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Design and Analysis of 3d Printed Gear for Automobile Wind Wiper

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Abstract: This Work Presents The State Of Art Concerning The Current Achievements In The Field Of 3d Printing. 3d Printing Offers Many Advantages In The Fabrication Of Composites, Including High Precision, Cost Effective, Minimize Time And Customized Geometry. Creation Of An Appropriate Model To Manufacture A Product Using 3d Printers Is Possible With The Help Of Various Modelling Programs Or Software. One Of The Most Popular Formats For Sharing Such Models Is Stl (Standard Triangle Language) Format. In This Paper, Automobile Wind Wiper Gear Is Modelled Using Autodesk Fusion-360 Software And Fusion Deposition Method (Fdm) Process Is Used For Printing The Gear In 3d Printing Machine With Pla (Poly Lactic Acid) Material To Print The Selected Automobile Gear And Its Analysis Is Performed.

Keywords: 3d Printing, Fdm, Automobile Wind Wiper Gear, Additive Manufacturing, Autodesk Fusion-360

I. INTRODUCTION

Additive manufacturing process is an emerging area in manufacturing sector to produce the products rapidly, accurately. It is an opposed method to a subtractive manufacturing process which involves either milling or cutting of work material in order to build the right shape. In additive manufacturing, the material is added as thin layers of size between 16 to 180 microns until it takes the desired product's shape. The term Additive Manufacturing holds various technologies in it like Rapid Prototyping, 3D Printing, Layered Manufacturing and Direct Digital Manufacturing. Among these 3D printing is considered in this work because it is quickly expanding field, popular and growing.

In 3D printing not only polymers can be used but also capable to use other materials like metals, glasses, ceramics etc. There exists various technologies even in 3D printing which are Stereo lithography (SLA), Fused Deposition Modelling (FDM), Selective Laser Sintering (SLS), Selective laser melting (SLM), Electronic Beam Melting (EBM) and Laminated Object Manufacturing (LOM).

Based on criterion of cost effectiveness, easiness in fabrication of product and materials that can be used to fabricate the product FDM technology is preferred and it is adopted in this work to prepare the prototype. 3D printing have applications in various fields like Aerospace, Automotive sector, Aviation, Consumer Products, etc. Plastic gears can be produced by Shaping or Hobbing, similarly to metal gears or alternatively by moulding which is uneconomical means of production. Whereas 3D printing creates solid parts by building up objects one layer at a time, with less time consumption, high accuracy and cost effectively dominating the limitations of traditional manufacturing techniques.

Fig. 1 3D Printer

II. LITERATURE REVIEW

Amarjeet R.Gupta, et.al [1] introduced the Plastic gears and also opened new opportunities for more efficient transmissions in many products along with reduced drive drive-cost, weight, noise and wear. Along with this the gearbox is a heavy component of the automobile. To reduce drive cost, noise and weight by replacing metallic gears with thermoplastic gears in the gearbox of identified low power moped is the objective of this work.

Initially the material is identified among heavy engineering plastics for manufacturing of gear. The material elected is tested in test laboratory and gears are manufactured using hobbing process with the same accuracy and specifications as that of metallic gears of the gearbox as discussed as in reference.

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Feng Zhanga, et.al.[2] Reviewed using 3D printing disruptive manufacturing echnology, Electrochemical Energy storage(EES) devices has fabricated from nano scale to macro scale, Which provides great dimension, porosity, and morphology accurately. It provides excellent controllability of the electrode thickness in a cost effective manner.

Gilberto Siqueira, et.al.[3] Discussed use of cellulose nanocrystals offers an attractive pathway for fabricating sustainable structures in 3D printing of renewable building blocks, This inks composed of anisotropic cellulose nanocrystals (CNC) that enable patterning of 3D objects. This serve as an important step forward toward the development of sustainable materials for 3D printing of cellular architectures with tailored mechanical properties.

Jian-Yuan Lee, et.al [4] Reviewed the fundamentals of 3D printing processes and the recent development of novel 3D printing materials such as smart materials, ceramic materials, electronic materials, biomaterials and composites etc.., It becomes an integral part of a multi process system or an integrated process of multiple systems to match the development of novel materials and new requirements of products.

Ramji Pandey, et.al.[5] Introduced about 3D printing which is an emerging technology with applications in several areas. The flexibility of the 3D printing system to use variety of materials and create any object makes it an attractive technology. Introduced Photopolymers as one of the materials to use in 3D printing with its potential to make products with better properties, numerous applications. A demo experiment was also carried out with fusion deposition modelling (FDM) by 3D printer.

Raj Kalavadiya, et.al [6] Discussed about the recent trends in rapid prototyping which is most common technique of additive layer manufacturing. In the 3D printer any component is produced with different in-fill patterns. By changing the parameters, it results a change in the characteristics of final product like strength and material cost. This research paper is to optimize the most economical infill patterns used in 3D printing which is fulfilling all required aspects. Validating of the optimization method by comparing the physical properties, time consumption, cost of traditional manufacturing methods and additive manufacturing method is done.

Tanmay Kotkar, et.al [7] Investigated use of advance manufacturing processes to produces complex Designs using 3d printing methods. Theoretical designing of Spur gear is done as per Lewis equation and 3D modelling is done using Solid works 2015 software, analysed using Finite Element analysis software ANSYS 15.0 and then Spur gear is manufactured using 3D printing FDM technique with four different filaments i.e. ABS, Nylon 12, PC and PLA. These types of Gears can be used in any power transmission system and can be manufactured with required load carrying capacity with short time of production and complex designs. This Gear is manufactured using additive manufacturing methods which will reduce the manufacturing time, easy to make customized gears instantly, reduce noise generated during meshing of gear at high speed, low rate of wear and increase in life of gear.

Xuan Pang, et.al [8] Discussed about 3D printing material Poly lactic acid (PLA) which is biodegradable, aliphatic polyester derived from lactic acid. In this work authors stated that it has similar mechanical properties to polyethylene terephthalate, but has a significantly lower maximum continuous use temperature. PLA products can be recycled after use either by re- melting and processing the material second time or by hydrolysing to lactic acid.

Xin Wang, et.al.[9] Reviewed on 3D printing techniques of polymer composite materials and the properties and performance of 3D printed composite parts and applications in the fields of biomedical, electronics and aerospace engineering and conclusions are given on suitable techniques based on their performance.

III. METHODOLOGY

In this paper, initially design is prepared in CAD software and converted into STL format, and then the file is exported into microSD card. This card is inserted into the slot in LCD controller of 3d printer machine, connected the power supply to PSU. From this Power Supply Unit the power is transmitted to remaining parts of the printing machine. After adjusting the commands in the control panel, the printer starts the printing the given cad model by moving the nozzle in desired x,y,z axis directions. After complete printing of the object the printer is set back to home position and stopped.

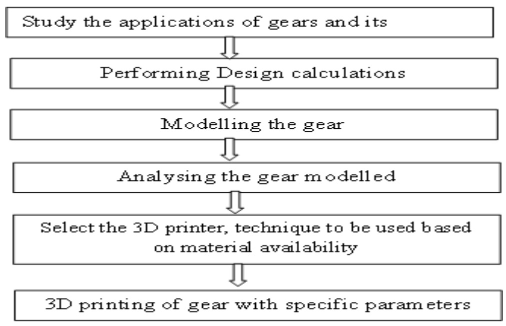

Fig. 2 Methodology

Table 1. Specifications of 3D printer

S.no	Description	Specification
1	Printer	•Technology: FDM •Type: Material extrusion •Assembly: DIY Kit •Mechanical arrangement: Cartesian-XZ-Head •Manufacturer: TEVO
2	Materials	• Filament diameter:1.75 mm • Printable material(s) used: PLA
3	Build volume	• 3D print size: Small • Print size millimetres (xyz):200 x 200 x 200 mm • Print size inches (xyz):7.9 x 7.9 x 7.9 inches
4	3D printer and printing properties	• Accuracy:12 x 12 x 4 Microns • Layer height:50 Microns • Feeder system: Direct • Extruder type: Single • Nozzle size:0.4 mm • Max extruder temperature:500 °F / 260 °C • Max heated bed temperature:230 °F / 110 °C • Max print speed:70 mm/s • Frame: Aluminium • Temperature controlled print chamber: No • Bed levelling: Manual • Print bed details: Heated bed • Display: LCD • Firmware: Open-source

3D printer can able to print desired CAD model, this printer mainly works on the principle of FDM (Fusion Deposition Method) process. In this work, "gear" is designed according to AGMA (American Gear Manufactures Association) and cad model is modelled in Fusion 360 software. Then the file is converted into STL format and saved in the Micro sd card, this card is connected to 3D printer, on supplying power and adjusting the commands the machine starts the printing of gear. This printed gear can be used in wind wipers of automobile and food processing machines.

IV. DESIGN OF WIND WIPER GEAR

Design procedure and Calculations

The design is carried out by considering standards according to AGSM (American Gear Manufactures Association) based on standards the geometric values of gear like module, pressure angle, diameter of gear and number teeth that gear required, remaining values like Diametrical pitch, Addendum Height, Total Height, Tooth thickness, Outer diameter, Root diameter, Width of tooth, Bore diameter Outer Diameter of hub and circular pitch are calculated and shown in Table 2.

Table 2. Design Calculations

Sno	Description	Value
1	Module (m)	1
2	Pressure angle (P)	200
3	Pitch diameter (D)	60mm
4	Number of teeth	60
5	Diametrical pitch (p)	1mm
6	Addendum Height (a)	1mm
7	Total Height (Ht)	2.33mm
8	Tooth thickness (Ct)	π/2×1 mm
9	Outer diameter (Do)	62mm
10	Root diameter	55.34mm
11	Width of tooth	10mm
12	Bore diameter	5mm
13	Outer Diameter of Core	35 mm
14	Circular Pitch	3.14mm

Determining diameter, width and tooth thickness according to standards for a gear helps in proper design of gear and applications in machines like wind wipers and food processing machines. With the given parameters, we need to calculate the other required geometrical parameters in order to create gear in any CAD software; here we used the software "Fusion 360" in order to create a Spur Gear model for wind wipers. Based on the given values gear is designed in the software. In order to create a spur gear we gave the values, pitch diameter, face width, number of teeth.

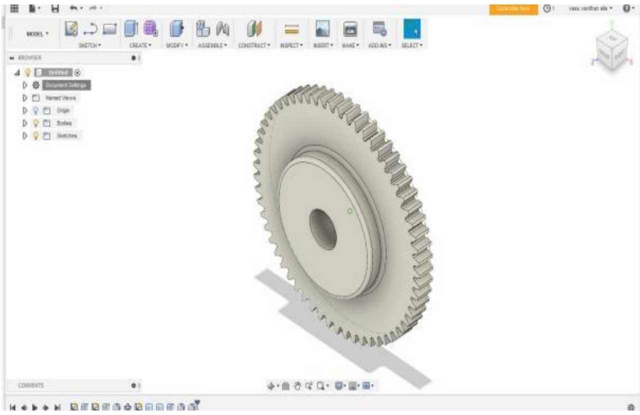

Fig. 3 Modelled in Fusion 360

After giving the required values to Gear in FUSION 360 software, the SPUR GEAR Model was created. After the model is created, the file is saved as two formats. i. STL format: This format is to export the file in the slicer software (i.e REPETITER HOST) in which further printer configuration and setting are done.

ii. IGES format: This format is to export the file in to ANSYS WORKBENCH 15.0 in which the analysis of gear is done.

Analysis and results

The spur gear is tested in ANSYS WORKBENCH 15.0 by applying material properties of PLA on the modelling of the spur gear.

Table 3. Material properties

Elastic Modulus	3.5Gpa
Tensile strength	50Mpa
Poisson's ratio	0.33
Shear modulus	2.4 Gpa
Density	1.3g/cm^2

Then file is saved in IGES format and imported in ANSYS WORK BENCH 15.0. Structural analysis is performed to ensure that output gear was acceptable. In order to perform static structural analysis, spur gear must be imported to WORKBENCH 15.0 software, in this the duplicate another gear is copied and both gears are made to contact each other than the both gears are meshed. Then after meshing, the contact of the gear is found and frictional stress is applied on tooth of both gears and the max value is recorded.

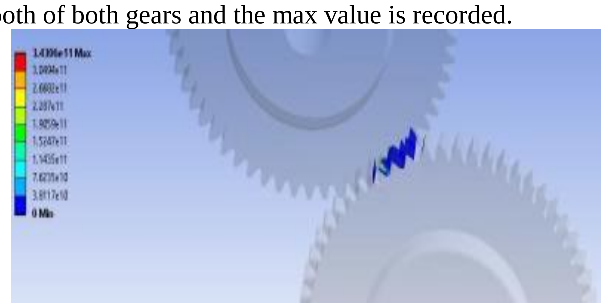

Fig. 4 Frictionless stress on the contact tooth

The obtained results are safe for using the gear in wind wiper. Then further analysis is done on both gears are total deformation and equivalent stresses. In further analysis the gears are tested to impact load conditions that are one gear is fixed and another is in motion. The analysis is followed like this initially the fixed support is applied on one gear then the moment of 206 radians/sec is applied on another gear and the results are evaluated. Maximum stress on tooth is 1.3 MPa.

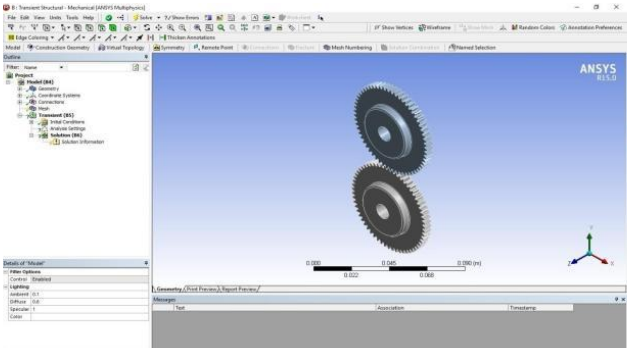

Fig. 5 Mating of gears

Importing the gears in ANSYS software and mating with each other so that contact of each gear is made.

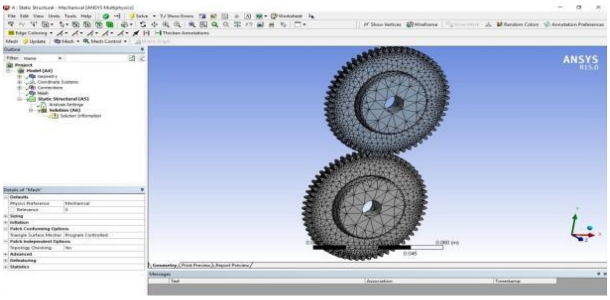

Fig. 6. Meshing of Gears

The two gears are auto meshed after contacting with each other.

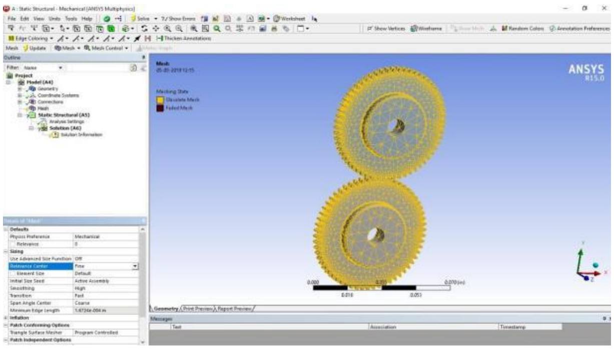

Fig. 7 Finding the absolute mesh

After meshing the absolute mesh is found for Accurate results.

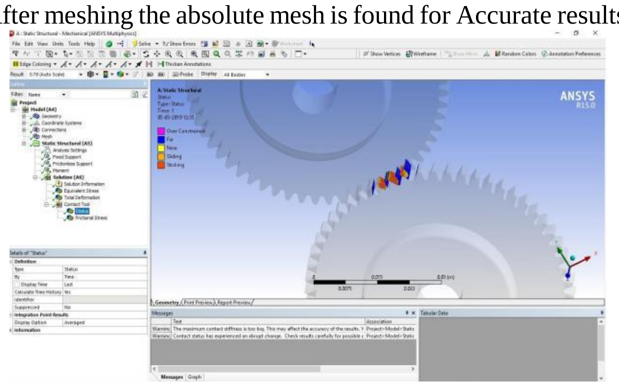

Fig. 8 Contact status of tooth

In static structural analysis of gears the contact status of tooth is indicated with different colours.

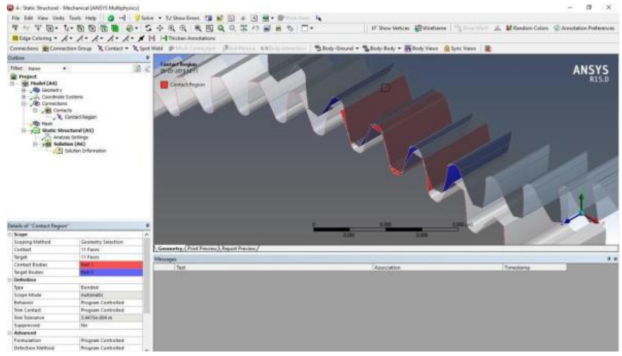

Fig. 9 Contact Region

These are the contact region of gears blue colour is contact region of first gear and red colour is another gear.

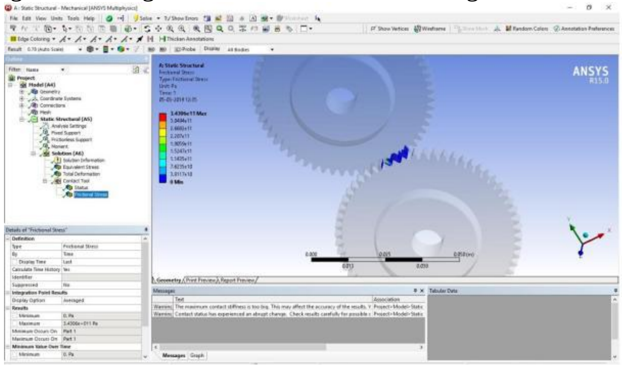

Fig. 10 Static structural analysis of gear

The static structural analysis of gear and the results are shown left side of window.

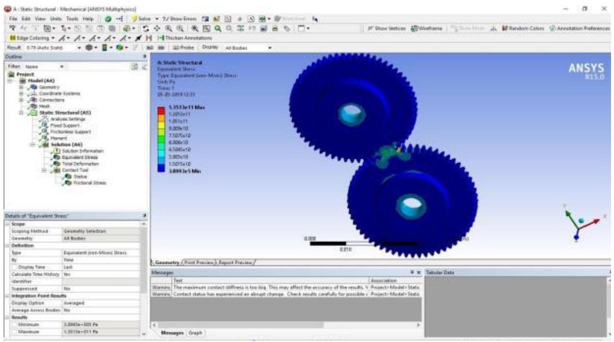

Fig. 11. Equivalent stress

The given loads are solved and equivalent stress of gears are recorded.

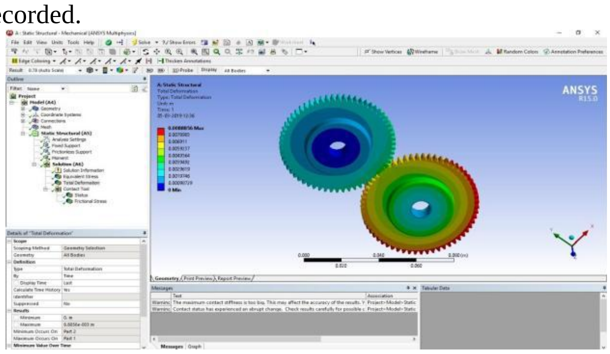

Fig. 12 Total deformation of gears

The results from the numerical simulations is confirmed that the gear can be used up to 2000 rpm of magnitude 206 radians/sec,

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The maximum temperature of gear during the mechanism is 50^0c-80^0c according to standard measurements But this gear can bear temperature upto 150^0c -170^0c so we can use efficiently as windshield wiper gear. Analysis has also shown that the total amount of stress acting on tooth from this we can conclude that the force acting on tooth should not exceed that load in order to use the gear effectively.

The following are the limitations which are obtained from the analysis as results:

i. Maximum Safe Tooth Load : 1.252 Kilograms.

ii. The maximum stress on gears is: 3.8 MPa

V. CONCLUSIONS

Automobile windshield wiper is manufactured using FDM technology with the help of 3D printer. From the analysis, it is concluded that a constant speed rotation can be maintained with a constant input torque without any complicated considerations for the gear moment. The sustainability of the gear is increased when compared to the standard measurements. The sustainable temperatures are increased from 50^0C to 170^0C which makes the design effective. The analysis also identified that the maximum operable speeds of the wind wiper gear is 2000rpm, max. Safe tooth load is 1.252 kgs and max. Stress that can withhold by the gear is 3.8 MPa.

REFERENCES

1. Amarjeet R.Gupta, Application of different thermoplastic gears in the gear box moped, IJFEAT, Vol no:6, 2013.
2. FengZhang, MinWei, Vilayanur Viswanathan, Benjamin Swart, Yuyan Shao, Gang Wu, Chi Zhou, 3D printing technologies for electrochemical energy storage, Nano Energy, Elsevier, 2017.
3. Gilberto Siqueira, Dimitri Kokkinis, Rafael Libanori, Michael K. Hausmann, Amelia Sydney Gladman, Cellulose Nanocrystal Inks for 3D Printing of Textured Cellular Architectures, Advanced science news, 2017.
4. Jian-Yuan Lee, Jia An, Chee Kai Chua, Fundamentals and applications of 3D printing for novel materials, Applied materials today, Volume 7, Pages 120-133, 2017.
5. Ramji Pandey, Photopolymers in 3D printing applications, ARCADA, 2014.
6. Raj Kalavadiya, Sahil Kalal , Prof. Dilavarsinh Dodia, Prof. Priyank Zaveri, Optimization of Infill Patterns for Spur Gear in 3D Printing using PLA, Research Gate, 2017.
7. Tanmay Kotkar, Prashant Masure, Pundalik Modake, Chirag Lad, Basanagouda Patil, Modelling and Testing of Spur Gear made of Different 3D Printed Materials, IJSRSET, 2018.
8. Xuan Pang, Xiuli Zhuang, Zhaohui Tang and Xuesi Chen, Polylactic acid (PLA) Research, development and industrialization, Vol No:11, 1125–1136, 2010.
9. Xing wang, Man Jiang, Zuowan Zhou, Jihua Gou, 3D printing of polymer matrix composites: A review and prospective, Journal in Composites, Part B, Engineering, November 2016.
10. Izabela Hager, Anna Golonka, Roman Putanowicz, 3D printing of buildings and building components as the future of sustainable construction, Elsevier, 2016.
11. Jeffrey W. Stansbury, Mike J. Idacavage, 3D printing with polymers: Challenges among expanding options and opportunities, Journal in Dental materials, Vol. 32(1), October 2015.
12. Adriano Ambrosi and Martin Pumera, 3D-printing technologies for electrochemical Applications, Journal in Royal Society of Chemistry, 2016.
13. N. Rajesh, M. Yohan, Recent Studies In Aluminium Metal Matrix Nano Composites (Ammncs) – A Review, IJMET, 2016.

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