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Design & Analysis of Helical Gear of Washing Machine Transmission System

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ABSTRACT

Gears are power transmission components used to transfer power from one shaft to other. Polymer gears finds its applications in all the segments of mechanical power transmission system because of its high strength to weight ratio. These types of Gears can be used in any power transmission system and can be manufactured with required load carrying capacity and complex designs. Helical gear used in transmission system of washing machine is considered in this project work. Design & FEA analysis done and compared with analytical method. Material Selection is one of the important parameter for design. This gear is made of Poly lactic acid polymer material. 3D modelling is done using Solidworks 2015 software. Finite Element analysis software ANSYS 15.0 is used to study the load carrying capacity of Helical Gear.

Keywords: Helical Gear, Transmission System, CAD design.

I. INTRODUCTION

Gears are machine elements, which are required to transmit power between shafts rotating at different rotational speeds. By adding teeth of the proper shape on disk, power can be transmitted without slip at uniform rate. In any pair of gears, the smaller one is called pinion and the larger one is called gear. When pinion is the driver, it results in step down drive in which the output speed decreases and the torque increases. On the other hand, when the gear is the driver, it results in step up drive in which the output speed increases and the torque decreases.

Reverse Engineering Method is used to measure all the Parameters of the Transmission Gear. 3D Modeling of Transmission Gear has been done according to the dimensions obtained from Reverse Engineering. Solidworks 2015 is used for 3D designing of the Transmission Gear because of its user Friendly GUI. Analysis of Spur Gear is done in Finite element analysis software i.e. ANSYS Workbench 15.0. Stresses and deformations have been calculated. Analysis is done for Transmission Gear made of all the PLA 3D printed material. Static structural analysis is used to find the structural strength of the Transmission Gear subjected to loading.

In this project, Objective is to Design the transmission gear for Videocon Washing Machine using additive manufacturing Process and to study the behaviour and to replace the existing drive gear used in Videocon washing machine.

Project work Methodology:

- Gear Drive application in Videocon washing machine.
- Study of Design and Mechanism of Gear.
- Modelling of Gear using Reverse Engineering
- FEA of Gear to study its performance

II. SELECTION OF GEAR

A. Selection of Washing Machine

Videocon 6.2 kg Fully Automatic Top Load Washing Machine
Brand: Videocon
Model Name: T7269NDDL
Function Type: Fully Automatic Top Load
Washing Capacity: 6.2 kg
Maximum Spin Speed: 720 rpm
Technology Used: Smart Inverter Technology, Turbo Drum

B. Polymer Gear Transmission System

Figure 1. Transmision Sysytem of Videocon Washing Machine

The Transmission system in the Videocon washing machine is composed of internal teeth helical gear made of polymer Materials. Poly lactic acid is used for the manufacturing of helical Gear in the Machine. This is the main Component of the transmission system through which drum of washing machine rotates.

Figure 2. Transmission Gear Made of PLA

III. DESIGN AND ANALYSIS OF HELICAL GEAR

A. Reverse Engineering

Reverse engineering, also called back engineering, is knowledge or design information from a product and reproducing it or reproducing anything based on the extracted information. The process often involves disassembling something and analysing its components and workings in detail.

Figure 2. Reverse Engineering of Helical Gear

B. 3D Modelling using Solidworks

Solid works is a solid-modelling computer aided design (CAD) and computer aided engineering (CAE) computer program that runs on Microsoft windows. Solidworks also includes additional advanced modelling features such as gear mating and cam follower mates which allow model gear assemblies to accurately reproduce the rotational movement of the actual gear train.

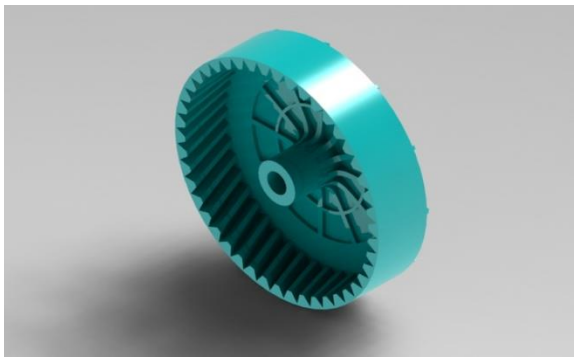

Figure 3. Section Headin3D Model of Transmission Gear in Solidworks

IV. THERIOTICAL STRENGTH CALCULATIONS

A. Tangential Load Calculation

Given Data

Rated power of motor: 330W

Rated RPM: 800 rpm

Pitch diameter of gear 58 mm

No. of teeth on gear 46

Module of gear 1.25

Rated torque applied on gear:

$$M_t = \frac{60 * P}{2\pi * N} = 3.939\ Nm\ = 3.939\ * 10^3\ Nmm$$

Tangential load on gear tooth:

$$F_t = \frac{2\ *\ M_t}{d}\ = 135.827\ N$$

B. Bending Strength Calculation

As $F_t = m * b * y_p * \sigma_b$ ---------- From PSG Design data book

Therefore,

$$\sigma_b = \frac{F_t}{m * b * y_p}$$

Here, b = width of gear = 26mm

yp = Lewis form factor = $\left(0.154 - \frac{0.912}{z}\right) = 0.13417$

Thus,

$[\sigma_b]$Theo= 31.149 MPa.

V. FEA FOR GEAR STREGTH CALCULATIONS

FEA works by breaking down a real object into a large number (thousands to hundreds of thousands) of finite elements, such as little cubes. Mathematical equations help predict the behaviour of each element. A computer then adds up all the individual behaviours to predict the behaviour of the actual object. Finite Element Analysis is a mathematical representation of a physical system comprising a part/assembly (model), material properties, and applicable boundary conditions {collectively referred to as pre-processing}, the solution of that mathematical representation {solving}, and the study of results of that solution {post-processing}.

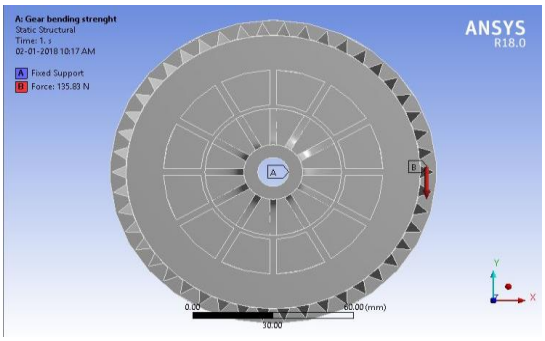

Figure 4. Defining Materials and Boundary Conditions for Transmission gear

Simulation results of Helical Gear Simulation

A. Stress in PLA Helical Gear

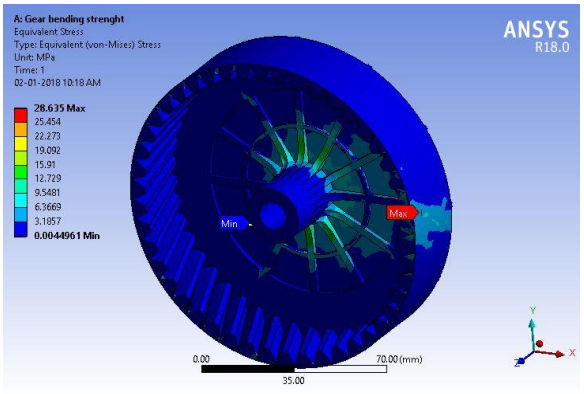

Figure 5. Von misses stress in geometry of PLA Transmission Gear

B. Displacement in PLA Helical Gear

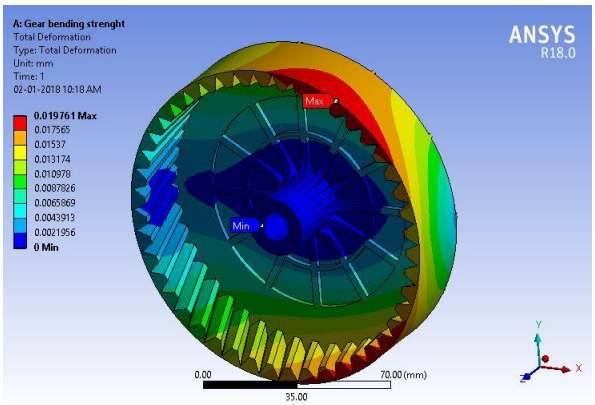

Figure 6. Displacement in PLA Transmission Gear

VI. RESULTS AND CONCLUSIONS

The above table shows that bending stress produced in the Helical Gear is approximately 31.149 MPa which is less than the yield strength of the material i.e. 44.8 MPa. This shows that, the Gear is designed with a FOS of 1.7.The theoretical and FEA stress values are approximately nearer to each other with an error of 8.07%.

Table 1. Displacement in PLA Transmission Gear

Sr. No	Theoretical Stress, MPa	FEA Stress, MPa	% Error
1	31.149	28.635	8.07

This type of Component design using advance manufacturing process will result into fast product development. This helps the Manufacturer to manufacture the parts without investing highly into Research and Development. This also helps the designer to design the complex designs without worrying about the manufacturing Process.

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