Design and Fatigue Analysis of Epicyclic Gearbox Carrier

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Abstract

Gear box is used for the transmission purpose. The load, environmental effect etc. parameters are affect the carrier. In this present study the carrier is used as the present study. The input parameters selected for analysis is force, pressure, load etc. are taken as fixed parameters. For each fatigue analysis, total deformation, von-mises stress and the fatigue life is evaluated. By using creo-parametric 2.0, the different modify model is created, and by using the ansys 14.5 software, analysis of that generating model is done. The task would be accomplished with the help of manual calculation and validate with the help of kiss-software. And also it is accomplished with the help of CAD modelling and finite element analysis by using CREO-PARAMETRIC-2.0 AND ANSYS 14.5 software.

Keywords: Fatigue Life, Von-Mises Stress

I. INTRODUCTION

Planetary gearbox is used in machineries and machine tools to obtain speed reduction, which in turn increases the torque. These gearboxes are used in many applications such as automatic automobile transmissions and hybrid transmission systems. The construction of planetary gearbox is such that, it has the sun gear in the middle and it is meshed with one or more planet gears. The planet gear is in turn meshed with the ring gear. The sun gear and planet gears are together placed inside the carrier.

The recent advances in mechanics and computational techniques have provided the capabilities of increasing the life of the product using finite element analysis. In this paper, fatigue life increase in planet carrier of planetary gearbox has been carried out using finite element analysis. The gearbox is used in which application. Which is a mechanical device powered by planetary gear reduction system. The exploded view of the gearbox assembly is shown in Figure 1. Manufacturers focus is on life increasing along with the high performance in the products. Finite element (FE) analysis provides the most effective solution. In this analysis, the part of gearbox carrier is constructed as solid model and the model is meshed for FE analysis. FE analysis was carried out by providing the forces and boundary conditions. The stress distribution and deflection plots obtained from FE analysis are described in this paper. The new model with the change of geometry as well as change in material were developed and validated by comparing and verifying the results.

Fig. 1: Exploded View of Gearbox Assembly
II. PROBLEM DEFINITION

The traditional method of designing involves over design of components in order to reduce the risk of failure of component during its function. The advances in FE techniques help to design the component with appropriate design by changing the geometry and changing the material without affecting the function. In this paper, FE analysis is conducted for the planetary gearbox carrier used in winch application, manufactured at Elecon Engineering Private Limited, Anand. The static analysis has been carried out on planet carrier. Fatigue analysis of carrier for epicyclic gear box is carried out because of the epicyclic gear box is subjected to high torque therefore; it is found that failure of carrier at intermediate shaft position.

III. PLANET CARRIER

The function of the planet carrier is to hold one or more peripheral planet gears of the same size, meshed with the sun gear and ring gear. The geometry of the planet carrier is as shown in figure 2.

Fig. 2: Planet Carrier of the Gear Box

IV. MATHEMATICAL MODELLING

The technical specification of the epicyclic gear box carrier is as shown below.

- Power: 555 kW
- Input speed: 10.6 rpm
- Torque: 500000 Nm

- The calculation of stress, load and pressure at the shaft position is as below.

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>ANALYTICAL RESULT</th>
<th>KISSOFT RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>499986.7552 NM</td>
<td>500000 NM</td>
</tr>
<tr>
<td>Fr</td>
<td>1011001.647 N</td>
<td>1015542.42 N</td>
</tr>
<tr>
<td>Fa</td>
<td>0 N</td>
<td>0 N</td>
</tr>
<tr>
<td>Ft</td>
<td>2777704.195 N</td>
<td>2790178.57 N</td>
</tr>
<tr>
<td>F</td>
<td>2955971.063 N</td>
<td>2969246 N</td>
</tr>
</tbody>
</table>

- The pressure is considered for analysis. So, the relation between pressure and force is,

\[ P = \frac{F}{A} \]

Here, the pressure is considered for analysis. So, the relation between pressure and force is,

\[ P = \frac{F}{A} \]

Here, area of holes is 13194.7 mm²
\[ P = \frac{2955971.063 \times 4}{13194.7} = 56.0067 \text{ MPa} \]

But, there are 4 holes. So, \( p = 224.027 / 4 \cdot P = 56.0067 \text{ MPa} \)
V. FINITE ELEMENT MODELLING

A. Introduction to Structural (Static) Analysis:
With the widespread adoption of CAE approach to design, finite element analysis became integrated with the design and analysis procedure. Structural (Static) analysis is used to analyse parts and assemblies to find :-

- Maximum Stresses
- Deformed Shapes (Deformation)

B. Structural (Static) Analysis Procedure:
The analysis of a structure during its design process is accomplished by the solution of the partial differential equations that describe the given model. The structural (static) analysis involves the following procedure:-

1) Pre-Processing: It includes the description of the geometry or model, the Physical Characteristics of the model and the mesh generation.
2) Solution: It involves the application of the finite element analysis.
3) Post-Processing: It includes the visualization and interpretation of the results of the solution.

- The meshed model of the existing carrier model is as shown in figure 3 and that meshed is called hex dominant mesh and it is also called as block mesh.

Fig. 3: Meshing Model

VI. RESULTS AND DISCUSSIONS

Static analysis was carried out for the fatigue life increased. Initially, the analysis was carried out for the existing model of the carrier. Von-Mises stress and fatigue life is observed for the existing model as shown in Figure 4 and 5.

A. Design Modifications Undertaken:
After extensive reviewing and studying the basic concepts of the stress, life etc. some design modifications were made in order to reduce the stresses to the safe limit and increase the life of gear carrier. The following design modifications are done in the existing gearbox carrier:

- The material is changed in existing model from 18crnimo6-7 to 20nicrmo13.
- The model geometry is changed in existing model.
- The material is changed in modify model from 18crnimo6-7 to 20nicrmo13.

B. Following Figures Shows Stress Analysis of Carrier from Existing Carrier:
C. Geometry Change Model and Its Analysis:

D. Change in Material of the Modify Model:
The comparison of existing model and modify model is as below:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>deformation</th>
<th>Equivalent stress(von mises)</th>
<th>Life (cycle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing model</td>
<td>0.051376 mm</td>
<td>202.8 MPa</td>
<td>24359</td>
</tr>
<tr>
<td>Material change model</td>
<td>0.051157 mm</td>
<td>198.58 MPa</td>
<td>26314</td>
</tr>
<tr>
<td>Modify model</td>
<td>0.030989 mm</td>
<td>129.2 MPa</td>
<td>127000</td>
</tr>
<tr>
<td>Material change of modify model</td>
<td>0.024177 mm</td>
<td>99.776 MPa</td>
<td>430790</td>
</tr>
</tbody>
</table>

VII. CONCLUSIONS

The following conclusions can be made.

1) When the material of the carrier model is changed by 20nicrmo13 instead of 18crnimo6-7 there the von-mises stress is reduced from 202.8 MPa to 198.58 MPa as well as their fatigue life is increased by 24359 cycles to 26314 cycles.
2) In the existing model there the rib of the model is changed than von-mises stress is reduced from 198.58 MPa to 129.22 MPa and the fatigue life of carrier is increased by 26314 cycles to 127000 cycles.
3) If that modify model material is changed, the von-mises stress is reduced from 129.2 MPa to 99.776 MPa and the fatigue life of the carrier is increased by 127000 cycles to 430790 cycles.

So, overall conclusion is that if the material of the gear carrier is changed than the fatigue life is very increased and the von-mises stress is at its permissible limit.

REFERENCES