the essential food items which are purchased from the market. So, SARS-CoV-2 virus can easily be transmitted from human to human through food commodities. Ultraviolet (UV) exposure based cheap methods have been proposed for chemical free disinfection of the food items which can be easily designed at home with less technical knowledge.UV-C light is required to be exposed into the food for disinfection purposes. There are three types of UV rays namely UV-A, UV-B, UV-C. Wavelength of UV-A rays in the electromagnetic spectrum lies between 315 nm to 400 nm. Wavelength range of UV-B light is 280 nm to 315 nm.**

Keywords: UV Light, Coronavirus

I. INTRODUCTION

Covid19 changed all of humankind in 2020. Due to its fast and efficiently spreading nature, we were forced to use face masks and gloves to protect from everything we touch. Well we can use masks to protect us outside but what about the things we bring home from the market or things we exchange with other people. For example: We cannot apply sanitizers on fruits, vegetables, packed food, batteries etc. We buy from outside or we can't sanitize files, paperwork that doctors exchange with patients or employees exchange with each other.

Well we solve this huge problem with a smart electronics system powered by an Arduino. We design a 60 degree disinfection box using ultraviolet sterilization to solve the issue. The system makes use of 8 UV C tubes to achieve this task. Now UV C has been proven to kill all viruses within a matter of seconds.

Wavelength of UV-C light lies between 100 nm to 280 nm.A wooden box has been prepared to disinfect the food items from the virus. Since UV-C light is harmful to skin, it is very much essential to disinfect the food items in a closed environment so that it does not come in contact with any human or animal. To meet this vital requirement, a closed wooden box is utilised to disinfect the food items which ensures the safety of human skin from UV-C light. Six numbers of lamps emitting UV-C light and a food holder are placed in the box for the operation. Arrangement of food holder and UV-C lamps inside the box is shown in fig.

Food is kept in the net type holder before supplying the power for 15 min. The net type holder will produce shadow in the bottom side of the food. Multiple lamps in different positions are placed to ensure the presence of light in the complete surface of food during operation.

The Arduino COVID Disinfection box has the following Key Aspects:

- 360 Degree Disinfection
- Proven to Deactivate all Coronaviruses
- Automatic Timer based Shutoff and Alerting
- Can Sterilize Mask, Packed Food, Electronics etc
- Variable Sterilization Timer Setting
- Automatic Safety Shutoff
- Easy To Use
- No Water No Chemicals | Environment Friendly

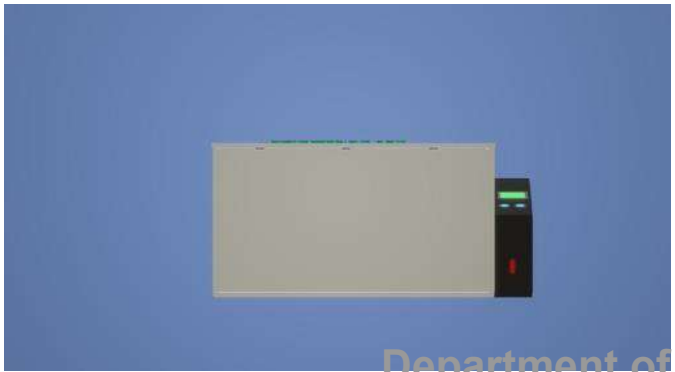
The Arduino controller takes user input for time setting and starts sterilization when the start button is pressed. It automatically shuts off when the sterilization time is completed. Also an automatic shutoff system shuts off the sterilization if the lid is opened by the user between ongoing sterilization.

II. COMPONENTS

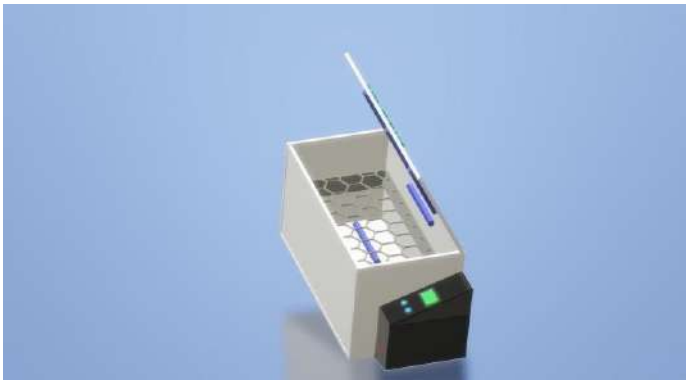
1. Arduino Uno-The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.
2. LCD Display
3. Buzzer
4. Lid Sensor
5. UV-C Tubes
6. Buttons
7. Metal Mesh
8. LED's
9. IC's
10. Resistors
11. Capacitors
12. Diodes
13. Transistors
14. Transformer
15. Base frame
16. Supporting Frame
17. Mounts and Joints
18. Screw and Bolts

III. BLOCK DIAGRAM

FRONT VIEW



3D View



IV. WORKING

The Arduino controller takes user input for time setting and starts sterilization when the start button is pressed. It automatically shuts off when the sterilization time is completed. Also an automatic shutoff system shuts off the sterilization if the lid is opened by the user between ongoing sterilization.

Coronavirus Sterilizer box uses chemical-free multi focal UV Light exposure, covering 100% of the surface of the items placed inside the oven from 360 degrees. UV-C of the wavelength 253.7 nm is used here because at this wavelength the germicidal activity is maximum. A treatment duration of 10 minutes shall be sufficient enough to sanitize and disinfect the surfaces properly. However, it depends on the object being placed for disinfection.

Step 1: Place the machine on any flat surface near a normal power socket.

Step 2: Open the top lid and place items to be disinfected such as groceries, masks, etc on the metal surface, next to each other with some space between each item.

Step 3: Turn on the pre-programmed safety switch which starts the time disinfection cycle along with the UV Light Indicator.

Once the disinfection is complete, you can take out the items from the oven.

With the country touching a new landmark in the number of positive coronavirus cases along with more than 1,500 deaths, the need to protect oneself from the highly contagious virus is extremely imperative. Especially when the deadly C-virus can survive on any surface for a significant period of time, increasing the risk of contracting the disease manifold.

V. APPLICATION

- Disinfection in houses, classrooms, restaurants etc.
- Disinfection of food, small electronics like phones and even small objects.
- Can be used in factories and shops.
- Can be used in airplanes
- can be used for any size of the products

VI. FUTURE SCOPE

With the ongoing Coronavirus Pandemic the sterilizer can play an important role to eliminate or disinfect the virus thus leading to decreased number of cases of coronavirus resulting in complete elimination of coronavirus.

VII. CONCLUSION

During March 19–April 9, 2020, most survey respondents reported frequent handwashing and surface disinfection to prevent COVID-19. These practices are important components of a layered approach to COVID-19 prevention, which also includes wearing masks and physical distancing. We also identified gaps in these self-reported practices; 7% of respondents said they were not handwashing often and 26% said they were not disinfecting surfaces often. We also found that men, younger people, people with lower incomes and lower education levels, and people in self-rated poor health generally reported lower rates of both frequent handwashing and surface disinfection. These practice gaps among sub-populations vulnerable to COVID-19 (men and people in poor health) are of particular concern. Practice gaps for those with low incomes are also concerning, given that underlying health conditions are more prevalent in this group. Keeping that in mind our team has created a project based on UV-C which will help them to get rid of the disinfectants from all the products including foods, clothes, masks, books etc. without any worry and is also affordable to each and every range of earners.

VIII. ACKNOWLEDGEMENT

This Design/Research is guided by our mentor MR.SURESH KUMAR, by contributing excellent suggestions and support from the start and giving us knowledge throughout the project. We would also like to express our acknowledgement to the Head of the Department of Mechanical and automation Engineering, Mr. NEERAJ KUMAR at Dr. Akhilesh Das Gupta Institute of Technology and Management for their co-operation.

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ELECTROLYTIC CONDUCTIVITY SENSOR FOR CORNERING OF TWO-WHEELER: A REVIEW

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Abstract

The suspension system is the main part of the vehicle, where the shock absorber is designed mechanically to handle shock impulse. The objective of this work is to propose a method to make the cornering of Two-Wheeler Convenient and safer for Rider who is riding the vehicle. As we know that in two-wheeler market, the rider can get good handling at cost of poor comfort. Good Comfort and handling are not available together in current two-wheeler products. If user wanted to have good comfort, then Suspension of vehicle available will be soft and they will not give rider the proper Confidence while cornering since a small mistake on the pit on the road can make vehicle unbalanced. Some two-wheeler like YAMAHA provides a solution for this problem by using Broad Tyres with Soft Suspension but that also comes at very high cost which budget customer cannot afford. Also by using broad tyres efficiency of vehicle reduces and its mileage also. Because of these Reason and using Broad tyre in bike is not in budget of Normal Buyer. To Solve all these Problems, this method proposes an idea to use Phenomena of Electrolytic Conduction Sensor to give rider comfort but not at cost of poor stability while Cornering. In this Method, Rider feels comfortable while riding and confident while Cornering the Vehicle. The method is Pocket Friendly and Doesn't Reduces the Efficiency or Mileage of two-wheeler Vehicle.

Keywords: Efficiency, Mileage, Suspension.

1.Introduction

Stability is not a big concern while thinking of a car or any other three or Four-Wheeler Vehicle. But in case of two-wheeler, Stability is always a matter of concern and its manufacturers are always confused in between stability and Comfort.

If Manfacturers want to give stability while cornering, they are not able to give desired comfort to rider. This is because to give Stability while cornering Two-wheeler Manufacturers need to give stiff Suspension and these Stiff suspension cannot give desired comfort to Rider.

Kartik et al.[1] Observed that suspension serve for the dual purpose. The first purpose is to absorb shock impulse and dissipate kinetic energy and the second purpose is vehicle handling and braking. It also balances vehicle frames and stability and secure straight running stability and rotationality of the vehicles.

Manpreet et al. [2] observed that shock absorber consist of spring and damper system where spring is elastic member as well as device which stores mechanical energy. It is also known as oil pumps, a piston is installed at the end of piston rod and runs hydraulically. When vehicle moves on a road then it moves up and down due to jerks or damps condition of road.

Sagar et al. [3] states that Mono shocks gives a superior vehicle handling and provides safety while braking than telescopic fork. The spring in Mono shocks have been designed by consideration of many practical condition like dynamic resistance, road tracks and aerodynamic properties. In Mono shock suspension design the uneven vibration in the telescopic forks have been balanced using the mass centralization concept. This design of suspension using mass centralization concept may antiquate the present telescopic forks and alloy steel is most suitable for suspension system.

Niranjan et al. [4] in 2013 Studied the main functions of automobile suspension systems are to isolate the structure and the occupants from shocks and vibrations generated by the road surface. The suspension systems basically consist of all the elements that provide the connection between the tires and the vehicle body. It is a flexible element used to exert a force or a torque and, at the same time, to store energy. The force can be a linear push or pull, or it can be radial, acting similarly to a rubber band around a roll of drawings. The torque can be used to cause a rotation.

Vijayeshwar et al.[5] in 2014 Choosen the mono suspension system for various two wheelers in their study. The present work focuses mainly on obtaining the optimal spring dimensions without affecting the riding comfort for mono suspension system.

This Method uses brief concept of electrolytic conduction on a sensor which uses electromagnets to give a good comfort on straight roads or in other condition and a better cornering by increasing the lean angle of vehicle even with less broad tyre. This Method can make the suspension stiff while cornering and soft while riding on a straight roads. Problem of actually using a bicycle for your transportation as they are very much concerned about the speed, safety, comfort etc. This sensor uses Phenomenon of Electrolytic conduction which can be applied on Suspension System and it indicates driver easily while making certain lean angle.

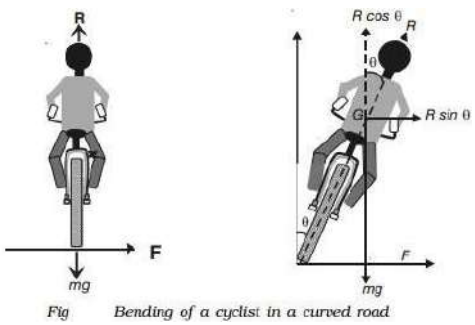


Fig Bending of a cyclist in a curved road

Vehicle suspension system:

A suspension system is an essential element of a vehicle to isolate the frame of the vehicle from road disturbances. Figure 1 shows a typical car suspension system. It is required to maintain continuous contact between a vehicle's tyres and the road. The most important element of a suspension system is the damper. It reduces the consequences of an unexpected bump on the road by smoothing out the shock. In most shock absorbers, vibration energy is converted to heat and dissipates into the environment. Such as, in the viscous damper, energy is converted to heat via viscous fluid. In hydraulic cylinders, the hydraulic fluid is heated up.

Suspension systems are categorized as passive, active and semi-active considering their level of controllability.

The active suspension system actuates the suspension system links by extending or contracting them through an active power source as required. Conventionally, automotive suspension designs have been a compromise between the three contradictory criteria of road handling, suspension travel and passengers comfort. In recent years the use of active suspension systems has allowed car manufacturers to achieve all three desired criteria independently. A similar approach has also been used in train bogies to improve the curving behaviour of the trains and decrease the acceleration perceived by passengers. But this makes the system expensive and increases the design complexity and energy demands.

We have seen that electrical conduction in solids is associated with the drift of free electrons in the solid A similar mechanism may be used to account for the conduction of electricity in liquid metals. In other liquids electricity is conducted by the migration of positive and negative ions through the liquid. When two terminals, or electrodes, are immersed in a liquid and a source of emf is connected to them, there will be a current through the liquid. Under the influence of the electric field established between the positive terminal, or anode, and the negative terminal, or cathode, the ions drift through the liquid.

The process of solution is evidently furthered by the way the molecules of the solvent can attach themselves to the ions of the Ionic substances are relatively insoluble in nonpolar solvents, such as benzene. When electrodes are immersed in an electrolytic solution, the ion and its associated water of hydration drift as a unit through the liquid, so that the effective mass of the ion is the mass of the entire assemblage.

The electrical conductivity of a liquid depends upon the number of ions per unit volume and upon their drift velocity. The drift velocity of an ion varies with the electric field intensity, with the mass of the ion, and with other factors as well.

The measurement of electrolytic conductivity in aqueous media is a useful analytical tool applied in various fields of science and technology. Although electrolytic conductivity is a non-specific parameter, it may be used as an estimate of the concentration of ionized substances in a liquid sample. Under given conditions, electrolytic conductivity is a useful and accessible measure of water quality, replacing laborious and expensive chemical analyses. Electrolytic conductivity measurements are applied for water purity assessment (e.g., in pharmaceutical, semiconductor and power plant industries); for the evaluation of water quality under regulations and standard practices (e.g., for drinking water and water used in the food industry and in health care); and for water analysis (e.g., in environmental monitoring).

2.Proposed Methodology

As proposed, the Method is based on electrolytic conduction and electromagnets.

1. The apparatus used consist of a tube, tap Water, NaCl, copper wires, battery (9V),Electromagnets(2),MonoSuspension(Rear).

2. All Components are arranged and shown as Figure

3. There are 2 tubes in vertical direction which all of them are connected to each other, which means if solution is filled from one tube it will be equally distributed in other Tubes. So, both tubes will be filled at equal Level.

4. The Middle tube has copper wire immersed in it.

5. Make sure that mono-suspension is used on softer side.

6. The two electromagnets used in the method will have some pole while working.

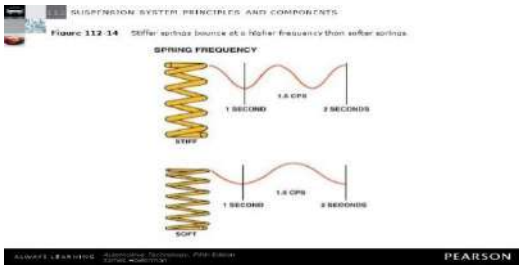
7. The two electromagnets are placed at two ends of rear Suspension.

8. In Case of electric two-wheeler vehicle, Main Battery can be directly connected instead of 9V battery.

9. The Electromagnets should be designed and installed at ends of suspension in way that when they get activated .Their same pole will be facing each other and They repel each other.

10. Two End Tubes should be covered with coverings having small holes over it while center tube should sealed with covering of no holes.

Fig 3 Soft and Stiff Suspension



3.Working Concept

To Understand Situation 1

Consider Rider is Moving Appropriate Direction of Road. So, Left of rider is left of reader as right of Reader. This will make easy to understand this Mechanism.

Now Assume the Case of Rider taking Left Turn
In this case when rider leans himself with two-wheeler, the copper wire in tube 1 comes in contact with NaCl Solution immediately and circuit will be complete now and both electromagnets will be facing each other with same poles

Since, Two Magnets are mounted at two ends of mono-suspension, the same will repel each other due to which suspension don't get compressed easily and become stiff.

It can be understand that two ends of suspension are repelling each other and don't reduce distance between them very easily. So, the suspension becomes stiff and help the rider to achieve better cornering at higher lean angle.

Situation 2

Now Assume Rider is Taking Right Turn

In this case , when rider leans himself with two wheeler, the copper wire in tube comes in contact with NaCl Solution immediately and circuit will be complete now and both electromagnets will be facing each other with same poles and activate both the electromagnets. Since they are facing each other, they will again repel and suspension STIFFER. This will improve Cornering with lean

at a greater angle.

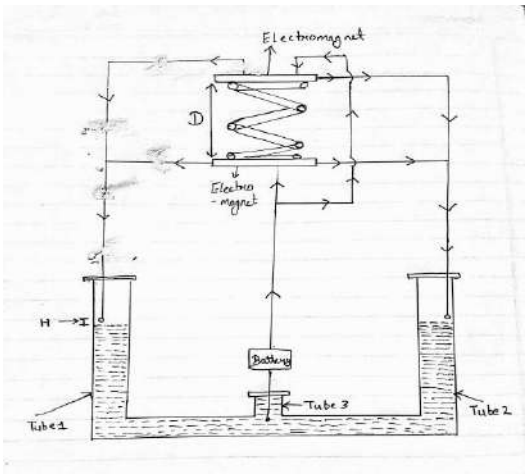
Situation 3

Now, Assume Rider is moving on a straight road.

In this case when rider is moving on straight path then

He/she needs comfortable and soft suspension and and since in this case, Neither copper wire in tube 1 nor Copper wire in tube 2 is immersed in NaCl solution. the circuit will be open circuit for both cases. Now we have kept Softer Mono-Suspension so they provide the desired comfort to rider on a straight road.

This is the reason because of which we have opted for Soft Mono Suspension for rear part in Starting



Experimental Setup for Electrolytic Conductivity

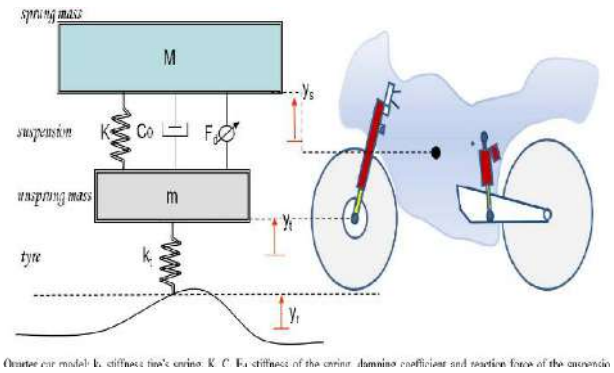
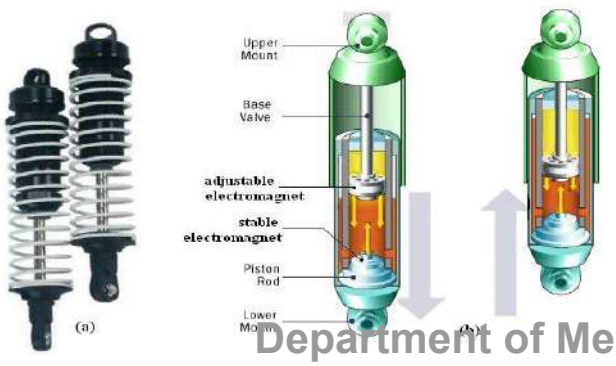


Fig 4. Smart Sensor Network for Suspension of Two-wheeler Vehicle



Electromagnetic suspension system

4.Result and Discussion

Electrolytic conduction and electromagnets are the base for this Method.

From Above Proposed Method, the Phenomenon of electrolytic conduction is used in very unique approach. It is also observed that for a given fixed radius of tubes.

$$Q \propto 1/D$$

Where Q = Lean Angle

D = Distance between two electromagnets mounted at two sides of suspension.

It is also noted that user can reduce the interference of this system upto some limit while cornering in the following ways:

1.User can increase the distance between end point of copper wire and top point of NaCl Solution in the tube. If the distance between copper wire is increased then the system will not get activated immediately to make suspension stiffer.

2.If Distance (D) between two electromagnets is increased then repelling force will be less and suspension will become less stiff. And if distance is increased, then repelling force increases and stiffness of suspension will also increase.

$$Q \propto 1/D$$

$$Q=K*D$$

K= constant of proportionality $K=Q/D$

The Value of "K" is beyond the exposure of this paper.

Suspensions due to easy availability of various parts and simple structure. However, more recently, electromagnetic actuators have emerged as a potentially superior alternative, showing lower power consumption and higher bandwidth abilities. Active suspension systems that adapt to the road profile have been considered as capable of reckoning larger improvements in ride and

handling performance, in distinction to devising the system robust to vehicle parameter fluctuations. For this, look-ahead preview control is being actively developed by motorcar manufacturers. The multiple model adaptive control approach is a control method that is potently appropriate to this type of suspension adaptation.

5.Conclusions

This Proposed system is of great use. In Country like India, where people usually buy budget bike and don't care much about safety and comfort and some cases they are not known whether vehicle they are driving is safe or not.

Most of the Accidents in India occur while two-wheeler rider is cornering their vehicle. This system will definitely save life as well as many people who buy budget bikes to daily commute. This System will make ride comfortable without compromising safety of rider.

Design of adequate suspension system is a highly a difficult control problem due to the complicated relationship between its components and parameters. The researches were carried out in suspensions systems cover a broad range of design issues and challenges. As degrees of freedom goes on increasing from one degree (whole system) to four, seven, eight etc. complexity in analysis increases. While two-degree of freedom suspension system can give effective Performance measurement with less complexity and simple structure.

Moreover, it makes our city more physically and mentally fit. So, Turning Sensor and improving the comfort and efficiency of vehicles makes it more popular among the common citizen and they can think of using it as a main of transport even by riding for 10 to 20 km very easily in just half an hour, without any tiredness.

6.Future Scope

This system is designed for all type of two-wheeler whether they are petrol or electric. But this system will have better compatibility with electric two-wheeler and electricity by this system is directly provided by batteries of two-wheeler. These HPV vehicles are going to be the future. Even today such special vehicles are designed for movement within a large institute.

INNOVATIVE DESIGN: As an HPV, there can be a lot of design of these cycles provide versatility in them and any of them can be preferred according to the demand of work

E-GADGETS/SENSORS: There is a lot more to think about its modification scope, as the whole idea is new and demands innovation in every aspect. Even proximity sensors can be used to provide extra support to the rider while riding and such a lot more.

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Modification in 2 Wheeler Seat Design for Safety

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ABSTRACT

In today's competitive world, automobile seat design has been considered as an important criterion to satisfy the comfort expectation of the population. This present dissertation highlights the comparative study for the bike seats available in the market and also proposed the novel seat design for better comfort. Statistical tool has been utilized to analysis the number of bikes reviewed for driver's seat features. From the results it has been concluded that modified bike seat design is superior in terms of form, shape, seat features, usability and comfort.

Keywords

Automotive Engineering; Seat Design; Ergonomics; Two-Wheelers

Introduction

Today's globalized business sector rivalries among the different auto commercial ventures drive the motorbike makers to plan their items particular to customers' decisions and fulfillment. During the design and development of bike seat, driver's posture is the most important factor to be considered among others the user comfort has to be maximized. The human impression of short and long haul solace is immeasurably subject to the seat plan alongside the position of controls on the handle and side of the motorbike. The way of vibration persisted by the drivers and presence of poor workstation design likewise brings about poor carriage while driving that prompt physiological side effects of distress and agony. With development in innovation the needs and desires of the client's increments in appreciation of picking up a more agreeable and tastefully satisfy item. The solace capacity and wellbeing of a seat is extremely imperative to a bicycle's outline and creation. Drivers' solace is just as essential as the utilitarian and stylish parts of autos since it is given more inclination by the clients for an agreeable commute. As the situated carriage of a person opens him to a mixture of musculoskeletal inconveniences, sitting solace is of top need that requires ergonomic mediations in the early outlining stages. In this part the need to take up this work alongside foundation is talked about. It additionally displays a survey of accessible pertinent writing. Destinations of the present work alongside system received to achieve the objectives have been examined here.

Background of The Work

Looking around the various discomforts in the current motorcycle seat designs, we thought to do the survey of some existing bike seats to get the best among them. We choose set of people for survey which were the college students who are generally having the riding experience of 4-5 years. So we took 3 bikes of 150-160 cc segment (Yamaha R15, Bajaj Pulsar, and TVS Apache RTR) and surveyed 15 students of our college for all the three bikes each.

Purpose of Statement

As in most rapidly-growing economies, India's citizens are commuting longer distances to their workplaces . The way millions in India are choosing to do this is via motorized two-wheelers (scooters, motorcycles and mopeds). As more two-wheelers are on the roads, safety concerns increase. Two-wheeler designers and manufacturers have an opportunity to include safety features specifically intended for two-wheeler drivers . The project intends to outline some of the factors that make riding a two-wheeler safer and the design approach used to address a subset of these needs.

Problem Statement

There are large number of motorcycles present in the market with different seat designs now-adays. But the main problem is that no seat is perfect, different seats are having some parts of them which are more comfortable among the other motorbikes. The aim is to study the different bike seats present and do the subjective analysis to design the new seat which would be having selected features from different bike seats to provide a new comfortable design. Subjective analysis is done using the data from the survey conducted among the selected group of population.

The objectives of this task can be determined as follows:

• To conduct a survey of different bike seats of a particular group of population.

• To collect the data and organising it in a better way to extract the required information.

• To do the statistical analysis of the surveyed data using statistical tool.
• Surveying to justify the new seat designed.

Literature Review

Significant endeavors have been made in the past via scientists to give the creators of bicycle seats with powerful rules towards giving the car business more agreeable seats. The ability to comprehend the solace level gave by the car seat requires a top to bottom comprehension of biomechanics of situated stance, seat geometry impact on people, seat properties and the vehicle environment on saw solace. Seat comfort is a complex phenomenon (Looze et al, 2003). Looze et al. (2003) made an analysis of the scientific literature concerning the relationship between sitting comfort and discomfort and objective measures. He found pressure distribution was the objective measure that provided absolute transparency in its association with the subjective ratings. Looze et al (2003) focused on 3 comfort effects and Nordin (2004) on the effects of sitting and back complaints. Lueder (2004) uses the literature to show the importance of movement while seated and Zenk (2008) made a literary review of comfort and sitting while driving. Factors influencing the subjective ratings also include skin perception, muscular activity, posture, joint

angle interface, pressure, stiffness and suspension of the seat cushion and backrest. Posture variation and frequencies of posture changes are also measured. Mergl (2006) states that the seat should reduce postural stress and optimize muscular tension. Porter et al. (2003) explained the importance of pressure distribution to avoid high pressure areas. For instance, the tissues around the ischial tuberosities are subjected to extremely high pressure while sitting that can result in reduction of blood circulation through the capillaries. In such cases it is necessary to realign body position, else then the symptoms of aches, pain, discomfort and numbness start surfacing up. Nordin (2004) also showed that sitting in restricted postures as well as sitting in combination with vibration is a risk factor. This means that for bike seats the risk is there. Ariens (2001) showed that unsupported static postures also increase the chance of neck pain. Bower-Carnahan et al directed overview on inclination of overwhelming truck drivers with respect to seat outline. The general appraisals for driver solace and customizable suspension damping included them as the most imperative highlights. This study additionally indicated the areas of physical inconvenience through an uneasiness point plot.

The five ranges specifically that were very identified with seating inconvenience:

Discomfort in upper neck and back; created principally because of strain of driving throughout the day and because of the necessity of keep up the head in legitimate position for broadened spans. Discomfort in shoulders; starting principally because of dishonorable situating of seat as for controlling wheel and directing wheel edge.

Discomfort in lower back because of deficient and dishonorable lumbar backing.

- Discomfort in rear end ascribed to the uneven weight connected at the human-seat contact locale.
- Discomfort in back area of thighs simply over the knee district created because of disgraceful weight.
- Despite the fact that the workstation and geometry of truck and auto are diverse, the concerns relating to the seat solace and feeling of inconvenience can be by and large tended to.

Methodology

The approach adopted to accomplish the present work is described as below:

• Select the bikes of same segment for conducting survey.

• Checking on and arranging the parameters or highlights in charge of the comfort discernment on the buyers

• Selecting the group of population for survey.

• Surveying of the users for rating of various attributes for comfort and discomfort of users.

• Collection of Data and organizing it using a statistical workbench. This gives us the seats with best attributes and features.

• New seat is designed using the statistical data from the survey with best features and attributes of scanned seats. Customer feedback and suggestions are also incorporated and modifications are done.

• Survey is done to justify the new designed seat.

2.1 Subjective Assessment

In this assessment process, a group of people were chosen to give the survey. Questionnaire was prepared to explore and establish the various aspects of the bike seat and the comfortability of the user. Participants (n=15) aged in the range of 22-30 having driving experience not less than 6 months were interviewed. Three main bikes of 150 cc – 160 cc range were surveyed .Ratings of each was determined by each of the participants. Question was based on how the bike seat affect the comfort and discomfort of the whole body of the user.

It was mainly divided into two parts:

- Assessment of pain perception in body parts
- Assessment of seat features

The seat features and afflicted areas of the body that endure the maximum pain are defined as follows:

Seat Features Considered for Assessment	Body Parts Pain Perception
Distance from handles	Buttock
Height of seat	Lower back
Cushion softness	Upper leg
Shape of seat	Shoulder
Adjustment Features	Neck
	Arms
	Head

Features and afflicted areas of the human body

ACKNOWLEDGEMENT

we have taken in this project .however it would not have been possible without the kind support and help of many individuals and the departments . we would like to extend our sincere thanks to all of them authors would like to thank our respective professors under whose guidance this research was accomplished

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Power GenerationUsing Piezoelectric Materials

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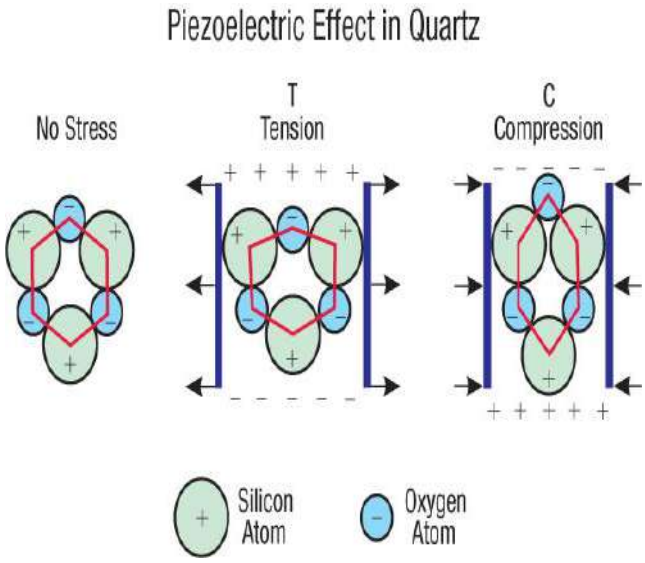
Abstract— The purpose of this paper is to provide a solid explanation for the generation of reliable amount of power by using the conversion of mechanical energy into electrical energy using piezoelectric materials. The aim is to find a suitable and efficient source of electrical energy by using our surrounding, I've used the mechanical energy produced from our footsteps in order to produce sufficient and reliable amount of energy.

Index Terms— Energy harvesting, piezoelectricity, piezoelectric effect, energy conversion.

I. INTRODUCTION

Regarding our crucial need for energy for its importance in all aspects of life, the searching for renewable and non-renewable energy sources was a must. In



recent years, fossil fuel is considered the only and most reliable source of energy that human being used. Concerning the benefits of this fossil energy, it is endanger of running out because its formation takes millions of years. Furthermore, its uttermost

disadvantage lies in the toxic gases which affects our environment in addition for our shield, the Ozone layer. This is a serious threat which affect our way of living, and the solution was reducing the use of the fossil fuel and substitute it with green energy sources.

II. PIEZOELECTRICITY

Piezoelectricity is a property for some materials which lies in generating electrical voltage when mechanical force is subjected into it and vice versa. This phenomena was discovered by the Curie brothers in 1880, they have discovered a relation between electricity and pressure in certain materials. After several experiments they discovered that some materials such as quartz, ceramic and potassium sodium tatrates, when subjected into mechanical stresses, the natural formation of charges breaks up therefore an electric voltage will be produced. This process can be done using the principle of energy harvesting. Energy harvesting is defined as capturing finite amounts of energy from one or more of the surrounding energy sources. From this principle the need of piezoelectricity and piezoelectric materials is considered a wonderful solution for the stated above problems. We totally know that the substance is formed from particles, when these piezoelectric particles such as quartz or ceramic are under mechanical causative such as pressure, this will change the neutral formation of the charges inside the particles, and this will lead to have a converging between the particles. As a result, formation of a positive charge and negative charge. Consequently, formation of an electric voltage. Piezoelectric materials have two important properties that are defined as direct & converse effects. Direct effect is the property of some materials to develop electric charges when mechanical stress is exerted on them. While converse effect is the opposite of the direct effect. This effect can be used significantly in our daily life, which is used as a transducer. This transducer is our main subject of study in this paper. It consists of two metallic

plates separated by a crystal from quartz or other piezoelectric material. When subjected into mechanical stress, one or both of the plates vibrates, this vibrations will be transferred to the crystal, and this will produce a low alternating voltage. This AC voltage will be transferred to the metallic plates and amplified to an equal value to the mechanical stress. *The following figure illustrates the shape of piezoelectric quartz transducer.*

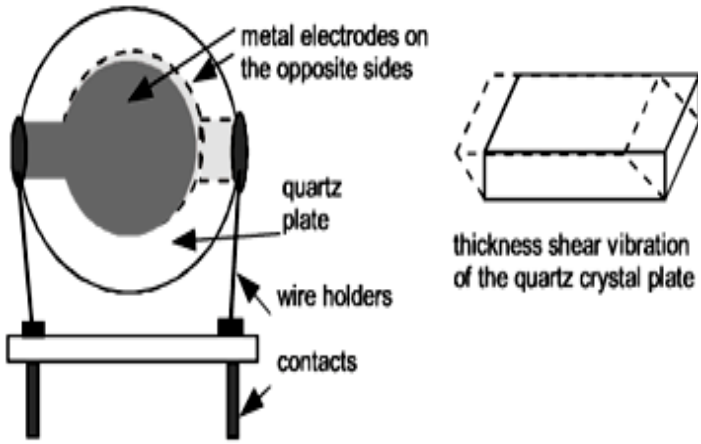


Figure 1. Piezoelectric quartz crystal microbalance and scheme of vibrations.

The advantages of piezoelectric materials: 1- Self-generating, no need for external sources.

2- Easy to implement and use.

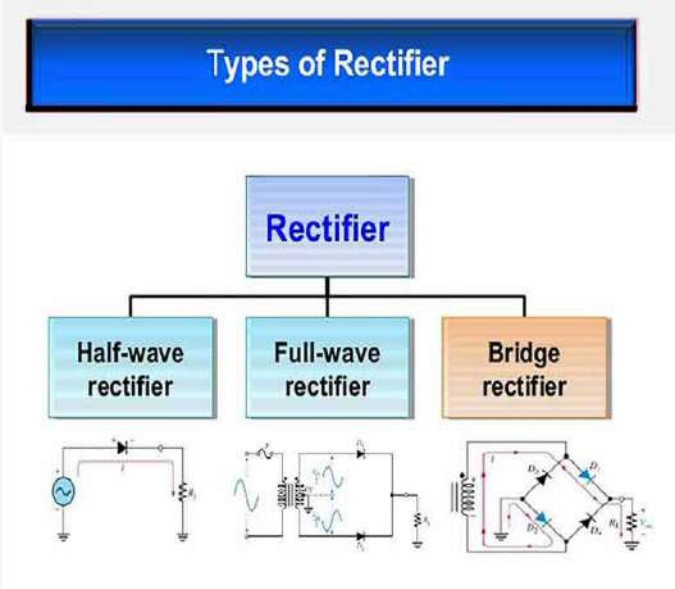
3- Can be shaped and formed as desired.

On other hand, there is some disadvantages related to the piezoelectric materials:

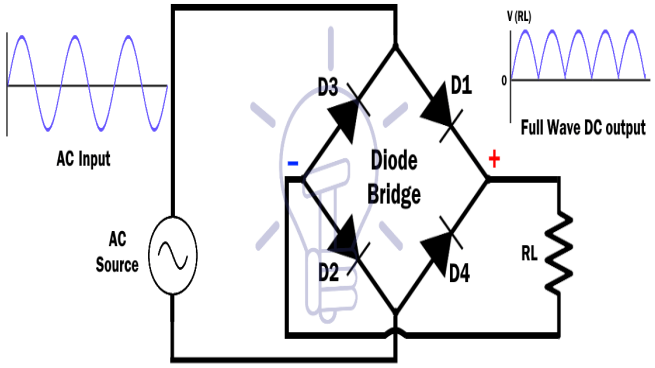
1- Can't be used in stable conditions, it needs continuous vibrations.
2- The output voltage may vary according to the temperature and humidity.

III.FULL WAVE RECTIFICATION

As discussed earlier, piezoelectric materials are used for producing AC voltage. From this perception, the importance of transforming this AC voltage into DC voltage is a must because DC voltage can be stored and used later in various applications. This process is called rectification, we use an element called a diode, which is made using silicon or germanium. The rectification process is divided into two main types:

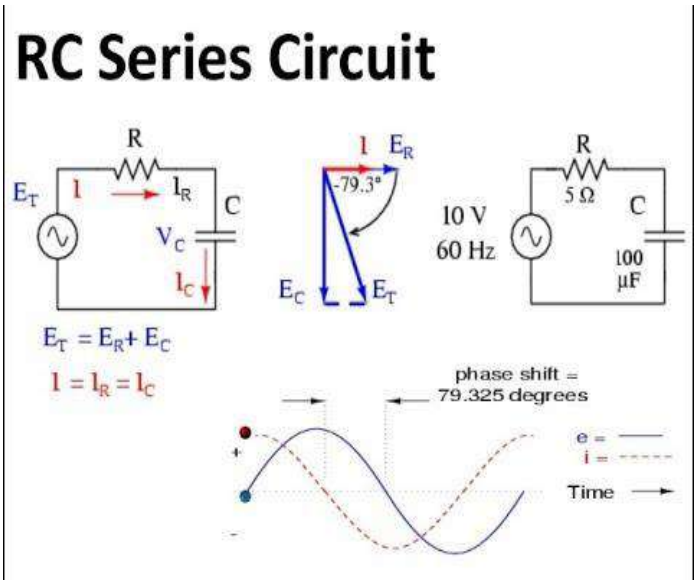


In our research, we will use the full wave bridge rectifier because of its ease of implementation, cheaper cost & high efficiency. The working principle of a full wave rectifier is simple, the circuit diagram is given below:



Bridge Rectifier Output

The output wave of the rectifier contain considered amounts of ripples, which will affect the storing ability of the battery. So, we must use a suitable filter in order to eliminate these ripples from the output wave to get a pure DC wave. Simple filters such as the RC filter can be used.



IV. ENERGY STORAGE

This section will clarify the method of storing electrical energy after being rectified and transformed into DC. Batteries are one of the most usable method of storing energy by converting the electrical energy into chemical energy and vice versa. They are being used for its simple implementation and its large capacity. Scientists classified the batteries according to its ability for recharging:

1- Primary batteries.
2- Secondary batteries.

The primary batteries can produce current immediately on assembly. They are disposable and can be discarded after being used. We can find them in portable devices such as alarm and communication circuits. Whereas secondary batteries must be charged before use, they are recharged by applying electrical currents, which reverse the chemical reactions that occur during its use. In this paper, we will focus on rechargeable batteries because of its ability to be charged and discharged.

These batteries can be classified into two main categories:

1- Lead Acid Batteries
2-Lithium-Ion Batteries.

Lead acid batteries consists of two electrodes in addition for electrolyte that maintain the connection between the electrodes. Lead represents the negative electrode, whereas lead-oxide represents the positive electrode. The sulfuric acid is the electrolyte when the battery is charged, and in the case of being discharged the electrolyte will be lead sulfide. On the other hand, lithium-ion batteries have a lot of configurations but the most common is having a lithium-oxide on the positive electrodes and carbon on the negative one. The principle of this type is connecting the anode and the cathode into a dc voltage, which in our case is the output of the full wave bridge rectifier. So, redox reactions will take a place and a chemical energy will be stored in the battery.

Consequently, when we want to use this batteries, the stored chemical energy will be converted into electrical energy using redox reactions also, which will generate an electromotive force that will let the current flow to the load.

V. MODELLING A PIEZOELECTRIC SYSTEM

This section shows the proposed model is derived starting from the linear constitutive equations of the material and by means of the formal electromechanical analogies. Given to the link between the lumped elements of the circuit modeling the device and the physical aspects. The constitutive equations of a piezoelectric material establish a linear relation between two electrical variables, respectively the electric field strength E (V/m) and the electric displacement D (C/m2), and two mechanical variables, respectively the stress σ (N/m2) i.e. the exerted force per unit area, and the strain = Δl lo , i.e. the normalized deformation.

$D = \varepsilon . E + d . \sigma$ (1)

$\delta = d . E +$ SE. σ (2)

Where,

: The electric permittivity of the piezoelectric material at null stress

SE: Elastic compliance at null electric field strength.

Multiplying both equation 1 with a conventional unit area and equation 2 with a unit length. The new formulas is easily modeled with lumped circuital elements since it refers to:

Cf: Lumped capacitance

Kv: Lumped stiffness.

Therefore, the change of variables lead to the following form:

$\boldsymbol{Q} = Cf . v + d . f$ (3)

$\boldsymbol{u} = d . v + Kv-1 . f$ (4)

Where,

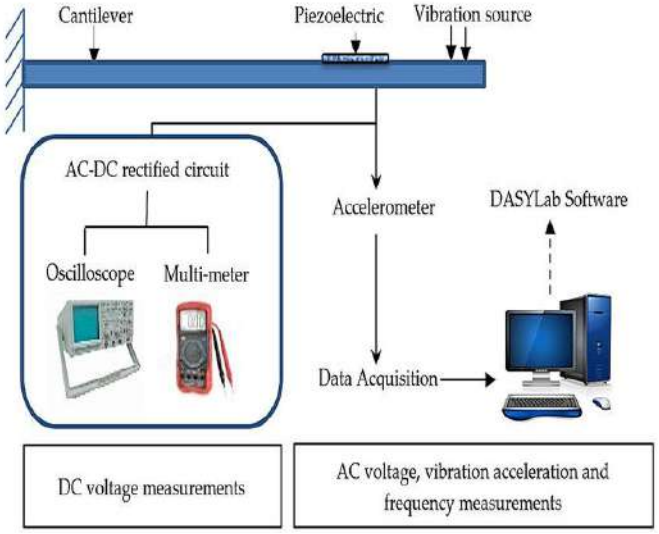
Q :The charge (C)

U: Displacement (m).

The first right hand term in equation 3 recognizable as the constitutive circuital equation of a capacitor, whereas the second is the charge induced on the piezoelectric particle surface as a consequence of the applied force. The first right hand term in equation 4 refers to the displacement generated as a consequence of the applied voltage,

whereas the second term is represented by Hooke's law, where Kv is the material stiffness in (N/m) when a short circuit is applied between the metal surfaces collecting the charges. In this project we will use piezoelectric harvesting kit, manufactured by Piezo Systems Inc. The model used contains of three major elements:

1- Piezoelectric bending generator
2- Piezo energy harvesting circuit
3- User application



A. The piezo bending generator:

When the Energy Harvesting Bender is flexed, one layer is compressed while the other is stretched, resulting in power generation. It may be excited by intermittent pulses or continuously from low frequency to resonant frequency (where rated displacement is achieved at the lowest force level).

B. Piezo energy harvesting circuit:

The self-powered Piezo Energy Harvesting Circuit collects intermittent or continuous energy input from the piezo generator and efficiently stores their associated energy in an onboard capacitor bank. During the charging process, the capacitor voltage is continuously monitored. When it reaches 5.2V the module output is enabled to supply power to an external (user) load. At this point 55 mJ of energy are available. When "generator" energy input is high, the output voltage remains ON continuously. Capacitor voltage is clamped at 6.8V. If external power demand exceeds generation, the output voltage decreases. When the output voltage drops to 3.1V, power to the load is switched OFF and is not turned on again until the capacitor bank has been recharged to 5.2V. The circuit accepts input voltages from 0V to ±500V AC or DC and input currents to 400 mA.

VI. CONCLUSION:

The aim of this research is to find a suitable, reliable and efficient source of power from the resources that surrounds us. Generating electricity using mechanical stresses is a huge portal because it will open the horizon for generating electricity using our daily life habits such as walking. Piezoelectricity permits us to generate portions of power can be collected and stored in batteries then used in other applications. Piezoelectric generated power proportionally related to the surface area of the piezo and the amount of stress being applied. Applying this into the hallway of crowded malls, buildings, etc. will help to save huge amounts of money for generating power that is used for lightning as example.

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AERODYNAMIC FAIRING FOR HUMAN POWERED CYCLE

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Abstract- *The key areas with the interest of Human Powered Vehicles (HPVs) are the significance of aerodynamic design and ways to improve overall aerodynamics. Wind tunnel testing was undertaken at the RMIT wind tunnel with a selection of both faired and unfaired vehicles. Within these tests and vehicles, different components were also analysed and tested. The wind tunnel testing was used to identify key characteristics of these HPVs, and, by identifying the different results obtained it was possible to understand more about the aerodynamics of HPV. Drag force values were obtained during wind tunnel testing, these drag values were compiled and compared. A key result was the importance of fairings, where travel could require significantly less effort as the faired vehicle tested provided only a quarter of the aerodynamic hindrance of any of the unfaired vehicles. Another significant finding was the effect of vehicle add-ons which showed how some small components could have a relatively large negative impact on drag.*

Keywords- *A human-powered vehicle, Fairing, aerodynamically optimized shape, CFD,*

I. INTRODUCTION

With the current issues associated with fossil fuels and carbon emissions, the need for alternate energy methods is greater than ever. The National Pollutant Inventory suggests that transport is responsible for 13.5% of Australia's total greenhouse gas emissions. There is a large focus in the issues and improvement of life is focusing on transportation, with this in mind current research is focussed on finding alternate fuel methods to power such vehicles. This study focuses on a great alternative for transportation that does not harm the environment and also provides the user with health benefits. The Human Powered Vehicle (HPV) is a pedal-powered mode of transportations therefore its success is measured by the effective transfer of pedal power to forward motion. Mechanical power losses will not be considered in this study. Evidence suggests that despite low speeds aerodynamic drag has a significant effect on average speed and rider. The aerodynamics of the vehicle is sometimes more important than the mechanical aspects of the vehicle. This hindrance causes a loss of effectiveness of power transfer to motion. The current study was aimed at understanding the aerodynamics, and in turn, helping to achieve better efficiency of these vehicles and increasing the appeal of the HPV. There are many different designs and industrial assumptions; with the aid of wind tunnel testing, it was possible to isolate key designs and characteristics that make these vehicles successful. The tests were initially based on the vehicles to be presented in the Royal Automobile Club of Victoria (RACV) energy breakthrough challenge. The event involves close to 100 participants from various primary and secondary schools across Australia. To validate findings the event was attended and the vehicles were analysed.

II. ADGITM HPVC Society

Participating in HPVC throughout these regular years, we found some comfort issue during the sudden braking test. A shockwave is felt by the driver. So here we come with this idea to increase comfort and remove the problem of shock during sudden braking.

III. Human Powered Vehicle Challenge

Human Powered Vehicle Challenge (HPVC) is an engineering design and innovation competition that allows students to network and apply engineering principles through the design, fabrication, and racing of human-powered vehicles.

IV. American Society of Mechanical Engineers

ASME (American Society of Mechanical Engineers) is a non-profit membership organization that enables collaboration, knowledge sharing, career enrichment, and skills development across all engineering disciplines, toward a goal of helping the global

engineering community develop solutions to benefit lives and livelihoods.

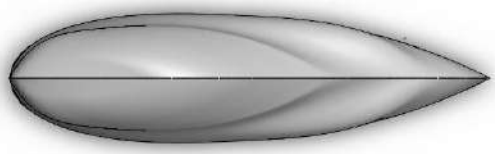

Figure 1: Top view of the fairing.

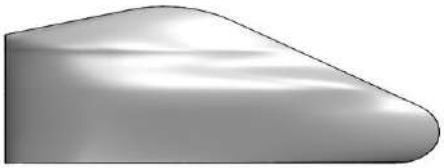

Figure 2: Side view of the fairing.

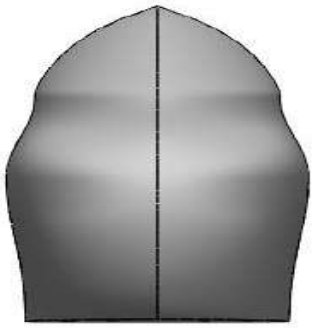

Figure 3: Front view of the fairing.

V. THEORY REVIEW

1. CFD Model Development

The CFD model was based upon a CAD representation of a long-wheelbase Land Rover and an actual livestock trailer. This geometry was generated from physical measurements to ensure the correct shapes were modelled. The following steps were then taken to construct the CFD model:

1.1 Solution

Domain Due to the computationally expensive nature of this problem, the asymmetry plane was used to speed up calculations. The air volume surrounding these vehicles effectively had a semi-elliptical cross-section. The blockage imposed upon the flow by the vehicles was 0.2% based upon the frontal area ratio. To fully capture the turbulent wake behind the vehicles, a domain length of 2.5m was used with the wake region extending twenty vehicle lengths behind the trailer. Later analysis on this geometry established that the external boundaries were placed sufficiently far from the vehicles so that blockage effects did not alter the solution.

1.2 Boundary Conditions

Air entered the solution domain through a single velocity inlet and exited through a pressure outlet at atmospheric pressure. An inlet velocity was used and this was matched by a moving ground plane. The initial turbulence level occurring in the domain was specified in terms of the turbulence intensity which was set at 0.25% and the turbulent length scale which is defined as 7% of the characteristic length, giving a value of 0.66m. Moving boundaries were implemented on the wheels for each vehicle with appropriate rotational velocities.

1.3. Grid Structure

Decomposition of the solution domain was essential to generate a grid that adequately represented the geometry. The air volume was split longitudinally into two distinct zones resulting in a core region and an adjacent shell spanning the entire length of the domain. The core region was further decomposed into three zones which permitted 0.1 million prism cells to be used upstream of the vehicles and a further 1.0 million cells downstream.

VI. METHODOLOGY

Having developed a procedure for obtaining accurate CFD results, the next stage was to integrate this with an optimization method such that an optimum design could be found.

VII. Design Variables and Objective Function

Initial results from the baseline configuration showed that 39% of the total vehicle drag acted on the headboard, with 34% attributable to the tailboard and the remaining 27% belonging to the wheels and other minor surfaces. When considering the best location for a drag-reducing fairing, clearly a shape optimized headboard fairing offers the greatest potential.

VIII. Metamodel

CFD post-processing carried out on all fairing designs responded to the metamodel building, which in this case was based on the MLS with a quadratic base function and a Gaussian weight decay function.

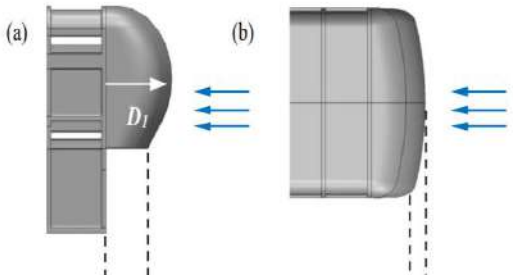

Figure 4: Affect of curvature on flow.

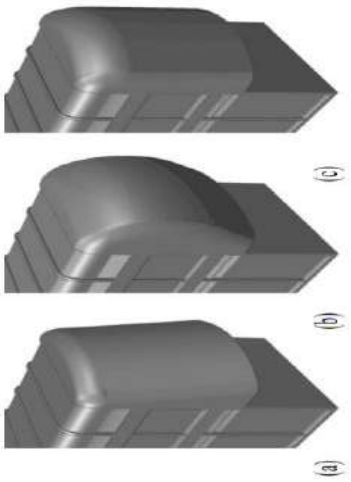

Figure 5: Curve region according to need.

IX. RESULT AND DISCUSSION

The bare trikes came in various formations shapes and sizes, and these variations allowed for the isolation of factors affecting aerodynamics and their respective efficiencies. Observations indicated that seating angle was a big factor as the leading vehicles had a far reclined position allowing for a reduced frontal area, even less than that of the vehicles tested above. Another important factor was the addition of external components, with the less successful race participants' vehicles having different components outside of the vehicle body, while the leaders of the race either removed components or enclosed them. Another interesting characteristic observed was the vehicles with a smooth flow. Although some vehicles had a small frontal area some had somewhat rough figures, where wind flow would not have a smooth path, and these vehicles were without major race success. Although their shapes were smooth, the few vehicles that had drivers heads external to the main body did not have any visor or wind deflection.

X. FUTURE SCOPE

These vehicles are going to be the future. Even today such special vehicles are designed for movement within a large institute.

INNOVATIVE DESIGN: As an HPV, there can be a lot of design of these cycles that provide versatility in them and any of them can be preferred according to the demand of work.

CHAINLESS TRANSMISSION: Many modifications like chainless assembly or idler gear transmission can be used to increase the speed and efficiency of the vehicle.

IMPROVED BRAKING: Hydraulic brakes in place of mechanical brakes can be used to increase the braking safety of the vehicle.

E-GADGETS/SENSORS: There is a lot more to think about its modification scope, as the whole idea is new and demands innovation in every aspect. Proximity sensors can be used to provide extra support to the rider while riding.

CONCLUSION

The magnitude of aerodynamic drag significantly varies with the test vehicles' physical profiles. The fairings and canopy used in this study showed a significant reduction in aerodynamic drag compared to unfaired vehicles and open faired vehicles. The seating position in an HPV plays an important role. Additionally, the reclining position further backward may provide better physical advantages for endurance as indicated by observation at a race event. As expected, component add-ons and their positions generally increase drag more at low speeds than at high speeds.

SNAPS OF A DESIGNED HPV

Figure 6: Isometric view of an HPV.

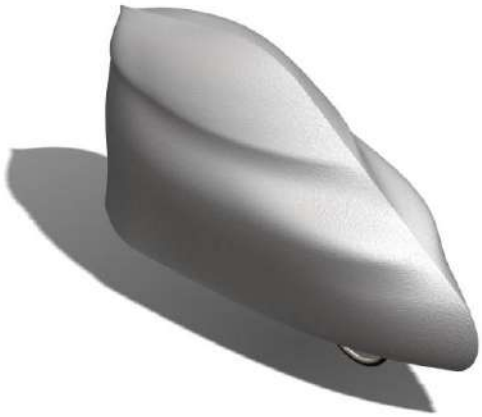

Figure 7: HPV with a fairing.

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Optimizing oxygen concentrator device for quick, surplus and emergency oxygen supply

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Abstract*— *Oxygen concentrator device uses atmospheric air content and extracts oxygen from filtering out rest of the gases. In The oxygen concentrator is an effective supply source in home oxygen-therapy (HO). Only 13 concentrators (41.9%) supplied a percentage of oxygen higher than 87% at a flow of two litres per minute. An oxygen concentrator is a device that concentrates the oxygen from a gas supply (typically ambient air) by selectively removing nitrogen to supply an oxygen-enriched product gas stream. The oxygen generation capacity, oxygen quality and overall output of machines can be improvised by incorporating another mechanism to generate oxygen chemically along with the main sequence of process in a concentrator. It can also be used as a backup feature for the device in case of any power failure or technical difficulties .

Keywords*— *Oxygen Concentrator, Catalyst, Zeolite Bed, Hydrogen Peroxide

I. INTRODUCTION

The ongoing novel coronavirus disease (COVID-19) pandemic is threatening the global human population, including in countries with resource-limited health facilities. Severe bilateral pneumonia is the main feature of severe COVID-19, and adequate ventilatory support is crucial for patient survival. Although our knowledge of the disease is still rapidly increasing, this review summarizes current guidance on the best provision of ventilatory support, with a focus on resource-limited settings. Key messages include that supplemental oxygen is a first essential step for the treatment of severe COVID-19 patients with hypoxemia and should be a primary focus in resource-limited settings where capacity for invasive ventilation is limited. Oxygen delivery can be increased by using a non-rebreathing mask and prone positioning. The presence of only hypoxemia should in general not trigger intubation because hypoxemia is often remarkably well tolerated. Patients with fatigue and at risk for exhaustion, because of respiratory distress, will require invasive ventilation. In these patients, lung protective ventilation is essential. Severe pneumonia in COVID-19 differs in some important aspects from other causes of severe pneumonia or acute respiratory distress syndrome, and limiting the positive end-expiratory pressure level on the ventilator may be important. This ventilation strategy might reduce the currently very high case fatality rate of more than 50% in invasively ventilated COVID-19.

An oxygen concentrator is a medical device that concentrates oxygen from ambient air. Atmospheric air has about 78 per cent nitrogen and 21 per cent oxygen, with other gases making up the remaining 1 per cent. The oxygen concentrator takes in this air, filters it through a sieve, releases the nitrogen back into the air, and works on the remaining oxygen.

This oxygen, compressed and dispensed through a cannula, is 90-95 per cent pure. A pressure valve in concentrators helps regulate supply, ranging from 1-10 litres per minute.

According to a 2015 report by the WHO, concentrators are designed for continuous operation and can produce oxygen 24 hours a day, 7 days a week, for up to 5 years or more.

The number of manufacturers entering the oxygen concentrator market increased exponentially as a result of this change. Union Carbide Corporation invented the molecular sieve in the 1950s which made these devices possible. It also invented the first cryogenic liquid home medical oxygen systems in the 1960s.

A. Oxygen concentrator

An oxygen concentrator has an air compressor, two cylinders filled with zeolite pellets, a pressure equalizing reservoir and valves and tubes. During the first half-cycle the first cylinder receives air from the compressor, which lasts about 3 seconds. During that time the pressure in the first cylinder rises from atmospheric to a few times normal atmospheric pressure (about 20 psi) and the zeolite becomes saturated with nitrogen. As the first cylinder reaches near pure oxygen (there are small amounts of argon, CO2, water vapour, radon and other minor atmospheric components) a valve opens and the oxygen enriched gas flows to the pressure equalizing reservoir, which connects to the patient's oxygen hose. At the end of the first half of the cycle, the air from the compressor is directed to the 2nd cylinder. Pressure in the first cylinder drops as the enriched oxygen moves into the reservoir, allowing the nitrogen to be desorbed back into gas. Part way through the second half of the cycle there is another valve position change to vent the gas in the first cylinder back into the ambient atmosphere, keeping the concentration of oxygen in the pressure equalizing reservoir from falling below about 90%. The pressure in the hose delivering oxygen from the equalizing reservoir is kept steady by a pressure reducing valve.

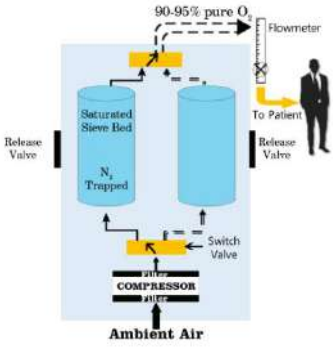


Fig. 1. *Layout of an Oxygen Concentrator*

B. Hydrogen Peroxide and Reaction

Hydrogen peroxide H2O2 is a very convenient, immediate source of oxygen for a variety of uses and at a wide scale of applications, from small household needs to larger scale oxygen generation.

The general reaction of the hydrogen peroxide decomposition results in the formation of water molecules and oxygen gas:

$$2\ H2O2 \rightarrow 2\ H2O + O2$$

In practice however, this reaction does not occur easily without a catalyst. Commercially available solutions of hydrogen peroxide (industrial, cosmetic and food grade) are always stabilized against decomposition and they contain chemicals that prevent formation of oxygen under normal conditions. This is why the solution of hydrogen peroxide can be stored for a prolonged period of time.

Fig. 2. Hydrogen Peroxide

Oxygen generation from catalytic reaction with hydrogen peroxide There is however no easier generation of oxygen gas than Catalytic Oxygen Generation method with the catalyst developed by Hydrogen Link. The catalyst is in the form of a granulate (3-5 mm), which immediately induces decomposition of hydrogen peroxide with the release of gaseous oxygen, leaving behind clean water. In order to initiate the oxygen flow, simply pour some pharmacy grade hydrogen peroxide onto the catalyst granules. The reaction ceases when H2O2 is consumed and you can simply add the next portion of the hydrogen peroxide to your container. From time to time, the excess of water can be poured out from the container, in order to make room for the upcoming hydrogen peroxide feed. The feeding can be alternatively applied dropwise or as a continuous flow feed.

Catalysts can be very efficient in the decomposition of hydrogen peroxide. It is a fast and convenient method of producing oxygen, where high flow of oxygen can be easily and safely achieved.

For domestic use Yeast present in the bread also acts as catalyst and helps in the breakdown of hydrogen peroxide. The yeast contains a special chemical called catalase that can act as a catalyst to help break down hydrogen peroxide. Catalase is present in almost all living things that are exposed to oxygen, and it helps them break down naturally occurring hydrogen peroxide.

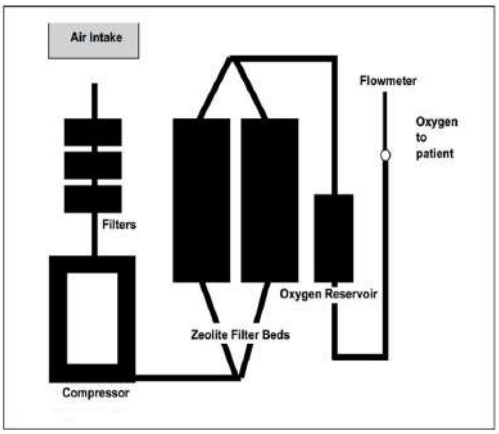
When Hydrogen Peroxide (2 H2O2) reacts with yeast it makes water (H2O) and Oxygen (O2) 2 H2O2 -> 2 H2O+O2

Fig. 3. Catalytic generation of oxygen

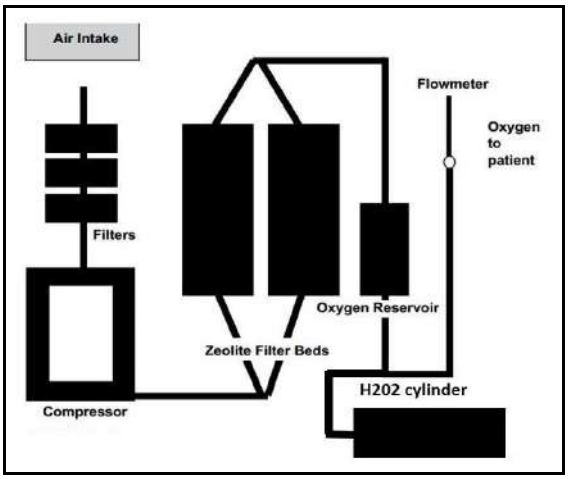
II. CHANGES IN THE APPARATUS

An oxygen concentrator has an air compressor, two cylinders filled with zeolite pellets, a pressure equalizing reservoir and valves and tubes. During the first half-cycle the first cylinder receives air from the compressor, which lasts about 3 seconds. During that time the pressure in the first cylinder rises from atmospheric to a few times normal atmospheric pressure (about 20 psi) and the zeolite becomes saturated with nitrogen. As the first cylinder reaches near pure oxygen (there are small amounts of argon, CO2, water vapour, radon and other minor atmospheric components) a valve opens and the oxygen enriched gas flows to the pressure equalizing reservoir, which connects to the patient's oxygen hose. At the end of the first half of the cycle, the air from the compressor is directed to the 2nd cylinder. Pressure in the first cylinder drops as the enriched oxygen moves into the reservoir, allowing the nitrogen to be desorbed back into gas. Part way through the second half of the cycle there is another valve position change to vent the gas in the first cylinder back into the ambient atmosphere, keeping the concentration of oxygen in the pressure equalizing reservoir from falling below about 90%. The pressure in the hose delivering oxygen from the equalizing reservoir is kept steady by a pressure reducing valve.

An additional tank with hydrogen peroxide is to be installed before the flowmeter. The cylinder will contain hydrogen peroxide (H2O2) and catalyst and the oxygen generated will be passed to the flowmeter. A second inlet will be placed for catalyst feed and to control the concentration .By this a successful rich oxygen supply can be provided to the patient without making the machine more bulky and no major modifications.



(a)



(b)

Fig. 4. Oxygen Concentrator (a) present design ; (b) modified design

III. Safety And alternate application

The recommended changes are completely safe to implement as no fumes are evolved during the breakdown of Hydrogen Peroxide. Also there is no chemical changes happening during the reaction. The By product of the reaction is also not harmful .

When Hydrogen Peroxide (2 H2O2) reacts with yeast it makes water (H2O) and Oxygen (O2) 2 H2O2 -> 2 H2O+O2

A. Coupling the cylinder to nebulizer unit

The cylinder module of hydrogen peroxide can be coupled with nebulizer unit to control and maintain the pressure and flow rate of oxygen. This device will be cheaper and can be used in emergency where quick and fresh oxygen is needed.

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"Scope of Machine Learning in Mechanical Engineering"

(Based on Machine Learning)

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ABSTRACT

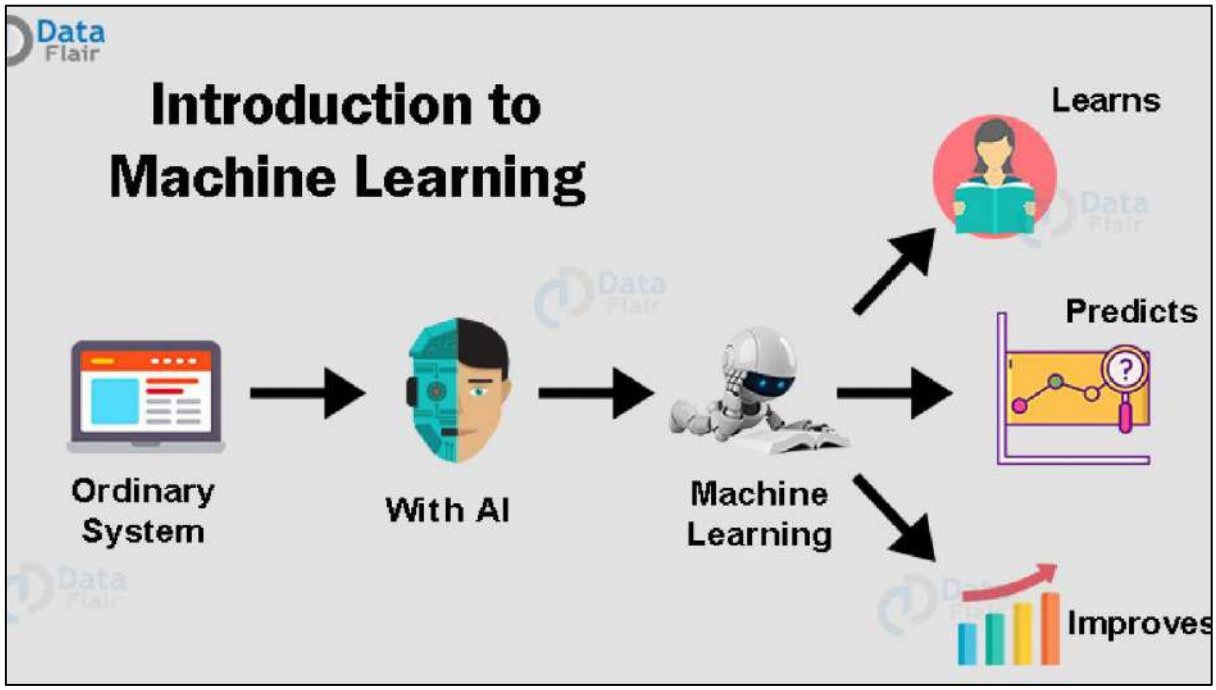
Machine learning is concerned with enabling computer programs automatically to improve their performance at some tasks through experience. Manufacturing is an area where the application of machine learning can be very fruitful. However, little has been published about the use of machine-learning techniques in the manufacturing domain. This paper evaluates several machine-learning techniques and examines applications in which they have been successfully deployed. Special attention is given to inductive learning, which is among the most mature of the machine-learning approaches currently available. Current trends and recent developments in machine-learning research are also discussed. The paper concludes with a summary of some of the key research issues in machine learning.

INTRODUCTION

Machine learning is a method of data analysis that automates analytical model building. It is a branch of artificial intelligence based on the idea that systems can learn from data, identify patterns and make decisions with minimal human intervention.

Machine learning is the science of getting computers to act without being explicitly programmed. In the past decade, machine learning has given us self-driving cars, practical speech recognition, effective web search, and a vastly improved understanding of the human genome. Machine learning is so pervasive today that you probably use it dozens of times a day without knowing it. Many researchers also think it is the best way to make progress towards human-level AI. In this class, you will learn about the most effective machine learning techniques, and gain practice implementing them and getting them to work for yourself. More importantly, you'll learn about not only the theoretical underpinnings of learning but also gain the ractical know-how needed to quickly and powerfully apply these techniques to new problems.

Today's Artificial Intelligence (AI) has far surpassed the hype of blockchain and quantum computing. This is due to the fact that huge computing resources are easily available to the common man. The developers now take advantage of this in creating new Machine Learning models and to re-train the existing models for better performance and results. The easy availability of High-Performance Computing (HPC) has resulted in a sudden increased demand for IT professionals having Machine Learning skills.



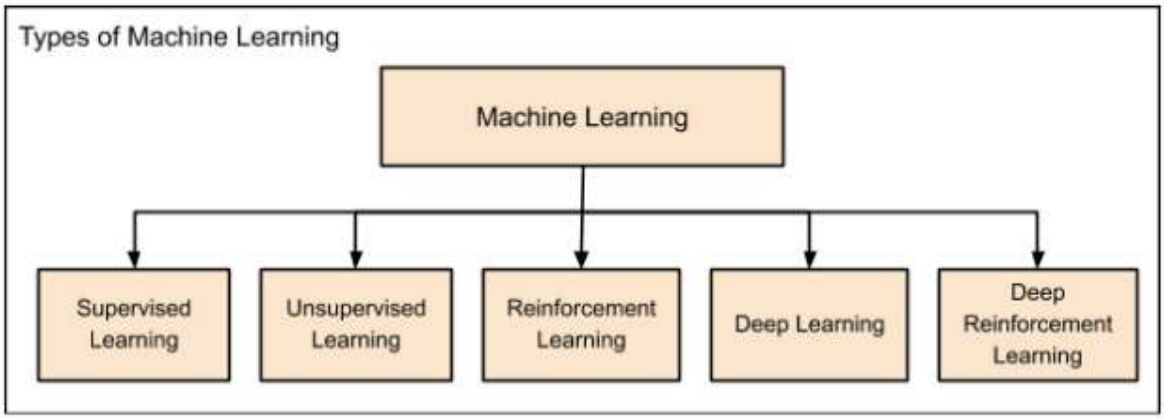
Predictive causal analytics – If you want a model that can predict the possibilities of a particular event in the future, you need to apply predictive causal analytics.

Prescriptive analytics – If you want a model that has the intelligence of taking its own decisions and the ability to modify it with dynamic parameters, you certainly need prescriptive analytics for it. This relatively new field is all about providing advice.

Machine learning for making predictions — If you have transactional data of a finance company and need to build a model to determine the future trend, then machine learning algorithms are the best bet.

Machine learning for pattern discovery — If you don't have the parameters based on which you can make predictions, then you need to find out the hidden patterns within the dataset to be able to make meaningful predictions. This is nothing but the unsupervised model as you don't have any predefined labels for grouping

Machine Learning – Categories of Machine Learning



Machine learning evolved from left to right as shown in the above diagram.

- Initially, researchers started out with Supervised Learning. This is the case of the housing price prediction discussed earlier.
- This was followed by unsupervised learning, where the machine is made to learn on its own without any supervision.
- Scientists discovered further that it may be a good idea to reward the machine when it does the job the expected way and there came Reinforcement Learning.
- Very soon, the data that is available these days has become so humongous that the conventional techniques developed so far failed to analyse the big data and provide us the predictions.

- Thus, came the deep learning where the human brain is simulated in the Artificial Neural Networks (ANN) created in our binary computers.
- The machine now learns on its own using the high computing power and huge memory resources that are available today.
- It is now observed that Deep Learning has solved many of the previously unsolvable problems.
- The technique is now further advanced by giving incentives to Deep Learning networks as awards and there finally comes Deep Reinforcement Learning.

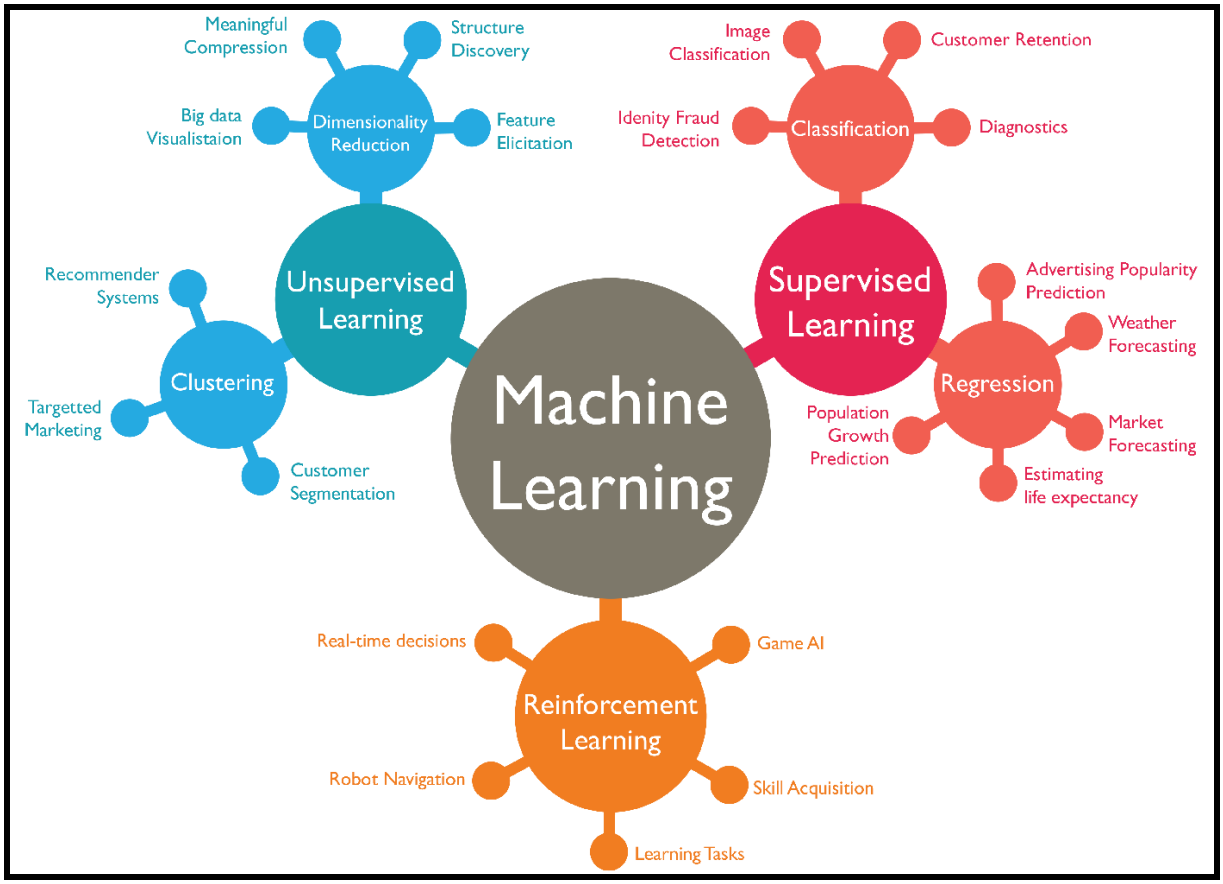
Supervised learning algorithms are trained using labelled examples, such as an input where the desired output is known. For example, a piece of equipment could have data points labelled either “F” (failed) or “R” (runs). The learning algorithm receives a set of inputs along with the corresponding correct outputs, and the algorithm learns by comparing its actual output with correct outputs to find errors. It then modifies the model accordingly. Through methods like classification, regression, prediction and gradient boosting, supervised learning uses patterns to predict the values of the label on additional unlabelled data. Supervised learning is commonly used in applications where historical data predicts likely future events. For example, it can anticipate when credit card transactions are likely to be fraudulent or which insurance customer is likely to file a claim.

Unsupervised learning is used against data that has no historical labels. The system is not told the "right answer." The algorithm must figure out what is being shown. The goal is to explore the data and find some structure within. Unsupervised learning works well on transactional data. For example, it can identify segments of customers with similar attributes who can then be treated similarly in marketing campaigns. Or it can find the main attributes that separate customer segments from each other. Popular techniques include self-organizing maps, nearest-neighbour mapping, k-means clustering and singular value decomposition. These algorithms are also used to segment text topics, recommend items and identify data outliers.

Semi supervised learning is used for the same applications as supervised learning. But it uses both labelled and unlabelled data for training – typically a small amount of labelled data with a large amount of unlabelled data (because unlabelled data is less expensive and takes less effort to acquire). This type of learning can be used with methods such as classification, regression and

prediction. Semi supervised learning is useful when the cost associated with labelling is too high to allow for a fully labelled training process. Early examples of this include identifying a person's face on a web cam.

Reinforcement learning is often used for robotics, gaming and navigation. With reinforcement learning, the algorithm discovers through trial and error which actions yield the greatest rewards. This type of learning has three primary components: the agent (the learner or decision maker), the environment (everything the agent interacts with) and actions (what the agent can do). The objective is for the agent to choose actions that maximize the expected reward over a given amount of time. The agent will reach the goal much faster by following a good policy. So the goal in reinforcement learning is to learn the best policy.



* Technique Under

Supervised Learning

- Linear Regression

  Regression analysis is a set of statistical methods used for the estimation of relationships between a dependent variable and one or more independent variables. It can be utilized to assess the strength of the relationship between variables and for modelling the future relationship between them. Regression analysis includes several variations, such as linear, multiple linear, and nonlinear. The most common models are simple linear and multiple linear. Nonlinear regression analysis is commonly used for more complicated data set in which the dependent and independent variables show a nonlinear relationship. Regression analysis- simple linear regression.

  Simple linear regression is a model that assesses the relationship between a dependent variable and an independent variable. The simple linear model is expressed using the following equation:

  $$\text{“}Y=a + bX + \varepsilon\text{”}$$

  Where:

  - Y- Dependent variable
  - X- Independent (explanatory) variable
  - a - Intercept
  - b - Slope
  - ε – Residual (Error)

- Multiple Linear Regression

  Multiple linear regression analysis is essentially similar to the simple linear model, with the exception that multiple independent variables are used in the model. The mathematical representation of multiple linear regression is:

  $$Y= a + bX_1 + cX_2 + dX_3 + \varepsilon$$

  Where:

  - Y- Dependent variable
  - X_1, X_2, X_3- Independent (explanatory) variable
  - a - Intercept
  - b, c, d - Slope
  - ε – Residual (Error)

- Logistic regression

  Logistic regression is a statistical model that in its basic form uses a logistic function to model a binary dependent variable, although many more complex extensions exist. In regression analysis, logistic regression[1] (or logit regression) is estimating the parameters of a logistic model (a form of binary regression). Mathematically, a binary logistic model has a dependent variable with two possible values, such as pass/fail which is represented by an indicator variable, where the two values are labelled "0" and "1".

  Consider a model with two predictors, x_1 and x_2, and one binary (Bernoulli) response variable Y, which we denote $p=P(Y=1)$. We assume a linear relationship between the predictor variables and the log-odds (also called logit) of the event that $Y=1$. This linear relationship can be written in the following mathematical form (where ℓ is the log-odds, b is the base of the logarithm, and βi are parameters of the model):

$$\ell = log_b \frac{p}{(1-P)} = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$

  We can recover the odds by exponentiating the log-odds:

$$\frac{p}{(1-P)} = \mathrm{b}^{\beta_0 + \beta_1 x_1 + \beta_2 x_2}$$

Unsupervised Learning

- Kmeans Algorithm

  Kmeans Algorithm is an iterative algorithm that tries to partition the dataset into Kpre-defined distinct non-overlapping subgroups (clusters) where each data point belongs to only on group. It tries to make the intra-cluster data points as similar as possible while also keeping the clusters as different (far) as possible. It assigns data points to a cluster such that the sum of the squared distance between the data points and the cluster's centroid (arithmetic mean of all the data points that belong to the cluster) is at the minimum. The less variation we have with the clusters, the more homogeneous(similar) the data points are within the same cluster.

The way kmeans algorithm works is as follows:

1. Specify number of clusters K.
2. Initiate centroids by first shuffling the dataset and then randomly selecting K data points for the centroids without replacement.
3. Keeping iterating until there is no change to the centroids. i.e assignment of data points to clusters isn't changing.

- Compute the sum of the squared distance between data points and all centroids.
- Assign each data point to the closest cluster (centroid).
- Compute the centroids for the cluster by the average of the all-data points that belongs to each cluster.

The approach kmeans follow to solve the problem is called Expectation-Maximization. The E-step is assigning the data points to the closet cluster. The M-step is computing the centroid of each cluster. Below is a break down of how we can solve it mathematically.
The objective function is:

$$J = \sum_{i=1}^{m} \sum_{k=1}^{k} W_{ik} \| x^i - \mu_k \|^2$$

Where $W_{ik}=1$ for data point xi if it belongs to cluster k, otherwise, $w_{ik} =0$. Also, μ_k is the centroid of x^i's cluster.
it's a minimization problem of two parts. We first minimize J w.r.t W_{ik} and treat μ_k fixed. Then we minimize J w.r.t μ_k and treak W_{ik} fixed. Technically speaking, we differentiate J w.r.t W_{ik} first and update cluster assignments (E-step). Then we differentiate J w.r.t μ_k and recompute the centroids after the cluster assignment from previous step (M-step). Therefore, E-step is:

$$\frac{\partial J}{\partial w_{ik}} = \sum_{i=1}^{m} \sum_{k=1}^{K} \|x^i - \mu_k\|^2$$

$$\Rightarrow w_{ik} = \begin{cases} 1 & \text{if } k = argmin_j \|x^i - \mu_j\|^2 \\ 0 & \text{otherwise.} \end{cases}$$

In other words, assign the data point x_i to the closest cluster judged by its sum of squared distance from cluster's centroid. And M-step is:

$$\frac{\partial J}{\partial \mu_k} = 2 \sum_{i=1}^{m} w_{ik}(x^i - \mu_k) = 0$$

$$\Rightarrow \mu_k = \frac{\sum_{i=1}^{m} w_{ik} x^i}{\sum_{i=1}^{m} w_{ik}}$$

Literature review

Irrespective of the industry, production systems usually comprise a selection of manufacturing processes in accordance with DIN 8580 [1] and handling operations as defined in VDI 2860 [2] (Fig. 1). In the following, exemplary ML use cases in the respective subcategories as well as cross-process applications will be given for a rough orientation on ML potentials.

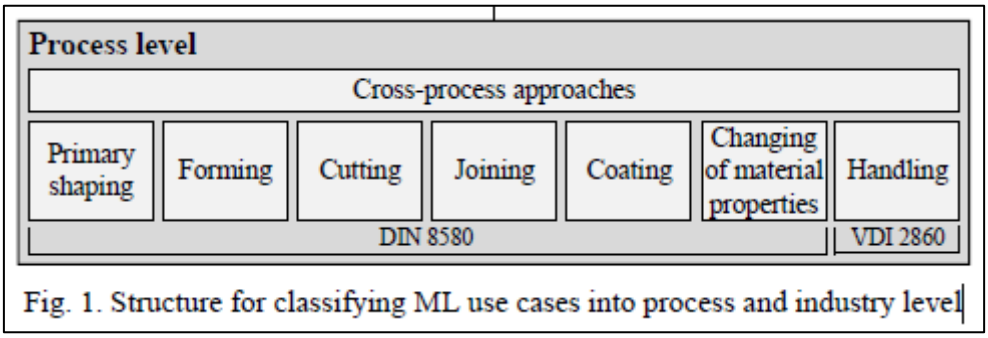


Fig. 1. Structure for classifying ML use cases into process and industry level

Primary shaping

According to DIN 8580 [1], primary shaping is the manufacturing of a solid body from shapeless material by creating cohesion. In literature, ML-based approaches can already be found for individual processes, such as casting. For instance, by evaluating process data and detecting implied correlations, Saleem et al. [3] apply ML for enabling an intelligent process control in foundries. In addition, Rössle and Kübler [4] present a ML approach for real-time quality prediction in die-casting based on process data acquired by high-resolution sensors. Although a clear allocation of additive manufacturing into the main groups of DIN 8580 is not possible, most additive pro-cesses can be assigned to primary processing [5]. By using ML, powder feedstock can be characterized by its microstructure [6]. During layer generation, the process can be monitored by evaluating acoustic emissions [7] or image data [8].

Forming

Forming represents the manufacturing through plastic change of the form of a solid body by preserving both the mass and the cohesion [1]. As with primary shaping, some ML approaches already exist. In [9], a novel approach for categorizing forming processes into multiple failure classes based on ML is presented, already showing a good prediction of the on-set of necking.

Moreover, Dib et al. [10] apply ML for defects prediction in metal forming processes. In another example, ML is used for anomaly detection in press-hardening [11].

Cutting

According to DIN 8580 [1], cutting describes processes in which a form is altered by means of reducing material cohesion. In this context, machining represents the most important subgroup, summarizing cutting processes in which layers of material are mechanically separated from a workpiece in the form of chips by means of cutting tools [1]. As summarized in [12], different ML use cases have already been implemented in machining processes, e.g., for diagnostics and prognostics of machine tools, parameter optimization or product quality prediction. For instance, Al-Zubaidi et al. [13] provide an overview of applying ANN in milling processes, focusing on the prediction of surface roughness and cutting force as well as on the estimation of tool life and wear.

Joining

As stated in DIN 8580 [1], joining is defined as bringing together two or more workpieces of geometrically defined form or such workpieces with amorphous material. Starting with the field of welding, a large number of ML approaches already exist. Petković [14] presents a supervised learning approach for quality prediction in welding processes using support vector regression. In [15], ML algorithms are applied for the classification of welds based on arc sound signals. In contrast, Khumaidi et al. [16] present a visual inspection system for the classification of welding defects based on CNN.

Coating and changing of material properties

The last two main groups of DIN 8580 [1] constitute the coating as well as the changing of material properties. While the former processes apply a firmly adhering layer of shapeless material to the surface of a workpiece, e.g., painting, the latter change the material properties within the product itself, e.g., tempering. In thermal spraying, for example, an ML-based vision system can be used to evaluate the alignment of the plasma gun nozzle using images of a test spray pattern [17]. With regard to heat treatment, Oh and Ki [18] introduce a deep learning model for predicting the hardness distribution in laser heat treatment of tool steel.

Handling

In accordance with VDI 2860, handling is a part of material flow and principally defined as the realization, defined change or temporary maintaining of a specified 3D arrangement of geometrical bodies in a reference coordinate system [19]. It can be grouped into multiple different domains, including object manipulation and insertion but also localization, inspection and support functions such as environment evaluation. So far, a lot of ML applications address the autonomous planning and optimization of trajectories for articulated robot arms as well as sensor data processing, e.g., for 6DoF pose estimation.

APPLICATION OF MACHINE LEARNING IN AUTO INDUSTRY

From parts suppliers to vehicle manufacturers, service providers to rental car companies, the automotive and related mobility industries stand to gain significantly from implementing machine learning at scale. We see the big automakers investing in proof-of-concept projects at various stages, while disruptors in the field of autonomous driving are trying to build entirely new businesses on a foundation of artificial intelligence and machine learning.

There are huge opportunities for machine learning to improve both processes and products all along the automotive value chain. But where do you focus? And how can you make sure your investments in machine learning aren't just expensive, "one-and-done" applications? We've rounded up four machine learning use cases that can be implemented using open-source technologies and offer long-term value beyond the initial application.

1. Quality Control

Image recognition and anomaly detection are types of machine learning algorithms that can quickly detect and eliminate faulty parts before they get into the vehicle manufacturing workflow. Parts manufacturers can capture images of each component as it comes off the assembly line, and automatically run those images through a machine learning model to identify any flaws. Highly-accurate anomaly detection algorithms can detect issues down to a fraction of a millimetres. Predictive analytics can be used to evaluate whether a flawed part can be reworked or needs to be scrapped. Eliminating or re-working faulty parts at this point is far less costly than discovering and having to fix them later. It saves on more expensive issues down the line in manufacturing and reduces the risk of costly recalls. It also helps ensure customer safety, satisfaction and retention.

To implement an image recognition and analytics model, the manufacturer needs an accurate dataset containing hundreds or even thousands of parts images, each one tagged with information such as pass, fail, issue A/B/C, etc. The data scientist constructing the model must also have domain expertise regarding allowable tolerances and the potential performance and safety impact of various flaws.

The same approach can be used for all component manufacturing as well as throughout the vehicle assembly line. Image recognition and analytics models can play multiple roles across the automotive value chain — such as recognizing and evaluating tiny variations in tread wear patterns to help develop new and better-performing tires, providing quality control for paint and other finishes, and enabling hazard avoidance for Advanced Driver-Assistance Systems (ADAS) and autonomous driving systems. For this reason, many organizations would realize greater value from an enterprise data science platform, rather than a point solution designed for a single use case.

2. Root Cause Analysis

When an issue arises at any point in the product lifecycle — whether it's something found early in the manufacturing process or an issue affecting multiple vehicles in the field — organizations scramble to determine the exact cause and how to resolve it. The brand's reputation (and possibly consumer safety) is at stake.

During the manufacturing phase, identifying the root cause(s) of an issue is a lengthy and painstaking process. Root cause analysis uses massive amounts of testing data, sensor measurements, manufacturer parameters and more. Performed with traditional methods, it's also incredibly hard.

Root cause analysis for issues in the field isn't any easier. Today's vehicles are highly complex, and each driver has unique behaviour, maintenance actions and driving conditions. Some issues arise only under very unique circumstances that were unseen in the manufacturing process.

Machine learning techniques can vastly accelerate root cause analysis and speed resolution. Anomaly detection algorithms can analyze vast amounts of system and driver data efficiently. And they can perform this analysis using additional data types and in far greater quantities than traditional methods can handle.

For example, during the manufacturing phase, the use of image data as an input for root cause analysis helps organizations correlate failure modes to possible flaws in the underlying manufacturing procedures.

With issues arising in the field, text recognition and Natural Language Processing enable the inclusion of service provider notes in the analysis process. Each of these approaches can reveal very specific root causes months faster than traditional analysis — and oftentimes diagnose issues that may not be uncovered any other way.

3. Predictive Maintenance

Machine learning can provide far more precise and — importantly — evolving maintenance recommendations to help drivers protect their vehicle investment as well as their safety. Rather than a static maintenance schedule that gets updated a few times a year, a predictive analytics model can continue to learn from thousands of performance data points collected from manufacturing plants, suppliers, service providers and actual vehicles on the road. The industry is well on its way to completely customized maintenance schedules that evolve over time to be increasingly more tailored to individual drivers and vehicles, and can even adapt to changing conditions and new performance information.

Predictive maintenance helps increase customer satisfaction and brand reputation, while also improving compliance with recommended maintenance. It can also be a source of additional revenue for car makers as an added-value service.

Note: The same technologies enable predictive maintenance for fleet management, saving on major repairs and protecting the ROI on each vehicle. Predictive maintenance can also help keep

manufacturing systems working at optimal performance levels — protecting yield, helping to ensure quality and safety, and ultimately saving time and money.

4. Supply Chain Optimization

Throughout the supply chain, analytical models are used to identify demand levels for different marketing strategies, sale prices, locations and many other data points. Ultimately, this predictive analysis dictates the inventory levels needed at different facilities. Data scientists constantly test different scenarios to ensure ideal inventory levels and improve brand reputation while minimizing unnecessary holding costs.

After analyzing the gap between current and predicted inventory levels, data scientists then create optimization models that help guide the exact flow of inventory from manufacturer to distribution centers and ultimately to customer-facing storefronts. Machine learning is helping parts and vehicle manufacturers — and their logistics partners — be more efficient and profitable, while enhancing customer service and brand reputation.

Staying Ahead of the Curve

The automotive sector is nothing if not competitive. Machine learning and data science are the new frontier, enabling organizations to discover and harness hidden value in their operations — and create new opportunities for growth. The open-source community is the engine of innovation across most of data science, which is why automotive executives would be wise to embrace a platform that leverages innovation from open source. Cutting-edge open-source software packages and libraries in a centrally managed, enterprise-class data science platform enable data science teams to do more than just bolt on various point solutions. They can collaborate, learn and evolve to address thousands of use cases with just one platform.

What are machine learning use cases in the automotive industry?

Innovations became an integral part of automotive development, moreover, we are already familiar with self-driving cars, real-time parking systems, and other trends in this area. But what else can we expect from active using machine learning and artificial intelligence in the automotive domain? Let's figure it out in our article on the example of seven AI&ML use cases.

QUICK NAVIGATION

- Machine learning adoption in the automotive industry
- Machine learning use cases in the automotive market
    - Design and development
    - Quality control
    - Predictive maintenance
    - Cause analysis
    - Supply chain optimization
    - Autonomous and electric vehicle optimization
    - Intelligent parking mode
    - Marketing for automakers

With self-driving cars under development, the adoption of artificial intelligence and machine learning in the auto industry is well underway. Leading car manufacturers use these technologies in their business processes from design development to the sale of a car. Let's find out what the use cases for artificial intelligence (AI) and machine learning (ML) in the automotive industry are, and what benefits automakers can get by adopting these technologies.

MACHINE LEARNING ADOPTION IN THE AUTOMOTIVE INDUSTRY

Artificial intelligence in self-driving cars is the future of the industry, while machine learning in the automotive industry is becoming more common.

- The market for AI in cars will reach $215 billion of annual value by 2025.
- AI machine-learning car installations are expected to rise by 109% by 2025.
- BMW uses artificial intelligence to create autonomous cars that are expected to be available next year.
- Tesla machine learning is used to create a very sophisticated system capable of deep learning to improve its computer vision, predicting, and route planning skills.
- Artificial intelligence and machine-learning self-driving cars are predicted to be here very soon since the recent pandemic has accelerated innovation in the auto industry because of the need for contactless delivery.

MACHINE LEARNING USE CASES IN THE AUTOMOTIVE MARKET

Below are the main artificial intelligence and machine learning use cases in the automotive industry. What's more, we outline the paths you can take to make your car manufacturing business more optimized, customer-centric, and innovative.

DESIGN AND DEVELOPMENT

The use of artificial intelligence begins at the development stage for a new car. At this stage, innovative technologies work together. With the help of augmented and virtual reality, it is possible to create a more thoughtful design concept and eliminate possible errors before they become costly.

The current level of development of artificial intelligence in cars is quite impressive. An intelligent system can suggest thousands of designs for future parts and models, and auto manufacturers can choose the best options. Volkswagen is already using this approach. It is called Generative Design and is based on a specific idea or problem that you need to address for the car's design like making it more compact without losing quality and a sense of space.

QUALITY CONTROL

Once the parts are developed, approved, and put into production, it is necessary to carefully control their quality. In the auto industry, the quality of every part is critical as it can make the difference between life and death in a critical situation. Using object recognition technologies as well as built-in comparison capabilities, sensor-based artificial intelligence assesses the quality of every part on the production line. Defective objects are immediately removed. Moreover, the artificial intelligence of Audi recognizes not only defects but also the smallest scratches so that even little things won't disappoint the future car owner.

PREDICTIVE MAINTENANCE

Predictive analytics is one of the strongest capabilities of artificial intelligence and machine learning. This is also one of the most promising ways to use machine learning in the automotive industry, which can be implemented in two ways.

1. **With predictive intelligence**, automakers can monitor the health of their equipment. The advantages of this approach are obvious because it allows for the uninterrupted operation of the parts manufacturing plant since all possible problems of maintenance, repair, and replacement of equipment are solved before they arise (reactive maintenance).
2. **The predictive ability of artificial intelligence** for cars can be used to help car owners keep their cars running. For example, the Tesla AI app notifies drivers of the need for technical inspections, oil changes, and other maintenance operations. There are even remote diagnostic capabilities.

CAUSE ANALYSIS

The essence of predictive maintenance is that the system analyzes the equipment, compares its specs with industry and safety standards, adds specific information about the operation of the enterprise, and receives a forecast about when a certain part will fail. The essence of reactive maintenance is to prevent this situation and replace a critical part before it crashes the production system. If an unforeseen situation has already happened though, this is a good reason to analyze the prerequisites and find the root cause.

Artificial intelligence and machine learning cannot live without data. These systems can analyze a huge stream of historical and current information, find anomalies and invisible patterns, and draw conclusions about what led to a certain breakdown.

SUPPLY CHAIN OPTIMIZATION

Supply chain optimization is challenging for any business, and auto production is no exception. In the case of the auto industry, its supply chain is extremely complex. This business is highly influenced by political and social factors, it's quite difficult to manage inventory, the cost of raw materials fluctuates, plus low-quality production increases product recalls. Fortunately, all these problems can be solved with AI automotive solutions.

For example, with the help of the Blue Yonder AI and ML project, it becomes possible to optimize an automotive supply chain, plus take into account the fluctuating prices of the resources and adjust the final price accordingly. What’s more, using machine learning and artificial intelligence in self-driving cars to optimize their routes will be one of the future challenges.

AUTONOMOUS AND ELECTRIC VEHICLE OPTIMIZATION

Autonomous and electric vehicles are still in the early stages so there is no established trust in them. To get these technologies adopted worldwide, especially with the pandemic and the need for autonomous delivery, machine-learning start-ups are focused on making these devices manageable, predictable, and safe. For example, the British project Spark collects driving data to better understand the strengths and weaknesses of the machine-learning-based autonomous vehicles.

INTELLIGENT PARKING MODE

Smart parking is no longer just a dream. It has become a common component of a smart city ecosystem. In response to this trend, car manufacturers are creating cars that have built-in smart parking systems that tell the driver about the presence or absence of free parking places saving him time and fuel.

To do this, automakers need strong systems for analyzing data on city traffic and driver behaviour, plus they need to equip the car with sensors and computer vision features.

MARKETING FOR AUTOMAKERS

It would be a shame to miss out on the marketing opportunities that have opened up with artificial intelligence and machine learning in the automotive industry. With its help, auto manufacturers can attract more qualified leads and competently guide them through the sales funnel taking into account the specifics of car sales.

Plus, you can dramatically improve the user experience by combining artificial intelligence for marketing with virtual reality as Porsche has already done. This company invites drivers to test the vehicle in a virtual environment before purchasing. Of course, the data on driver behaviour in the application is collected and carefully analyzed to develop marketing strategies.

Conclusion

As can be seen from the exemplary applications, ML holds great potential in production. However, missing industry-specific guidelines as well as the unstructured way of representing possible use cases prevent companies from applying ML to own production problems. Therefore, this paper provides a structured overview of various ML use cases from a process and an industry sector perspective. The process perspective mainly covers the manufacturing process groups of DIN 8580, handling operations according to VDI 2860 as well as cross-process approaches. On the industry level, exemplary ML use cases in the production of electronics, electric motors, automotive transmission components and medical devices are out-lined. Although the structured overview is anything but complete, it is already a good basis to identify own use cases from an opportunity-push perspective. However, most of the approaches mentioned are still subject of research and not yet ready for practical use or even widespread. Therefore, research on the application of ML must be further promoted and, above all, the necessary data be provided. As always, it is important to get started to avoid falling behind in the long run.

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Reconstruction and Simulation of Patient Specific Mandibular implant using Computer aided designing and 3D printing technology

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Abstract

Reconstruction of mandibular defects after trauma or tumor resection is one of the most challenging problems faced by maxillofacial surgeons. Historically, various auto grafts and alloplastic materials have been used in the reconstruction of these types of defects. The use of individualized designed biomaterials has opened new possibilities in reconstructive surgery, and now, it is possible to use the patient's computed tomography (CT) to construct patient-specific implants (PSIs). A case of a class II c mandibular bone defect and reconstruction of the defect using a customized 3D-printed titanium implant is described in the paper. Along with this the paper highlights the complete work process of creation of an implant until the Finite element simulation of the same. The treatment had excellent postoperative aesthetic and functional results without complications.

Keywords - Maxillofacial defects, Mandible, 3D printing, Biomaterials, Additive Manufacturing, Reconstruction, CAD

Introduction

Maxillofacial deformities are the deformities that occur in the oral or facial region. These deformities majorly occur in the maxilla and mandibular region. Maxillofacial deformities are embarrassing to patients and may negatively affect their physical and psychological health, potentially resulting in serious psychiatric, familial, and social problems.[1] These deformities can be congenital, caused by malformation and developmental disturbances, or acquired, caused by pathologies such as necrotizing diseases and oncosurgeries or trauma.[2]

Classification of mandibular defects

The classification of mandibular defect is based upon HCL classification by Jewer and Boyd et al. (1989)- modified by Boyd et al. (1993) [3] To classify bony mandibular defect three letters are used

- ‘H’ – (Hemi-mandibulectomy) stands for lateral segment defect ‘of any length’ including the condyle,
- ‘C’ – stands for Central defects including the ‘entire’ anterior segment (including 2 canines and 4 incisors) and,
- ‘L’ – stands for Lateral defects excluding the condyle.

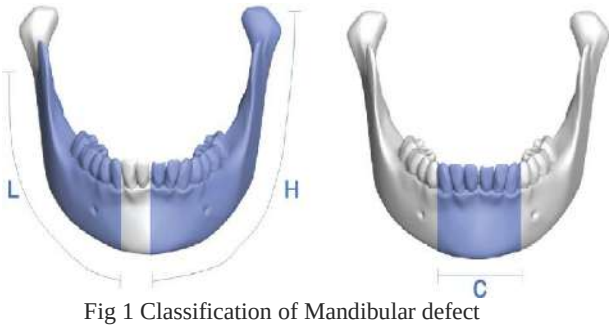

Fig 1 Classification of Mandibular defect

Maxillofacial reconstruction involves implanting artificial substitutes for intraoral and extra oral structures such as the eyes, ears, nose, maxilla, mandible, oesophagus, cranial bones, and palate.[4] Maxillofacial prostheses are primarily fabricated using acrylic resin and/or silicone, according to the facial structure of the patient. The prostheses are retained and supported by a number of structures such as osseointegrated implants,[5] the remaining skin with or without adhesive, body cavities, and teeth.[6]

Maxillofacial prostheses have an important impact on the patient’s quality of life and self-esteem, as they can immediately correct the defects that occur after surgical procedures.[5] The prostheses allow individuals to reintegrate into their social and familial environments, making them happier and more confident. In order to achieve success, it is necessary to integrate different health professionals, such as doctors, nurses, psychologists, physiotherapist, speech therapists, and dentists for prosthetic rehabilitation.

Materials and Methods

Additive Manufacturing (AM) provides extensive customisation as per the individual patient data and requirements for Medical applications. Individual patient models are in three-dimensional (3D) sections developed through customised software. These include implants, soft tissue, foreign bodies, vascular structures, etc. The medical technology aims to assist, maintain or restore a person's mobility.[7] In many cases, doctors need custom-made designs implants used for patients which are less in number and differ from patient to patient. Additive manufacturing fulfils the need and products are quickly available and produced at an economical price. The 3D printing technology has been in use more than three decades in the automobile and aeronautical industries. In the medical field, the use of this technology was limited only to 3D printing of anatomical models for educational training purposes. Only with the recent advancements in developing novel biodegradable materials has the use of 3D printing in medical and pharmaceutical fields boomed.[8] Today, additive manufacturing technology has wide applications in the clinical field and is rapidly expanding. It has revolutionized the healthcare system by customizing implants and prostheses, building biomedical models and surgical aids personalized to the patient, and bio printing tissues and living scaffolds for regenerative medicine.


Fig 2 3D printed implants

Various biomaterials are now available for the design of various prosthesis and implants. Biomaterials are natural or synthetic substances that are in contact with biological systems, and help to repair, replace, or augment any tissue or organ of the body for any period of time. An ideal 3D printing biomaterial should be biocompatible, easily printable with tuneable degradation rates, and morphologically mimic living tissue. The majority of biomaterials used in current medical 3D printing technology, such as metals, ceramics, hard polymers, and composites, are stiff, and thus widely used for orthodontic applications.[9] Soft polymers, including hydrogels, are widely used in bio printing cells for tissue/organ fabrication. The hydrogel microenvironment mimics the extracellular matrix of a living tissue, and thus, cells are easily accommodated. The materials used to fabricate maxillofacial prostheses include vinyl plastisol, acrylic resins based on polymethyl methacrylate (PMMA), titanium alloys (Ti6Al4V), polyurethanes, latex, and silicone polymers[10], [11]. Silicones and acrylic resins are the most used materials for maxillofacial reconstruction.[10], [11]

Case Description

A patient[1] with a Class II c defect was selected for the purpose of the research. The patient has a broken bone in the body and ramus region of the right side of the mandible. The overall length of the defect is estimated to be 37.8 mm.

Fig 3 Defected Mandibula (Cad Model)

Process Workflow

Data Acquisition - The CT[2] scans of the patient were taken to find out the extent of bone loss in the mandible region. The CT scans are available as a large number of DiCom dataset each representing a different layer. A 3D Stl mesh file was then generated from the DiCom dataset using Meshmixer software. The geometry is then cleaned up to be used in CAD software for further processing.

Creation of Implant - The cleaned up geometry is then imported in Cad software (Solidworks) for processing. The property that the right and left side mandible is almost identical for perfect shape, is used for creation of an implant. The mid plane technology is used to create a mirror image of the left mandible. This mirror image is then used to extract the implant region from the body. This Implant is further edited to allow an easy and proper implant assembly using the medical screws or any other technique.

Finite element simulation - The finite element method is used to study the effect of force on the implant assembled in the mandible. A transient structural analysis has been carried out upon the implant to find the stress and strain on the implant region. The various bite forces and occlusion forces have been considered.

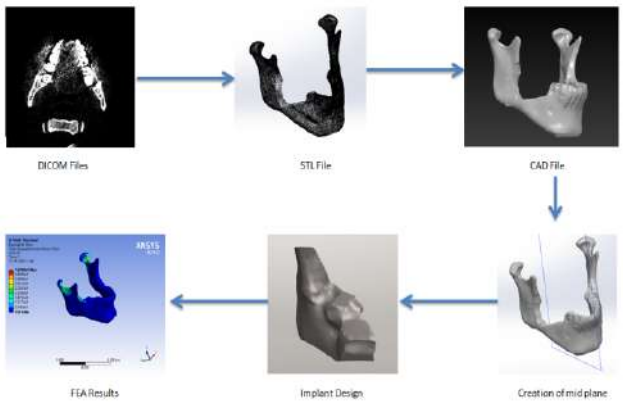

Fig 4 Process Workflow

[1] Fictitious case

[2] Computed Tomography

Results

The design of implant is carried out by conversion of the Stl mesh file to an editable CAD file which is processed in Solidworks. The implant made has an overall Volume of 9269.17 mm^3 and a Surface Area of 3126 mm^2. The implant is made using mid plane, that is used to construct a mirror image of the half jaw and then the implant area is extracted.

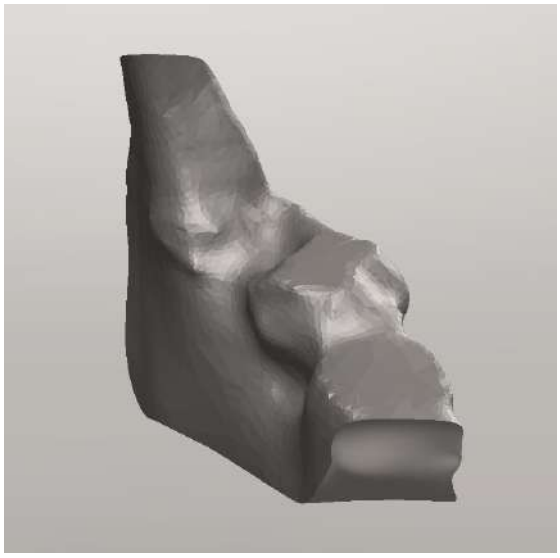

Fig 5 Implant Design

The finite element simulation of the constructed implant is carried out in the transient structural module of Ansys Workbench. The complete assembly of the implant as well as the defected jaw is simulated.

Mass of Implant	41.71 g
Mass of Mandible bone	138.417 g
Total mass	180.127 g

The mesh constructed is made up of tetrahedral elements.

Nodes	311527
Elements	181958

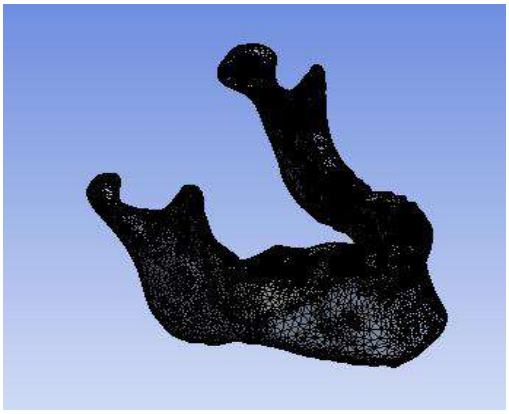

Fig 6 Mesh on the part

The material of the implant was chosen as Titanium alloy (Ti6Al4V). The material properties of both the implant as well as the bone of mandible are listed below.

Calcium Phosphate (Mandible Bone)	
Density	1900 kg/m^3
Young's Modulus	1.34 e+10 Pa
Poisson Ratio	0.222
Bulk Modulus	8.033 e+9 Pa
Shear Modulus	5.482 e+9 Pa

Ti6Al4V (Implant)	
Density	4500 kg/m^3
Young's Modulus	1.1 e+11 Pa
Poisson Ratio	0.33
Bulk Modulus	1.078 e+11 Pa
Shear Modulus	4.135 e+10 Pa

The forces that are applied upon a mandible include the bite force as well as the occlusion force.[12]

Occlusion Force	
Incisors	22 ± 11 N
Premolars	52.5 ± 13.5 N
Molars	131.5 ± 24.5 N
Bite Force	
Incisors	183.48 ± 14.71 N
Premolars	392.07 ± 31.43 N
Molars	601.83 ± 60.80 N

The stress strain contour is then plotted using the stimulation data.

Part	Maximum Stress (MPa)	Minimum Stress (MPa)
Mandible Bone	5.0269 e+03	0.0918
Implant	1.8115 e+03	6.623

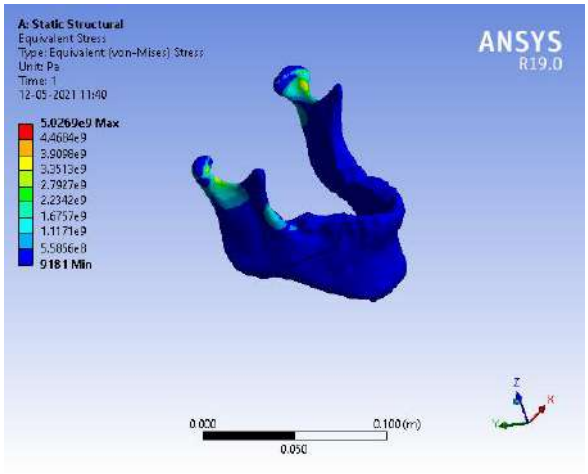

Fig 7 Stress Contour

Part	Maximum Strain (m/m)	Minimum Strain (m/m)
Mandible Bone	0.4769	1.2548 e-06
Implant	1.781e-02	6.688e-05

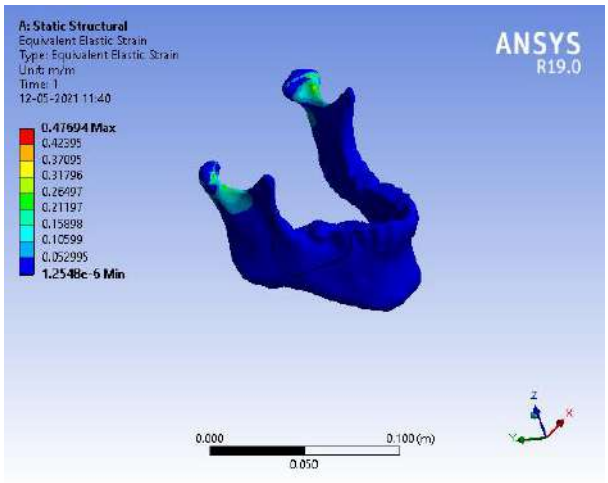

Fig 8 Strain Contour

Conclusion

The titanium implants are easily customizable, easily workable especially with the help of 3d virtual planning techniques, bio inert and non-porous; they represent an ideal alloplastic material for mandibular reconstruction.

Also various other biomaterials are been researched upon that could be easily worked upon using 3D technologies and can be available for use in upcoming years. Moreover metal implants like titanium implants also provide a scope for topology optimization reducing the weight and cost of the implant.

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Design and Fabrication of Regenerative Braking System

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Abstract— **As in today's world, where there are energy crises and therefore the resources are depleting at a better rate, there is a requirement of specific technology that recovers the energy which gets usually wasted. So, just in case of automobiles one among these useful technologies is "The Regenerative Braking" system. Regenerative braking is an energy recovery mechanism that slows a vehicle or object by converting its Kinetic Energy into a form which will be either used immediately or stored until needed. Using regenerative braking system in automobiles enables us to recover the K.E. of the vehicle to some extent that is lost during the braking process. The converted K.E. is stored for future use or is fed back to the facility system of the vehicle. This energy is often stored during a battery or bank of capacitors for later use. Energy also can be stored with the assistance of a rotating flywheel which is one among the foremost inexpensive and effective method of storing and regenerating power. The present invention provides energy-storing regenerative braking system by transmitting the flywheel force as a torque tending to oppose the forward rotation of a wheel on applying the brakes.**

When riding a vehicle, a great amount of kinetic energy is lost when braking, making start up strenuous. The goal of our project was to develop a product that stores the energy, which is normally lost during braking, and reuses it to help propel the rider when starting. This was accomplished with a generator fitted with rubber wheel whose parameter were optimized based on engineering, consumer preference, and manufacturing models. The resulting product is one which is practically and potentially very profitable in the marketplace.

In this project we use the heat energy in lightening the LED which is lost in applying the brakes. After applying brake on the wheel, the kinetic energy of the wheel is transferred to the rubber wheel attached to the generator which is then transformed in the electrical energy. This electrical energy is used to light the LED. We can also use this energy for other purposes by storing in the batteries.

Keywords—Regenerative braking, Kinetic Energy, Capacitors, Flywheel, Propel, Generator, LED

I. INTRODUCTION

A Regenerative Brake, is an energy recovery mechanism which slows a vehicle or object down by converting its kinetic energy into another form, which can be either used immediately or stored until needed.

These kinds of brake allow batteries to be used for longer periods of time without the need to be plugged into an external charger. These types of brakes extend the range of fully electric vehicles. The energy efficiency of a conventional brake is only about 20 percent, with the remaining 80 percent of its energy being converted to heat through friction. Regenerative braking could reclaim as much as half of that wasted energy, which equates into more motion produced by the fuel we are paying for instead of using that fuel to create heat that is being dissipated inoperative into the environment.

Regenerative braking is a braking method that utilizes the mechanical energy from the motor by converting kinetic energy into electrical energy and fed back into the battery source. Theoretically, the regenerative braking system can convert a good fraction of its kinetic energy to charge up the battery, using the same principle as an alternator.

II. WORKING PRINCIPLE

Regenerative Braking system works on the principle of Law of Conservation of Energy.

"It states that the total energy of an isolated system remains constant. It is said to be conserved over time. Energy can neither be created nor destroyed - only converted from one form to another."

Regenerative braking is a braking method that utilizes the mechanical energy from the motor by converting kinetic energy into electrical energy and fed back into the battery source. Theoretically, the regenerative braking system can convert a good fraction of its kinetic energy to charge up the battery, using the same principle as an alternator.

Regenerative Braking system is the way of slowing vehicle by using motor as a brake. Instead of the surplus energy of a

vehicle being wasted as unwanted heat, the motor act as a generator and return some of it to the overhead wires as electricity.

In regenerative braking mode, it uses the motor to slow down the car. When the driver applies force to the brake pedal then the electric motor works in reverse direction thus slowing the car. While running backwards, the motor acts as the generator and recharge the batteries.

III. MECHANISM

Our project is working with the help of AC motor.AC motor drive wheel shaft and on other side we have an alternator which is also attached with wheel shaft. On other side of alternator, we have DC gear motor which is attached with wheel shaft. In this arrangement we have shifter, which help to move our system on AC motor to DC gear motor for breaking (when brake applied AC motor's power get off automatically).

When AC motor move, it rotates wheel shaft and wheel shaft rotate alternator and alternator charge battery. When we want to apply brake, we have to lever down the shifter from AC to DC gear. DC gear motor applies force on the shaft for stopping the system. Simultaneously DC motor move and produce energy for our system.

In this way we can charge the battery form the braking of the vehicle.

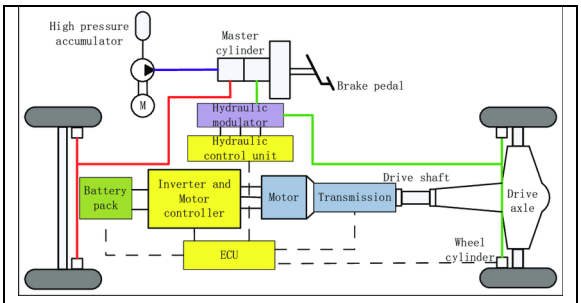

Figure 1-Structure of single axle series regenerative braking system

IV. COMPONENTS

- DC Gear Motor (Dynamo)
- Alternator
- AC Motor
- Two Wheel
- Shaft (approx 700mm)
- Pully
- Pully Bolt
- Fix Baring
- Shifter Rode
- Shifter Circuit (in between AC motor and Dynamo)
- Battery 12V, 4.5 AMP
- Iron Frame

V. ADVANTAGES

- Increases the overall energy efficiency of a vehicle.
- Better Performance.
- Reduced Brake Wear– Cutting down the replacement brake linings cost, the cost of labour for installation.
- Reduced wear and tear of Engines.
- Reduced emissions–Cuts down on pollution related to power generation.
- Cuts down on pollution related to supply generation.

VI. DISADVANTAGES

- Added Weight-Extra components can increase weight.
- Complexity-depends on control necessary for operation of regenerative braking system.
- Cost of components, engineering, manufacturing, and installation is high.
- Friction brakes are still necessary.
- Added maintenance requirements depend on the complexity of design.

VII. CONCLUSION

The regenerative braking system used in the vehicles satisfies the purpose of saving a part of the energy lost during braking. The regenerative braking system is designed to partially recover the battery charge wasted in braking of the vehicle. The energy is converted into heat by friction brakes which are dissipated to the environment. This Energy is utilized to rotate the rotor of generator converting mechanical energy of wheels into useful charge of battery. The regenerative braking system cannot be used as main braking system of vehicle as it cannot bring the vehicle to rest.

ACKNOWLEDGMENT

Authors would like to thank our respective professors under whose guidance this research was accomplished.

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PROJECT VASU: A WIND-SOLAR HYBRID

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***ABSTRACT*-Project VaSu is a vision through which we aim to maximize the use and implementation of renewable energy resources and non-conventional energy resources. The name VaSu is a hybrid name of the names "Vayu" (Wind) and "Surya" (Sun) thus projecting and highlighting the purpose ofthis project. Moreover the name Vasu, in Hinduism is referred as the deities of Lord Indra and the name Vasu reflects the meaning of "Brilliance", thus embarking the approach and results of our project. We aim to implement a Savonius vertical axis wind turbine all across various hotspotsof our city (as of now, which we also aim to expand further) where we can experience high speed winds for e.g: running traffic roads and highways, railway tracks, open farms, huge open terraces, etc. Moreover we have attached a Automatic Solar Panel just above the windmill which will follow thedirection of the sun in order to concentrate maximum solar power onto the solar panels.**

We direct towards a low-cost approach to build our project so that we can achieve a good return-on-investment (RoI) without hampering with any safety or quality issue.

By this hybridization of mechanical and electronics studies, we focus on harvesting energy in any way possible so that it can help the growing energy needs of our nation

Keywords: Windmill, Solar, VAWT, Design

I. INTRODUCTION

Wind energy is one of the non-conventional forms of energy and it is available in affluence. Electricity can be generated with the help of vertical axis wind turbine. This projects aims of utilizing this wind energy in most effective manner to get the maximum electric output, and therefore we selected highway as our installation site where we can take the advantage of the moving vehicles on both the sides of the road.

The use of wind power mills goes way back to the 9th century in Afghan and Persian region where Panemone Windmills were used to draw water. It was the first horizontal axis windmill to be found in existence.

The first windmill manufactured in the United States was designed by **Daniel Halladay**, who began inventing windmills in 1854 in his Connecticut machine shop.

The **Grafelijke Korenmolen van Zeddam** is a tower mill in Zeddam, the Netherlands. The mill may have been built before 1441, making it the oldest windmill in existence in the Netherlands.

The first windmill in Africa was made by **William Kamkwamba**. William, from Malawi, is a born inventor. When he was 14, he built an electricity-producing windmill from spare parts and scrap, working from rough plans he found in a library book called Using Energy and modifying them to fit his needs.

The Darrieus **VAWT** was invented in 1931 by a French engineer named George Jeans Marie Darrieus [4]. In the patent he proposed, there were two kinds of rotors included both the "curved blade"and "straight-bladed." Usually, the wind turbine with curved blade is just called as Darrieus **VAWT**.

In the present work, turbine is design and fabricated as per the specifications, the blades used are semi-circular shape and are connected to the disc which is connected to shaft. Shaft is then coupled with pulley with the help of bearing, and then pulley is connected to the alternator, which generates the power. The power developed is stored in battery and then can be used for street light, signal or toll.

In this project a small model has been created for testing purpose. This project also aims for maximum output with minimum cost indulges, so that the government can think over this project and can implement this type of vertical axis wind turbine on highways at low cost.

Moreover we have also attached an automatic solar tracking panel on the top of our windmill. Trackers direct solar panels or modules toward the sun. These devices change their orientation throughout the day to follow the sun's path to maximize energy capture.

II. TYPES OF VERTICAL AXIS WIND TURBINES (VAWTs):

The two main types of Vertical Axis Wind Turbines are:

1. **SAVONIUS** wind turbine: Savonius wind turbine which firstly developed by Sigurd J. Savonius in 1922 is a drag type turbine that is relatively suitable for low wind speed. The advantages of the Savonius type wind turbine are to receive wind from all directions, easy and inexpensive in its manufacture, and can rotate at a fairly low angular velocity. The Savonius wind turbine has great initial torque at low wind speeds.

2. **DARRIEUS** Wind Turbine: Darrieus wind rotor is a vertical axis wind turbine that is a very promising kind of wind converters at remote and domestic locations that have soft and weak wind potential and speed. This design of the turbine was patented by Georges Jean Marie Darrieus, a French aeronautical engineer; filing for the patent was October 1926

III. WINDMILLS IN INDIA:

the country currently ranks fourth in the world in wind power generation after China, the US and Germany.

India experienced its highest-ever wind capacity addition of 5.5 gigawatts (GW) in 2016-2017, and the South Asian nation plans to achieve 60GW of power from wind by 2022.

Wind energy currently accounts for about 10% of India's total installed electricity generation capacity.

The Government of India is offering various fiscal and financial incentives to promote wind power projects across the country via private sector investment. Through the National Institute of Wind Energy (NIWE), the government has installed more than 800 wind monitoring stations.

NS Energy profiles the top five wind farms in India:

1. **Muppandal Wind Farm**- Capacity: **1,500MW**
2. **Jaisalmer Wind Park**- Capacity: **1,064MW**
3. **Brahmanvel Wind Farm**- Capacity: **528MW**
4. **Dhalgaon Wind Farm**- Capacity: **278MW**
5. Vankusawade Wind Park: 259MW

IV. METHODOLOGY:

The components to be used in the project are:

1. Blades
2. Shaft
3. Pulley
4. Dynamo Mini-Generator
5. Solar Panel
6. Bearings
7. Battery

1. ***BLADES***: The blade is designed in semicircular shape so as one blade passes another blade comes in the position of first. Wind turbine blades have on aero foil – type cross section and a variable pitch.

2. ***SHAFT:*** While designing the shaft it should be properly fitted to blade. The shaft diameter should be selected in order that it should be fitted on the disk. The shaft material is G.I Steel and it should be aligned in a way so that it can sustain the forces acting on it and can rotate easily.

3. ***PULLEY:*** There are 2 pulley used one big pulley and one short. Big pulley is attached to the shaft and lower pulley is attached to the dynamo mini-generator. Both the pulleys are attached with the help of a belt. This pulley increases the rotational

Wind power is one of the key renewable energy sources for electricity generation in India. With 37.5GW of capacity installed,

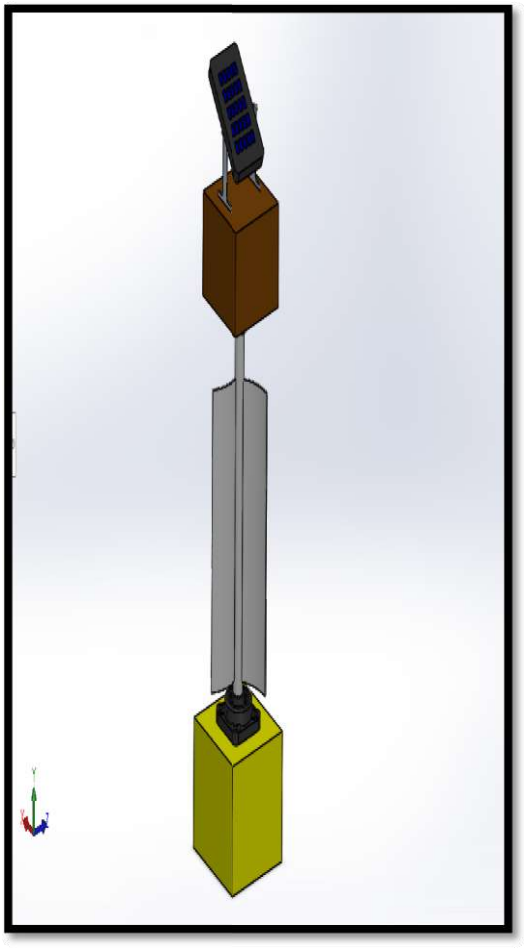
speed of the turbine.

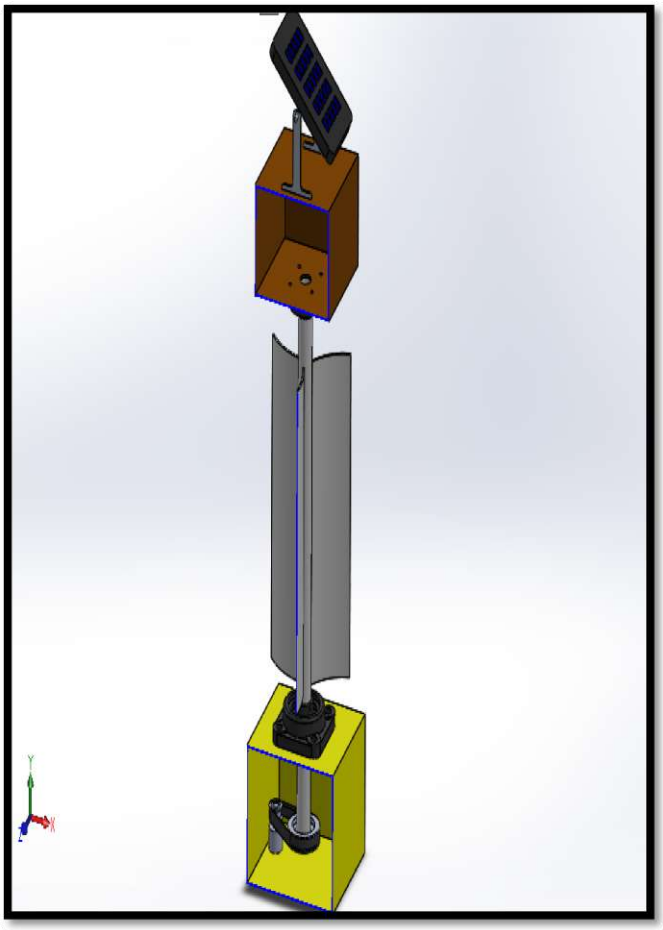
4. ***DYNAMO MINI-GENERATOR:*** The dynamo mini-generators convert mechanical rotation into electric power. When the shaft is rotated by the movem nt of blades, it rotates the pulleyand causes rotation in our generator. By the virtue of electromagnetism, we convert the rotational power into electrical power and the generated electricity is stored in the battery. It is belt-driven.

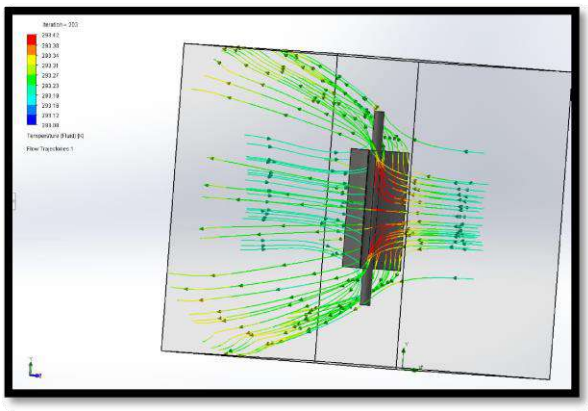
5. ***SOLAR PANEL:*** A Solar PV module is an assembly of photo-voltaic cells mounted in a framework for installation. Photo-voltaic cells use sunlight as a source of energy and generate direct current electricity. A collection of PV modules is called a PV Panel, and a system of Panels is an Array. Arrays of a photovoltaicsystem supply solar electricity to electrical equipment.

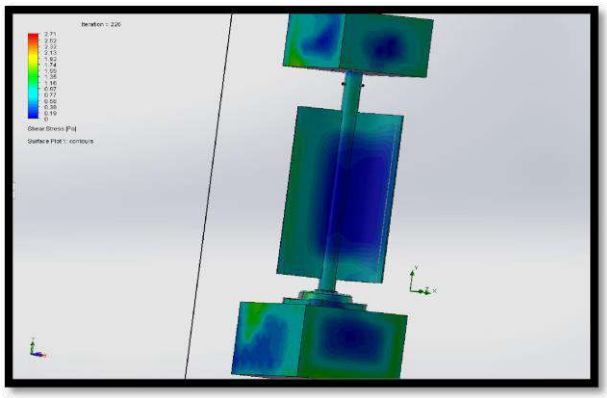
6. ***BEARINGS:*** For the smooth operation of Shaft, bearingmechanism is used. Bearing are generally provided for supportingthe shaft and smooth operation of shaft. For the ease of performance, we have used flange Ball bearing.

7. ***BATTERY:*** A 1Ah battery is used to store the energy produced by the dynamo. This battery can also be used to store theelectricity produced by the fitted solar panel.









V. ANALYTICAL STUDY:

In the analytical study, we studied our model's and blades' potential to withstand real life situations. Our approach in the analysis included the following:

VI. **Temperature** Gradient (by considering room temperature).

VII. **Pressure** Gradient (by considering atmospheric pressure)

VIII. **Velocity** Gradient, for the following wind speeds:

a. **7m/s** (Moderate speed)

b. **14m/s** (High speed)

c. **21m/s** (Extremely high speed, thunderous)

d. **Shear Stress** Gradient

VI. THE AUTOMATIC SOLAR PANEL

In Project VaSu, we have used an automatic solar panel, in which our solar panel will follow the sun's direction east to west and keep its face normal to the sun throughout the day. It helps concentrate maximum energy dissipated by the sun. This is done by the use of motor drivers, photo-sensors and a very intelligent microcontroller board famously known as Arduino Uno..

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in fuctions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards.

Source: Wikipedia

Arduino has some sound advantages, such as large user community, free and broad ranges of libraries of codes, relatively low cost components, and so forth. Its disadvantages are that; its small and user has to work in a relatively small (rather tiny) space.

Source: Researchgate

VII. DESIGN STUDY CALCULATIONS:

Examining our design, certain things are noted:

1. Shaft diameter: 50mm
2. Blade angle: 20 degrees (π/9 radians)
3. Total length of the model: 5 ft
4. Total length of the blade: 2ft
5. Tip Speed Ratio: 0.6
6. Diameter of windmill: 350mm
7. Breadth of blade: 150mm

On further calculations, we observed:

Diameter: 350mm

Height: 2ft

Wind speed: 21m/s (for calculation)

Turbine losses: 30%

Wake losses: 5%

Results:

Available wind power: 2.978 kW

Output power before losses: 0.849 kW

Expected efficiency: 25.82%

Source: Omni Wind turbine calculator

Note: Real calculations might differ, this is a theoretical approach, and therefore it stands a chance to be incorrect.

VIII. RESEARCH & DEVELOPMENT (R&D)

The R&D prospects related to this project are:

1. Expanding the blade size while reducing the shaft diameter to grasp maximum wind energy.
2. To use a single bearing to reduce unnecessary loads.
3. To use a simple board made by the virtue of cheap and useful parts (breadboard, etc.) instead of using an Arduino Uno board (as its not made specifically for this purpose, hence it's expensive).
4. To try making the parts from recycled plastic to encourage the idea of waste management.
5. To market portable sized windmills so that it can be easily installed in Residential complexes.

IX. CONCLUSION:

This paper has presented the synopsis of our Major Project, i.e. Project VaSu (Wind-Solar Hybrid). It has shown all the required information about the introduction, objective, plan, advantages and application of the project. Renewable Energy is the future and major advancements in this field of energy are required to meet thedaily high-rising energy needs of our society. This concept can increase the efficiency of our energy thus helping in increasing productivity in the industrial sector and our main motive is to ease the energy input in the renewable sector (wind and solar energy).

X. ACKNOWLEDGEMENT

We would like to extend an immense gratitude towards the staff of our college **Dr. Akhilesh Das Gupta Institute of Technology & Management** for providing us an opportunity to put forward our vision of Project VaSu in the form of our Major Project. We would like to appreciate the immense support provided by our **honorable HOD Sir** and other faculty members who are always there to guide us and help us in the time of need. We would like to extend our sincere gratitude to Mr. **Yashpal** for guiding us in our project.

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Economic Analysis of a Commercial Hydroponic System

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***Abstract*— Hydroponic gardening is a method of growing plants without soil using only mineral nutrient solutions in water. Terrestrial plants may be grown with only their roots exposed to the nutritious liquid, or, in addition, the roots may be physically supported by an inert medium such as perlite, gravel, or other substrates. In the present work, we look at the financial feasibility of a hydroponic plant system.**

Keywords— hydroponics, gardening, farming, break-even analysis.

I. INTRODUCTION

Hydroponics is a technique of gardening, whereby instead of using soil as a medium, plant roots are suspended directly in a nutrition rich solution [1]. The main advantages of this method are [2]:

- Uses as low as 10% of the water used in traditional farming.
- Does not require insecticides and pesticides as it is completely indoor.
- Crop is healthier as it interacts directly with nutrients.
- Yield quality is good due to non-usage of chemicals and minute control over parameters like temperature, humidity, pH of medium, nutrient density etc.
- Gives up to 10-20 times more yield than traditional farming due to multiple level farming.
- A crop can be grown round the year without worrying about seasonal variation.

However, this method also has some down sides:

- Major downside is its high upfront and maintenance cost.
- It is compatible with very few crop types, like tomatoes, strawberries, lettuce, spinach, etc.
- It requires a skilled workforce for proper operation.
- It requires rigorous monitoring, round the clock, unlike traditional farming.

II. REQUIREMENT ANALYSIS FOR GROWTH PIPE AND TOWER

For the sake of calculation, certain assumptions are needed to be made. First of all, we start with the growth tube. Each growth tube is 1m long square PVC pipe, with sides of 5cm. Each such tube can accommodate 10 seedlings placed at adequate distance of 6 cm as shown in Fig 1.

Secondly, we need to build a growth tower, to accommodate these tubes. A one meter long platform can accommodate 20 growth tubes, placed side by side. For the ceiling height of 3.657 m, we can stack 6 such platforms at the gap of 3.175 cm. The growth tower is shown in Fig. 2.

From the above assumptions, we can calculate plants per unit area. One platform is of area 1 m^2. Hence, with 6 platforms stacked, we can grow 1200 plants per m^2. Supposing, we leave 25% of the area empty for human interaction, we get 180,000 plants in our warehouse.

To accommodate these plants, we need 18,000 m^2 PVC pipes and to accommodate these pipes, we need to build 150 stands. To build each tower, 50 m (with reasonable tolerances) of aluminum pipes with a diameter of 25mm is required. Hence, we need a total of 7,500 m pipe.

Other, than basic infrastructure, we would need other equipment like reservoir tub for nutrient solution, air conditioning, dehumidifier, LED panels for artificial lighting, drainage pipes, nutrient concentrates (Mixture A and Mixture B), acid solution for regulating pH, and TDS, pH, and conductivity measuring devices [3].

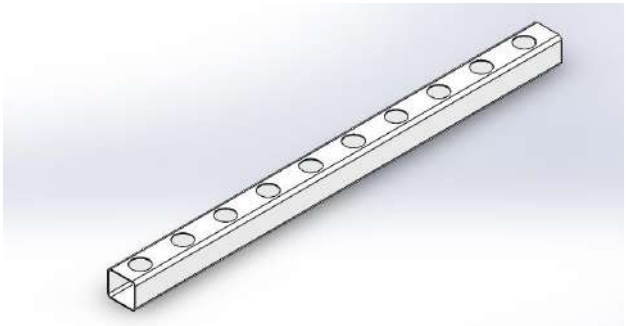

Fig. 1 PVC growth pipe

Fig. 2 Growth tower

III. Cost Analysis

A. Fixed Cost Analysis

Fixed cost comprises goods and installations that need to be purchased only once. For example, warehouse, air conditioning, towers, growth tubes etc. [4]. The major fixed costs expenses have been shown in table 1. The estimated fixed cost for setting up the system is around 2.5 crores (INR) approximately.

Table 1 Fixed Expense

S.No.	Product	Rate	Quantity	Price (INR)
1	Warehouse		300 sq m	2cr. *
2	Air Conditioner (2 ton)	50k/piece	4 no.	2 lakhs
3	Square PVC pipes	10/meter	1800 m	18 k
4	Aluminum pipes	250/meter	7500	18.75 lakhs
5	LED panels	100/sq m	900	90 k
6	Dehumidifier system (500 litre)	5 lakhs*	1	5 lakhs*
7	Other misc. costs			25 lakhs

(means estimated figure)*

B. Periodic Cost Analysis

Periodic cost refers to expenses that occur on a periodic basis. For example, electricity bills, water bills, salaries, etc. Some of the periodic expenses are listed below in the table 2. The monthly expense of the system is around 6 lakhs (INR) approximately.

Table 2 Periodic Expenses

S. No.	Commodity	Cost	Period	Cost per month
1	Electricity (5000 units approx)	40k	1 month	40k
2	Water (400 kl)	48k	1 month	48k
3	Nutrients	5k*	1 month	5k
4	Other Misc.		1 month	5 lakhs

IV. Revenue Analysis

Crops like lettuce, basil, and cherry tomatoes are some of the most profitable crops in hydroponics. Let us consider lettuce for our farm for its ease of growth [5]. It has a crop cycle of around 8 weeks and can easily sell for Rs 150-350 per kg (INR). Each plant yields around 200g-250g of lettuce.

We have 180,000 plants in our plant. Let us assume a success rate of 80%. This leaves us with minimum revenue of 43.50 lakhs per crop cycle.

- Yield = 29,000 kg
- Selling Price (Lower limit) = 150 per kg
- Revenue = 43.50 lakhs
- Crop Cycle = 6-8 weeks ≈ 2 months
- Monthly Revenue = 21.75 lakhs (INR)

V. Cost Recovery Analsis

Cost recovery period, is defined as the period in which, the profit obtained pays up for the initial investments.

- Initial investment i.e. Fixed Cost = 2.5 crore
- Monthly expenses = 6 lakhs
- Monthly Profit = 15.75 lakhs
- Payback period = 41.67 month ≈ 42 months = 3.5 years

Hence, the entire system would pay for itself in less than 3.5 years.

VI. Conclusions

Hydroponics is referred to as the agriculture of the future for a reason. It consumes 10th of water as compared to traditional farming, gives better yield and most importantly is highly profitable [6].

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CLOUD COMPUTING

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***Abstract*— Cloud computing is a rapidly developing and excellent promising technology. It has aroused the concern of the computer society of whole world. Cloud computing is Internet-based computing, whereby shared information, resources, and software, are provided to terminals and portable devices on-demand, like the energy grid. Cloud computing is the product of the combination of grid computing, distributed computing, parallel computing, and ubiquitous computing. It aims to build and forecast sophisticated service environment with powerful computing capabilities through an array of relatively low-cost computing entity, and using the advanced deployment models like SaaS (Software as a Service), PaaS (Platform as a Service), IaaS (Infrastructure as a Service),HaaS (Hardware as a Service) to distribute the powerful computing capacity to end-users. This paper will explore the background and service models and also presents the existing research issues and implications in cloud computing such as security, reliability, privacy, and so on**

I. INTRODUCTION

Cloud computing is not a new concept; it is originated from the earlier large-scale distributed computing technology. However, it will be a subversion technology and cloud computing will be the rapid revolution in the Computer Science and Information Technology field. Which represent the development trend in the IT industry from hardware to software, software to services, and distributed service to centralized service. Cloud computing is also a new mode of business computing is virtualization. It will be widely used in the near future. The core concept of cloud computing is reducing the processing burden on the users. Eventually users use a wide variety of devices, including PCs, Laptops, Smart Phones, and PDAs to access different kinds of utility programs, storage, and application development platforms over the Internet. All these services offered by cloud computing providers. An advantage of the cloud computing technology includes cost savings, high availability, and easy scalability. However, still there exist many problems in cloud computing today, the current researchers or practitioners pointing that data security and privacy risks have become the primary concern for people to transfer or migrate to cloud computing.

II. DEFINITION

"Cloud" is a virtualized pool of computing reusable resources. It can: o Control or customizing a variety of different workloads. o Batch update of back-end and front-end operations with GUI applications. o Rapidly deployment and increase workload by physical or virtual machines. o Support for redundancy, self-healing and highly scalable API. o Real-time monitoring resource usage [4]. Cloud computing is categorically into three major segments: "Applications", "Platforms," and "Infrastructure". Each segment serves a different purpose and offers different products for businesses and individuals around the world. The server administrator monitoring traffic and client demands to ensure everything runs accurately. It follows a set of rules called protocols and using software is called middleware.

- **Software as a Service (SaaS)** : In this model software deployment over the internet is deployed to run behind a firewall in LAN or personal computer or laptop. This is a "pay-as-you go" model. The capability provided to the end-users is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web enabled e-mail). The end-users does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user specific application configuration settings.

- **Platform as a Service (PaaS)** : It is the delivery of computing platform and solution stack as a service. Trust of use the middleman's equipment to develop their own program and deliver it to users through Internet and servers. The capability provided to the end users to deploy the cloud infrastructure, user created or acquired applications using programming languages and tools supported by the provider. The end user does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage. PaaS providers offer a predefined combination of OS and application servers, such as WAMP platform [5] (Windows, Apache, MySql and PHP), LAMP platform (Linux, Apache, MySql and PHP), and XAMP (X-cross platform) limited to J2EE, and Ruby etc. Google App Engine, Salesforce.com, etc are some of the popular PaaS examples.

- **Infrastructure as a Service (IaaS)** : The platform virtualization or infrastructure as a service. The capability provided to the end users is to provision processing, storage, networks, and other fundamental computing resources where the end user is able to deploy and run arbitrary software. This can include operating system and applications. The user does not manage or control the underlying cloud infrastructure but it has control over operating systems, storage, deployed applications, and possibly limited control of select networking components. Rather than purchasing servers, software, data center space or network equipments, clients etc., this resource is fully outsourced and controlled by outsourcing organizations. Some of the common examples are Amazon, GoGrid, 3tera, etc Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.

- **Hardware as a Service (HaaS)** : According to Nicholas Carr [6], "the idea of buying IT hardware or even an entire data center as a pay-as-you-go subscription service that scales up or down to meet your needs. But as a result of rapid advances in hardware virtualization, IT automation, and usage metering and pricing, I think the concept of hardware-as-a-service, let's call it HaaS, and may at last be ready for prime time." This model is advantageous to the enterprise users, since they do not need to invest in building and managing data centers. In the future days HaaS has to be available on pre and post paid payment basis.

III. DEPLOYMENT-MODEL

Public Cloud (or External Cloud) : In this model, computing resources are dynamically provisioned over the Internet via Web applications or Web services from trusted third party provider. Public clouds are run by third parties, and applications from different customers are likely to be mixed together on the cloud's servers, storage systems, and networks. Although the public cloud has compelling advantages, there existing the hidden risk of security, regulatory policy compliance and quality of service (QoS) requirements.

Private Cloud (or Internal Cloud) : In the private cloud deployment, computing resources are used and controlled by a private enterprise. It is generally deployed in the enterprises data center and managed by internal personnel or service provider. The main advantage of this model is that the security, compliance, and QoS are under the control of the enterprises

Hybrid Cloud (or Mixed Cloud) : The Hybrid Cloud environment intersects and combines multiple public and private cloud models. It enables the enterprise applications to running state-steady workload in the private cloud, and requesting the public cloud for intensive computing resources when peak workload occurs. Hybrid clouds introduce the complexity of determining how to distribute applications across both a public and private cloud.

Community Cloud(or Group Cloud): In this Community deployment model several organizations jointly construct and share cloud infrastructure as well as policies, requirements, values, and concerns. The cloud community forms into a degree of economic scalability and democratic equilibrium. The cloud infrastructure could be hosted by a third-party vendor or within one of the organization in the community. This is emerging cloud used by many social networking website like facebook, orkut, etc.

IV. CLOUD COMPUTING FEATURES

Cloud computing brings an array of new features and advantages compared to any other computing paradigms. There are briefly described in this section.;

o Scalability and On-Demand Services - Cloud computing provides resources and services for users on demand. The resources are scalable over several data centers.

o Quality of Service (QoS) - Cloud computing can guarantee QoS for users in terms of hardware or CPU performance, bandwidth, and memory capacity.

o User-Centric Interface - Cloud interfaces are location independent and they can be accessed by well established interfaces such as Web services and Web browsers.

o Autonomous System - Cloud computing systems are autonomous systems managed transparently to users. However, software and data inside clouds can be automatically reconfigured and consolidated to a simple platform depending on user's needs.

o Pricing - Cloud computing does not require up front investment. No capital expenditure is required. Users may pay and use or pay for services and capacity as they need them.

V. CLOUD COMPUTING ISSUES AND IMPLICATIONS

The new paradigm of cloud computing provides sophisticated benefits and advantages over the previous computing paradigms and many organizations are customizing, migrating and adopting it. In the last few years, cloud computing has grown from being a promising logic; business is virtualization concept to one of the fastest growing segments of the IT industry. Now, recession-hit companies are increasingly realizing that simply by tapping into the cloud and gain fast access to best-of-breed business applications or drastically boost their infrastructure resources, all at negligible cost. However, there are still a number of issues, challenges and implications are identified, which are currently addressed by researchers, academicians and BI (business intelligence) practitioners..

1. **Security:** Clouds provide companies are still concerned about security when using cloud computing. Users are also worried about the vulnerability to attacks, when information and critical IT resources are outside the firewall. Where is the data more secure, on local hard drive or on high security servers in the cloud? However, in the cloud, the data will be distributed over the network through individual computers regardless of where the repository of data is ultimately stored. Industrious hackers can invade virtually at any server, and there are the statistics show that one-third of breaches result from stolen or lost laptops and other devices and from employees' accidentally exposing data on the Internet, with nearly 16 percent due to insider stealing.

2. **Reliability:** Clouds computing still always offer round the clock reliability. There were few cases where cloud computing services suffered few hours' outages. In the present and future days to expect more cloud computing providers, richer services, established standards and best practices. Servers in the cloud have the same problems as your own resident servers. The cloud servers also experience downtimes and slowdowns, what the difference is that users have a higher dependent on cloud service provider (CSP) in the taxonomy of cloud computing. Once you choose a particular provider, you may be locked-in, thus bring a potential business secure risk.

3. **Privacy**: Different from the traditional computing model, cloud computing utilizes the virtual computing technology, users personal data may be scattered in various virtual data center rather than stay in the same hard drive physical location, even across the national borders, at this time, data privacy protection will face the controversy of different legal systems. On the other hand, users may leak hidden information when they accessing cloud computing services. Attackers can analyze the critical task depend on the computing task submitted by the users [9].

4. **Open Standard**: Open standards are critical to the growth of cloud computing. Most cloud provider's interpretation with APIs which are typically well-documented but also unique to their implementation and thus not interoperable. Some vendors have adopted others' APIs [10] and there are a number of open standards under development, including the OGF's Open Cloud Computing Interface. The Open Cloud Consortium (OCC) [11] is working to develop consensus on early cloud computing standards and practices.

5. **Performance**: The major issue in performance can be for some intensive transaction-oriented and other data intensive applications, in which cloud computing may lack adequate performance. Also, users who are at a long distance from cloud providers may experience high latency and delay.

6. **Bandwidth Cost:** Cloud computing offered companies, can save money on hardware and software; however they could incur higher network bandwidth charges. Bandwidth cost may be low for smaller Internetbased applications, which are not data intensive, but could significantly, grow for data-intensive applications.with a ratio of quantities and units. For example, write "Temperature (K)," not "Temperature/K."

VI. CONCLUSION

In this paper, to analyze and discussed an emerging technology: Cloud Computing. The evolving is one of the core platform for Computer Science (academics) and Information Technology (industry) in the professional world. It describes cloud background, evolution, definition, service models, deployment models and some existing issues. There is no doubt that the cloud computing is the emerging development trend in the future. Cloud computing brings us the approximately infinite computing capability, good scalability, ondemand service and so on, also challenges at security, reliability, and privacy, legal issues and so on. Because of this, it has been attracted by everyone including the attackers. The paper is expected to be a right path or URL for those who works or does research in cloud computing. We acknowledge the cloud computing era, to solving and prevent the existing issues and implications for maximum necessity is required.

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Review & Study of Biogas Generation

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Abstract*—Switching to environmentally friendly systems and methods to face and overcome the global environmental crisis, renewable energy resources are considered to be as the proper alternative energy which are quite helpful in reducing the CO_2 emissions, thus making environment less harmful. In addition to this, though the improvement of renewable energy converters is in a faster rate, the systems to extract the wasted energy in conventional energy conversion systems haven't developed much yet compared to their technologies. Although we all know from the First Law of Thermodynamics that Energy is neither created nor destroyed, we often analysis the areas where the energy is created but couldn't be useful. This means that any energy which is not transferred to useful energy stores or useful work is said to be wasted as it is lost to the surroundings*

Keywords—renewable energy, anaerobic digestion, fermentation, digester, biogas, environment, biodegradable

I. INTRODUCTION

Energy, in any form, is the basic need for the development of the modern world. In today's scenario, we require energy for even small task. Our country India has grown into one of the most powerful developing nations over the years. The rapid advancement can be seen in every sector of the economy. Within our development process, we have seen rise in our population and therefore the resources for the energy generation in order to meet the population need, have gained a new height. Thus, India now has electric supply even in the most remote mountains. Due to the dependency, over the years of this development process, the ratio of production to the consumption has doubled. This ever-increasing supply is a sign of development but is proving to be a threat to our environment as most of these resources are non-renewable energy resources and thus, have only limited sources. Fossil fuels, a most common type of resource for most of the energy generation, is depleting rapidly. Moreover, there combustion process results in harmful residues which have resulted to be toxic and have caused a great amount of pollution.

To avoid exhausting of these energy resources in order to save mankind from complete darkness, switching to energy conservation is the new cheapest source of energy which will not only be eco-friendly but also an ultimate Sustainable Development process. Thus, to meet up the regular demand of the energy, we need to design a system that will produce electricity without destroying the nature.

The need of alternative and green sources of energy at a household level and how biogas produced from the everyday organic waste has the potential and possibility to replace LPG cylinders at houses, shops etc. and empower us to step towards an eco-friendly future is what we have aimed for in this project, since Biogas is the product of anaerobic vitiation of biodegradable matter.

II. OBJECTIVE

The purpose of this small-scale experiment is to find the perfect input matter that is easy to obtain and therefore, will produce the maximum amount of gas within small period of waste retention. And to look for various factors which can yield the biogas production to its maximum.

III. CONCEPT

Biogas is the mixture of gases produced by the breakdown of organic matter anaerobically, which means in the absence of oxygen. This process of breakdown of organic mater is called Anaerobic Digestion. It is also sometimes called as Bio-methanation. Biogas is a renewable energy source, and an environmentally friendly fuel made purely from local feedstocks which is suitable for a diversity of uses like as a fuel for road vehicle, etc. Biogas is produced by the anaerobic digestion with anaerobic organisms, also called Methanogen, which digest materials inside a closed system. This digestion of materials is referred as Fermentation of biodegradable materials. This closed system is called as Anaerobic Digester, Biodigester or sometimes Bioreactor. Some organic wastes are more difficult to break down in a digester than others. Food waste, fats, oils, and greases are the easiest organic wastes to break down, while livestock waste tends to be the most difficult. Mixing multiple wastes in the same digester, referred to as co-digestion, can help increase biogas yields. After capturing the biogas, we can produce heat and electricity to use them in engines, micro turbines, and fuel cells. We can also upgrade the biogas into bio-methane, also called renewable natural gas or RNG, and injected into natural gas pipelines or used as a vehicle fuel.

A. BIOGAS COMPOSITION

Biogas produced from various organic waste materials comprises of gases like methane, carbon dioxide, nitrogen and trace amounts of some other gases (hydrogen, oxygen, etc.). The composition of the gases is given below in the table:

COMPONENTS	CONTENT %
METHANE (CH_4)	50-70
CARBON DIOXIDE (CO_2)	30-40
NITROGEN (N_2)	0-10
OXYGEN (O_2)	0-0.1
HYDROGEN (H_2)	0-1
HYDROGEN SULPHIDE (H_2S)	0.1-0.5

Table 1. Composition of various gases in biogas [1]

B. PROCESS GENERATION

Biogas can be produced from a vast variety of feedstocks. The biggest role in the biogas production process is played by microbes feeding on the biomass.

Digestion process carried out by these microorganisms creates methane, which can be used as an alternative gas for natural gas, after being upgraded to Biogas. Waste materials containing organic nutrients are also produced in the process, which can be used for agriculture purposes.

The Anaerobic Digestion is a biological process that breaks down organic materials anaerobically, into methane (CH4) and carbon dioxide (CO2) majorly, and into some other gases too.

Biogas and biofertilizer production from agricultural waste is based on the quality of organic substances to produce biogas when decomposing anaerobically. The biological processes in anaerobic digestion happens in four stages. These processes happen partly simultaneously. These are[2]:

- **Hydrolysis:** Biodegradable waste is usually made up of organic polymer proteins, carbohydrates & fats. Then the breakdown of these into smaller molecules such as amino acids, simple sugars and fatty acids takes place. The fermentative bacteria hydrolyze these complex organic matters into soluble molecules. Most molecules, which are comparatively large, are further broken down in the next stage of acidogenesis so that they can produce methane.

- **Acidogenesis:** Acidogenesis in anaerobic digestion is where remaining products of Hydrolysis are broken down by the Acidogenic bacteria. These fermentative bacteria make the tank's environment acidic in nature while producing ammonia, H2S, CO2, H2, organic acids and volatile fatty acids and meager amounts of other by-products. The acids produced are carboxylic acids like acetic acid, propionic acid, butyric acid etc.

$$C_6H_{12}O_6 \rightarrow 2CH_3CH_2OH + 2CO_2 \quad \ldots (1)$$

- **Acetogenesis:** Acetogenesis is the production of acetate from carbon and energy sources by acetogens and is a derivative of acetic acid, the catabolization of the products created in acidogenesis into H2, CO2 and acetic acid. Majority of the remains are broken down by Acetogens and can be utilized by methanogens to create methane.

- **Methanogenesis:** It is the final process in which methane is produced by Methanogens from the remaining products of Acetogenesis and few remains from Acidogenesis as well as Hydrolysis. The final products of these steps of Anaerobic digestion are Acetic acid and carbon dioxide. Acetic acid and carbon dioxide can be broken down to methane by methanogens in two general pathways.

$$CO_2 + 4H_2 \rightarrow 2H_2O\ CH_3COOH + CH_4 \quad \ldots (2)$$

This is further broken down into:

$$2H_2O\ CH_3COOH + CH_4 \rightarrow CH_4 + CO_2 \quad \ldots (3)$$

The CO2 can be converted into methane and water through this reaction, Methanogenesis is the main way to produce methane which contains Acetic acid. This stage leads to generation of methane and CO2.

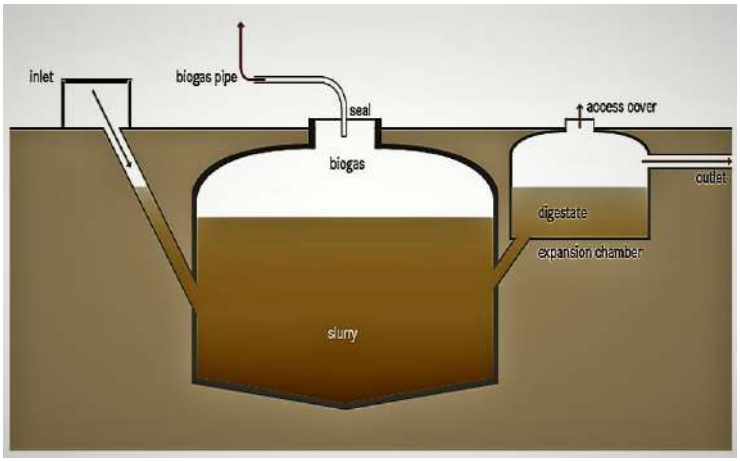


Figure 1. Biogas general plant layout [13]

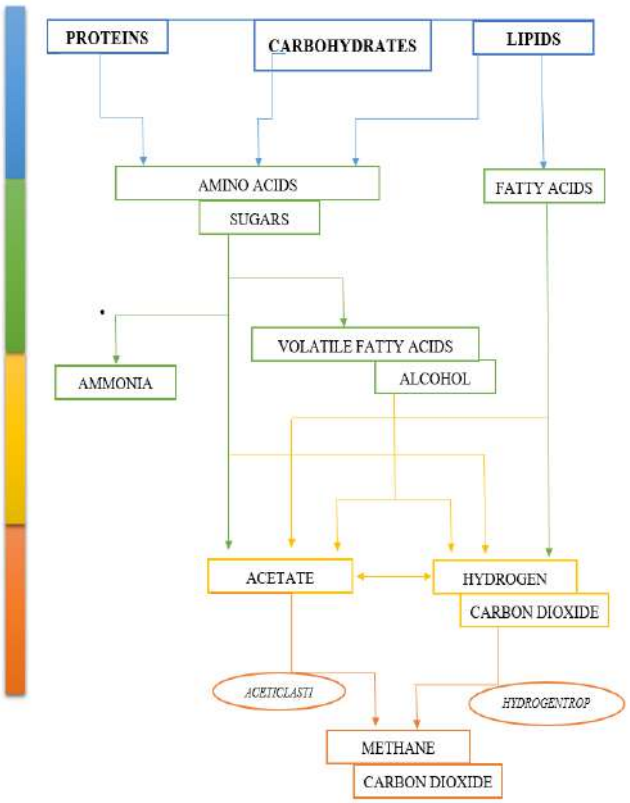


Figure 2: Fermentation Breakdown

The above flow diagram figure represents the procedure of particulate organic material undergoing anaerobic fermentation, comprising of different processes. The different processes are highlighted by their respective color in the below table:

COLOR	PROCESS
	HYDROLISIS
	ACIDOGENESIS
	ACETOGENESIS
	METHANOGENESIS

Table 2: Color coding of different steps of fermentation

C. FACTORS AFFECTING THE PRODUCTION OF BIOGAS

The various factors which affect the production of biogas dominantly are:

- Retention time
- Temperature inside the digester
- Digester size & shape
- Sublayer composition
- Working pressure of the digester
- pH value of Fermentation medium
- C/N Ratio

D. BIOGAS FEEDSTOCK

Anaerobic digestion is peculiarly suited for the wet organic matter and is commonly used for sewage and effluent treatment. Almost every organic waste can be processed through anaerobic digestion. This includes biodegradable waste materials such as waste paper, grass clippings, leftover food, sewage and animal waste which excludes the wood waste. This is due to the fact that the most of the anaerobic microorganisms are unable to degrade lignin polymer present in the cell walls of the wood, thus, making wood an undigested organic matter.

The general feedstock for biogas plants includes biodegradable materials like waste paper, grass clippings, leftover food, peels, fodder, sewage and animal waste, etc. In our report, we are covering majorly household waste, landfill waste and the agricultural waste as the feedstock for the generation of the gas. And the waste has been collected from across the whole college campus apart from the canteen.

1. Agricultural Feedstock

- Animal manure
- Energy crops
- Algal biomass
- Crop residues

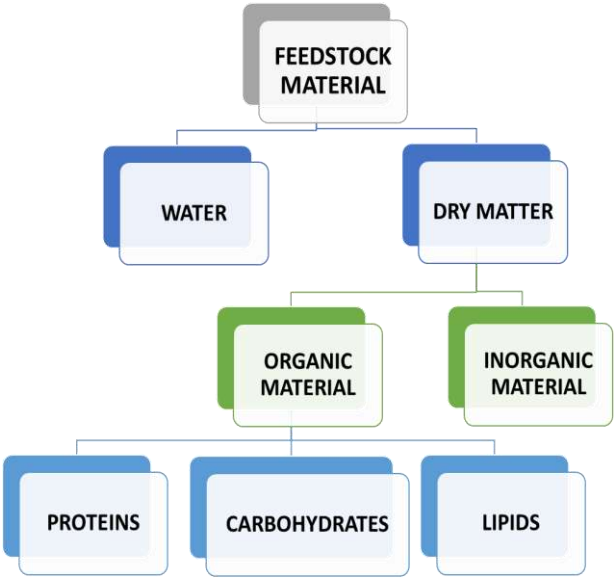
2. Community-Based Feedstock

- Solid Waste
- Sewage sludge
- Grass clippings/garden waste
- Food wastes
- Institutional wastes etc.

3. Industrial Feedstock

- Food/beverage processing
- Dairy
- Starch industry
- Sugar industry
- Pharmaceutical industry
- Cosmetic industry
- Biochemical industry
- Pulp and paper
- Slaughterhouse/rendering plant etc.

Figure 3: Classification of feedstock



E. DIGESTER

Digester is the main part of the Biogas plant.

A digester is a huge vessel or a container in which various biological and chemical reactions take place, to produce Biogas under the process of anaerobic digestion, resulting in different loading and digestion rates.

Biogas digester are of various types, depending upon the design, size or capacity varying from small-scale to large scale industrial digester, and the mode of operation, they are classified accordingly.

Digesters are classified as:

1. Based on the design:

- Stand Alone digester
- On-farm digester
- Digester at wastewater treatment plants

2. Based on type of feedstock:

- Single type of feedstock digester
- Co-digester

3. Based on the content of moisture:

- Wet solid digester
- Dry solid digester

4. Based on the loading of organic matter:

- Batch-fed
- Continuous-fed

5. Based on the dome type:

- Movable Drum type
- Fixed Dome type

1) FIXED DOME TYPE PLANT [3]

The fixed dome type plant is one of the popular biogas plants in India besides the KVIC Model. This plant concept was firstly developed in China. The digester in such plant has an inlet tank, fermentation chamber and an outlet tank. There is an inlet pipe which is used to feed the digester. The gas, thus produced is stored under the dome, located at the top of the digester. Thus, the fermentation chamber or the dome acts as the gasholder. Further the gas is removed through the pipe attached at the top of the chamber. Janata Model or Deenbandhu Model, is the very first Fixed dome type plant model developed in India.

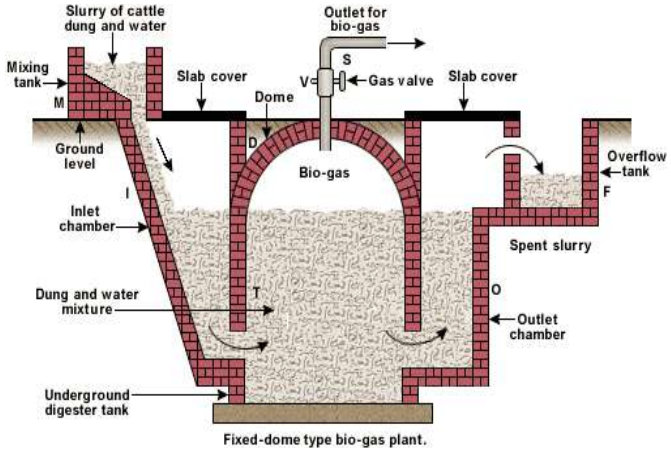


Figure 4. fixed dome type plant [4]

2) MOVABLE DRUM TYPE PLANT [3]

The Movable Drum type biogas plant was the biogas plant first developed in India. The digester in this plant is located underground with an inlet and an outlet. The gas is stored in a moving drum located above the ground. The general material used for constructing the drum is steel. There is a central guide pipe used to the drum, according to which the drum rotates up and down. The movement of the drum depends upon the capacity of gas being stored in it. The KVIC Model or the Conventional Model is the first movable drum type plant of India.

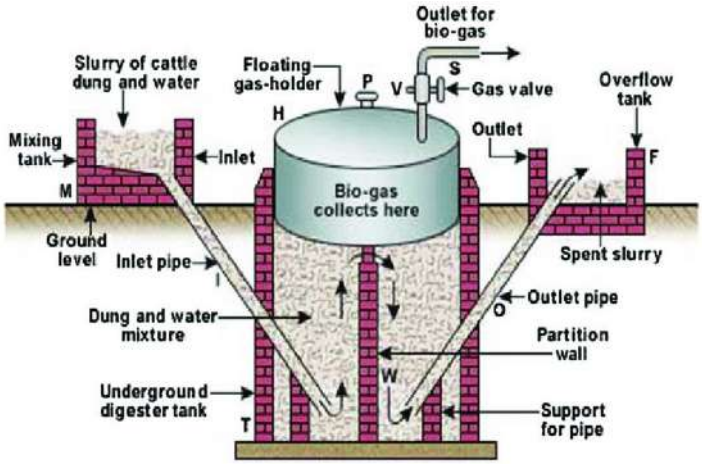


Figure 5. Movable drum type plant [4]

IV. EXPERIMENTAL SETUP [5]

Biogas is produced when biodegradable waste is left to decompose by the action of bacteria in the absence of oxygen over a period of time. Following are the steps which were taken to conduct the experiment:

- A semi solid mixture was formed by mixing all the collected waste components. It was also mixed with fresh Cow Dung waste to enhance the reaction process. Yeast was also added for fermentation. This served as a base material for the reaction process in the Biogas Generator.

- The Experimental procedure was carried out in the plastic bottles of capacity 20L. The effective volume of the reactors was maintained to its full capacity. Experiments were carried out in the ambient temperature 30-38°C, which is the mesophilic range. For the 20L reactor 4000 ml of waste mixture is added.

- Four different sets were designed and set up to conduct the tests at different compositions of kitchen waste, agricultural waste, college waste, household waste and water were added. Apart from this the comparison was conducted between the rate of biogas generation through waste one with the addition of cow dung and the other without it. And the calculations along with the graph was plotted for the same.

The bottles were setup appropriately with an inlet, a small outlet for the regular sample collection and gas outlet leading to a pneumatic trough for gas collection and volume measurement. pH was measured using digital pH meter and total solid concentration was also measured.

TOTAL SOLIDS (TS%): The amount of solid remaining in the sample taken after the water molecules present in it are evaporated. The sample, 10 gm (approx.) is taken and poured in a foil plate and dried to a constant weight at about 105°C in furnace.

TS% = (Final weight/Initial weight) * 1**00**

Each of the sets was left for a retention period of 8 days and observations were recorded on a regular basis.

A. DESIGN APPROACH

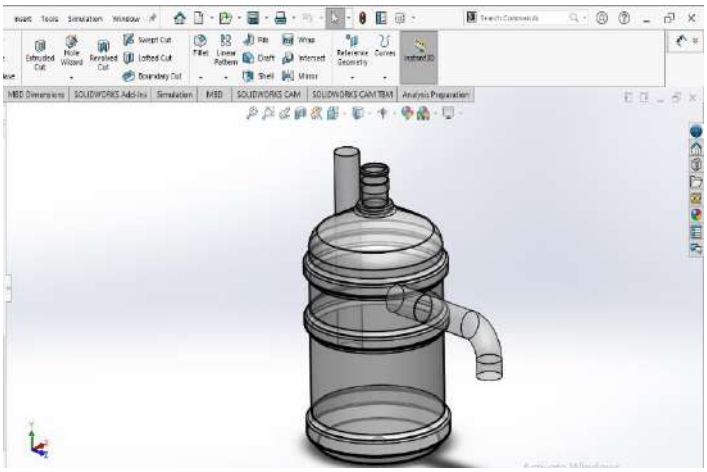


Figure 6.1. Design of digester

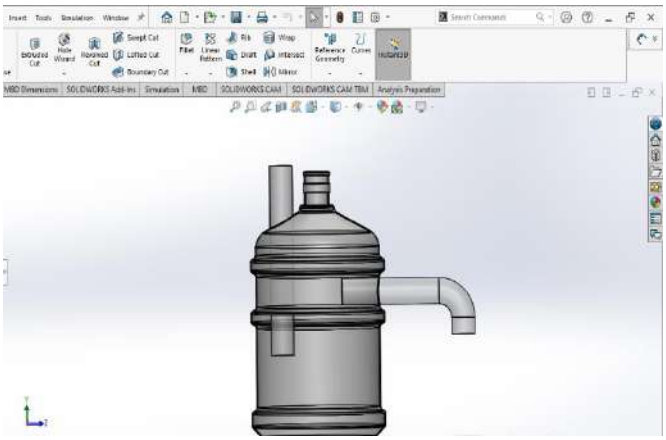


Figure 6.2. Side view

The main objective of our design approach is to design such a simple digester using the techniques available to us at our level, considering the factors like the cost efficiency, feasibility, material used, location and accessibility.

We have constructed our digester using a 20L Bisleri water can. This water bottle is made of plastic. Polyethylene Terephthalate, abbreviated as PET, a thermoplastic polymer resin of the polyester family, is the particular type of plastic from which this 20L water bottle is made. Due to this substance's excellent moisture barrier, high rigidity and high impact resistance like properties, we chose this material for the construction of our digester. Additional to this, it is translucent as well as it is ideal for high speed filling which was what we needed for our digestate. The bottle has been pierced from two sides. One hole from the top is from where one PVC pipe is inserted which acts as the inlet for the digestrate. The other hole is from the side where the other PVC pipe is inserted which acts as outlet pipe.

For designing CAD model of our project, we have chosen to use Solid works because of its ease to use and seamless, integrated workflow design. We created all the main components one by one in solid works.

Figure 6.3. Physical setup of digester

V. OBSERVATION [6]

A. PLANT CAPACITY

The plant capacity of a biogas plant is the maximum total volume of gas and slurry that it can consist. For example, the expected amount of gas produced per day is called as the plant capacity or plant size. Biogas production can be reported in this way because the feedstocks used usually do not change very much, leading to a predictable daily production level. "rated daily gas production" in calculations when the calculations use an expected daily production level and will use "total plant volume" if the calculations are referring to the volume of the plant.

B. RATED DAILY GAS PRODUCTION

The rated daily gas production is the volume of gas that a biogas plant is designed to produce each day if operated under optimal conditions. Measured in m3 /day, this shows the amount of biogas that is produced. The energy content of biogas will mostly depend on the methane content of the biogas, which should be about 65%. This needs to be taken into account when converting figures from gas production to energy production.

C. TOTAL PLANT VOLUME

The total plant volume is the sum of two components: the digester volume and the gas storage volume. It is measured in m3. The digester volume is the maximum amount of slurry that the plant can hold, while the gas storage volume is the amount of gas it can hold when full of slurry. The latter is usually a proportion of the former. The digester volume may also include a safety margin or "dead zone volume", which is used to prevent waste overflow on days when biogas production is higher than normal or biogas use is unusually low.

D. TOTAL FEEDSTOCK VOLUME

The total feedstock volume is the average amount of material added to the biogas plant each day. This includes the amount of waste and other feedstocks added each day (waste volume) and the amount of water added to these inputs (added water volume). The total feedstock volume should be recorded in m3 /day, but this can be measured in litres and converted to cubic metres (with three decimal 5 places) by dividing the measured amount by 1,000 (i.e., 1 m3 = 1,000 litres).

E. WASTE VOLUME

The waste volume is the volume of organic material added to the digester. This can include animal, human, food and agricultural waste, as well as other feedstocks collected and used in the digester.

F. FEEDSTOCK RETENTION TIME

The retention time is the average amount of time that feedstocks will stay in the digester before they are pushed out through the outlet pipe. The retention time is measured in days and is simply calculated as the digester volume divided by the total feedstock volume (i.e., daily waste and added water volume). Because the digester volume is usually measured in m3, this is why the feedstock volume is also usually recorded in m3.

G. TOTAL SOLID CONTENT

Most organic material contains a significant amount of water. This is known as its moisture content and, as it is only water, does not contribute to biogas production. The total solid content of a feedstock is the opposite of this and is the amount of dry matter present in the material. This is measured as the weight of the dry. matter divided by the total (wet) weight of the feedstock and is recorded as a percentage of the total (wet) weight. So, for example, if 1 kilogram (kg) of household kitchen waste contains 600 g of water, then its moisture content is 60% and its total solid content is 40%.

H. TEMPERATURE

The temperature within the digester is an important variable that affects the speed of gas production (production per day) and the total amount of biogas that can be produced from any feedstock. In small-scale biogas plants, the bacteria that produce biogas work most effectively when the temperature of the slurry is 20-45°C. Within this range, biogas production will vary, so the size of a biogas plant is usually designed to ensure that daily gas production is maximized. In colder climates, the slurry may need to be heated to keep it within this temperature range, in which case some of the biogas may be used for this purpose. If this is the situation in a country, then this share of the biogas production should be recorded as consumption in the energy sector in that country. [7]

I. CALCULATIONS

During the course of the retention period the volume of gas produced was measured daily, while the pH and TS% were measured on days 1, 4, 5 and 8 respectively. The recorded observations are shown below.

Day/ Set No.	1	2	3	4	5	6	7	8	Avg
1	32	35	21	10	20	43	26	10	24.62
2	83	152	120	55	51	62	90	110	90.37
3	86	75	60	33	35	22	71	105	60.87
4	195	344	262	120	152	154	218	282	215.8

Table 3.1. Biogas production per day (in ml) [8]

Here, table 3.1 indicates that the waste collected from kitchen, produced a higher amount of gas as compared to cow dung due to its high nutritional value. Hence, it proves to be a more effective waste for biogas generation.

Set/Day	Set 1		Set 2		Set 3		Set 4	
	PH	TS %	PH	TS %	PH	TS %	PH	TS %
1	7.1	8.1	7.1	6.2	7.3	8.2	7.2	6.0
4	6.6	7.4	5.7	5.3	6.5	7.6	5.8	5.4
5	6.7	7.3	6.3	5.5	7.0	7.7	6.6	5.2
8	6.5	7.1	5.0	4.6	6.6	7.1	4.9	4.6

Table 3.2. Total solid concentration with pH [8]

Table 3.2 is descriptive of the fact that the pH reduces with the advancement of the process due to the production of fatty acids by bacteria. Sets 2 & 4 (containing kitchen

waste) show a rapid decrease in pH, which indicates that the reaction is fast. Microorganisms consume kitchen waste faster than cow dung that is why the hydrolysis and acidogenesis reactions are also fast. Sets 2 & 4 also show higher decrease of Solid Concentration.

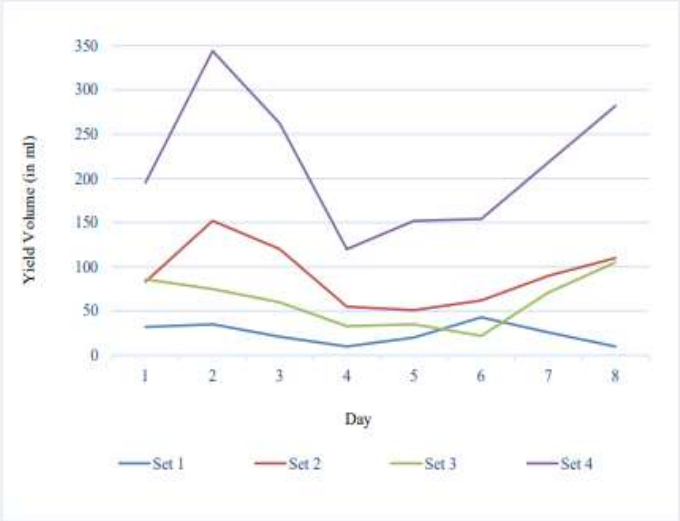


Figure 7. Biogas produced vs Days [8]

The graph in Fig. 7 shows increasing gas production up to day 3, after which it slows down and starts to decrease as the pH falls below 7 due to the production of higher amounts of acid inside the reactor bottles. The pH rises again after 4-5 days by the addition of water; hence gas is started to be produced again. It clearly shows that the strength of acid content directly affects the production process.

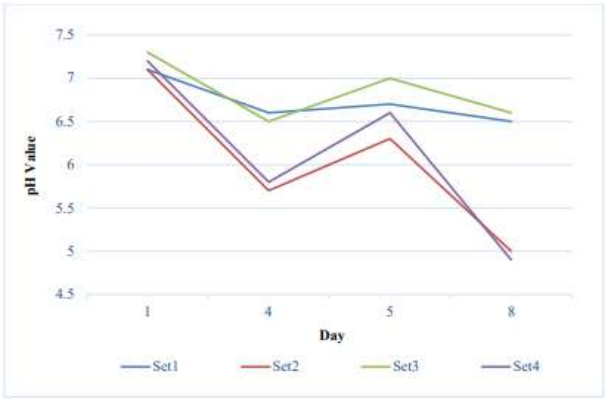


Figure 8. pH values vs Days [8]

As discussed above, the pH graph in fig. 6 also indicates that the pH drops from 7 to a lower value at around day 3 due to generation of acid. It increases again when water is added for dilution.
The set showing the most yield came out to be set 4 with an average production of 215.8 ml of biogas.

Comparison of Biogas to LPG Calorific value of LPG = 50 MJ/kg
Weight of single cylinder = 14.2 kg Energy in a cylinder (Net) = 14.2 x 50 MJ = 710 MJ Biogas comprises of approx. 60% methane.

Calorific Value of methane = 55 MJ/kg Density of Methane (NTP) = 0.668 kg/m3
Calorific value of methane at NTP = Calorific Value x Density = 36.74 MJ/m3 Calorific value of biogas = 0.6 x 36.74 MJ/m3 = 22.044 MJ/m3 (Since 60% is Methane)
The setup produced 215.8 ml of biogas every day on an average (Set 4)
Energy contained in 0.216 m3 of biogas = 0.216 x 22 MJ
Net energy in 0.217 m3 of biogas = 4.752 MJ
Energy generation on a monthly basis = 4.752 x 30 = 142.5 MJ
Assuming that an LPG cylinder lasts 30 days, a small-scale Biogas plant can produce energy equivalent to 20% of the LPG cylinder at negligible costs. If we setup 5 such plants, the monthly LPG requirement of a common household can be fulfilled using biogas only [8].

VI. METHODS TO INCREASE BIOGAS YIELD

There are various methods through which we can increase the efficiency of the biogas production. Some of the methods are listed below as following [9]-

1. Ensure that Mixing of Waste Products is Fully Optimized along with the proper installation of mixers
It is commonly justified that mixers or other methods of mixing waste products such as biogas sparging or stirrers play an important role in keeping biogas yield at an optimum level.
Mixers and agitators carry out the process of homogenization of digester substrate thereby conveying fresh nutrients to the biogas-bacteria. These bacteria commonly named as Archaea / Methanogens do all the biomass decomposition, which produces the methane gas.
The effective mixing of the digester volume by providing a constant supply of essential food to the biomass, increases the efficiency of the anaerobic digestion process and thus delivers a higher methane per unit of feed.
Mixers play an important role in running a stable anaerobic digester process. If the installation of Mixers is incorrect, it will eventually lead to the following factors:

- Development of heavy bottom-sludges which makes the mixture immobile.
- Lighter particulates continue to get collected on the surface, which if not separated by correct mixing techniques can result in the formation of floating matter, froth and bubbles. Over a period of time, it even tends to coalesce to form an apparently solid crust.

Apart from the efficiency, the odour reduction for the mechanism can be achieved by the better mixing as well Separation and layer-formation/stratification within the digester tank which leads to the depleted nutrient areas. That will lead to the change in the microbial species in the population, which can cause severe odour problems, and can even result in a complete failure of the digestion process at microbial level.

2. Reduction in Substrate Particle Size

Improvements in biogas yields have been observed from pre-treating feed materials to reduce the particle size of the organic feedstock.

The fermentation and rate of biogas production for all fibrous feedstocks can be significantly increased by introducing the pre-treatment for reduction of particle size.
Through the previous reports regarding anaerobic digestion of sisal fibre, the waste feedstock was carried out in 1 litre digesters. The fibre sizes ranging from 2 to 100 mm were taken into account, at an ambient temperature of 33 °C. The starter seed used was the sediment from a stabilization pond at a sisal production plant.

Proportion of Total Fibre Degradation
It was observed that the proportion of total fibre degradation rose from 30% to 70.21% for the 2 mm fibres, compared to untreated sisal fibres.
In addition, the results concluded that the methane yield was inversely proportional to the size of the particle.
Specifically, the methane yield increased by 23.12% when the size of the fibres was reduced to 2 mm size and was 0.221 m^3 CH_4/kg volatile solids. This can be compared with 0.181 m^3 CH_4/kg volatile solids which was all that was achieved for untreated fibres.
Reduction in the particle size can be achieved through the following technologies:

- A Dye for the Physical extrusion of biomass
- Applying the Ultrasonic disintegration methodology

3. Process of Co-digestion for Improved Biogas Yield [10]

Agricultural waste, undigested waste and animal waste can also be processed separately or along with municipal wastes. The typical biogas yield is about 5,000 scf (standard cubic feet) per ton of organic waste, but that varies greatly between different digestors and plants.

In this research paper, the experiment was conducted under the condition of 8% mass fraction of total solid. It was carried out in a self-manufactured anaerobic fermentation reactor, with animal waste, kitchen waste, household waste and cattle dung, and wheat straw as fermentation materials. The substrate from fermentation pool was used as the inoculation substance. This concludes that as far as possible the same microorganisms were present before and after co-digestion.

After a period of time the rate of biogas yield, retention period, and optimal temperature were determined for the co-digested reactor. This was compared with the same reactor without co-digestion. It was shown that the cumulative biogas yield of mixed anaerobic fermentation of pig dung and wheat straw was 2.3 times higher than that of the fermentation of pig dung alone.

But the observation concluded that there was no significant difference between the cumulative biogas yields of the mixed fermentation of cattle dung and wheat straw, and the fermentation of cattle dung alone.

Fermentation Conditions
The optimal fermentation temperature for the mixed anaerobic fermentation was above 30 degrees Centigrade, and the fermentation duration was about 2 months. The fermentation digestor was kept in two locations- one under the ground in the pit where the temperature was less than 20 degrees Centigrade and other on the ground where the temperature was above 30 degrees Centigrade. The duration was not always reduced by increasing temperature, and it would be not feasible to only use temperature to determine the duration of anaerobic fermentation. Therefore, it can be concluded that feasibility affected the result of the temperature on the Biogas yield.

4. Enzymes, Probiotics and Micro-elements can be used as Catalyst
The mixture of enzymes, probiotics and micro-elements is sometimes used as an additive, also referred as "catalysts" for increasing the biogas yield. Though additives cost additional money, and need to be continually fed, still additives can be a good tool to increase the rate of Biogas Production.
However, the manufacturers of a number of specialist companies claim that the additive allows them to achieve considerable yield improvements at a lower cost but far outweighed when the income from the additional biogas yield is considered.
In fact, the main advantages of successful enzyme application have increased the biogas yield from 13 to 38% without any changes in plant design.
It has even improved the stability of the process and thus increasing the rate of methane content produced in the biogas.
A further advantage stated for the Zorg Enzyme product is that it is possible to get whole of the biogas out of the main digester stage, without needing a post-digester stage. [11]

VII. BENEFITS OF BIOGAS [12]

- Similar to natural gas, biogas can also be used as a source of peak power that can be rapidly ramped up. Using stored biogas is beneficial as it restricts the amount of methane released into the atmosphere and reduces dependency over fossil fuels.
- Based on a waste-to-wheels assessment, compressed natural gas derived from biogas reduces greenhouse gas emissions by up to 90 percent approx. relative to petroleum gasoline.
- In addition to climate benefits, anaerobic digestion can lower costs associated with waste remediation as well as benefit local economies.
- Digestate, the material remaining after the digestion process, can be used or sold as fertilizer, reducing the need for chemical fertilizers. It can additionally, also provide the revenue when sold as livestock bedding.

- Even after being a renewable energy, the process of generation of biogas is natural and hence, doesn't requires energy for the generation, unlike the other renewable energies.
- The by-product of the biogas generation process is enriched organic (digestate), which is a perfect supplement to, or substitute for, chemical fertilizers. The fertilizer discharge from the digester can accelerate plant growth
- Renewable natural gas (RNG), or biomethane, is biogas that has been refined to remove carbon dioxide, water vapor, and other trace gases so that it meets natural gas industry standards. RNG can be injected into the existing natural gas grid and can be used interchangeably with conventional natural gas.
- Like conventional natural gas, RNG can be used as a vehicle fuel after it is converted to compressed natural gas (CNG) or liquefied natural gas (LNG). Further it can also be used in light- to heavy-duty vehicles.
- Like conventional natural gas, RNG can be used as a vehicle fuel after it is converted to compressed natural gas (CNG) or liquefied natural gas (LNG). The fuel economy of CNG-powered vehicles is comparable to that of conventional gasoline vehicles and can be used in light- to heavy-duty vehicles.

VII. CONCLUSION

The aim of this research was to have a review study on the production of biogas through anaerobic digestion which tells us that this process is non-conventional and even the generation technique is clean, environmental friendly and safe. Moreover, the biogas technology has the potential to overcome ecological imbalance crisis. One of the finest green sources of energies which can be adopted for the sustainable development. Also the biogas technology has enormous potential for electricity generation, which may prove a great boom to the world in futuresoon, since the demand for electricity is gradually increasing every day.

Considering the availability, it is available at every scale, provided from various sources like landfills, animal and agricultural waste, wastewater treatment facilities etc. Given that the resources available to us are utilized to the fullest, we can easily meet a significant part of the current petroleum gas requirement just from green and organic sources itself thus, decreasing our dependency on the fossil fuels and reducing the carbon footprint.

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A Computational Approach to Design & Optimization of Shell & Tube Heat Exchangers

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Abstract:

Shell and Tube heat exchangers are having special importance in boilers, oil coolers, condensers, preheaters. Shell and Tube heat exchanger is one such heat exchanger, provides more area for heat transfer between two fluids in comparison with other type of heat exchanger. To intensify heat transfer with minimum pumping power innovative heat transfer fluids called Nano fluids have become the major area of research now a days.

The primary aim is to evaluate the effect of different weight concentration and temperatures on convective heat transfer. Increasing the weight concentration and temperatures leads to enhancement of convective heat transfer coefficient. In the present, work attempts are made to enhance the heat transfer rate in shell and tube heat exchangers. A multi pass shell and tube heat exchanger with 16 tubes and 4 baffle plates is done using ANSYS. The CFD simulated results achieved at different angles of baffle plates. Based on the results, we found increment of overall heat transfer coefficient which results in the enhancement of heat transfer rate of heat exchanger.

Keywords **-** Shell and Tube heat exchanger, CFD, Fluent, Overall heat transfer coefficient

I. INTRODUCTION:

Heat Exchanger -

A heat exchanger is a system used to transfer heat between two or more fluids. Heat exchangers are used in both cooling and heating processes. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, conditioning, chemicalplants, proc essing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air. Another example is the heat sink, which is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant.

Types of Heat Exchanger:

Based on the design characteristics indicated above, there are several different variants of heat exchangers available. Some of the more common variants employed throughout industry include:

- Shell and tube heat exchangers
- Double pipe heat exchangers
- Plate heat exchangers
- Condensers, evaporators, and boilers

Shell and Tube Heat Exchanger -

A shell and tube heat exchanger is a class of heat exchanger designs. It Is the most common type of heat exchanger in oil refineries and other Large chemical processes, and is suited for higher pressure applications. As its name implies, this type of heat exchanger consists of a shell (a large pressure vessel) with a bundle of tubes inside it. One fluid runs through the tubes, and another fluid flows over the tubes (through the Shell) to transfer heat between the two fluids. The set of tubes is called A tube bundle, and may be composed of several types of tubes: plain, Longitudinally finned, etc. There can be many variations on the shell and Tube design. Typically, the ends of each tube are connected to plenums (sometimes called water boxes) through holes in tube sheets. The tubes May be straight or bent in the shape of a U.

Important parts in Shell and Tube Heat Exchanger -

The shell and tube exchanger consists of four major parts:

1. Front Header—this is where the fluid enters the tube side of the exchanger. It is sometimes referred to as the Stationary Header.

2. Header—this is where the tube side fluid leaves the exchanger or where it is returned to the front header in exchangers with multiple tube side passes.

3. Tube bundle—this comprises of the tubes, tube sheets, baffles and tie rods etc. to hold the bundle together.

4. Shell—contains the tube bundle.

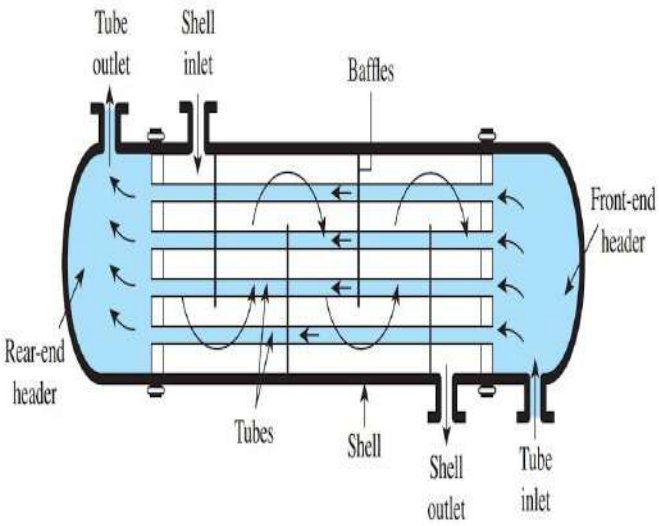

Fig.1 Shell and Tube type heat exchanger

3D Design Software:

3D software used for designing and analysis of shell and tube type heat exchanger are:

1. Solid works SW20.0

2. Ansys R15.0

II. LITERATURE REVIEW:

1. ***G.sRajmohans''DesignsandsCFDsAnalysissofs Shell andsTubesHeatsExchanger"***

In this paper researcher have done Comparison for several shell- and- tube heat exchangers with segmental baffles. The objective of this project is to design a shell and tube heat exchanger with segmental baffles and to study the flow and temperatures inside the shell and tubes using ANSYS software tool for the different baffles assemblies and orientation also overall heat transfer is calculated for each design. This project totally contains 5 designs for comparison. The process in solving simulation consists of modelling and meshing the basic geometry of shell and tube heat exchanger using CFD package ANSYS 14.5.In simulation it is shown how the temperature, pressure, velocity varies in shell due to different baffles orientation. Researcher gave result which indicates that the heat exchanger without any short-circuited flow has the higher heat transfer coefficient than the heat exchanger with leakage. It is found that for 0.5 kg/s mass flow rate there is no much effect on outlet temperature of the tube even though the baffle inclination is increased from 0° to 40°. However the shell-side pressure difference is decreased with increase in baffle inclination angle i.e., as the inclination angle is increased from 0° to 40°. The pressure difference is decreased by 6%, for the heat exchanger with 20° baffle inclination angle and by 19.57% for the heat exchanger with 40° baffle inclination angle with 36% baffle cut. It can be concluded that shell and tube heat exchanger with 40°inclination angle and 25% baffle cut results in better performance compared to 0°, 20° and 30° inclination angle

2. ***P.S.Gowthaman and S.Sathish ''Analysiss ofs Segmentals ands Helicals Baffle in Shell and tube Heat Exchanger''s***

Baffle is an shell side Component of shell and tube heat exchanger. The segmental baffle forces the liquid in a Zigzag flow and improving heat transfer and a high pressure drop and increase the fouling resistance and Helical Baffle have a Effective Performance of increasing heat transfer performance. The desirable features of heat exchanger obtain a maximum heat transfer Coefficient and a lower pressure drop. From the Numerical Experimentation result the performance of heat exchanger is increased in Helical Baffle instead of Segmental Baffle. From the Numerical Experimentation Results it is confirmed that the Performance of a Tubular Heat Exchanger can be improved by Helical Baffles instead of Segmental Baffles. Use of Helical Baffles In Heat Exchanger Reduces Shell side Pressure drop, ,pumping cost, weight, fouling etc as compare to Segmental Baffle for a new installation.

3. ***Sayali R.Bhandurge, Prof. A.M.Wankhade, Prof. P.K.Jadhao, Nikhils P.Talwekars ''Analysiss ands Experimentation of Shell and Tube Heat Exchanger with Different OrientationsofsBaffles"***

In this paper, researcher have done Experimentation along with CFD analysis on single pass, counter flow shell and tube heat exchanger containing Baffles at 0°,15°,30°,45° orientation. To study the heat transfer rate and pressure drop of shell side fluid and compare the result with Bell-Delaware method, Experimental setup is validated with help of Dittus- Boelter correlation. Nusselt number obtains from Experimental set up of 0° orientation and Dittus- Boelter correlation are within 5.72%. Experimental result of 0° orientation is also compare with CFD results in which Nusselt number are found to be within 12.50% and pressure drop is found within 5.55%.Results obtain from CFD analysis is also compare with Bell Delaware method and Nu in case of CFD is 3.35% of Bell-Delaware. Pressure drop Results in case of CFD is Found within 14.99%.CFD analysis at 15°,30° & 45° baffle orientation is also done and results are validate with help of Belle Delaware method. The overall conclusions are as follows, heat transfer coefficient and heat transfer rate is increased by 10% to 17% when baffle angle inclination changes from 0° to 45°,whereas pressure drop is decreased by 5% to 13.44% with change in baffle inclination from 0° to 45° which helps in reducing the pumping cost of shell and tube heat exchanger. From this experimental, CFD and Bell Delaware analysis it is found that as baffle angle

changes from 0 to 45 degree, Nusselt no. increases that is indirectly heat transfer rate is increase and pressure drop is reduces. Due to change in baffle inclination angle more turbulence will be created across the shell side, because of this heat transfer coefficient is increases which results in increase of Nusselt number and hence the heat transfer rate will increase. By varying the baffle inclination with fixed baffle spacing and the baffle cut values of 25% for 4.84 kg/sec shell side flow rates, the experimental results for 0° baffle inclination are compared with CFD simulation result and then compare with Bell-Delaware result, it is observed that experimentation and CFD result for 0° baffle inclination are in good agreement with Bell –Delaware results. The simulation results for 15°, 30°,45° baffle inclination compared with result from Bell-Delaware method. For properly spaced baffles, it is observed that the CFD simulation results are in good agreement with the Bell-Delaware results. The results are also sensitive to baffle cut selection, for this counter flow shell and tube heat exchanger with 10 baffles and baffle inclination of 45° gives slightly better result.

III. METHODOLOGY:

1. Computational Fluid Dynamics CFD -

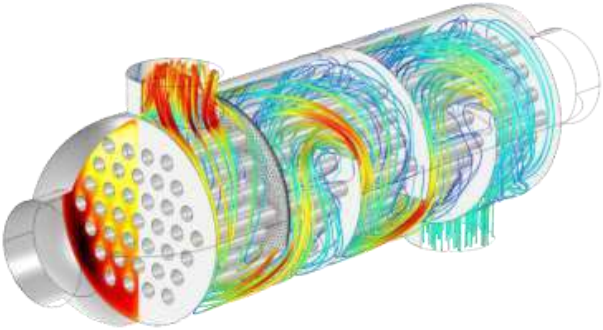

Fig.2 Fluid flow simulation for a shell and tube exchanger.

- CFD is a sophisticated computationally-based design and analysis technique. CFD software gives you the power to simulate flows of gases and liquids, heat and mass transfer, moving bodies, multiphase physics, chemical reaction, fluid-structure interaction and acoustics through computer modelling.

- This software can also build a virtual prototype of the system or device before can be apply to real-world physics and chemistry to the model, and the software will provide with images and data, which predict the performance of that design.

- CFD is one of the branches of fluid mechanics that uses numerical methods and algorithm can be used to solve Ansys Software is used for the simulation. Ansys is the finite element analysis code widely used in computer aided engineering (CAE) field.

2. Procedure for CFD Simulation –

Fig.3 Basic and Cross-section Model of shell and tube heat exchanger

Step1 - **Pre Processing**: In pre processing we pre examine all the conditions of the model and its material of which our heat exchanger made of by setting physical properties and model dimensional properties then we did the meshing part and input the initial boundary conditions at which we study the variations.

Then we put this model under practical boundary conditions where this shows the practical use in the industry.

Step2 - ***Processing:*** Calculations on computers will take place and ansys software will verify all the boundary conditions and all the inlets and outlets of both the hot and cold fluid running in the heat exchanger.

Step3 - ***Post-Processing:*** In post processing we will analyse the output given by the Ansys software and we will observe the variation of parameters in the heat exchanger during the running of fluids through the pipes and shell of the heat exchanger.

3 .Boundary Conditions –

- Boundary conditions are those conditions in which a heat exchanger would work or in that temperature and pressure an inlet and outlet we obtain from heat exchanger.
- The boundary condition will decide whether a heat exchanger is able to perform under those conditions or not.
- with the know of the boundary condition we can find out what type of heat exchanger we need and what type of material should be of heat exchanger.

Temperature Conditions:

Outside temperate is taken at room temperature (24^o C or 297K)

Inlet of hot fluid - 340 k

Inlet of cold fluid - 300 k

IV. DESIGN STUDY & CALCULATION:

Specification	Dimension
Length of Heat Exchanger, L	962mm
Shell Inner Diameter, D_s	152mm
Tube Length, l	762mm
Tube Outer Diameter, d_o	17mm
No. Of Tubes, N_t	16
Tube Pitch and Geometry, P_t	30, Triangular
Baffle Inclination, θ	0^o
Baffle Cut	50%
Baffle Spacing, ΔB_t	158mm
Baffle Thickness, t	15mm
No. Of Baffles, N_b	6

Table.1 Specifications of heat exchanger

V. ANALYTICAL STUDY :

Variation of Temperature –

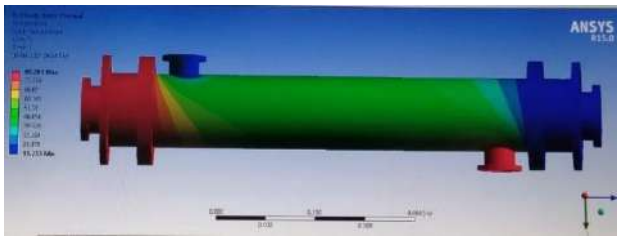

Fig.4:Temperature variation throughout shell and tube

The temperature Contours plots across the cross section at default inclination of baffle along the length of heat exchanger will give an idea of the flow in detail.Plots of temperature profile are taken for baffle inclination at 0°and we will take different angles for comparison among different baffle inclination.

Variation of Velocity –

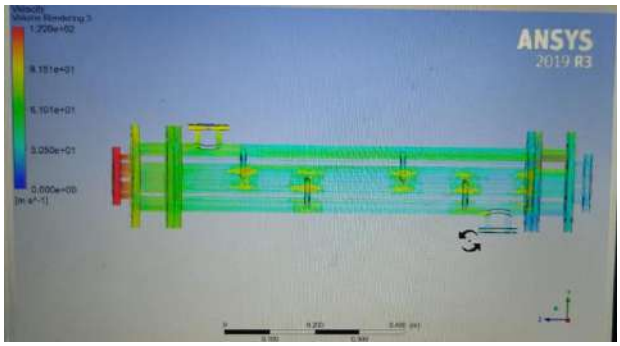

Fig 5: Velocity variation throughout shell and tube

Velocity profile is examined to understand the flow distribution across the cross section at different positions in heat exchanger. Velocity profile of Shell and Tube Heat exchanger at 0° Baffle inclination is produced and we will take different angles for comparison among different baffle inclination.

Variation of Pressure –

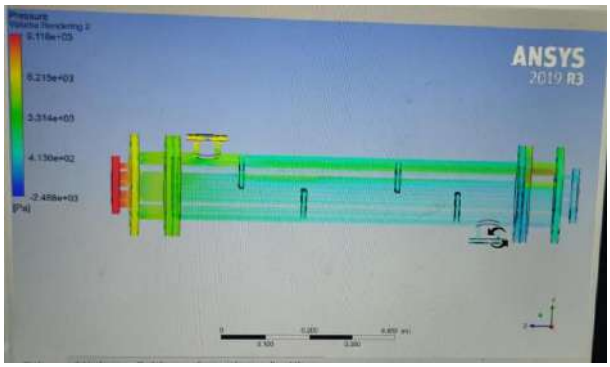

Fig 6: Pressure variation throughout shell and tube

The Pressure Distribution study lets us to know about the changes taking place inside the heat exchanger. Large pressure drop indicates abnormality such as flow diversion and losses that take place in the form of pressure drop.Pressure profile of shell and tube type heat exchanger at 0° baffle inclination is produced and we will take different angles for comparison among different baffle inclination.

Heat Transfer Rate –

$Q = m * Cp * \Delta T$

m = mass flow rate,
Cp = Specific Heat of Water,
ΔT = Temperature difference between tube side

At given boundary conditions, analysis is done on shell and tube heat exchanger from which we calculate heat transfer rate through above formula for determination of efficiency of heat exchanger.

VI. CONCLUSION :

The shell and tube heat exchanger is analyzed using ANSYS software and heat transfer coeffient, pressure drops are calculated. Also the shell side pressure increase rapidly with increasing flow rate. Since in a baffled heat exchanger, there is a obstruction to flow, drop in the pressure is definitely more when compared to the heat exchanger without baffles.

VII. *ACKNOLED*GEMENT:

We would like to extend an immense gratitude towards the staff of our college Dr. Akhilesh Das Gupta Institute of Technology & Management for helping us in our Major Project. We would like to appreciate the immense support provided by our honourable HOD Sir and other faculty members who are always there to guide us and help us in the time of need. We would like to extend our sincere gratitude to Mr. Awdhesh Poddar Sir for guiding us in our project.

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Modular Drone Experimental Vehicle

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Abstract

Modular Drone Experimental Vehicle or MDEV is a drone build on a quad copter architecture build modularly so it can accommodate different technologies and concepts. The 2 technologies we would be accessing here would be Electro-optical search target recognition and Direct Horizontal Motorised Propulsion. At the end both these concepts would be applied together in MDEV and also individually. EOSTR for search track assistance and DHMP for new prospective flight capabilities for drones.

Introduction

MDEV is a multi-purpose drone-based technology demonstrator test bed and the fact that it's modular helps in applying different technologies on it as well as maintenance and repairs.

The two technologies and concepts that are going to be tested in this project on MDEV would be:

1. Electro-optical search target recognition (EOSTR)- here object recognition programs are to be used in conjecture to the drove video feed being provided by the drone Electro optical sensors.

EOSTR

2. Direct Horizontal motorised propulsion (DHMP) concept: Under this concept we would try to implement pusher or pusher puller propellor to the motor so that horizontal movement of a quad copter could be enhance a be more akin to an airplane if needed.

MDEV main components

MDEV mainly can be broken down into 2 distinct categories by itself, the flight

system and the power system along with the Drone frame. The flight system consists of motors, propellers, electronic speed controllers (ESC's), flight controller, and the radio receiver. The power system consists of the battery and the power distribution board. The FPV system contains the flight camera, the video transmitter (VTx), and the antenna.

Electro-Optical Search Target Recognition

The object recognition programs are to be used in conjecture to the drone video feed being provided by the drone Electro optical sensors.

We would use python 3, OpenCV and MobileNet-SSD v3. OpenCV DNN supports models trained from various frameworks like Caffe and TensorFlow. It also supports various networks architectures based on YOLO, MobileNet-SSD, Inception-SSD, Faster-RCNN Inception, Faster-RCNN ResNet, and Mask-RCNN Inception.

Because OpenCV supports multiple platforms (Android, Raspberry Pi) and languages (C++, Python, and Java), we can use this module for development on many different devices.

Why OpenCV DNN?

OpenCV DNN runs faster inference than the TensorFlow object detection API with higher speed and low computational power.

Why MobileNet-SSD?

MobileNet-SSD can easily be trained with the TensorFlow-Object-Detection-API, Lightweight.

After loading the project resources and loading the models we would feed the image to the network after that the key steps are to give the desired threshold confidence and set class names and id box.

main.py

```
import cv2

img = cv2.imread('lena.png')

classNames= []
classFile = 'coco.names'
with open(classFile,'rt') as f:
    classNames = f.read().rstrip('\n').split('\n')

configPath = 'ssd_mobilenet_v3_large_coco_2020_01_14.pbtxt'
weightsPaths = 'frozen_inference_graph.pb'

net = cv2.dnn_DetectionModel(weightsPaths,configPath)
net.setInputSize(320,320)
net.setInputScale(1.0/ 127.5)
net.setInputMean((127.5, 127.5, 127.5))
net.setInputSwapRB(True)

classIds, confs, bbox = net.detect(img,confThreshold=0.5)
print(classIds,bbox)

for classId, confidence,box in zip(classIds.flatten(),confs.flatten(),bb
    cv2.rectangle(img,box,color=(0,255,0),thickness=2)
    cv2.putText(img,classNames[classId-1].upper(),(box[0]+10,box[1]+30),
                cv2.FONT_HERSHEY_COMPLEX,1,(0,255,0),2)


cv2.imshow("Output",img)
cv2.waitKey(0)
```

Image source Object detection model

Similarly, we can put the sources to a live camera feed too as shown below.

This is applied to the drone video receiver connected to the ground station computer to run the model hence

achieving EOSTR for the MDEV for application.

EOSTR running on laptop's webcam live feed

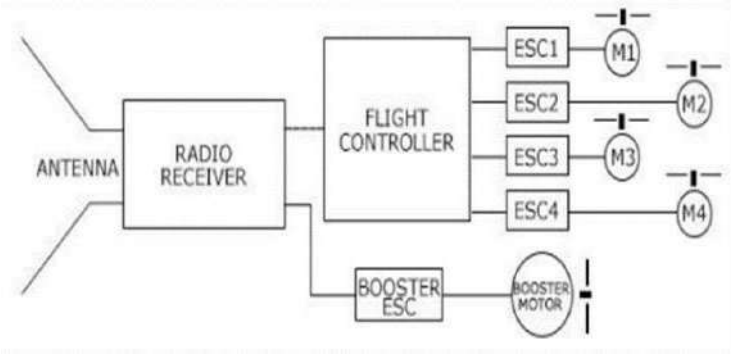
Direct Horizontal motorised propulsion

Under this concept we would try to implement pusher or pusher propellor to the motor so that horizontal movement of a quad copter could be enhance a be more akin to an airplane if needed.

To achieve this a 5th motor which would be called the booster motor here is connected to the radio receiver via flight computer via it's separate ESC while also being connected with the power supply in parallel.

Then in the Betaflight the 5 booster ESC motor is to be assigned with a 3-way switch for switching on and assigning desired throttle percentages to control the pusher thrust and switching as per the need.

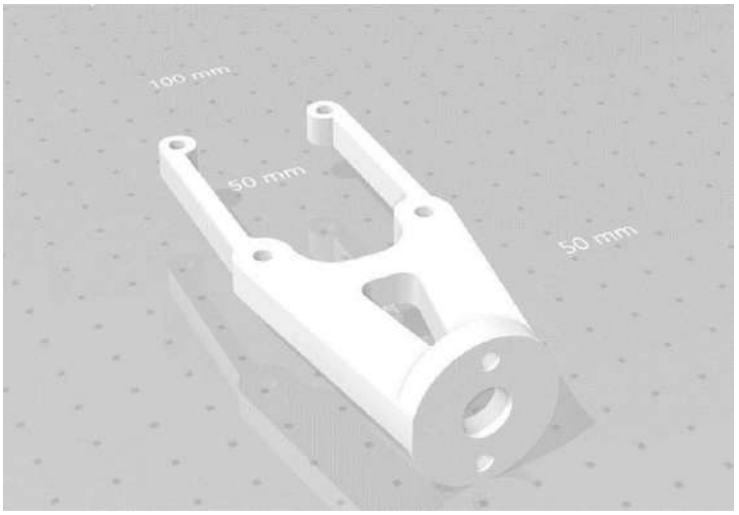
The connections are explained in the diagram below



DHMP control Diagram

Mechanically the 5th booster motor would be assembled with the main frame of the drone with a mount. We use a Martian 2 carbon fibre frame.

And the mount of the booster motor is shown below as a CAD rendering and it would be 3-d printed when the final assembly occurs.



Booster Motor Mount

The desired effect of the DHMP is to achieve more efficient travel as the drone has to face relatively less drag while traveling horizontally with the booster motor.

The idea is represented in the graphic below

The other desired effect is that the cruising speeds would be higher and the acceleration would be quick.

The Battery of the drone would be mounted a but offset to the front of the drone to counteract the weight of the mount and the booster motor so the centre of mass doesn't change much.

Static Thrust Calculation for Base Drone

Static thrust is defined as the amount of thrust produced by a propeller which is located stationary to the earth. This calculation is particularly important for this project because quadrotor helicopters are more likely to perform at low speeds relative to the earth. This low-speed performance ensures that the calculations of static thrust can be applied to a wide range of flight conditions. Also, it is important to note that the final calculations of static thrust are estimates and not actual values.

The first step in calculating static thrust is determining the power transmitted by the motors to the propellers in terms of rpm. The formula used is given in Equation 1.

$$Power = Prop\ Const * rpm^{Power\ factor} \qquad (1)$$

RPM = Kv*Volts

Motor Output Power = Power Absorption of Propeller

CONSTANT k = $5.3*10^{-15}$

Power = $k*RPM^3*Diameter^4*Pitch$

The next step is to determine the thrust produced by a propeller. Equation 2 gives thrust based on the Momentum Theory.

$$T = \frac{\pi}{4} D^2 \rho v \Delta v \qquad (2)$$

T=thrust [N]
D=propeller diameter [m]
v=velocity of air at the propeller [m/s]
Δv=velocity of air accelerated by propeller [m/s]
ρ = density of air [1.225 kg/m³]

A commonly used rule is that velocity of the air at the propeller is $v=\frac{1}{2}\Delta v$ of the total change in air velocity: Therefore, and equation 3 is derived.

$$T = \frac{\pi}{8} D^2 \rho (\Delta v)^2 \qquad (3)$$

Equation 4 gives the power that is absorbed by the propeller from the motor. Equation 5 shows the result of solving equation 4 for Δv and substituting it into equation 3. In doing so, Δv is eliminated and torque can be calculated.

$$P = \frac{T \Delta v}{2} \Rightarrow \Delta v = \frac{2P}{T} \qquad (4)$$

$$T = \left[\frac{\pi}{2} D^2 \rho P^2 \right]^{1/3} \qquad (5)$$

Finally, it is advantageous to express the results of equation 5 in terms of mass. Newton's Law, $F=ma$, $m=4T/g$.
m being the weight of the quadcopter.

Similarly, for non-lift related DHMP motor the horizontal thrust can be also calculated by equation 5.

Now applying the values to the equations mentioned above we will find the maximum theoretical static thrust required. Below are the specific values used in our model of quadcopter.

<u>Quadcopter Weight</u> ~ 600-700grams

<u>Propeller Characteristics (in inches)</u>

Diameter = 5 Pitch = 4

Motor Characteristics

K_v = 2000 Volts = 14.8v

RPM Generated by Motor

RPM = 2000*14.8 = 29600

Motor Output Power

Power(P) = $5.3*10^{-15}*29600^3*5^4*4$ = 343.63
(power in Watts, pitch and diameter in inches)

Static Thrust (in kg) produced by a Propeller

Air density = 1.18 kg/m^3 at 25^0C

Thrust(T)= $[(\pi/2)*(5*.0254)^2*1.18*343.63^2]^{1/3}$
= 15.2264 (thrust in Newtons, diameter in meters)

Max Thrust

Max thrust = T*4 = 60.9056

Newtons to Kg

In Kg = max thrust/ 9.8 = 6.2148

The Maximum Theoretical Static Thrust in Kilograms calculated from the formulas mentioned above turns out to be 6.2148kg.

Advantages of MDEV

- Being a Modular Architecture for the testbed switching parts and upgrading present capabilities in accordance of the need. Also, this makes the repairing rather easy and relatively more economical.

- The advantages of the first concept to be developed on MDEV which is Electro-optical search target recognition is that it makes search and tracking of humans in crowded or secluded environment easier and decreases the amount of effort required to scan an area.

- The advantage of the Second concept to be tested on the MDEV which is Direct Horizontal motorized propulsion is that it would provide a faster and more efficient method for Drones to traverse horizontally than a traditional drone.

Applications of MDEV

- The Modular architecture could be used to easily test and develop new technologies.

- The broad application of the EOSTR is that it can make search, tracking and recognition of targets much easier than standard methods which could be very useful for managing natural disasters and/or in security applications.

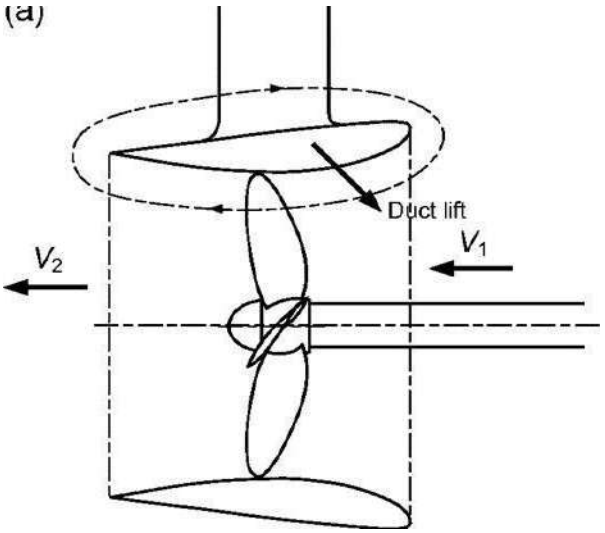
- The Broad application of DHMP is that it is much faster and more efficient than standard drones. At least in theory it should be fast enough to track speeding vehicles hence might be even replacing surveillance Helicopters in Urban environments in some conditions.

Possible Improvements

- The First improvement would be in the object detection model where we would try to fix the duplicate overlapping detections for a cleaner output.

- The other Direct improvement we might do next is that we might use Ducts for the booster propellor in DHMP. Particularly, we would be using the accelerating ducts in which

the inflow velocity and efficiency of the propeller is increased. This is the type that is used on heavily loaded propellers or propellers with limited diameter. As Ludwig Kort performed extensive research on this type, it is often called a "Kort nozzle". Also, because the propellor tip vortex should be reduced and hence it shouldmake the drone more silent and more efficient.



Propellor Duct and Duct Lift representation

- The other improvement that could be made is the use of FPV visors so more mobile operations of MDEV can be achieved hence nulling the need of a laptop in the ground station apparatus.

- Along with the above mention improvement a Raspberry Pi computer installation on the drone itself on which the EOSTR model could be run so the MDEV in its current form here could be completely independent of ground station computing and can be deployed much more freely and easily.

Conclusion

This paper has presented the report of our Major Project, i.e., MDEV. It has shown all the required information about the introduction, objective, plan, advantages and application of the project. From faster and easier testing and hence sequentially more efficient prototyping to the numerous advantages and applications EOSTR and DHMP brings MDEV has many uses and a bright prospect for further development.

EOSTER's application and working is shown in this report with image and live feed video outputs which is operating as intended.

DHMP's idea and application is also explained with its practical outcomes to be studied much more deeply in the coming major project final report.

We would like to extend our sincere gratitude to Dr. Pradeep Rohila for guiding us in our project. We would also like to appreciate the immense support provided by our honorable HOD Sir and other faculty members who are always there to guide us and help us in the time of need.

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Fabrication of an Electric Bike for Single Occupant

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Abstract

As we all know 21st century is going to shift towards electric vehicles from diesel/petrol vehicles and we are going to witness a revolutionary innovation in the sector of the Automobile Industry. This project is also based on innovation named as "electric bike"
[ROAD RANGER]. This project is designed, constructed, and finalized by Team Eco Cult.
Team Eco Cult is making a project *(ROAD RANGER)* which is an electric bike for a single occupant. This project is designed for colonies' works and roads with more ups and downs. The lightweight of the electric motorcycle makes the ride comfortable for the rider. This is a single-seater electric motorcycle with a high-speed motor and excellent range. The project is designed especially for youth who always have an eye on unique bikes. The design is also very attractive and the main motive of make Delhi green and clean is also fulfilled by this project. This is a budget-friendly electric motorcycle which should be affordable by all class.

Introduction

The rise of demand and constantly increasing the cost of petrol and diesel has been ruling India for ages; society needed a non-negotiable solution especially in India. Transportation is very important and to augment it, people started seeking transportation by different means of energy. Electric vehicles gave a breakthrough solution to satisfy the needs required thereby they started to flourish, by overcoming the hindrance. Electric Bikes are two-wheeler vehicles that use electricity as the source of fuel. Electric motorcycles are noiseless, pollution-free, zero-emission, and electrically driven. The operation and speed are controlled by the battery. To extend the variety of e-bikes and improve the production, fuel cells and petrol-electric hybrids could be introduced which are also on the verge of development and thus improving the efficiency of the electric drive system. The usage of electric bikes has turned out to be a solution for reducing pollution to a larger extent. To burgeon the sale of e-bikes it needs to be enhanced in quality, hence in the present study the e-bikes are designed with a frame that is light in weight when compared to conventional bikes for the purpose of efficacy.

Eco-Cult

Our Team is named as Eco-Cult. Eco-Cult is a combination of two words *i.e.* Economical and Cult. Economical means less expensive and cult means Team. Therefore, Eco-cult means Economical Team.
The main objective of Eco-Cult is to finalize an E-Bike which must be Economical and has good range, good speed, and good appearance.
To keep in mind all factors mentioned above Team Eco-Cult has fabricated an E-Bike named ROAD RANGER.

Road Ranger

Road Ranger is an E-Bike which is designed for the single occupant. This project is designed for roads with more ups and downs especially this more compatible for the colonies. The lightweight of this electric bike makes the ride comfortable for the rider. This is a one-seater electric motorcycle with a high-speed motor and excellent range. The project is designed especially for youth who always have a focus on unique bikes. The design is also very attractive and the main motive of this project is to make an E-bike that is Eco-friendly. This is a budget-friendly electric motorcycle which can be afforded by all class.

CONSTRUCTION, WORKING, PRINCIPLE, CLASSIFICATIONS OF E-BIKE.

The Electric bike is a bike that is driven with the help of a battery that is coupled to an electric motor.

Main principle:

It works on the principle that the electromotive force of an D.C. motor which receives electrical energy stored in D.C. battery.

Construction & Working:

It consists of a BLDC motor, controller, Battery, brakes, throttle, speedometer, etc.

Working:

We on the e-bike and start throttling due to which start running from the battery current flow to through the Controller that is used to monitor battery voltage and shut down when the battery voltage too low also far over-temperature protection like motor drawn Current from the and working as the motor is brushless DC hub motor so the current directly drawn from the battery in DC from without using dynamo and like this vehicle start running.

Classifications of e-bikes

Therefore, very broadly e-bikes can be classed as:

- E-bikes with pedal-assist only.
- E-bikes with power-on-demand and pedal-assist.
- E-bikes with power-on-demand only.

E-B IKE AND ITS COMPONENTS

Components of e-bike

- BLDC Motor
- Controller
- Battery
- Throttle/Accelerator
- Charger
- Speedometer
- Speed sensor
- On/Off ignition switch

E-Bike Components

BLDC Motor

Brushless Direct Current (BLDC) motor is a type of synchronous motor, where magnetic fields generated by both stator and rotate have the same frequency. The BLDC motor has a longer life because no brushes are needed. Apart from that, it has a high starting torque, high no-load speed and small energy losses. The BLDC motor can be configured in 1-phase, 2-phase, and 3-phase. Three-phase motors are the most popular among all the configurations and are widely used in E-bikes. The structure of a BLDC motor is divided into two parts: • Moving part called the rotor, represented by permanent magnet • Fixed part called the stator, represented by phase windings of

magnetic circuit.

Specification of BLDC Motor

Rated Voltage (DCV): 48V

Rated Power: 750W

Efficiency: 81%

Weight: 2.9Kg

Color: Silver

Wire Size: Long

Application: Electric Vehicle

Brake Type: Disc (Threaded Disc)

No Load RPM: 500 RPM

BLDC Motor

Controller

E-bike has a motor and a battery, but it's not that simple. You also need something in the middle called a controller to dose the power to the motor. Most motors these days have hall sensors to make them run smoother and also require a complex controller to dish out the power. The controller makes sure everything runs smoothly. Your throttle, motor, and battery all connect to your controller.

Specification of Controller

Rated Power:- 750W

Rated Voltage:- 48V

Brake:- Low/ABS

Speed:- 3 Variables

Auto Identification of the Hall Sensor: - YES

Auto Identification of the phase angle of 60 and 120degrees: - YES

Power & Pedal assist: - YES

Over Current Protection: - YES

The electric bike speed controller sends signals to the bike's motor hub in various voltages. These signals detect the direction of a rotor relative to the starter coil. Theproper function of a speed control depends on the employment of various mechanisms.

Controller

Accelerator/Throttle

The throttle mode is similar to how a motorcycle or scooter operates. When the throttle is engaged the motor provides power and propels you and the bike forward.

Throttle allows you to pedal or just kick back and enjoy a "free" ride! Most throttles can be fine-tuned like a volume dial between low and full power.

Li-ion Battery

The newest technology in batteries. They are pretty comparable to NiMH batteries, with the exception of two differences:

- They are a little bit lighter.
- Li Ion batteries last about 800 full charge cycles before they need to be replaced. But they are a little expensive than other batteries.

Specification of Battery

Volt:- 48V

Capacity:- 18Ah

Weight:- 12-15 Kg

Li-ion Battery

On/off/start switch of e-bike

An ignition switch, starter switch, or start switch is a switch in the control system of a motor vehicle that activates the main electrical systems for the vehicle, including "accessories". Historically, ignition switches were key switches that require the proper key to be inserted for the switch functions to be unlocked.

These mechanical switches remain common in modernvehicles, further combined with an immobilizer to only activate the switch functions when a transponder signal in the key is detected. However, many new vehicles have been equipped with so-called “keyless" systems, which replace the key switch with a push button that also requires a transponder signal"

On/off switch

Speedo Meter

A speedometer or a speed meter is a gauge that measures and displays the instantaneous speed of a vehicle.

Speedo Meter

Speed Sensor

Speed sensors let you accurately keep track of your current speed and level of support

Speed Sensor

Design of Sprocket and Chain for Electric Bike.

There are several parameters involved in the design of an efficient hybrid power system. This system is constructed by taking the following specifications and materials.

Chain drive

Chain Drive:- A Chain is an array of links held together with each other with the help of steel pins. This type of arrangement makes a chain a more enduring, long-lasting, and better way of transmitting rotary motion from one gear to another.

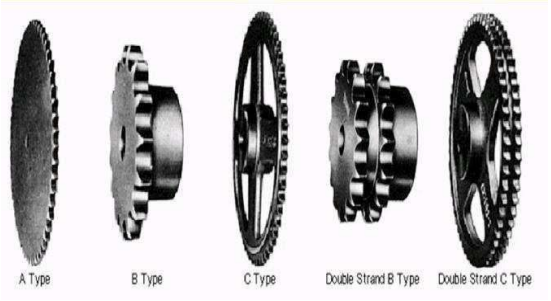
Sprockets

The chain engaging with the sprocket converts rotational power into rotary power and vice versa. The sprocket which looks like a gear may differ in three aspects:

•Sprockets have many engaging teeth but gears have onlyone or two.

•The teeth of a gear touch and slip against each other but there is no slippage in the case ofthesprocket.

•The shape of the teeth are different in gears and sprockets.



Sprockets

Proposed Calculations of an E-Bike

Calculation of Motor Power:-

Kerb Weight:- 90kg

Passenger Weight:- 70kg

Total Weight:- 90+70= 160Kg

Tyre Specification:- R16”/2.5

Rim Diameter:- 16*25.4= 406.4

Tyre Height:- 2.5*25.4= 63.5

Tyre Radius:- 406.4+63.5+63.5/2= 266.7 ~ 267mm

Tyre Circumference:- 2πr

= 2*3.14*267= 1.676 ~ 1.68m

Speed:- 35 Km/h = 35*1000/3600 = 9.7m/s

RPM at wheel = 9.7*60/1.68 = 346.42 ~ 347 rpm

Bike Frontage Area

Width:- 750 mm

Height:- 1110 mm

Person:- 600 mm

= 750 (1110+600)

1.28 m^2 * adjusting value 1.28*0.70

= 0.89 m^2

Air Density :- 1.2 Kg/m^3

Air Drag:- 0.82

Coefficient of Rolling Resistance :- 0.02

 # Total Force = Rolling Force + Drag Force

Rolling Force = mgC_{rr}

= 160*9.81*0.02

= 31.3 ~ 32 N

Drag Force = ½* air density*front area*v^2

= ½*1.2*0.82*0.89*9.7*9.7

= 41.200 ~ 41 N

F_T = 41+32

:- F_T*v

Motor Power = 70*9.7

= 708.1 W ~ 708 W

Hence, 750W Motor is selected.

Calculation of Battery Power:-

750W 48V Motor is selected

P=V*I

750 = 48*I

Current (I) = 15.62 Amp

: - Find out Watt Hour of Battery

Battery Efficiency is approx. 90%

So, The battery Watt Hour required = 750/90 = 833.33

The Battery Aph is required:-

P=V*I

833 = 48*I

I = 17.36 ~ 18 Aph

Hence, 48V 18Ah Battery is selected.

Advantages of E-Bike

FAST AND FLEXIBLE: The technology gives you the extra oomph you need to cover miles of distance with little effort. You can also still take advantage of the multi-purpose cycle lane and paths that are traffic-free, brilliant if you're living in a city to slash your commute time. These are getting more and more popular in cities as governments and councils urge people to give up their car.

The bikes have been developed over the years and now look almost like a normal bike frame, with only the subtle 'hum' giving them away. Take advantage of the lithe form and durability of an E-bike without anyone being the wiser!

CUT BACK EXPENSES: If you use the E-bike instead of a motor vehicle it will save you money in the long run. Petrol and diesel are costly in most countries, and occasional price surges can really impact your budget. While with E-bikes, you can buy affordable batteries which can last you 18-50 miles after a full charge depending on the level of assistance you use.

THEY'RE THE FUTURE TRANSPORTATION: The electric bike is on its way to being up there with its smart counterparts. Considering that this invention will improve continuously over time, what we have now might be the prototype of this promising transport.

Many countries in Southeast Asia took the lead in using E-bikes as a sustainable mode of transportation, and with the continuous rise of urban air pollution, there is a big future for E-bikes.

NATURE FRIENDLY: Climate change and global warming are serious issues and we all need to play our part. We might be facing our last stand to save our dying earth, and we can all contribute to this. E-bikes emit lower pollution per kilometer than motorcycles and cars. You can help by using an E-bike instead of a petrol or diesel car. They use energy with an average rate of 100 to 150 watts compared to 15,000 or so for a car. As a result, this can help to improve air quality.

WIDE VARIETY OF DESIGNS: With technology, everything is almost possible, and as the marketability of bikes increases, companies produce a variety of designs that can accommodate your needs. If there isn't the perfect one out there right now, you can be pretty sure there will be soon.

FUTURE SCOPE

Electric bicycles (E-Bikes) are bicycles that have a small electric motor and rechargeable batteries to assist the power provided by the rider. Electric bicycles are to witness significant growth over the forecast period owing to new technology developments and the increasing affordability and availability of productofferings.

Innovative technologies emerging in the e-bikes market are expected to drive market growth over the forecast period. For example, throttle-control, pedal-assist models, all-in-one retrofit kits and wheels, and electric cargo bicycles. The use of these bicycles in police patrol and various other security industries has contributed to a growing market with strong potential. These bicycles emit a lot less carbon than a car would. A study from Transportation Alternatives found that if 10% of New York City commuters biked to work just once a week instead of driving or taking public transit, they could cut back on 120 million pounds of CO_2 emissions per year that is equal to the amount of CO_2 released by 25,000 New York homes peryear.

CONCLUSIONS

Our project may provide a solution for this existing problem since charging the battery is done as the vehicle runs. It is very much suitable for young, aged people and caters to the need of the economically poor class of society. The most important feature of this e-bike is that it does not consume valuable fossil fuels thereby saving money.

It is eco-friendly & pollution-free, as it does not have any emissions. Moreover, it is noiseless and can be recharged with the AC adapter in case of emergency and cloudy weather. Purchase electric bike and save our mother earth and It is you Who can stop population and start a revolution.

The issues associated with electric bicycles may be addressed by custom-designed drives that are most efficient over a given operating bike. These include city e-bikes, hill e-bikes, distance e-bikes, and speedy e-bikes.

The results of the studies listed here can serve as a platform to improve electric bike performance if new drive systems are designed around key parameters that will result in improvement of the system performance.

Furthermore, they can be used for comparison of existing drives in a systematic, comprehensive, and technical way.

ACKNOWLEDGEMENT

Deep sense gratitude to project guide Assistant Professor Ankit Saxena whose overall direction and guidance have been responsible for the successful completion of this project. We would like to thanks all the faculty of the mechanical and automation engineering department who motivated throughout despite their schedules and commitments. Our sincere thanks to Neeraj Sir Head of the department, mechanical and automation engineering for the encouragement and guidance provided. And also we thank the almighty for bestowing upon us all his blessings for the compilation of this project. We would like to express our depth of gratitude to our parents for supporting us and motivating us toward our studies.

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4. Manufacturing Systems Engineering A Unified Approach to Manufacturing Technology, Production Management, and Industrial Economics

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VOICE BASED WEB ROBOTIC CONTROLLER

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***Abstract*—Here this paper represents the objective of a Web App based Drone or Robot Controller. In the era where automation is driving the world we are still far away from complete flexibility in this segment. Like for an example lets take Drone or Robots. These are one of the main assets of Automation Industry but still lags in flexibility. We know that these objects can be controlled by a normal joystick type controller, android app or an iOS app**

I.

II. INTRODUCTION

PRESENTING YOU THE COMPLETE SYNOPSIS ON WEB APP BASED ROBOTIC CONTROLLER WHICH WILL BE COMPLETELY BASED ON A WEB PAGE. ANYONE FROM ANY FIELD WITH BASIC INSTRUCTIONS CAN OPERATE A ROBOT FROM A LAPTOP WITH THE HELP OF A NORMAL WEB PAGE. YES WITH A NORMAL PAGE BASED ON WEB APP. EASY, FLEXIBLE, AFFORDABLE CONTROLLER FOR CONTROLLING DRONES OR ROBOTS.EASE OF USE

Flying a drone or operating a robot or operating a light sounds crazy right. But today in the world of automation this project is necessary and highly required. A controller which will be made with the help of technologies used in Web App. Technologies like JavaScript and its framework Node.js will be used to make. A library of Node.js called DGRAM will play the main role here.

Construction Path

How the construction will take place ?

1. Initially a Web Page will be made with the help of HTML, CSS, Booststrap and Basic JavaScript.

2. Backend code will be written by using Javascript framework called node.js and its library DGRAM.

3. A local wifi connection will be made with the help of professional drone, take for example DJI Tello and the ports will be made to connect with it in backend code written in Node.js

4. Lastly the commands can be passed through terminal (in MacBook) which will

trigger the following functions like takeoff, land in the following drone.

5. Also, the connection from frontend to backend will made via using API for the better look

Construction Setup –

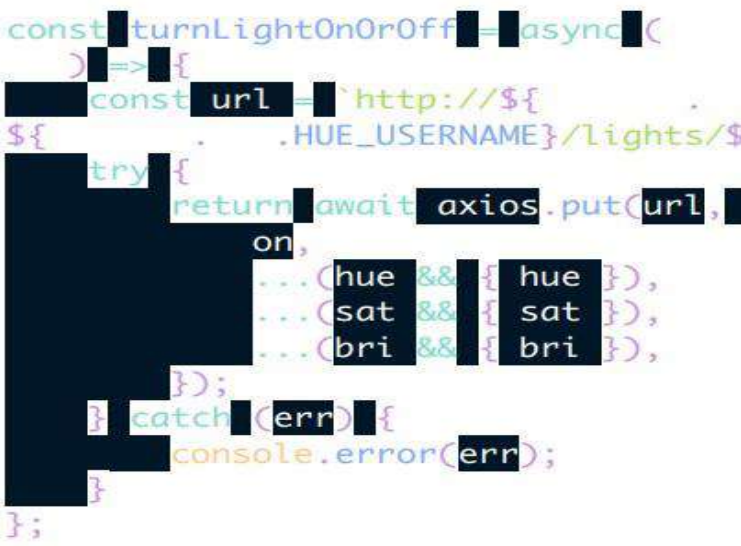
Tools - A drone or A Robotic Device. Technologies - WebApp Based Technologies like Javascript and Framework Node.js. A local wifi or hotspot will be made with the help of the professional robot or drone. • the IP address of your hub • a username • the ids of your bulbsAuthors and Affiliations

Working

The port will be called in the node.js code which will allow the ports to be connected properly.

Code Ex - const dgram : require('dgram') ; The connection will be made through ports using Hotspot. Code Ex - const PORT : 8889;

A message will be send to the device after the input has been given in terminal through commands. Commands will be tried to keep simple as possible like "take-off or land". Code Ex - Algorithms Needed to be done.



Current Status

As of now the Voice Command Based controller is now ready. Basic functions like On Off is being performed with that controller.

Raspberry Pie further needed to integrate with robotic device in order to take commands and perform accordingly.

Codes using Javascript and Voice Commands API has been used to make the controller more effective by using voice commands.

After these few certain commands a drone or a robot will receive a signal through terminal commands & will perform certain actions.

A complete flexible and friendly controller will be resulted which will be working on a simple Web Page from any device whether a smartphone or a laptop or a smart tv. The following advantages if this project becomes successful Completely Cost Efficient, No prior Experience or Training,

A friendly and flexible controller which can be used by anyone.R.

Literature Survey / Bibliography -

1. DJI - Reference for high end professional drones and device. 2. Ryan Dahl - Author and Founder of Node.js framework. 3. Google and Youtube - For further research in this project.

Conclusion and Advantage

THANK YOU

Use of Computational Intelligence for Real-Time Path Following of a Cooperative Robotic System

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Abstract: In this paper optimal trajectory following for a system of two cooperative serial manipulators is studied. First the kinematic redundancy problem is explained and the optimal path to resolve the system redundancy is obtained via Pontryagin's Minimum Principle. For the time integration of the equations and solving the two point boundary value problem, a shooting method is employed and initial values are updated based on two different methods: 1. Taylor series approximation, and 2. Genetic Algorithm optimum selection. It is concluded that due to the high dependency of the convergence rate to the initial estimations of the boundary conditions, Genetic Algorithm proves to be more reliable and faster; however, the whole proposed method is not suitable for the real-time purposes due to the excessive computation time requirements. To tackle this problem, an artificial neural network (ANN) is designed and trained to obtain the optimal solution for a new desired trajectory.

USE OF COMPUTATIONAL INTELLIGENCE FOR REAL-TIME PATH FOLLOWING OF A COOPERATIVE ROBOTIC SYSTEM

Abstract: **In this paper optimal trajectory following for a system of two cooperative serial manipulators is studied. First the kinematic redundancy problem is explained and the optimal path to resolve the system redundancy is obtained via Pontryagin's Minimum Principle. For the time integration of the equations and solving the two point boundary value problem, a shooting method is employed and initial values are updated based on two different methods: 1. Taylor series approximation, and 2. Genetic Algorithm optimum selection. It is concluded that due to the high dependency of the convergence rate to the initial estimations of the boundary conditions, Genetic Algorithm proves to be more reliable and faster; however, the whole proposed method is not suitable for the real-time purposes due to the excessive computation time requirements. To tackle this problem, an artificial neural network (ANN) is designed and trained to obtain the optimal solution for a new desired trajectory.**

Keywords— **Cooperative Robots, Computational Intelligence, Pontryagin's Principle**, **Genetic Algorithm, Neural Network**

1. Introduction

Parallel robots present very good performance in terms of accuracy, rigidity, ability to manipulate large loads, and fast acting. They are used in a large number of applications ranging from milling machines and automobiles to flight simulators and astronomy. Cooperative robots – a group of manipulators holding an object – are also of high significance, as compared to the single-arm structures. They can be used in flexible objects assembly, material handling, etc., in which the

capability of carrying large loads and high accuracy are needed [1]. During the past decades, there has been a large interest in using cooperative robot manipulators in dynamic analysis, trajectory planning, and control [2–8].

Kinematic redundancy is one of the important issues in this field to be solved. Different optimization methods are used for redundancy resolution, among which Pontryagin's Minimum Principle is one of the most practical methods [9,10]. This method has been utilized for single arm robots [11–13] and Cooperative robots [14–18] to optimize time, energy, joint torque, etc. The main challenge in implementing Pontryagin's method is finding a proper algorithm to solve a two point boundary value problem based on the intrinsic properties of the problem in hand.

In this paper the optimal control theory based on Pontryagin's Minimum Principle is investigated for a set of two cooperative 3-linked serial manipulators. To follow a specific workspace path, the optimum joint space trajectory is obtained. Due to the natural redundancy of the system, a shooting method with optimum boundary conditions is used to find the optimum trajectory. In order to update the initial shooting conditions, two different methods based on Taylor Series and Genetic Algorithm are employed and later compared to each other to show the convergence rate. It is discussed that the results of shooting method must be checked by other important conditions. Numerical solutions for some given task-space trajectories are obtained. An artificial neural network is then designed and trained using collected information from previously resolved trajectories to properly approximate the optimal configuration of the system for a new desired trajectory. The network validation is finally discussed by considering numerical cases. Unlike its predecessors [16,17], the method introduced herein, gives the energy optimal path in "real-time" by the aid of neural network regression.

2. Mathematical Modelling

Consider the vectors $\mathbf{q} \in \mathcal{R}^n$ and $\mathbf{X} \in \mathcal{R}^m$ to be the joint space and the work space vectors of a redundant system, respectively. n is the total number of joint space variables of the manipulators composing the system. m is the dimension of the task space. The problem is determination of a trajectory $\mathbf{q}(\mathrm{t})$ in the joint space so that the end effector starts its motion from point $\mathbf{X_0}$, passes the specified trajectory $\mathbf{X}(\mathrm{t})$ and reaches the final position $\mathbf{X_f}$. The kinematic equation of the system can be written as:

$$\mathbf{F}(\mathbf{q}) = \mathbf{X}(\mathrm{t}) \qquad (1)$$

The differentiated form of (1) is:

$$\mathbf{J}(\mathbf{q})\dot{\mathbf{q}} = \dot{\mathbf{X}}(\mathrm{t}) \qquad (2)$$

$\mathbf{J}_{m\times n}$ is the Jacobian matrix of the whole system where $m < n$ due to the system redundancy. The general solution to the differential (2) is [15]:

$$\dot{\mathbf{q}}(\mathrm{t}) = \mathbf{J}^{\#}\dot{\mathbf{X}}(\mathrm{t}) + (\mathbf{I} - \mathbf{J}^{\#}\mathbf{J})\mathbf{y} \qquad (3)$$

Where $\mathbf{J}^{\#}$ is called the pseudo inverse of Jacobian matrix and is defined as:

$$\mathbf{J}^{\#}(\mathbf{q}) = \mathbf{J}^{\mathbf{T}}(\mathbf{J}\mathbf{J}^{\mathbf{T}})^{-1} \qquad (4)$$

and the parameter $\mathbf{y} \in \mathcal{R}^n$ is an arbitrary vector which explains the redundancy. $\mathbf{I}$ is an $n \times n$ identity matrix. (3) explicitly represents r

edundancy by the second term of the right-hand side. This means that different answers can be obtained for $\dot{\mathbf{q}}(\mathrm{t})$. Therefore an index, *P*, can be optimized while keeping the end-effector on the desired task space trajectory. In this paper, index *P* is defined as below [10]:

$$P = \int_{t_0}^{t_f} \dot{\mathbf{q}}^{\mathrm{T}}\, \dot{\mathbf{q}}\, dt \qquad (5)$$

This index is an indicator for the total kinetic energy, computed during the whole mission time $[t_0, t_f]$.

In fact the problem leads to finding the joint space trajectory $\mathbf{q}(t)$ that optimizes the index, as well as satisfying the kinematic constraints while following the desired path by the end-effector.

2.1. Pontryagin's Minimum Principle

Consider a general dynamic system governing equation:

$$\dot{\mathbf{x}}(t) = \mathbf{f}(\mathbf{x}, \mathbf{u}) \qquad (6)$$

The control vector $\mathbf{u}^*$ is called the optimized control, if it leads the state $\mathbf{x} \in \mathcal{R}^n$ to be on the allowable desired trajectory and optimizes the performance index P as well:

$$P = \int_{t_0}^{t_f} f_0(\mathbf{x}, \mathbf{u}) dt \qquad (7)$$

To this end, the Hamiltonian is defined as:

$$\mathcal{H}(\mathbf{x}, \mathbf{u}, \boldsymbol{\psi}) = f_0 + \boldsymbol{\psi}^T \boldsymbol{f} \qquad (8)$$

where $\boldsymbol{\psi} \in \mathcal{R}^n$ is the adjoint vector. According to Pontryagin's Minimum Principle [10], in order to have $\mathbf{u}^*$ as the optimized control law during the time interval $[t_0, t_f]$, the following equations should be satisfied:

$$\dot{\mathbf{x}}^*(t) = {}^{\partial \mathcal{H}}/_{\partial \boldsymbol{\psi}} \qquad (9\text{-a})$$

$$\dot{\boldsymbol{\psi}}^*(t) = -{}^{\partial \mathcal{H}}/_{\partial \mathbf{x}} \qquad (9\text{-b})$$

$${}^{\partial \mathcal{H}}/_{\partial \mathbf{u}} = 0 \qquad (9\text{-c})$$

Equations (9-a) to (9-c) are a combination of algebraic and differential equations and the optimized trajectory is derived by solving them. They are necessary (not sufficient) conditions for the optimized control law which means a trajectory satisfying equations (9) is not the optimized path necessarily.

Generally, equations (9) may be solved using numerical integration but in the particular case of linear or parabolic Hamiltonian with respect to $\mathbf{u}$, the equations have analytical solution.

Considering (3) and (5) and by setting:

$$\mathbf{f}(\mathbf{q},\mathbf{y}) = \mathbf{J}^{\#}(\mathbf{q})\dot{\mathbf{X}}(\mathrm{t}) + \left(\mathbf{I} - \mathbf{J}^{\#}(\mathbf{q})\mathbf{J}(\mathbf{q})\right)\mathbf{y} \qquad (10)$$

The problem of obtaining the optimum trajectory for the redundant cooperative robot, can be defined as:

$$\dot{\mathbf{q}} = \mathbf{f}(\mathbf{q},\mathbf{y}) \qquad (11)$$

$$P = \int_{t_0}^{t_f} f_0\,(\mathbf{q},\mathbf{y})$$

and $f_0 = \mathbf{f}^{\mathrm{T}}\mathbf{f}$ is set to optimize the kinetic energy of the system while moving. By comparing these equations to (6) and (7), one can conclude that optimal trajectory problem may be solved using optimal control theory. One should note that herein, index *P* is in parabolic form with respect to $\dot{\mathbf{q}}$ and consequently with respect to $\mathbf{y}$. Thus, for this problem, equations (9) have the analytical solution in which [15]:

$$\mathbf{y} = -\tfrac{1}{2}[\mathbf{I} - \mathbf{J}^{\#}\mathbf{J}]\boldsymbol{\psi} \qquad (12)$$

and

$$\dot{\mathbf{q}} = \mathbf{f} \qquad (13\text{-a})$$

$$\dot{\boldsymbol{\psi}} = -\left[\frac{\partial \mathbf{f}}{\partial \mathbf{q}}\right]^{T}(2\mathbf{f} + \boldsymbol{\psi}) \qquad (13\text{-b})$$

where $\mathbf{f}$ in (10), can be rewritten as:

$$\boldsymbol{f} = \mathbf{J}^{\#}\dot{\mathbf{X}}(t) - \tfrac{1}{2}(\mathbf{I} - \mathbf{J}^{\#}\mathbf{J})\boldsymbol{\psi} \qquad (14)$$

2.2. Boundary Conditions

Since equations (13-a) and (13-b) have *2n* entries, to perform their time integration, *2n* boundary conditions are necessary. The evident boundary condition (at initial time) is:

$$\mathbf{F}(\mathbf{q}_0) = \mathbf{X}_0 \qquad (15)$$

The other boundary condition derived from the condition of a free right-hand endpoint (at final time) is:

$$\boldsymbol{\psi}(t_f) = 0 \qquad (16)$$

The former gives *m* boundary conditions and the latter gives *n* boundary conditions, making a total number of *n+m* conditions. The remaining *n-m* boundary conditions must be obtained from the transversality condition at the left-hand end point. That is, the initial adjoint vector $\boldsymbol{\psi}(t_0)$ should orthogonally intersect with the manifold $\mathbf{F}(\mathbf{q_0}) = \mathbf{X_0}$, giving a set of admissible points $\mathbf{q}$ at $t = t_0$. The mathematical explanation of this condition is:

$$[\mathbf{I} - \mathbf{J}^{\#}(\mathbf{q}_0)\mathbf{J}(\mathbf{q}_0)]\boldsymbol{\psi}(t_0) = 0 \qquad (17)$$

Note that there are totally *2n* boundary conditions at both sides of the trajectory. This leads to a two-point boundary value problem.

To solve multipoint boundary value problems, researchers have proposed an initial value adjusting method [10], which shall be explained briefly here for a two-point boundary value problem. First, the unknown right-hand endpoint (i.e. at the final time) boundary value is estimated. Second, the differential equations are solved as ordinary initial value problems by combining the estimation of the unknown right-hand endpoint boundary values with the known right-hand endpoint boundary values. Next, depending on the difference between the known left-hand endpoint (i.e. at the initial time) boundary values and their computed values (that is the error due to the prior guess), the estimation of the right-hand endpoint boundary values are modified. This try and error process is repeated until the error converges to zero.

Solving a two point boundary value problem using the mentioned method needs great computational effort. In order to mitigate this problem, and keeping in mind that if and only if

$\mathbf{q}(t_0)$ satisfies $\mathbf{F}(\mathbf{q}_0) = \mathbf{X}_0$, then $\mathbf{q}(t_f)$ satisfies $\mathbf{F}(\mathbf{q}_\mathrm{f}) = \mathbf{X}_\mathrm{f}$, the boundary conditions (15), (16), and (17) may be rearranged as:

$$F(\mathbf{q}_f) = \mathbf{X}(t_f) \qquad (18\text{-a})$$

$$\boldsymbol{\psi}(t_f) = 0 \qquad (18\text{-b})$$

$$\mathbf{e} = [\mathbf{I} - \mathbf{J}^{\#}(\mathbf{q}_0)\mathbf{J}(\mathbf{q}_0)]\boldsymbol{\psi}(t_0) = 0 \qquad (18\text{-c})$$

Equations (18) mean that the problem can be regarded as a two-point boundary value problem with *n-m* boundary conditions at the left-hand endpoint and *n+m* conditions at the right hand endpoint. Therefore, if equations (13) are integrated conversely from t_f to t_0 , the number of variables whose boundary values should be estimated and modified in the initial value adjusting method, is reduced to *n-m*. That is, the optimal redundancy control problem of equations (1) and (5) has been reduced to a minimum-value search problem of a dimension as the degrees of redundancy. Consequently, the *n-m* estimations are done at t_f and by backward integration, $\mathbf{q}_0$ and $\boldsymbol{\psi}_0$ are obtained. Then the condition **e**=*0* is checked and if it is not satisfied the estimation will be modified. This procedure is repeated until finding the roots of **e** in equations (18). This is an optimization problem to minimize the error **e**.

3. Iterative Method

To perform the optimization (explained above), herein two methods are employed and compared: 1) Taylor Series iteration loop and 2) the Genetic Algorithm.

3.1. Taylor Series Iteration Loop

In this iteration method, the estimated right-hand boundary value, *s*, is updated as:

$$s_{\mathrm{n+1}} = s_{\mathrm{n}} - (\frac{\partial \mathbf{e}}{\partial s})^{-1}\mathbf{e}_{\mathrm{n}} \qquad (19)$$

The iteration is repeated until second norm of **e** is small enough (near zero). In this method the first estimation is very important and the number of iterations highly depends on this estimation.

3.2. Genetic Algorithm

Genetic Algorithms (GA) are adaptive heuristic search algorithms premised on the evolutionary ideas of natural selection and genetic. The basic concept of GA is designed to simulate the process of survival of the fittest in natural systems necessary for evolution, specifically those that follow the principles first laid down by Charles Darwin. To solve an optimization problem, one must represent an intelligent exploitation of a random search within an admissible search space [19]. GA is a model of machine learning which derives its behavior from a metaphor of the processes of evolution in nature. This is done by creating a population of individuals represented by chromosomes, originally a set of character strings that are analogous to the base-4 chromosomes that are in human's DNA. The individuals in the population then go through the process of evolution.

In the nature, sexual reproduction leads to the formation of genetically variant children. In the molecular view point, some genetic characteristics (genomes) are exchanged between the chromosomes bumping together. This way of production of individuals of the new generation population is called "crossover" operation. The selection of the parents in the mathematical modelling, however, is usually based on the fitness (i.e. fitness-proportionate parent selection) of the individuals [20].

There are other types of formation of the individuals for a generation. Mutation is the transfer of a randomly selected chromosomes to the new generation while its genomes are randomly varied thus making Genetic Algorithm a stochastic process searching for the highly fit individual [20].

Besides a specific number of the fittest individuals are conveyed to the new generation without any alteration. This operator is called “Elite Transfer” and survives the best individuals through the evolutionary process.

To use GA method in this work, the estimated boundary values at right-hand side (final time) form the chromosome. Thus, the genome length is *n-m*. The cost function (to be minimized) is the second norm of the error vector **e** as defined in (18-c).

To use the traditional Genetic Algorithm method 20 individuals are used to form each generation. The initial population is randomly generated. The cross over fraction, mutation rate, and elite count of 0.7, 1.3, and 3 proved to work well, respectively. The stop condition is again defined as the second norm of error to be smaller than 10^{-2}.

4. Artificial Neural Network Modelling

The resolution of the redundancy by optimization of a cooperative system consisting two 3-linked serial manipulators is performed so far and a number of task space trajectories are applied to the system and the optimal joint space configurations are calculated for each trajectory by using the procedure described previously. If the defined system is employed to carry the object in a desired trajectory or few desired trajectories, the calculations can be done and the manipulators are trained to do the requested job. But what will happen in general case if the manipulators are asked to carry the object through new trajectories that the mentioned calculations have not been done for them?

In this paper it is tried to provide an artificial neural network and train it to answer the above mentioned question. This means that by using the calculated trajectories information, the designed artificial neural network will be trained in such a way to converge the network response to a proper optimal point with an acceptable error.

The neural network which is used here is a Multi-Layered Perceptron (MLP) with back propagation learning algorithm. The designed network consists of 3 hidden layers with 30, 40, and 30 number of neurons in each.

Back-propagation was created by generalizing the Widrow-Hoff learning rule for multiple-layer networks and nonlinear differentiable transfer functions. Input vectors and the corresponding target vectors are used to train the network until it can approximate a function. According to the universal approximation theorem [21], ANNs with biases, sigmoid hidden layers, and a linear output layer can approximate any function with a finite number of discontinuities.

There are variations of back-propagation algorithm. In the simplest one, the network weights and biases update in the opposite direction of the gradient. An iteration of this algorithm can be written:

$$x_{k+1} = x_k - \alpha_k g_k \qquad (20)$$

Where x_k is a vector of current weights and biases, g_k is the current gradient, α_k is the learning rate. In this work a heuristic technique with adaptive learning rule is used as the back-propagation algorithm which is able to perform fast training compared to the other methods.

5. Sample Problem and Numerical Solution

The mechanism shown in Fig 1-a. consists of two cooperative serial planar arms, each one having three links and three actuators. Both arms are fixed to the frame in their base located by distance *S* from each other. The joint variables q_1 to q_6 are relative angles of each link with respect to the previous one. The object to be manipulated has length l_e and centroid m_c is also shown.

The desired trajectory of the object in Cartesian space is:

$$\mathbf{X} = [x(t), y(t), \varphi(t)]^T \qquad (21)$$

In which $x(t)$ and $y(t)$ are measured in the base frame $\{X_0, Y_0\}$ and $\varphi(t)$ is the angle of the line connecting both revolute joints holding the object with respect to X_0 axis measured about Z_0 axis. The whole system can be considered as a parallel manipulator with 8 links, including the ground and the object. Using Grubler's formula the degrees of freedom is obtained to be 5 and the manipulated object has 3 degrees of freedom in the workspace. Thus, the problem has 2 degrees of redundancy.

Table 1 shows the length of the links for the current model. The desired trajectory as mentioned in (21) for this problem is considered to be:

$$\begin{cases} x(t) = 0.3t + 0.2 \\ y(t) = 0.1t^3 + 0.2t^2 + 0.3t + 0.1 \\ \varphi(t) = \frac{\pi}{6}\, t \\ t \in [0,1] \end{cases} \qquad (22)$$

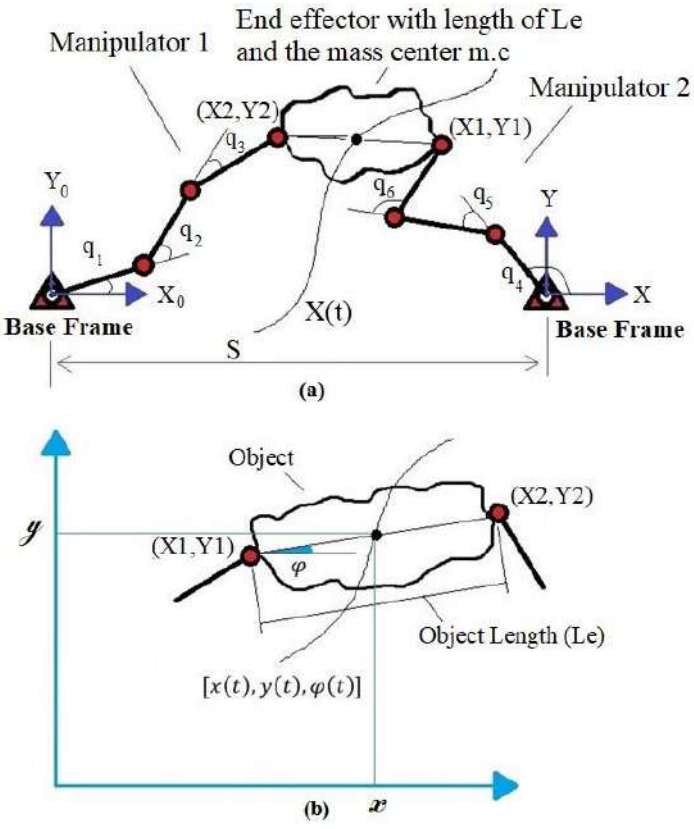

Fig1. a) The cooperative system with 3-linked serial manipulators, b) The task space parameters

The distance between the bases of the two arms and the length of the manipulated object are $S = 1\ m$ and $l_e = 0.2\ m$. In order to find the optimal trajectory (due to 2 degrees of redundancy), two joint variables: $q_1(t_f) = q_{1f}$ and $q_4(t_f) = q_{4f}$ are chosen as estimations of the right-hand end point boundary value of the joint space trajectory.

Table1: the manipulator lengths

	Arm 1			Arm 2		
Link No.	1	2	3	4	5	6
Link Name	l_1	l_2	l_3	l_4	l_5	l_6
Length [m]	0.5	0.4	0.3	0.5	0.4	0.3

The task space parameters x, y, and φ are depicted in Fig1-b. The trajectories of the end effectors of the arms will be $(X1(t), Y1(t))$ and $(X2(t), Y2(t))$ calculated by:

$$\begin{cases} X1(t) = x(t) - \frac{l_e}{2} cos(\varphi(t)) \\ Y1(t) = y(t) - \frac{l_e}{2} sin(\varphi(t)) \\ X2(t) = x(t) + \frac{l_e}{2} cos(\varphi(t)) \\ Y2(t) = y(t) + \frac{l_e}{2} sin(\varphi(t)) \end{cases} \tag{23}$$

As the kinematic equations of each manipulator are calculated independently from the other one, the defined performance index P in (11) can be calculated for each arm separately.

So the performance index P for the whole system can be written as:

$$P = P_1 + P_2 \tag{24}$$

In which P_1 and P_2 are the performance indices of manipulator 1 and 2, respectively. Because of the geometrical constraints of the arms, the first joint variable of each arm may vary in the range of: Arm 1: $q_{1f} \in [-0.08, 2.11]\ rad$, Arm 2: $q_{4f} \in [1.13, 3.03]\ rad$.

Table 2 represents the optimization statistics, including the first estimation of joint variables, their optimal values, and number of shooting method iterations to converge considering the defined computational error. It is clear from this table that for different first estimations of q_{1_f} (first link angle of manipulators at the time t_f), different optimal values and consequently different performance indices (P) are achieved via shooting method. Since the target of the problem is minimizing the performance index, so the lower value for the performance index will be acceptable here and also the configuration of manipulator that gives this minimum index will be optimum configuration.

Table 2: Optimization Statistics

Arm No.	First estimation of first joint (rad)	$\|e\|<$	Number of iterations	Optimal value for the first joint (rad)	Related P (rad.^{2}/s)
1	0.4	0.01	26	0.49	11.06
	1.2	0.01	23	1.05	5.76
	2	0.01	27	1.93	2.5
2	1.13	0.01	19	1.18	5.33
	1.5	0.01	31	1.38	5.57
	2	0.01	25	2.23	3.12

However, the question is how one can find the area that is near the optimum point to obtain an estimation of the optimum angle through shooting method. Fig 2. illustrates the variation of the error **e** as defined in equations (18) versus the estimation of the first link angle of manipulator 1 (q_{1_f}) at the end of time ($t_f = 1\ s$) and Fig 3. shows the variation of performance index for q_{1_f} .

In Fig 2., at 3 points, the error is near zero: point1: (q_{1_f}=0.49 *rad*), point2: (q_{1_f}=1.05 *rad*) and point3: (q_{1_f}=1.93 *rad*) but according to Fig 3. at the first and second points (q_{1_f}=0.49 *rad*) and (q_{1_f}=1.05 *rad*), we have the local maxima and the index at this point is bigger than the index at point (q_{1_f}=1.93 *rad*) that is local minima. It means that although the error in points (q_{1_f}=0.49 *rad*) and (q_{1_f}=1.05 *rad*) tends toward zero, it is not the true answer of the problem because there is another point in which the error tends toward zero (q_{1_f}=1.93 *rad*) and the performance index is local minima and less. Thus as we look for the minimum index, (q_{1_f}=1.93 *rad*) is the proper answer for the manipulator 1 at ($t_f = 1sec$).

Since the condition given by Pontryagin's maximum principle is the necessary (but not the sufficient) condition, therefore the transversality condition must be satisfied at the local maxima and minima of the performance index, hence, one has to compute the performance index directly to find the optimal solution.

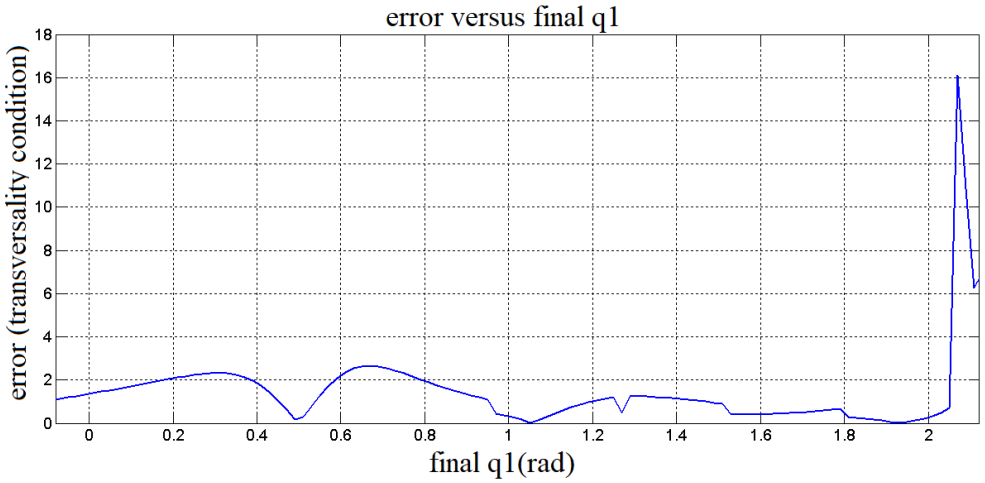

Fig 2. Variation of error with respect to the final first link angle of manipulator1 (q_{1_f})

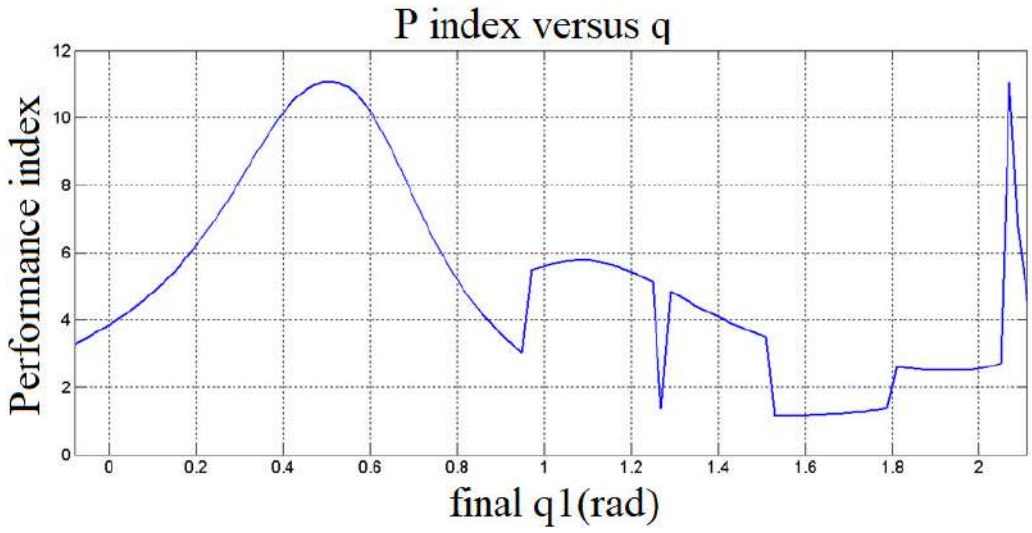

Fig 3. Variation of performance index with respect to the final first link angle of manipulator1 (q_{1_f})

In other words computation of performance index in addition to checking the transversality condition is necessary from the practical point of view. Figure 4 shows the transversality condition and performance index versus variations of the first link angle of manipulator 2 at the final position. It should be considered that $q_{4_f} \in [1.13,3.03]$ *rad*.

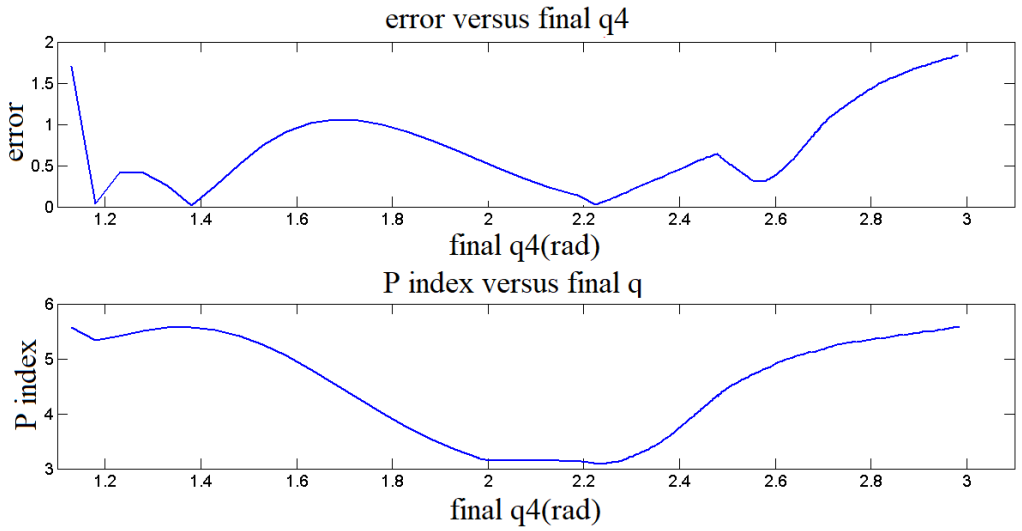

Fig 4. Variation of performance index and transversality condition in manipulator 2

Considering Fig 4. and Table 2 and according to the previous descriptions in a similar way the optimal value for the first angle of manipulator 2 at the final time is: (q_{4_f}=2.23). Consequently the minimum performance index *P* of the system according to the (24) is:

$P = P_1 + P_2 = 2.5+3.12$ *(rad2/s)*

Figures 5 to 10 illustrate the optimal trajectories of manipulators.

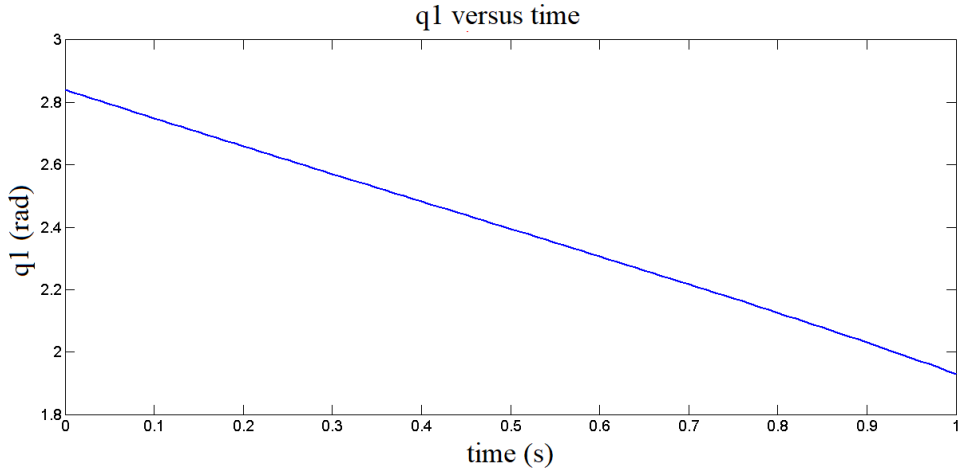

Fig 5. Optimal trajectory of first link in manipulator 1 (q_1)

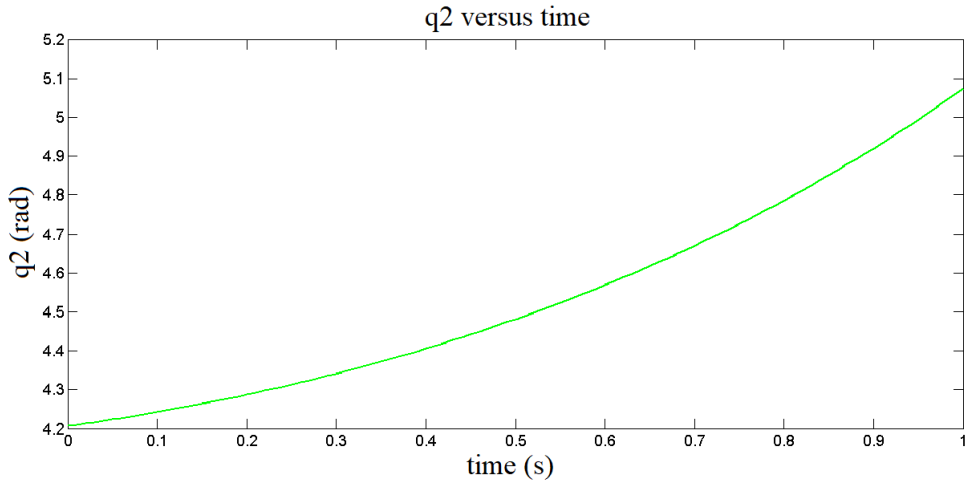

Fig 6. Optimal trajectory of 2nd link in manipulator1 (q_2)

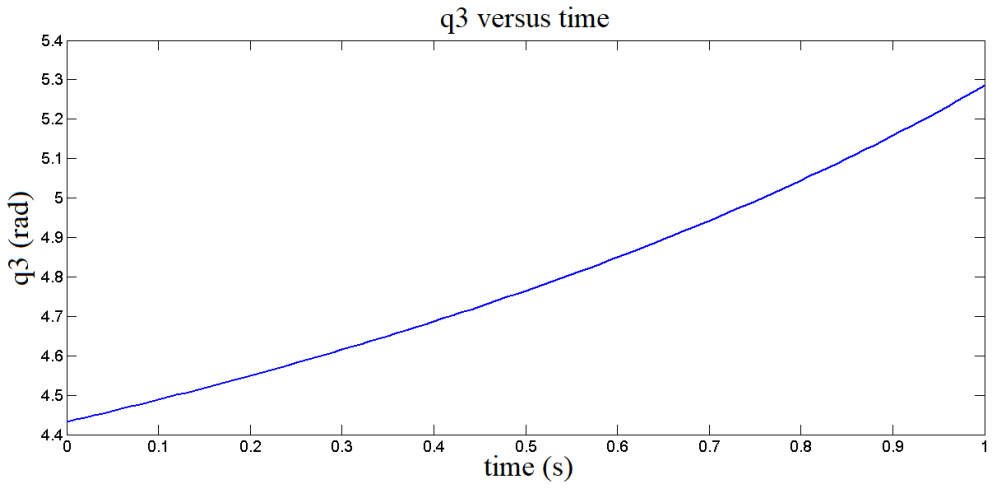

Fig 7. Optimal trajectory of 3th link in manipulator 1 (q_3)

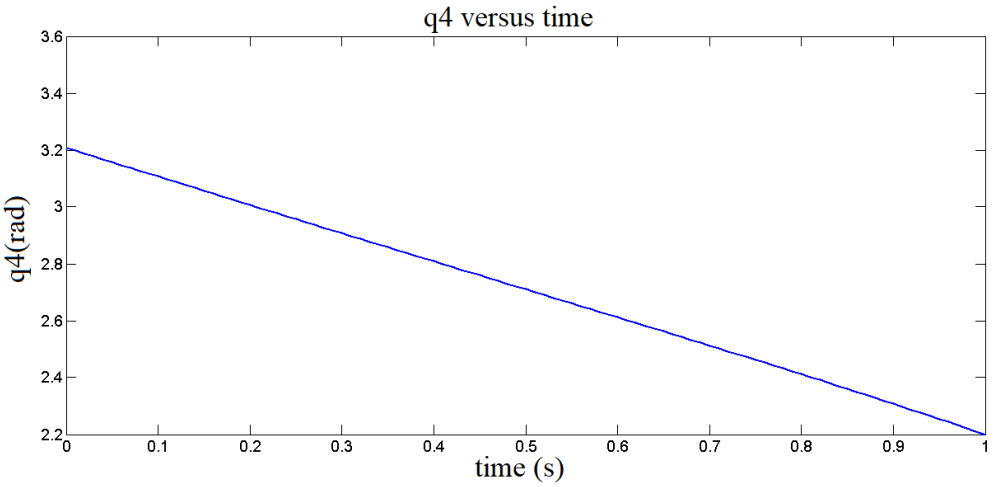

Fig 8. Optimal trajectory of first link in manipulator 2 (q_4)

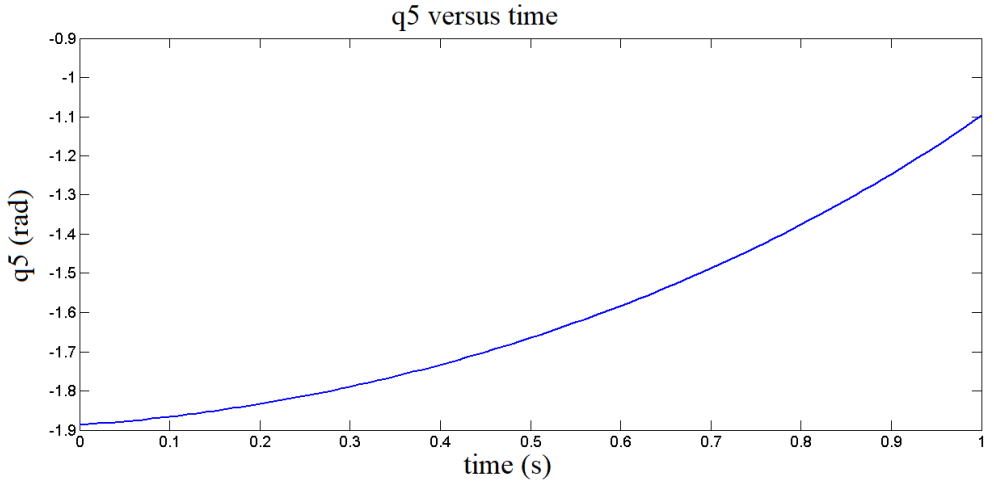

Fig 9. Optimal trajectory of 2nd link in manipulator 2 (q_5)

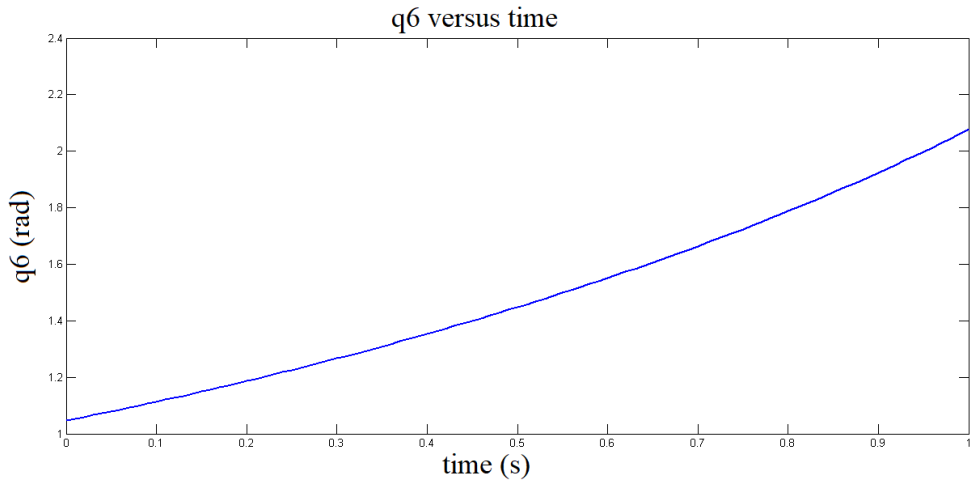

Fig 10. Optimal trajectory of 3th link in manipulator 2 (q_6)

5.1. Optimization: Taylor Series & Genetic Algorithm

In order to use GA method in this work, the estimated boundary values at the right-hand side (final time), form the chromosome. Thus, the genome length is *n-m*. The cost function (to be minimized) is the second norm of the error vector **e** as defined in equations (18). In fact, the iteration can be also done by GA method. For trajectory defined by (22) and considering figures 2 and 3 it can be concluded that the optimum angle for the first link of manipulator 1 at the end of time should be between 1.8 and 2 radians. To perform the optimization, two methods might be used as mentioned earlier. In the first method the iteration can be done according to the Taylor's series iteration - (19) - and the second way is genetic algorithm (GA) implementation. By using the first method the answer will be obtained as: (q_{1_f}=1.93 *rad*). As the curve of the Euclidean norm of the transversality condition is so steep (as seen in Fig 2.), therefore, it is forecasted that the rate of convergence to the proper answer by Taylor's series iteration (19) is not very satisfactory but gives the right answer. The other method for iteration should be used, to compare the rates of the convergence. Here GA method is used and it is compared to the procedure of the first method.

To use the traditional Genetic Algorithm method, herein 10 individuals are used to form each generation. The initial population is randomly generated. The cross over fraction, mutation rate, and elite count of 0.7, 1.3, and 3 proved to work well, respectively. The stop condition is again defined as the second norm of error to be smaller than 10^{-2}. It just took 4 generations to convergence. Figures 11 and 12 show the result of optimization by GA.

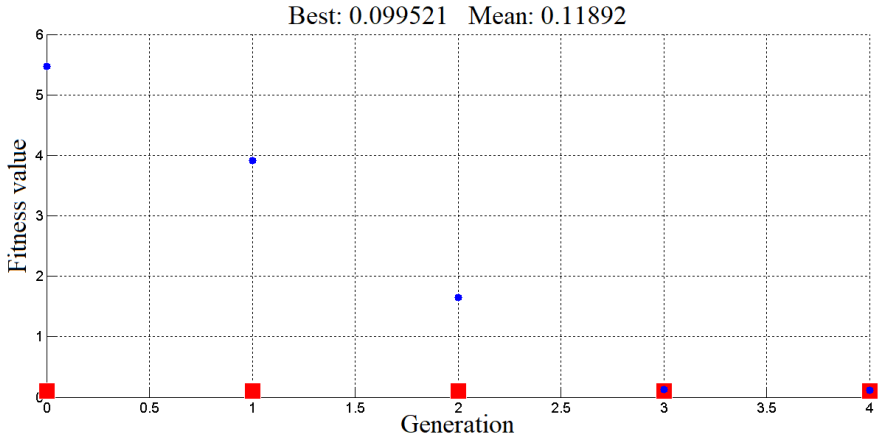

Fig 11. Optimization results in 4 generation

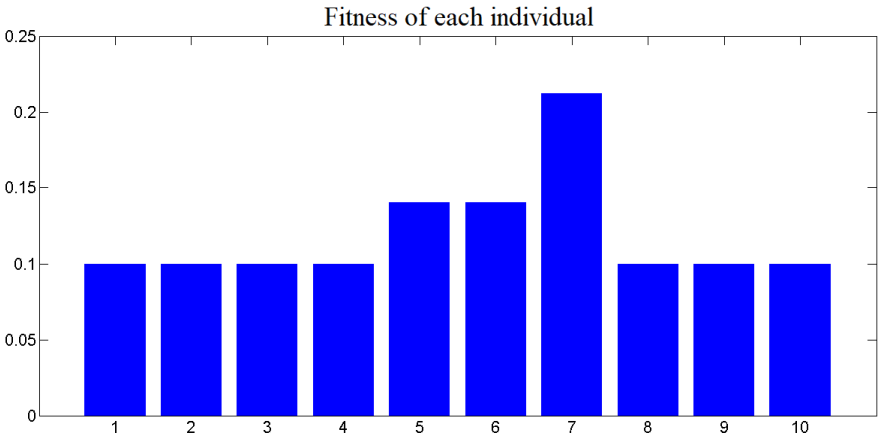

Fig 12. Fitness (transversality condition) of each individual of the last generation

It is seen in Fig 11. that after three generations the most of individuals of the generation is converged to the optimal point and therefore the cost function tends to zero. The optimal value obtained from GA optimization is 1.93 *rad*. Figure 12 shows the error (transversality condition) for the individual of the last generation.

From practical view convergence rate of the GA is higher than the Taylor's iteration. As mentioned before the steep curve of transversality condition that is shown as a sample for a desired trajectory, in Fig 2., proves this fact that the iteration by (19) will be converged to the optimum point by low rate. If the curve is smoother, then the convergence rate will be increased comparatively.

5.2. Artificial neural Network

The input of the designed network is a desired trajectory for the object given by a 2×101 matrix. If the desired trajectory is as following:

$$Tr(t) = \begin{bmatrix} x(t) \\ y(t) \\ \varphi(t) \end{bmatrix} \quad t \in [0,1] \qquad (25)$$

then the input of the network is defined as:

$$network\ input = \begin{bmatrix} x(t) - \frac{l_e}{2}\cos(\varphi(t)) \\ y(t) - \frac{l_e}{2}\sin(\varphi(t)) \end{bmatrix} \qquad (26)$$

$$t_1 = 0, t_2 = 0.01; \dots \dots . t_i = t_{i-1} + 0.01 \dots \dots t_{101} = 1$$

It must be considered that the above defined input is used for manipulator 1 according to the (23). The output of the network is the first link optimum angle (q_{1_f}). To design the network and train it, some information is needed. In fact some trajectories as the input of the network and their redundancy optimization as the output of network must be known. In this work the calculated information of 16 trajectories is used for the training procedure.

Input data have been divided up into training, validation and test subsets. 20 percent of data is used for the validation set, 20 percent for the test, and the remaining data as the training set.

Figures 13 to 16 show the regression graphs of the designed network. After 18 training iterations (epochs) the network met the defined progress limitation. Variations of the performance function (MSE) for all the three subsets are indicated in the Fig 17.

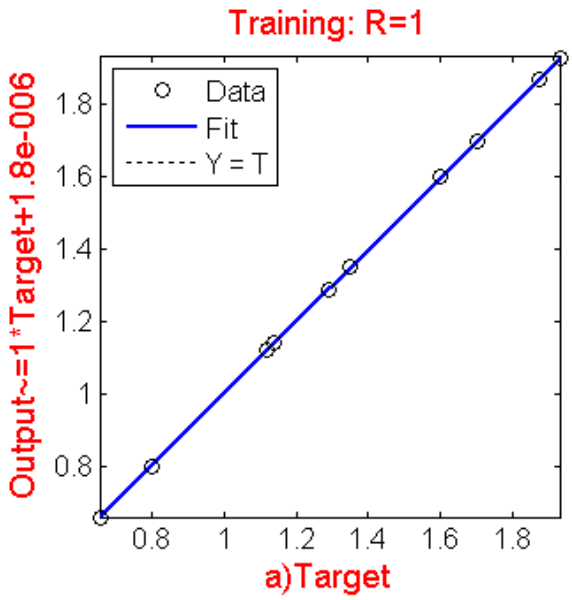

Fig 13. The training regression graph

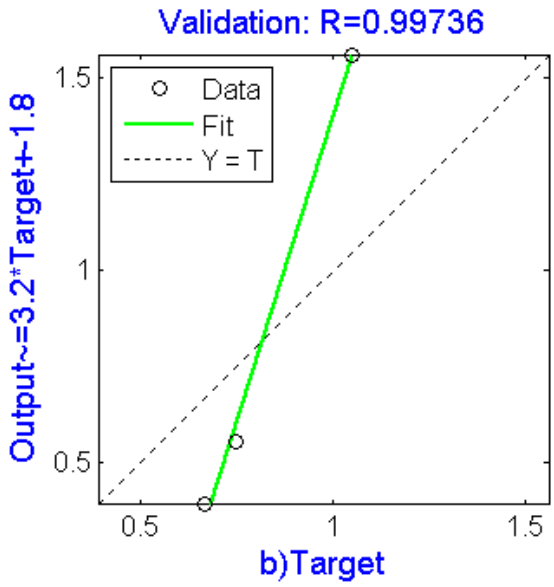

Fig 14. The validation regression graph

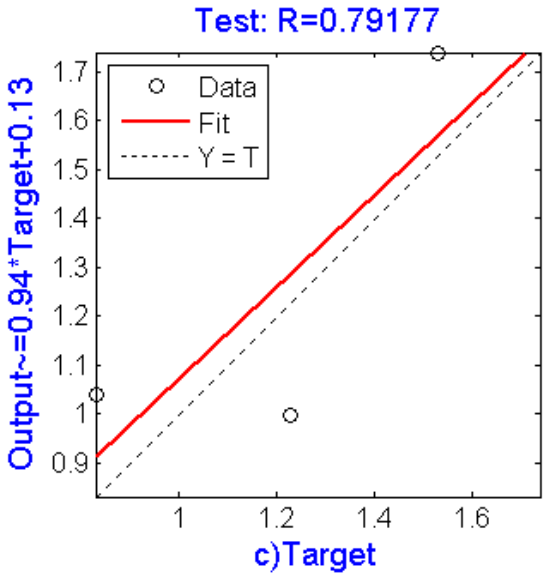

Fig 15. The test regression graph

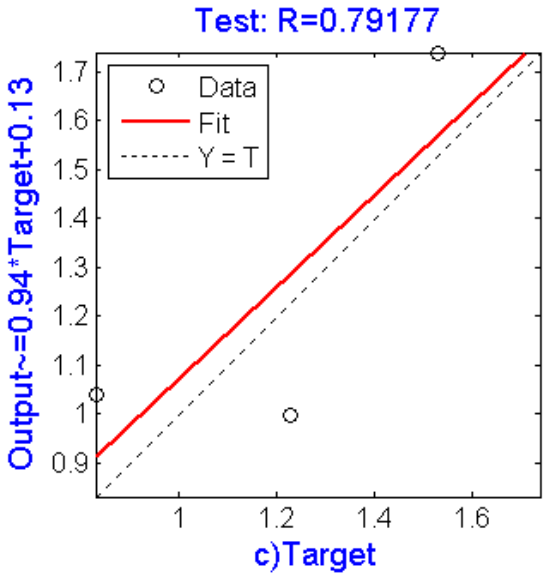

Fig 16. Regression graph of all

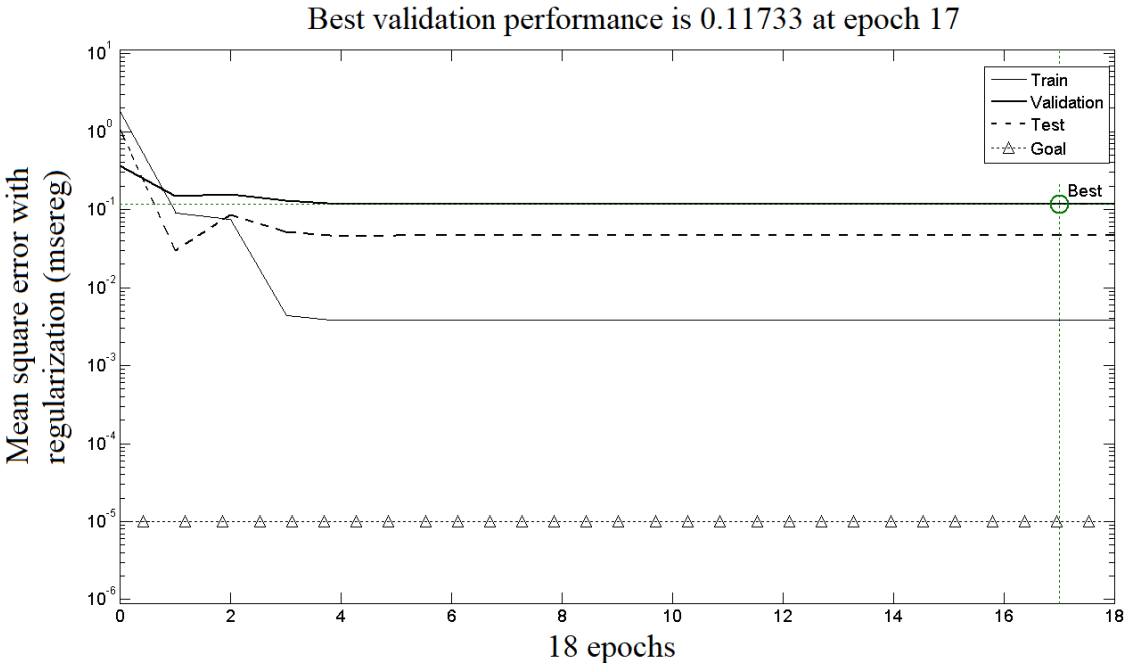

Fig 17. Performance graph of ANN training

One of the problems that occur during neural network training is called overfitting. The error on the training set is close to a very small value, but when new data is presented in the network the error would grow. The network has memorized the training examples, but it has not learned how to generalize them to the new situations. One method for improving network generalization is to use a network that is large enough to provide an adequate fit. Unfortunately, it is difficult to know beforehand how large a network should be for a specific application.

There are other methods for improving generalization that are implemented in the Neural Network. One of these methods which is used in this work is called regularization. This involves modifying the performance function, which is normally chosen to be the sum of the squares of the network errors on the training set.

As can be seen in figures 13 to 17, although the vector of information for network training is small, the trained network has acceptable performance. In fact, the above mentioned procedure

gives the view that by collecting more information from more trajectories and applying them to the network training, the behavior of the network will be better and accuracy will be increased.

6. Conclusion

The real-time trajectory generation was defined for a system of two cooperative three linked planar manipulators via the optimal control theory. The redundancy was resolved using Pontryagin's Minimum Principle and by numerical integration of the two-point boundary value problem. Two methods were used to estimate and update the initial boundary values: Taylor iteration algorithm and Genetic Algorithm. The optimization was done for the system and it was seen that the results were very close to each other. However, the rate of convergence to the optimum answer by using genetic algorithm is proved to be higher compared to the Taylor series updates. Actually the initial population of genetic algorithm is distributed through the admissible domain and consequently, approaching the optimal values is performed faster. The importance of both transversality condition and performance index simultaneously to find the proper answer is also studied.

Furthermore, it is tried to answer this question that if there is any way to find the optimum answer for a new trajectory without doing the time consuming calculation procedure beforehand. To answer this question the artificial neural network is employed to design a network to estimate the optimum answer with an acceptable amount of error. The quantity of layers and related neurons are calculated by trial and error method. The data of optimal solution for 16 trajectories are used to train the designed network. By applying the new trajectory to this network the answer is obtained and it is well comparable with the exact ones.

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