INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

IJARIIT

ISSN: 2454-132X
Impact factor: 4.295
(Volume 5, Issue 2)
Available online at: www.ijariit.com

Improvement in design of gearbox housing (Code No: MFO225DR) through static analysis

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ABSTRACT

Laxmi Hydraulics Pvt Ltd is a leading company in the manufacturing of pumps located at Solapur. A gear motor is manufactured by LHP for BHEL, Ranipeth. Input rpm for this gear motor is 1390 rpm with power 0.37 kW. It has a three-stage reduction gearbox output rpm of which is 17 rpm. The final output rpm is 1.1 rpm with torque 298 km. This is used in power plant for ESP – Electrostatic Precipitation. Since proper stress calculations are not done weight of housing is more. Stress calculation needs to be checked in ansys and material selection and design of gearbox housing need to be optimized. Gearbox housing of MFO225DR is designed as per the requirement of the gearbox. But stress calculation of box has not done. In this paper improvement in the design of gearbox housing is done.

Keywords— *Gear box housing, MFO225DR, Gea box casing, ESP*

1. INTRODUCTION & PROBLEM DEFINITION

This gearbox housing is used in a power plant for ESP. Definition of Electrostatic Precipitation removal of suspended particles (such as dust and acid mists) from a gas (such as air or blast-furnace gas) by charging the particles and precipitating them by applying a strong electric field (as by passing the gas between collecting and discharge electrodes in a precipitator).

Gear box housing of MFO225DR is designed as per the requirement of the gear box. But stress calculation of box has not done. The gear housing is the casing that surrounds the mechanical components of a gear box. It provides mechanical support for the moving components, mechanical protection from the outside world for those internal components, and a fluid-tight container to hold the lubricant that bathes those components. The gear box housing is not analyzed for stresses in various areas. Proper action for controlling stress and weight is not done. Analysis of part for different changes in sizes is required. Also, analysis for different material is also need to be done.

2. LITERATURE REVIEW

Design Analysis And Optimization For Foot Casing Of Gearbox, Vasim Bashir Maner, M. M. Mirza, Shrikant Pawar, Proceedings of 3rd IRF International Conference, 10th May-2014, Goa, India, ISBN: 978-93-84209-15-5. Foot casing is typically a metallic material and made by the casting process. In Top Gear Transmissions industry, foot casing is made by cast iron material. The industry is facing problem in excessive weight of foot casing. It is not as per optimum design. So there is more wastage in material and ultimately consumes more cost for casting as well as for machining. It weights around 71.6 kg. It is approx 32.6% of the entire gear-box assembly.

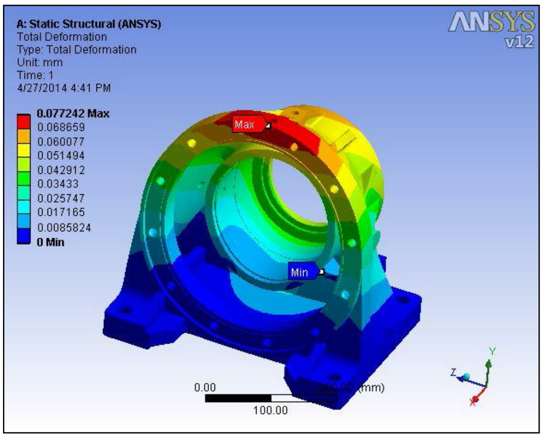

Fig. 1: Stress analysis

The gearbox casing is manufactured from cast iron FG260 material. The von misses stress is 36.544 MPa. Also, the maximum displacement of the casing is found 0.077242 mm. These results are so far better than the existing model

Transmission Weight & Efficiency Optimization In Off Road Vehicle (Tractor Gearbox), V Shrikant S. Joshi1, C. Maria Antoine Pushparaj, Control Theory and Informatics, www.iiste.org, ISSN 2224-5774 (Paper) ISSN 2225-0492 (Online)Vol.4, No.1, 2014. Weight optimizaton of transmission by selecting an appropriate cross section of gear box casing: Function of Transmission casing is to envelop gears and shafts, store the lubricant &also to act like chassis member for Tractor. Transmission casing contributes 70% of the total weight of Transmission. Following cross sections are selected for comparison.

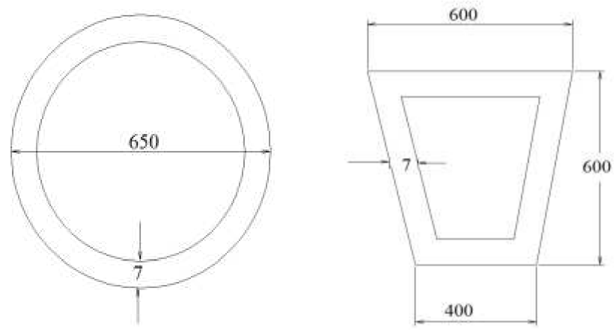

Fig. 2: Circular and Trapezium shape

Trapezium cross section is optimum for Gear box casing; it will also reduce the oil requirement for transmission.

Modal And Stress Analysis Of Differential Gearbox Casing With Optimization, **Shrenik M. Patil 1, Prof. S. M. Pise,** C Shrenik M. Patil et al Int. Journal of Engineering Research and Applications, www.ijera.com, ISSN: 2248-9622, Vol. 3, Issue 6, Nov-Dec 2013, pp.188-193. The process of casting design in the automotive industry has been significantly refined over the years through the capabilities of advanced computer-aided design and engineering tools. One of the significant benefits of these computer-aided capabilities is the direct access to CAD geometry data, from which finite element models can be quickly developed. Complex structures can be meshed and analyzed over a relatively short period of time. The application of advanced finite element analyses such as structural modification and optimization is often used to reduce component complexity, weight and subsequently cost. Important points to be considered at the design stage in order to reduce vibrations and noise in differential gearbox casing are as follows:
(a) Shape and structure of its housing
(b) Shape of stiffener
(c) Thickness of stiffener
(d) Layout of stiffener

Design And Stress-Strain Analysis Of Composite Differential Gearbox, Nitin Kapoor, Virender Upneja, Ram Bhool and Puneet Katyal, International Journal of Science, Engineering and Technology Research (IJSETR), Volume 3, Issue 7, July 2014. The main objective of this paper is to the developed a parametric model of differential Gearbox by using CATIA-V5 under various design stages. It is observed that Glass filled polyamide composite material is selected as the best material for differential gearbox and is found to suitable for different revolutions (2500 rpm, 5000 rpm and 7500 rpm) under static loading conditions. Comparisons of various stress and strain results using ANSYS-12 with Glass filled polyamide composite and metallic materials (Aluminum alloy, Alloy Steel and Cast Iron) are also being performed and found to be lower for composite material.

This paper concludes that the work relates to composite material differential gearbox as an effective alternative to existing metallic differential gearbox. Glass filled polyamide composite material is used for gears and are analysed using ANSYS for equivalent (Von-Misses) stress, displacement (total deformation) and maximum shear elastic strain for different revolutions (2500 rpm, 5000 rpm and 7500 rpm) under static conditions. Comparisons of various stress and strain results with Glass filled polyamide composite and metallic materials (Aluminium alloy, Alloy Steel and Cast Iron) are also being performed and found to be lower for composite material. By observing these analysis results, Glass Filled Polyamide composite material is selected as the best material for Differential gear box which in turn increases the overall mechanical efficiency of the system.

Research On Vibration And Acoustic Radiation Of Planetary Gearbox Housing, Tianmu Zhang; Dongyan Shi; Zhong Zhuang, College of Mechanical and Electrical Engineering, Harbin Engineering University, China. In this paper, an analysis model of planetary gearbox housing is constructed based on the Finite Element Method/Boundary Element Method (FEM/BEM). Its vibration and acoustic radiation characteristics are investigated. The main factors affecting its dynamic characteristics are observed through modal analysis. Then the impact of main structural parameters on transmission characteristics is investigated. Acoustic pressure nephogram, noise spectrum, noise radiation and modal contribution of housing surface are obtained through the numerical analysis. The effects of the main structure parameters on noise radiation characteristics are observed. It is shown that the rigidity of the front and back plate is weaker than the circumferential rigidity of the housing. However, reinforcing the local thickness of the front and back plate cannot improve the dynamic characteristics due to the effect of shifting in the gearbox housing. Finally, acoustic protection of the housing is carried out. It can be observed that changing the loss factor can effectively reduce the noise of the housing structure.

3. OBJECTIVE

- Stress analysis of gear box housing to find out critical areas.
- To reduce stress concentration in critical areas.
- To optimize the existing design of the gear box housing.
- To reduce the weight of gear box housing.
- To find out alternative option for the material for gear box housing.

4. NUMERICAL SIMULATION OF EXISTING GEARBOX HOUSING

Numerical Simulation of CI FG 150 Existing Gearbox housing is shown in fig. The boundary conditions were applied to the FEM model of Gearbox housing for the determination of equivalent stress, equivalent strain and total deformation. Fig. shows that the maximum Von Mises stress is developed at the hub section of the Gearbox housing is 101.48 N/mm^2.

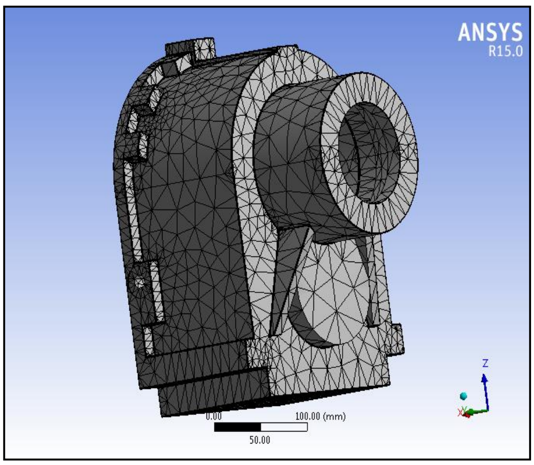

Fig. 3: Meshing of the Gearbox housing

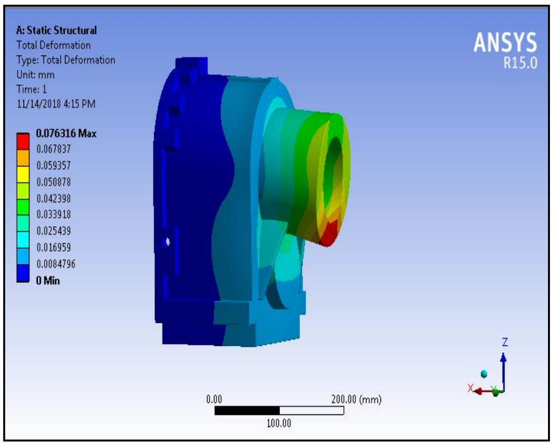

Fig. 4: Total Deformation

Table 1: Stresses in Existing CI FG 150 Gearbox housing

Numerical Simulation					
Nodes	**Elements**	**Volume 10^6**	**Mass Kg**	**Equivalent stress N/mm^2**	**Total Deformation mm**
83006	49854	3.7499	26.999	101.48	0.076316

5. IMPROVEMENT IN DESIGN AND MATERIAL

We observed that the maximum stresses are produced on the rib section. So the weight and stress dimensions of the rib can be reduced. So we have reduced the dimension of the rib by 1mm and then 2mm, 3mm and so on until we get appropriate values. This all changes are done on CI FG 150.

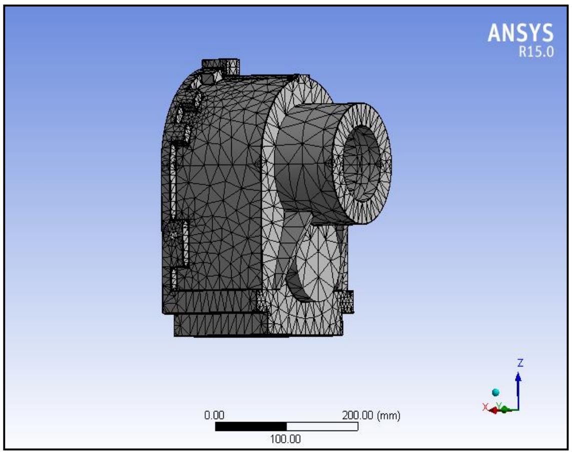

Fig. 5: Meshing of the Gearbox housing-1mm

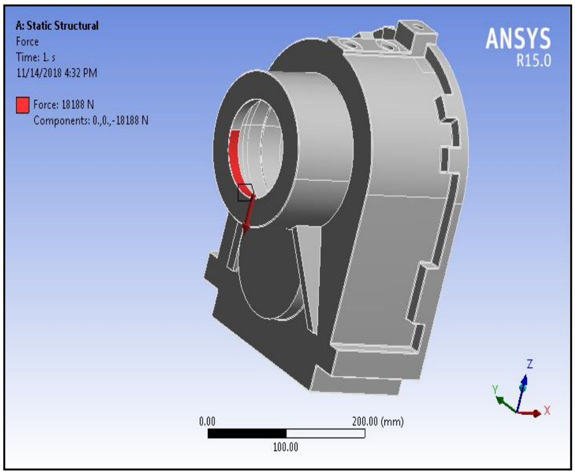

Fig. 6: Load application location

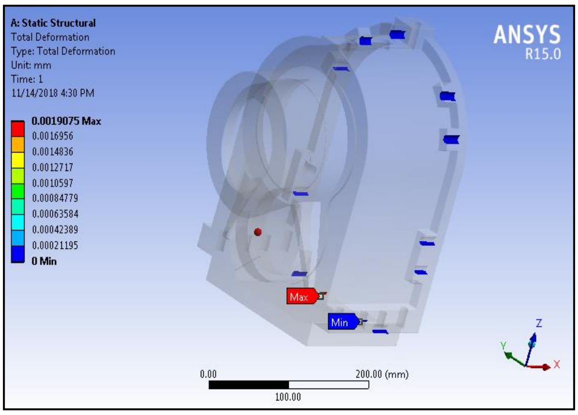

Fig. 7: Total Deformation

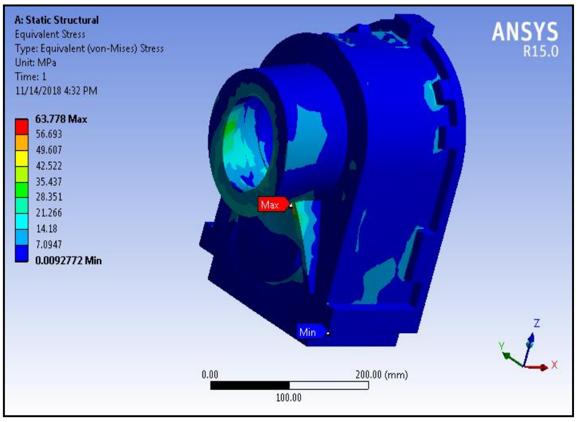

Fig. 8: Equivalent (Von-Mises) Stress

Table 2: Rib dimension reduced by 1mm

Numerical Simulation					
Nodes	Elements	Volume 10^6	Mass	Equivalent stress N/mm^2	Total Deformation mm
79366	47508	3.7445	26.96	63.778	0.0019075

Similarly, rib dimension is reduced by 2mm, 3mm and 4mm. Respective readings are mentioned in the table.

Table 3: Rib dimension reduced by 2mm

Numerical Simulation					
Nodes	Elements	Volume 10^6	Mass	Equivalent stress N/mm^2	Total Deformation mm
79391	47502	3.7392	26.92	64.403	0.078013

Table 4: Rib dimension reduced by 3mm

Numerical Simulation					
Nodes	Elements	Volume 10^6	Mass	Equivalent stress N/mm^2	Total Deformation mm
79391	47502	3.734	26.88	63.66	0.078822

Table 5: Rib dimension reduced by 4mm

Numerical Simulation					
Nodes	Elements	Volume 10^6	Mass	Equivalent stress N/mm^2	Total Deformation mm
79177	47360	3.7289	26.84	69.48	0.079808

Table 6: Comparison table – Design

Modification	Material	Mass kg	Equivalent Stress Mpa	Total Deformation mm
Existing	CI FG 150	26.99	101.48	0.07631
1mm reduced		26.96	63.778	0.00190
2 mm reduced		26.92	64.403	0.07801
3 mm reduced		**26.88**	**63.66**	**0.07882**
4 mm reduced		26.84	69.483	0.07980
Existing	CI FG 200	26.99	101.53	0.07636
1mm reduced		26.96	63.752	0.00046
2 mm reduced		26.92	64.291	0.07774
3 mm reduced		**26.885**	**63.666**	**0.07882**
4 mm reduced		26.84	69.483	0.07980
Existing	CI FG 250	26.99	101.53	0.07636
1mm reduced		26.96	63.75	0.00190
2 mm reduced		26.92	64.40	0.07801
3 mm reduced		**26.88**	**63.66**	**0.07882**
4 mm reduced		26.84	69.48	0.07980

From above observation table it is clearly observed that the Equivalent stresses are minimum when the Rib dimensions are reduced by 3mm.

Similarly, this procedure of reduction in dimensions of Rib is done for different materials, for FG 200 and FG 250.

The stress and deformation comparison for FG 150, FG 200, FG 250 is shown in comparison table. Also while comparison cost and availability of material is also considered.

6. RESULT

Table 7: Comparison table-Material

Sr No	Material Details	Equivalent Stress (MPa)	Weight (Kg)	Total Price Rs.	Avail-ability
1	**FG 150**	**63.66**	**26.88**	**1478**	**Yes**
2	FG 200	63.66	26.88	1559	Yes
3	FG 250	63.66	26.88	1693	No

7. CONCLUSION

7.1 Design

The existing model has a mass of **26.99 Kg**, with total deformation of **0.076316mm**, with equivalent elastic strain **0.00093067** and equivalent stress of **101.48 MPa.**

Whereas FG 150 with 3mm reduction in rib dimension has a mass of **26.88Kg,** with total deformation of **0.078822mm**, with equivalent elastic strain **0.0002048** and equivalent stress of **63.66 MPa.** This will be best-improved solution.

7.2 Material with 3mm reduction in rib dimensions

Considering cost, weight, availability and stresses, we can conclude that if **FG 150 material with 3mm reduction in rib dimensions** is the best optimum design for this gear box housing.

As the final output speed of the shaft is 1.1 rpm there is no possibility of failure of gear box housing due to dynamic force. So there is no need for modal analysis.

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