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Failure Diagnosis of Spur Gear in Two Stage Planetary Gear Box of Bagasse Carrier Machine used in Sugar Industry by Using FEA

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Abstract
In this paper we have selected agearbox of bagasse carrier machine which is used in sugar industry. In sugar industry, For feeding bagasse to boiler as well as to carry crushed bagasse coming from sugar mill, bagasse carrier and bagasse elevators are commonly used. This bagasse carrier machine is driven by planetary gearbox.
It is seen that the spur gear in second stage of that planetary gears fails under working conditions. So to diagnose the failure we have made the design calculations by using standard design procedure. later on, the analysis is made to find out the various stresses on the spur gears failure
As existing gears fails, the modified design parameters are calculated according to standard design procedure. According to new values, modelling of gears on CREO2.0modelling software is done. Later on static structural analysis is done by using ANSYS software with finite element approach.

Introduction

Planetary gear is one of the epicyclic gear, which is a gear system consisting of one or more outer gears, or planet gears, revolving about a central, or sun gear.

The gearbox considered in this thesis is two stage planetary gearbox (2P17). Every gear box manufactured and supplied by any industry has got a specific code number and a unique serial number. This combination of code number and serial number helps us in exactly identifying the unit supplied. The code number of the gear box gives full information about the exact type of the gear box. The letters 2P indicates the two stage planetary and 17 indicates the outer diameter of Ring gear in inches.

Each stage of the planetary gear box consists of a central Sun Gear meshing with accurately positioned three Planet Gears around it which in turn mesh with the internal teeth of the outer Ring Gear. Normally, the Ring gear is stationary & forms the part of the housing, input is given to the sun gear & output is derived from the three planet gears through a planet carrier. Gears used in this gearbox are spur gears. However, out of these three members any one can be held stationary, second is driven by input and the output can be derived from the third member. Due to this flexibility, planetary gear boxes have a large variety and innumerable applications. As total load is shared by three planets, the torque handling capacity of this type of gear box is very high compared to all other types of gear boxes. Hence, in all high torque applications, planetary gear box is the only economical solution and is most preferred worldwide. It also gives the highest weight /volume ratio i.e. in a given space, this type of gear box can handle the highest torque.

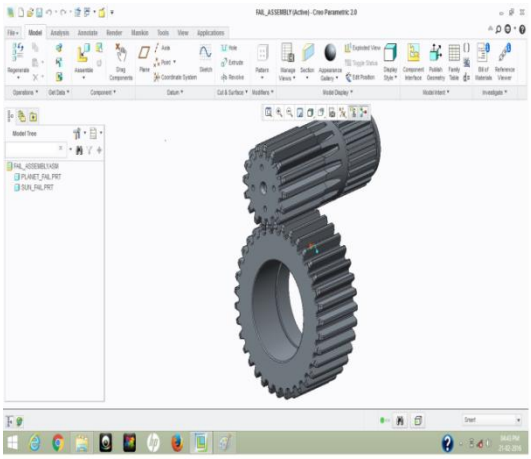
The two stage planetary gearbox for which we are designing the spur gear is mostly used in sugar industries on bagasse carrier machine.

Failure diagnosis of spur gears

To diagnose the failure in existing design of spur gear in two stage planetary gearbox, we have first designed a CAD model of spur gears according to

numerical design parameters using CREO 2.0 modelling software. & then presented this CAD model on ANSYS software for static structural analysis, so that we can find out various stresses on spur gears due to which failure occur.

A. CAD Model of spur gears



B. Static structural analysis

The CAD model isconverted into IGES format and then it is represented on ANSYS software for static structural analysis.

Applying the analytical values of flank pressure and shear force, various types of stresses can be find out because which tooth of the spur gear can fail.

C. FORCES ACTING IN GEAR

Tangential force

$$Ft = \frac{2Mt}{d}$$

$$= 138.15 \times 10^3 \text{ N}$$

Radial force

$$Fr = Ft \tan \alpha$$

$$= 138.15 \times 10^3 \tan(20)$$

$$= 50.282 \times 10^3 \text{ N}$$

The normal force acting on the tooth.

$$Fn = \frac{2Mt}{d2\cos\alpha}$$

$$= \frac{2 \times 22.28 \times 10^6}{140\cos 20}$$

$$= 338.71 \times 10^3 \text{ N}$$

Static Structure Analysis of Existing Spur Gear& Result

The assembly CAD model of sun and planet gear in meshing is converted into IGES file, then it is imported to ANSYS-11.0. then material properties are applied to both the gear ie18CrNiMo7.after that mesh operation is applied and then rotational velocity is given to the gears in rad/sec. then we have applied the pressure value. As both the gears are mounted on shaft, frictionless support on both the gears is given. Following ANSYS images shows preprocessing analysis

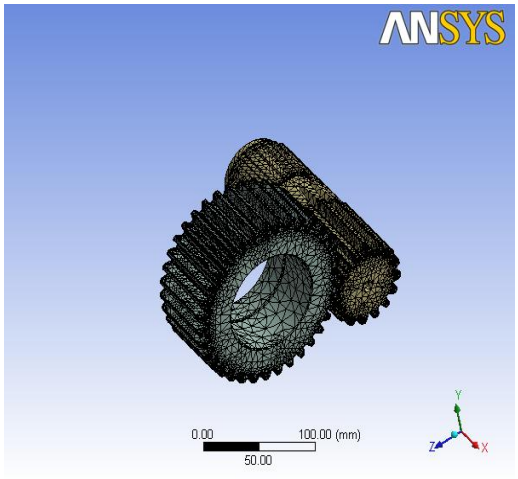


Fig 01 Meshing of sun and Planet Gear

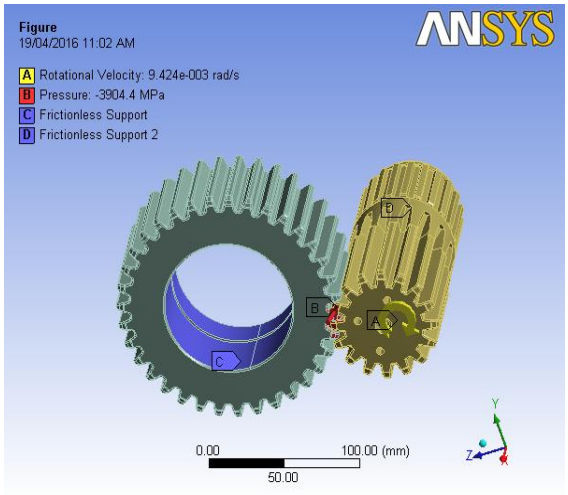


Fig 02 supports, pressure and velocity

- Rotational velocity=9.424 rad/sec isapplied in the direction as shown in fig by 'A'
- Pressure = -3904.4 MPa is applied as shown in fig by region 'B'.
- Frictionless support C and D is given to planet and sun gear respectively.

Result and solution

After this pre-processing, static structure analysis is done and find out results of various stresses in post processing. This post processing involves finding the values of total deformation, equivalent stress, normal stress.

Following fig shows the post processing results of ANSYS.

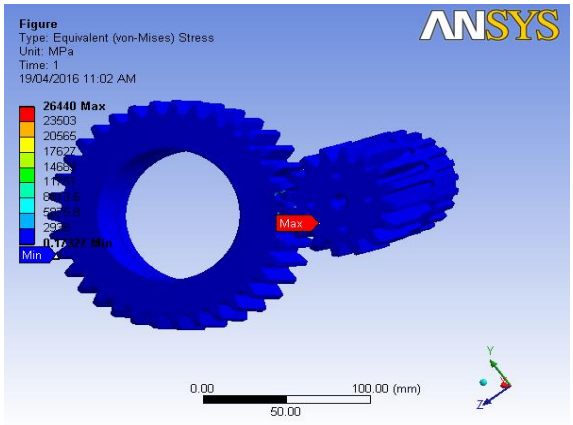


Fig 3 Von-Misses Stresses of sun and planet spur Gear

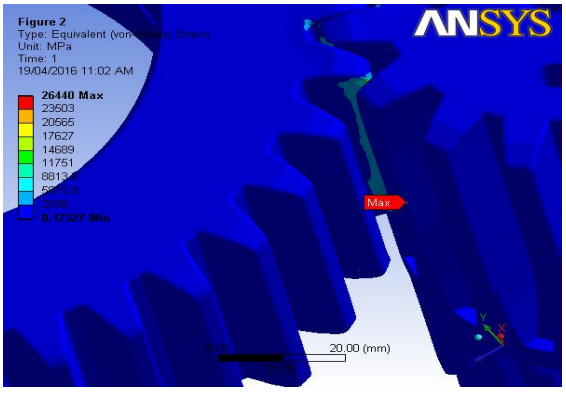


Fig 04 Enlarge view

The equivalent (Von-Mises) stress found to be 8813.6 MPa

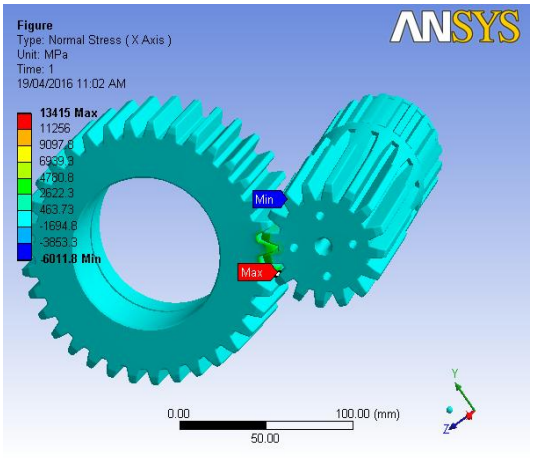


Fig 05 Normal Stresses of sun and planet spur Gear

- The minimum normal stress = 463.73 MPa
- And maximum normal stress = 4780.8 MPa

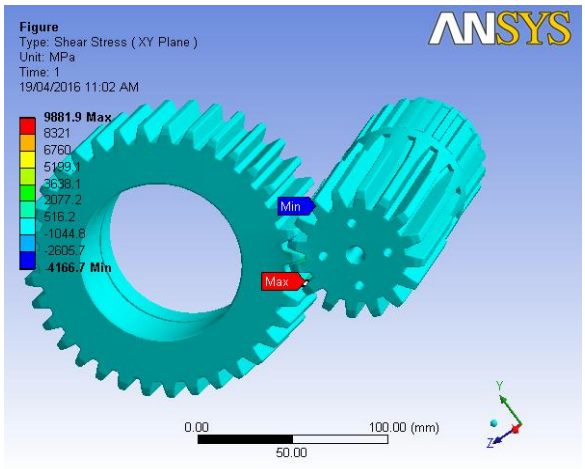
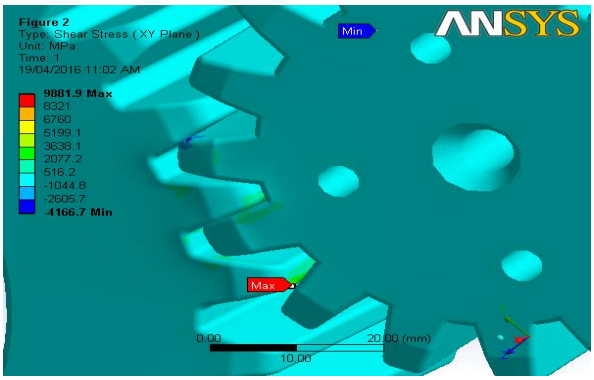


Fig 06 Shear Stresses of sun and planet spur Gear



- Minimum shear stress = 516.2 MPa
- Maximum shear stress = 3638.1 MPa

Conclusion

Gear analysis uses a number of assumptions, calculations and simplification which are intended to determine the maximum stress values in analytical method. In this paper, FEA technique is used to diagnose the failure of spur gears in two stage planetary gearbox.

According to ANSYS result, we can say that spur gears in two stage planetary gearbox can fail in shearing due to continuous dynamic load, as the gearbox which is under study is mounted on sugar bagasse carrier machine in sugar industry.

Recommendation And Future Work

This thesis paper may give enlightenment about the characteristics of involute helical gears and evoke previous works of various bodies that are

involved in gears research and production. Furthermore this study contribute to a better gear design, assist technological institutions and all those who are interested in spur gears. More work can be done to improve this study and to obtain better output.

Further three dimensional numerical method of investigation and study can be conducted on the analysis of bending and contact stresses for all types of gears such as helical, bevel and other tooth forms. Further numerical method of investigation and study can be conducted on the whole gearbox with all elements in the system including gear casing and bearing.

The bending and contact stress analysis of gears made of composite materials using three-dimensional finite element analyses can be recommended as future work

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