

Modeling and Manufacturing of Helical Gear by using 3D Printing Technology

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Abstract: The helical gear has many diverse applications such as locomotives, marine applications, automobiles, printing presses, cooling towers, power plants, steel plants, and railway machine. Helical gears are gears where the axes of the two shafts intersect and the tooth-bearing faces of the gears themselves are conically shaped. Helical gears are most often mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well. The teeth on helical gears are cut at an angle to the face of the gear. When two teeth on a helical gear system engage, the contact starts at one end of the tooth and gradually spreads as the gears rotate, until the two teeth are in full engagement. This gradual engagement makes helical gears operate much more smoothly and quietly than spur gears. Finally, by using 3D Printer prototypes are made and the conclusion explains the different possible ways to improve the design for better productivity and gives the overview of the way in which the Helical Gear can be designed even better. All the components are designed in CAD application so called CATIA and assembled with in the constraint boundaries. Individual parts of the product are 3D printing.

Keywords: Helical Gear, 3D Printing Technology

1. Introduction

The software used to design the gear is CATIAV5 it is the modern form computer aided design (CAD), program. It enables designers to create a mathematically correct solid model of an object that can be stored in a database. When the mathematical model of a part or assembly is associated with the properties of the materials used, we get a solid model that can be used to simulate and predict the behavior of the part or model with finite element and other simulation software. The same solid model can be used to manufacture the object and also contains the information necessary to inspect and assemble the product. The marketing organization can produce sales brochures and videos that introduce the product to potential customers. SolidWorks and similar CAD programs have made possible concurrent engineering, where all the groups that contribute to the product development process can share information real-time.

Sketcher is used to create two-dimensional representations of profiles associated within the part. We can create a rough outline of curves, and then specify conditions called constraints to define the shapes more precisely and capture our design intent. Each curve is referred to as a sketch object.

After the completion of the modeling it is converted into standard lithography file it will convert the model into slices, the file uploaded in the Rapid prototype machine i.e. 3D printing machine Prototyping or model making is one of the important steps to finalize a product design. It helps in conceptualization of a design. Before the start of full production, a prototype is usually fabricated and tested. Manual prototyping by a skilled craftsman has been an age old practice for many centuries. Second phase of prototyping started around mid-1970s, when a soft prototype modeled by 3d curves and surfaces could be stressed in virtual environment, simulated and tested with exact material and other properties. Third and the latest trend of prototyping, i.e., rapid prototyping (RP) by layer-by-layer material deposition, started during early 1980s with the enormous growth in computer aided design and manufacturing (CAD/CAM) technologies when almost unambiguous solid models with knitted information of edges and surfaces could define a product and also manufacture it by CNC machining. The historical development of rp and related technologies is presented in below.

The technology used in the rapid prototype system is Fused Deposition Modeling, it is one of the type of rapid prototype modeling system, by using this technology there is a change in the applications, usage of this technology is very different The final step in the process chain is the post-processing task. At this stage, generally some manual operations are necessary therefore skilled operator is required. In cleaning, excess elements adhered with the part or support structures are removed. Sometimes the surface of the model is finished by sanding, polishing or painting for better surface finish or aesthetic appearance. Prototype is then tested or verified and suggested engineering changes are once again incorporated during the solid modeling stage.

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Finally, the prototype is manufactured by using the 3D printer or Rapid prototype technology. The Helical Gear is manufactured by using the 3D Printing technology.

2. Helical gear

Helical gears are similar to spur gears except that their teeth are cut at an angle to the hole (axis) rather than straight and parallel to the axis like they are in the teeth of a spur gear. Helical gears are manufactured as both right and left-handed gears. The teeth of a left-handed helical gear, lean to the left when the gear is placed on a flat surface. The teeth of a right-handed helical gear, lean to the right when placed on a flat surface.

In spur gears the teeth are parallel to the axis whereas in helical gears the teeth are inclined to the axis. Both the gears are transmitting power between two parallel shafts. At any time, the load on helical gears is distributed over several teeth, resulting in reduced wear. When two helical gears are engaged as, the helix angle has to be the same on each gear, but one gear must have a right-hand helix and the other a left-hand helix. In helical gear the line contact is diagonal across the face of the tooth.

Hence gradual engagement of the teeth and the smooth transfer of load from one tooth to another occur. Helical gears are capable of providing smoother and quieter operations at the same time transmit heavy loads. They are useful for high speed and high power applications, quiet at high speeds. Helical gears operate with less noise and vibration than spur gears. At any time, the load on helical gears is distributed over several teeth, resulting in reduced wear. Due to their angular cut, teeth meshing results in thrust loads along the gear shaft. This action requires thrust bearings to absorb the thrust load and maintain gear alignment.

They are widely used in automobile industries in manufacturing of vehicles and marine ships.

Contact stress analyses for spur and helical gears are performed between two gear teeth at different contact positions during rotation. Two examples of spur and helical gears are presented to investigate the respective variations of the contact stress in a pair of mating gears with the contact position. The variation of the contact stress during rotation is compared with the contact stress at the lowest point of single tooth contact (LPSTC) and the AGMA (American Gear Manufacturers Association) equation for the contact stress. In this study, we can see that the gear design that considers the contact stress in a pair of mating gears is more severe than that of the AGMA standard. This study presents the change in the contact stress of spur and helical gears in relation to the contact position. Regarding changes in the contact stress, the maximum value measured at the lowest point single-tooth contact is compared with the contact stress calculated based on the AGMA standard. According to the analysis, the design that considers the contact stress is stricter than the AGMA standard. The values calculated by using finite element analysis are below the contact fatigue

strength of the material; hence, they yield the appropriate strength and safety.

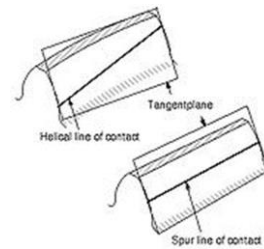


Fig. 1. Figure showing different lines of contact

Helical gears offer a refinement over spur gears. The leading edges of the teeth are not parallel to the axis of rotation, but are set at an angle. Since the gear is curved, this angling causes the tooth shape to be a segment of a helix. The angled teeth engage more gradually than do spur gear teeth. This causes helical gears to run more smoothly and quietly than spur gears. Helical gears also offer the possibility of using non-parallel shafts. With parallel helical gears, each pair of teeth first makes contact at a single point at one side of the gear wheel; a moving curve of contact then grows gradually across the tooth face. It may span the entire width of the tooth for a time. Finally, it recedes until the teeth break contact at a single point on the opposite side of the wheel. Thus force is taken up and released gradually.

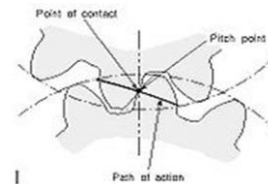
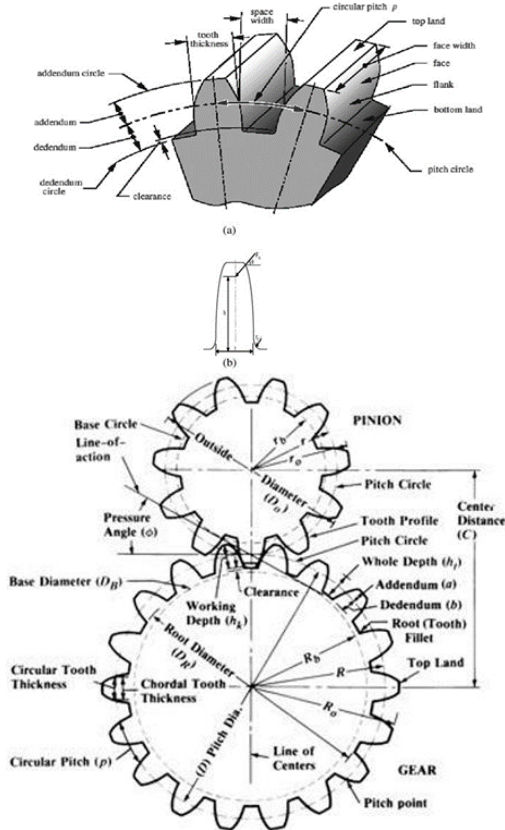


Fig. 2. Pitch point

Helical Gear Geometrical Proportions:

1. $p = \text{Circular pitch} = d_g \cdot p / z_g = d_p \cdot p / z_p$
2. $p_n = \text{Normal circular pitch} = p \cdot \cos \beta$
3. $P_n = \text{Normal diametrical pitch} = P / \cos \beta$
4. $p_x = \text{Axial pitch} = p_c / \tan \beta$
5. $m_n = \text{Normal module} = m / \cos \beta$
6. $\alpha_n = \text{Normal pressure angle} = \tan^{-1} (\tan \alpha \cdot \cos \beta)$
7. $\beta = \text{Helix angle}$
8. $d_g = \text{Pitch diameter gear} = z_g \cdot m$
9. $d_p = \text{Pitch diameter pinion} = z_p \cdot m$
10. $a = \text{Center distance} = (z_p + z_g) \cdot m_n / 2 \cos \beta$
11. $a_a = \text{Addendum} = m$
12. $a_f = \text{Dedendum} = 1.25 \cdot m$



Terms Used in Gear Geometry from Table 1 on page 217
 Fig. 3. Helical gear geometrical proportions

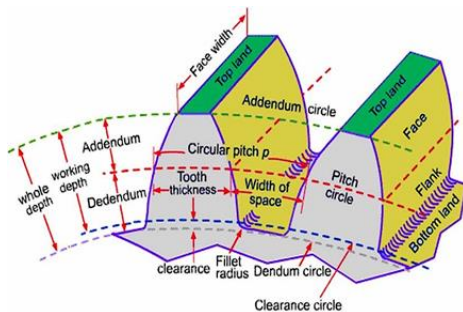


Fig. 4. Details of helical gear

3. Modeling of helical gear

A. Basic Sketch

Go to file and select part design. In mechanical design, select part designing module. Then, we enter into part designing and we can see 3 plane xy, yz and xz planes. Now go to sketcher tool bar and select sketcher and select yz plane. then we will enter into sketcher module. In sketcher module go to profile features and select circle and create circles as specified in fig. 7.

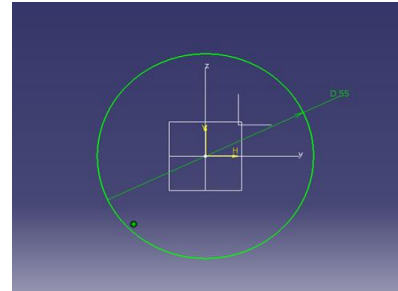


Fig. 5. Sketch

And we enter into the part module select the exit workbench in the sketch module, to add material from the profile select shaft feature from sketch based feature. revolve: This Feature is used to add material by revolving the sketch around an axis. Select shaft select the profile and select the axis of revolution. Give the angle.

B. Extrude

To adding the material to get the extrude tool in part module as shown in figure 8.

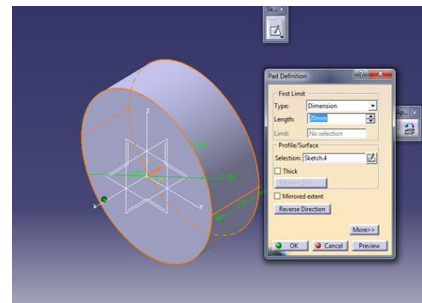


Fig. 6. Creating solid

C. Steps to Design Gear Tooth

To creating the curves by using the helical values so after we can create the profile for adding the material by using curves as shown in figures.

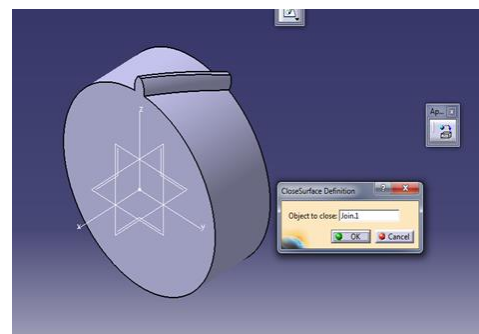


Fig. 7. Closed surface

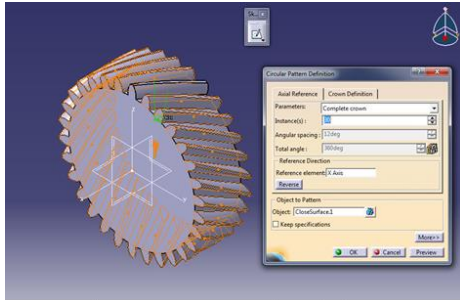


Fig. 8. To shows for circular pattern

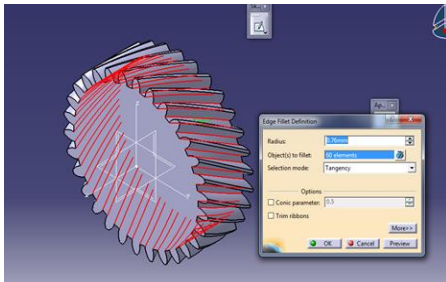


Fig. 9. Applying fillets

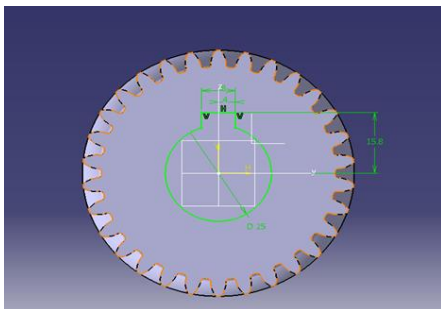


Fig. 10. To sketch

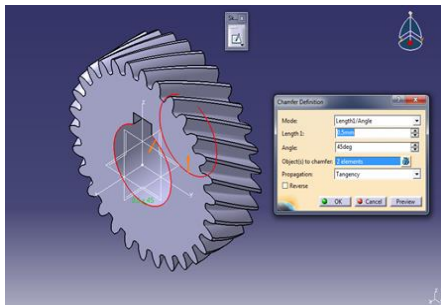


Fig. 11. Applying chamfer

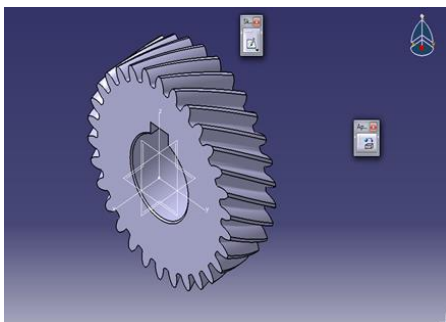


Fig. 12. Helical gear

From the above figure we represent the modeling of helical gear by using CATIA V5 software. We use this software because it is commonly used software we can do complex designs in CATIA V5. So we selected this software for designing the helical gear.

4. Fused deposition modeling

Fused Deposition Modeling (FDM) process a movable (x-y movement) nozzle on to a substrate deposits thread of molten polymeric material. the build material is heated slightly above (approximately 0.5c) its melting temperature so that it solidifies within a very short time (approximately 0.1 s) after extrusion and cold-welds to the previous layer as shown in figure various important factors need to be considered and are steady nozzle and material extrusion rates, addition of support structures for overhanging features and speed of the nozzle head, which affects the slice thickness. More recent FDM systems include two nozzles, one for part material and other for support material. The support material is relatively of poor quality and can be broken easily once the complete part is deposited and is removed from substrate. In more recent FDM technology, water-soluble support structure material is used. Support structure can be deposited with lesser density as compared to part density by providing air gaps between two consecutive roads.

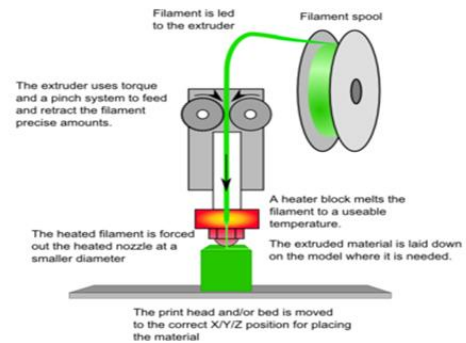


Fig. 13. Fused deposition modelling process

5. Process of 3D printing technology

Here we are getting the 3d object by using (Fused Deposition Modeling Process)

Step 1- To Develop the Cad Model

Designing the 3d model with the help of 3d modeling software like CATIA, CREO, SOLIDWORKS, UNI GRAPHICS, by using modeling tools.

Step 2- Converting the Cad Model into .STL File Format

In this step we will save the cad model in .STL format. Go to the file--save as--give the name and choose the file format as STL.

Step 3- Generating the G-Codes to the Cad Model by Using Kisslicer Software.

Open the .STL in Kisslicer and import the model.

Choose the required machine settings.



Fig. 14.

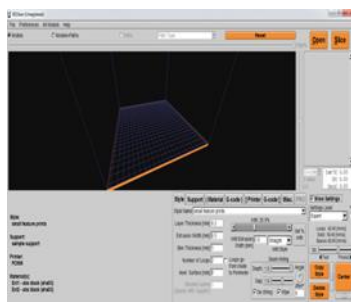


Fig. 15

- Select open and browser to .STL file then click ok.

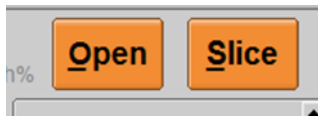


Fig. 16

- Specify height for scale or limit of the printer.

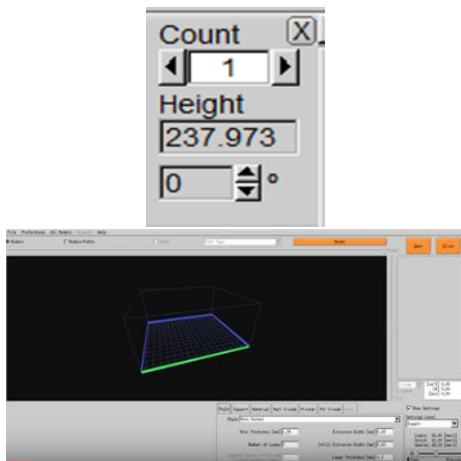


Fig. 17

On right side we can see open file. Click and browser to stl file from 3d software. Then we can see the 3d component on the cube box.

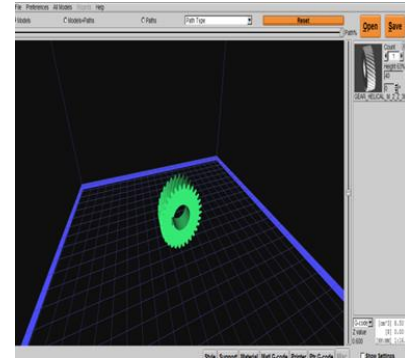


Fig. 18

6. Result

A. 3D Printing dimensions

Model	- Helical Gear
Product size before scale	- 67.1%
Scale model	- 11%
Fill density	- 8%
Shells	- 2
Layers printed	- 107
Steps in 3d printing	- 1111
Dimension of the model	- 11*33.4*33.4
Triangle	- 5380
Edges	- 1210
Material used	- Polylactic acid(white)
Frame temperature	- 100°C
Right nozzle temperature	- 240°C
Left nozzle temperature	- 100
Left filament	- 3.1g
Right filament	- 1.2g
Estimated amount	- 4.2g/1.54m
Time duration	- 0hr 54min 3 sec
Estimated amount	- 4.2g/1.54m



Fig. 19.

This is the prototype that is manufactured with the help of 3D printer.

7. Conclusion

We conclude that many complex designs are designed in the modeling b using the CATIA V5 software in the present advanced technology. All the components are designed in CAD

application so called CATIA and assembled with in the constraint boundaries. Individual parts of the product are 3D printing. Finally, by using 3D Printer prototypes are made and the conclusion the different possible ways to improve the design for better productivity and gives the overview of the way in which the HELICAL GEAR can be designed even better.

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