Review of Static Structure Analysis of Gear Box Casing

Jainik Makwana[1] Prof. (Dr.) P. M. George[2] Prof. (Dr.) V. J. Patel[3]
[1]Student [2,3]Assistant Professor
[1,2,3]Department of Mechanical Engineering
[1,2,3]B.V.M Engineering College. V.V. Nagar, Anand, Gujarat, India

Abstract— Using the FEA method, an analysis has been carried out of the forces and its effects on different parts of casing and also by carrying out the experimental procedure using strain gauge, it has been found out that we can measure the strain at a different location on casing and therefore evaluation of the stress values on those locations in order to validate FEA results can be done. This review work can help in future for optimization and design modification of gear box casing for better output performance. Also, it is possible to carry out reverse engineering in design of gear box casing.
Key words: Gear Reducer Housing, Gear Box Casing

I. Introduction

Gearbox is considered to be an important component of any heavy machinery. The gearbox housing plays a crucial role as it houses the transmission components. The different components housed are gears, bearings, shafts along with oil. The housing of gearbox contributes largely towards the total weight of the gearbox and hence it requires a very careful design procedure. A variety of forces will be acting on gearbox housing during operations, which are to be kept in consideration while designing the gearbox housing. Stress analysis can be defined as an engineering discipline and science that determines the stress in materials and structures subjected to static and dynamic forces or loads. FEA method is used to analyze static properties of the casing and transmission parts in high-speed class. The effects on gearbox in the action of structural load can be considered and gearbox stress distribution can be satisfied for working condition with the use of ANSYS. The measurement of strain can be done in many ways, the most common being with a strain gauge. This is a device whose electrical resistance varies in proportion to the amount of strain in the device. For example, the piezo-resistive strain gauge is a semiconductor device whose resistance varies nonlinearly with strain. The most widely used gauge, however, is the bonded metallic strain gauge.

Force analysis for helical gears can be made in similar manner as in the case of spur gears but because of the helix angle, an additional force component is produced, which should be taken into consideration. This force appears as an axial force with the resulting axial thrust on the bearings. Types of forces generated on helical gear tooth:

- Tangential force (Ft)
- Axial force (Fa)
- Radial force (Fr)

When a pair of parallel helical gears meshes, the following conditions must be satisfied for proper running of the set:

- The gears must have helix angles of equal value;
- The gear teeth of each member must have the same module, and
- The gear teeth of each member must have opposite helices, that is, one gear must have right-handed helical teeth while the other gear must have left-handed ones.

II. Literature review

A. M. Davis et al.M. Davis, Y.S. Mohammed, A.A. Elmustafa, P.F. Martin and C. Ritinski [1]

Author has analyzed the design for static and dynamic loading of a gear reducer housing with FEA. The FEA was used to test the cast iron housing to determine any potential problem areas before reaching the production stage. Once analysis was completed, the motor adapter was redesigned to lower stresses using the information from the FEA and compared with the field test data.

1) FEA of Gear Reducer Housing

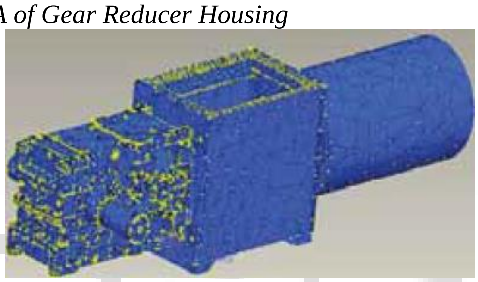

Fig. 1: FEA model mesh

In this method, the simulation of the bolt as a spring element passing through the two fastened parts is done. It was observed that the load was completely transferred through the bolt rather than the touching components. Although this assembly was very large, it was simplified by removing many structurally insignificant features. Analyzing the entire system (reducer housing, coupling box and motor) as an assembly made it very complicated to simulate. More complexity in the model, in terms of features, means more elements and hence less accuracy. Significant effort was made to simplify the model while maintaining the structural properties of the system. Here, the loads applied were the weight of the entire system and the torque reaction due to the action of the output shaft. The initial torque on the system at startup is observed to be 300% of the rated torque. This factor of three had been taken into account while applying the loads.

2) Static Analysis

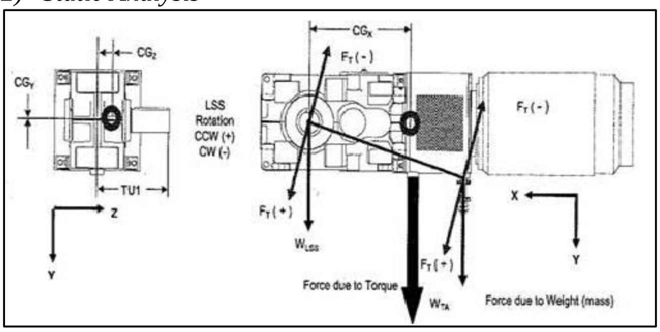

Fig. 2: Free-Body Diagram

Here, the reducer housing is connected to the rest of the assembly by four bolts at the high-speed, end-face of the housing. The free-body diagram of the entire drive system is given in below Figure.

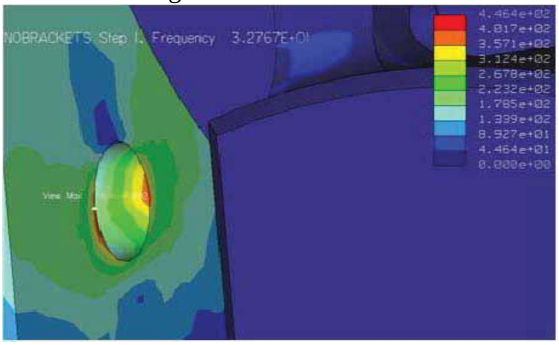

Fig. 3: Stress distribution on reducer interface.

The high-stress (stress concentrated) areas are the sharp edges and holes. Higher stresses are due to the stress concentration in the area where the geometry is smaller and thinner. It was observed that the failure of gear reducer housing units was directly related to the combination of both static and dynamic loadings. High stresses arose in the gear reducer housing from both the large sizes of the components, improper gear meshing and impact, and from vibrations coming from the system.

B. Tushar. N. Khobragade, P.Priyadarshni [2]

The strength of a gear box is an important parameter to be taken into account while designing. In this literature, the gear box selected is also two stage gear box. The gear box housing is analyzed statically by two softwares namely ANSYS 11.0 and hyper mesh to compare the results. The comparison obtained was quite positive. Thus the scope of the paper is limited to statically analyze and compare simulation using two simulation models. The objective of the paper is to emphasis the brief methodology adopted in static analysis of the gearbox casing. It was observed that the strength of the gear box casing is important since the complete power pack is subjected to both static and dynamic loading.

1) Process Methodology

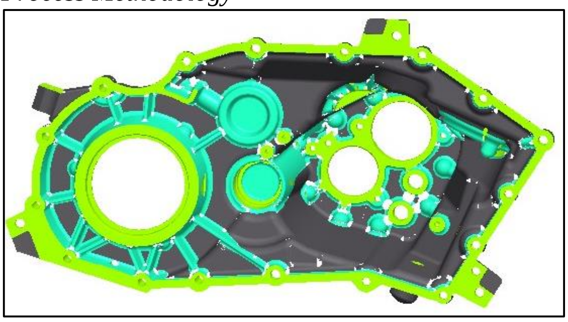

Fig. 4: CAD Model of the main casing

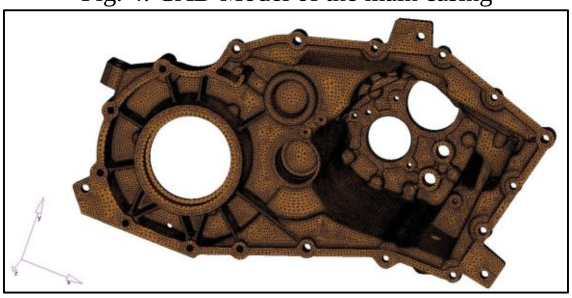

Fig. 5: FEA model of the main casing

To carry out the analysis, CAD model was created and imported into the respective format to the simulation software.

Then determination of the boundary conditions was done, allowing studying the material properties and the loading pattern is to be determined by studying the assembly of the model.

The mesh generation in the FEA model is most important step in analysis to achieve realistic simulation results.

Von misses stress is obtained using both the softwares.

Benefits obtained by implementing analysis in the design of the gear box casing are as follows:

- It helped in developing an optimum design.
- It helped in selection of appropriate material for cost effective design.
- Reduced prototype development and testing time.

Thus the static analysis of gear box casing has facilitated in development of an optimum gearbox design. This optimization has been achieved in terms of time, cost and material. The analysis has enhanced in reduction of product development cost and time.

C. M. Mahesh Babu, Y. Rameswara Reddy [3]

In this literature, it is observed that the modeling was done by CATIA software and analysis was done by ANSYS Work bench. To reduce the stresses, three ways considered were: design modification, without design modification material changing and with design modification and material change. A process plan for gearbox analysis included CAD model, applying boundary conditions, selection of material, material prosperities and choosing good casting process.

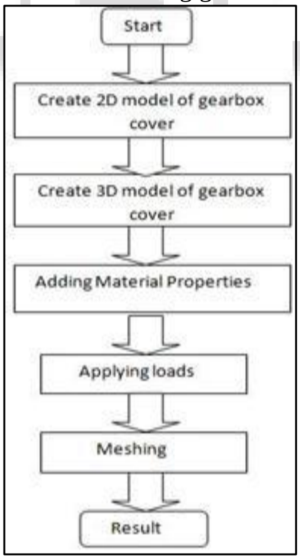

Fig. 6: Process Chart

It was considered that the loads acting on the casing were weight of the casing, bearing reactions and axial force. The main objective of this research work is,

- To carry out structural analysis using ANSYS Workbench for analyze effect of stresses on the component.
- For design modification and optimization of component for better performance output.
- a possibility of the reverse engineering in design of gearbox casing.

D. Vasim Bashir Maner, M. M. Mirza, ShrikantPawar [4]

In this review, Foot casing is typically a metallic material and made by casting process. In Top Gear Transmissions industry, foot casing is made by cast iron material which weights around 71.6 kg. It is approximately 32.6% of entire gear-box assembly. Now, industry is facing problem of excessive weight in foot casing. It is not as per optimum design. So it results in the wastage of material and ultimately consumes more cost for casting as well as for machining. To solve this problem it is essential to carry out the analysis of foot casing and redesign the existing foot casing in order to save material as well as cost. 3D model is generated in PRO-E software, while static analysis is done in ANSYS software. Optimization is based on ANSYS results, which can be used to enhance the efficiency of the design process. The process is repeated until all specified criteria are met. Final results are more optimize than existing design. Foot casing is made by cast iron (FG260) material.

Author has calculated the bearing reactions (vertical and horizontal) on the basis of tangential load in addition to self-weight of the casing. Here also, it has been found that the study has the same benefits and future scope as above papers.

E. Syed RizwanUlHaque, Prof. Dongyan Shi, Tauseef Ahmed [5]

The objective of the paper is to emphasize on static analysis by using sub modeling approach of the Gearbox casing. Sub-modeling utilizes two separate models. A full or global model representing the entire structure is used to transform global loads to local deformation. The sub-model includes the local geometric details with an appropriate mesh density. The sub-modeling algorithm then interpolated the deformation from the global model to the sub-model "cut boundaries" and solved the local stress state. Here as author has taken bevel gears he has calculated the radial, axial and tangential load acting and also the weight of the gear box assembly and performed the analysis using ANSYS. The results obtained in this literature are for Von misses stress and maximum deformation.

F. BoštjanKova, RokKamnika, Andrej Štrukelja, Nikolai Vatinb [6]

In this literature review, Strain gauge is first installed at the point of interest by bonding and adhesive materials. Selection of strain gauge and data processing system were the most important parameters to be taken care. This paper shows that how the strain gauge is to be located at the point of interest and how the strain measurement can be recorded and analyze.

For proper installation of the strain gauge following steps were followed.

- Solvent degreasing.
- Surface abrading.
- Application of strain gauge layout lines.
- Surface conditioning.
- Neutralizing.

As the length of the strain gauge conductor changed, a proportional change in the resistance was observed giving the flow of current in the circuit. This current or voltage is directly related to the strain and thus measurement is done. Readings of strain from strain gauge can be directly related to the stress and thus stress value at the particular location can be calculated.

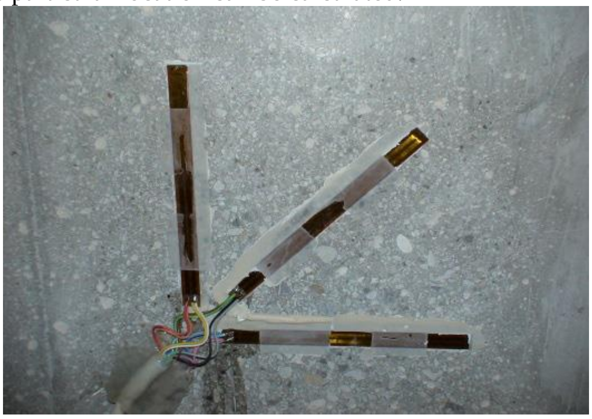

Fig. 7: Three strain gauges applied at one point on the bridge (measuring the strain in three directions)

G. Mitesh Patel, Prof. A.V.Patil [7]

This work focuses on the force, deflection, and stress analysis of 3-stage helical gearbox housing designed and manufactured by steward machine company, Birmingham, Alabama. The triple reduction helical gearbox was made of ASTM A36 Steel. The reactions were used to apply loads to the finite element model of housing. Static structural analysis was performed using a combination of shell and solid elements to determine the deflection and to estimate the stress distribution in the housing. The aim of this study is to reduce weight with less stress and deformation so that changes in materials.

In order to analyze the material which would have the better result for the given loading conditions, author considered different material in ANSYS software and simulation was done in order to check the suitability of the material which can meet the requirement satisfactorily. It is reviewed here that, the weight optimization of gear box casing by applying different materials in ANSYS can be done.

Different steel grades used for weight optimization of casing are: ASTM A36 Steel, Invar Steel, High Carbon Steel

H. Mitesh Patel, Prof. A.V.Patil [8]

Here, it is observed that the triple reduction helical gearbox was made of ASTM A36 Steel. This literature gave the idea about the optimization of gearbox casing by considering different conditions: Casing without Stiffener and Rings, Casing with Stiffener Casing with Ring and Stiffener. For above three conditions, the results of equivalent von-misses stress and total deformation were obtained. In this literature it was observed that the third condition (casing with stiffeners and rings) gives the best results. This gave an idea that another design modifications can be made by changing the dimensions of the stiffeners which will help in overall weight and size optimization of casing.

III. CONCLUSIONS

This review work clears the understanding of the analysis of forces acting on the gear box casing in static condition. Using FEA method, the effect of different force conditions can be checked. The FEA analysis gives the idea about future scope in modification and optimization of case design in terms of cost, time and material. This review work also gives the idea about the strain gauge installation process and different materials used for installation. If the strain gauge experimentation carried out, on the basis of strain values at different locations, stress can be found out using the stress-strain formulations. This will give the validation of software results.

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