Design Optimization of Transmission Housing using FEA

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Abstract— A transmission housing has certain functional requirements based on which it was designed through the years. During the design of a gearbox there has been hardly any rigorous design procedure adopted for transmission housing. There is need for a definite design procedure in consideration of a large number of failures in such designs. We are going to prepare the Design Analysis of a transmission housing using Finite Element Analysis (FEA) Method. Like gear and shafts transmission housing is also important transmission component. Thus the strength of transmission housing is to be important parameter to be taken into account while designing. After getting 3D model pre-processing is prepared by using Ansys. The proper inspection of the material and understand the critical region in the casting. The FEA analysis helps to understand the critical region and non-critical region. The analysis helps to proper optimization of geometry and helps to reduce the size or increase the size and increase the total life of the component. Optimized design for the transmission housing found out by this process in which it has the best performance without any failure and with minimum loads acting on the housing. FEA also be carried out on design of the gearbox housing to check whether the design is safe or not.

Key words: Finite Element Analysis (FEA), Transmission Housing

I. INTRODUCTION

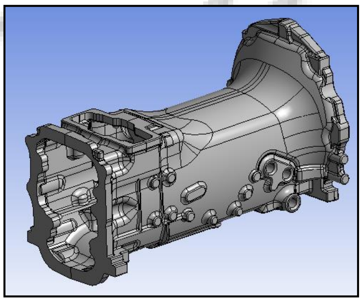


Fig. 1: Transmission housing

For the portion of the transmission that covers the flywheel and the clutch or torque converter of the transmission on vehicles powered by internal combustion engines bell housing or transmission housing is an incorrect term. Tractor transmission housing is subjected to harmonic excitation, gear meshing excitation, load fluctuations, varying speed and torque conditions. Transmission errors and internal excitations are the root cause of vibration and noise.

II. OBJECTIVES & METHODOLOGY

The prime objective of this result is to find out optimum material for transmission housing to sustain load fluctuations harmonic excitation and gear meshing excitation, varying speed and torque conditions.

Under this we are aiming:

– To understand the stress analysis of transmission housing by using properties of different materials.
– To obtain dynamic characteristics i.e. natural frequencies and mode shapes of the transmission housing using modal analysis in ANSYS 16.
– To generate realistic and representative finite element model of transmission housing, which will be then used to evaluate possible deformation pattern (mode shapes) and natural frequencies by comparing properties of different materials.

We are having 3D model of transmission housing. The different mechanical and physical properties of gray cast iron FG220, gray cast iron FG260, structural steel, aluminum alloy are going to be studied. Analysis will be done using ANSYS16. The static analysis of the model is performed by applying boundary conditions and forces which are calculated according to the data provided by the company. The natural frequencies of model in free-free conditions are calculated using ANSYS16, and by applying the boundary conditions also to compare with theoretical and operating frequencies.

III. EXPERIMENTATION

A. Meshing:

It is one of the basic activities the help in converting the constructed geometry into nodes and elements. It involves discretization of the geometric domain into valid zones for analysis. Fig 2 shows meshing geometry. The figure below shows the detailed meshing of housing. It consists of 276323 nodes and 157112 elements.

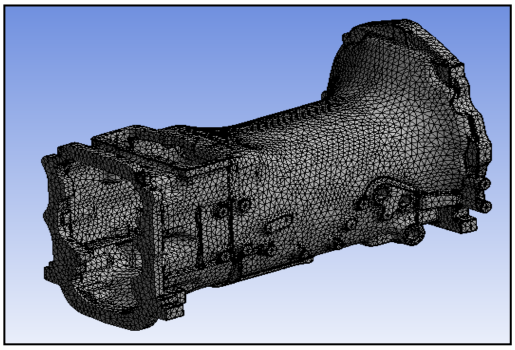


Fig. 2: Meshing of component

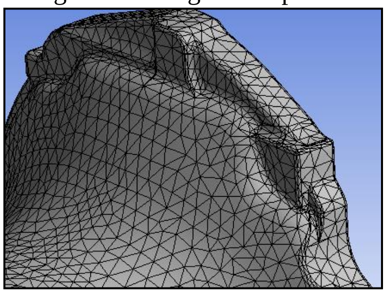


Fig. 3: Element type –second order tetrahedral

B. Adding Material Property:

Mesh definition is followed with associating the appropriate material properties that covers relevant properties like Young's modulus, density, Poisson's ratio, etc. In this project carried with the four types of materials which are gray cast iron FG220, gray cast iron FG260, structural steel, aluminum alloy and their properties are shown in below table 1

Materials	Density (kg/m^3)	Young's Modulus (Pa)	Poisson's Ratio	Bulk Modulus (Pa)	Shear Modulus (Pa)
Grey Cast Iron FG220	7200	1.1×10^{11}	0.28	8.33×10^{10}	4.296×10^{10}
Grey Cast Iron Grade FG 260	7200	1.28×10^{11}	0.26	8.89×10^{10}	5.07×10^{10}
Structural Steel	7850	2.0×10^{11}	0.30	1.67×10^{11}	7.692×10^{10}
Al Alloys	2770	7.1×10^{10}	0.33	6.96×10^{10}	2.669×10^{10}

Table1. Mechanical properties of materials used

C. Assigning Boundary Conditions:

In this model we applied fixed support at the base and applied moment of 1836 Nm at the hollow portion of housing.

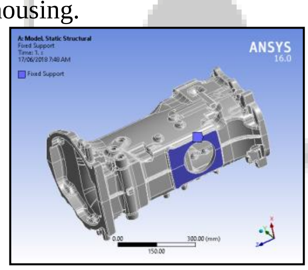


Fig. 4: Fixed Support

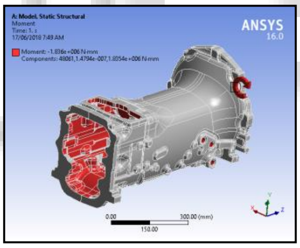


Fig. 5: Loading Condition

IV. RESULTS & DISCUSSION

The FEA analysis of tractor transmission housing evaluates result for first six natural frequencies and mode shape. Table 2 shows the variation of natural frequencies for all four materials.

A. Static analysis

Effects of steady loading conditions on a structure are calculated by static analysis by ignoring inertia and damping effects.

1) Stress

The equivalent von-misses stresses are obtained for gray cast iron FG220, gray cast iron FG260, structural steel, aluminum alloy from the ANSYS. From result it is clear that the maximum stress occurs only at the upper part of housing and the maximum value is 19.76 MPa for gay cast iron FG260 material.

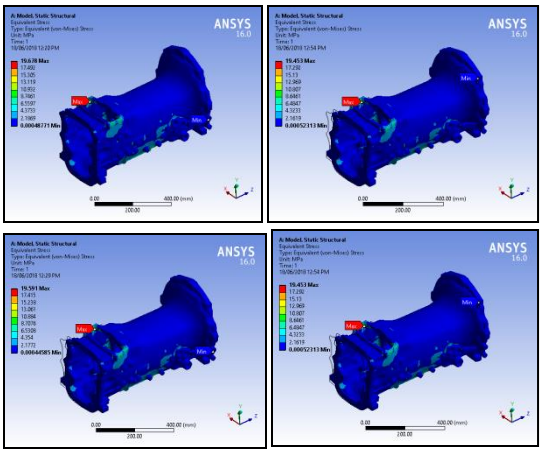


Fig. 6: Equivalent (Von-Mises) stress distribution

2) Deformation

The maximum deformation for applied load is 0.083mm is for AL alloy at the upper portion of back side.

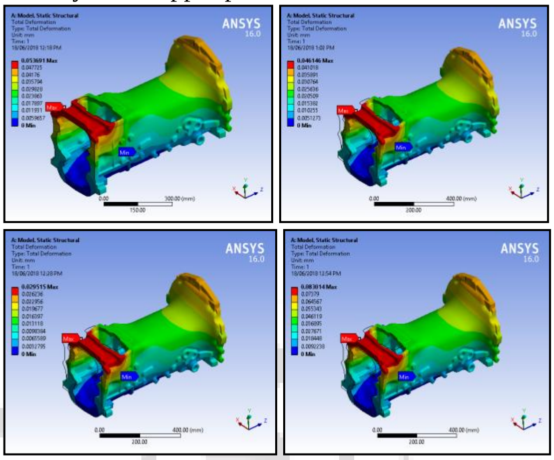


Fig. 7: Total deformation of different material

B. Modal Analysis

Modal analysis will help you reduce the noise level emitted by your product. Modal analysis assists in pointing out the reasons of vibrations because cracking issues of components. Modal analysis can improve the overall product performance in specific operating conditions.

1) Gray Cast Iron FG220

The FEA simulation shows that the natural frequencies of grey cast iron FG220 varies (229.34-567.99) Hz, grey cast iron FG260 varies (247.41-613.45) Hz, structural steel (296.2-732.45) Hz and Al alloys (297.29-733.01) Hz. The higher order frequency variation shows the excellent structural rigidity by eliminating lower order frequency (Table 2). The critical frequency range for transmission housing varies (0-35) Hz. So in order to eliminate the resonance the frequencies should not fall in this range. The present simulation results show higher order frequency (229.34-733.01) Hz, much higher than critical frequency. For tractors Lower order frequency causes resonance of gearbox housing. Resonance occurs due to matching of harmonic excitation frequency with natural frequency of transmission housing causing excessive vibration and leads to failure of vehicle transmission system. Higher order frequencies of a material housing ensure prevention from resonance. Free vibration analysis results conclude, all materials are suitable for transmission housing manufacturing. Figure 8 to figure 11 shows the six selected mode shapes and corresponding natural frequencies of different materials.

2) Gray Cast Iron FG220

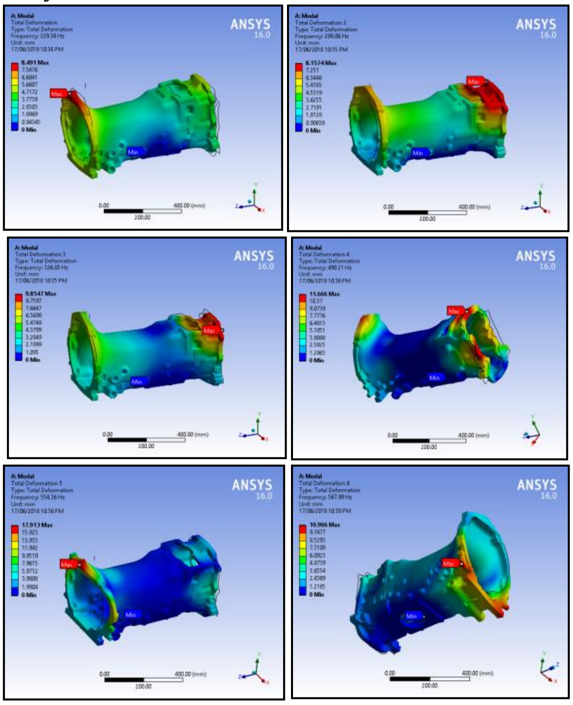


Fig. 8: Mode shapes for FG220

3) Gay C I FG260

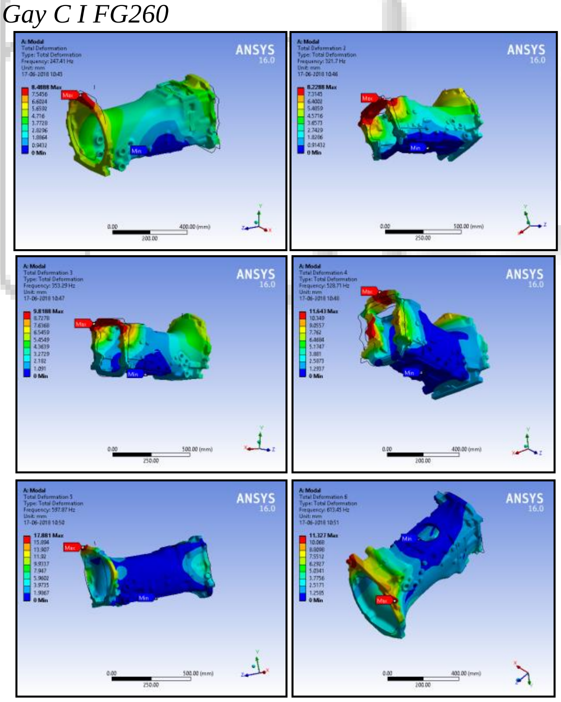
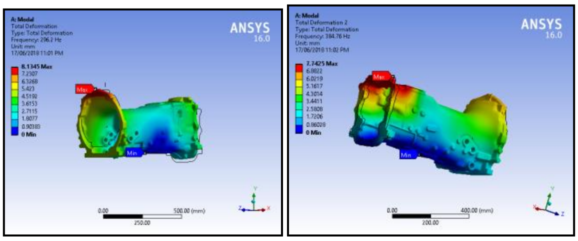


Fig. 9: Mode shapes of FG260

4) Structral Steel



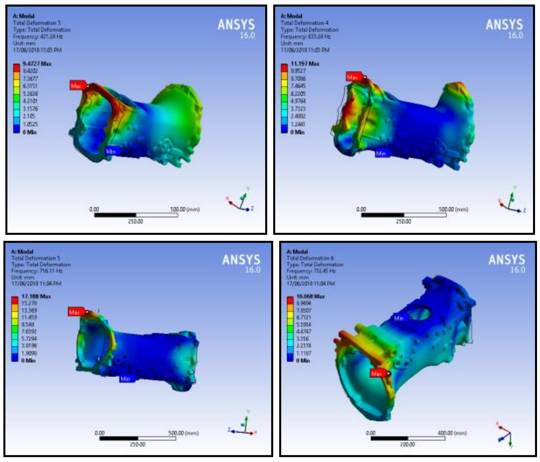


Fig. 10: Mode shapes of structural steel

5) Auminium Alloy

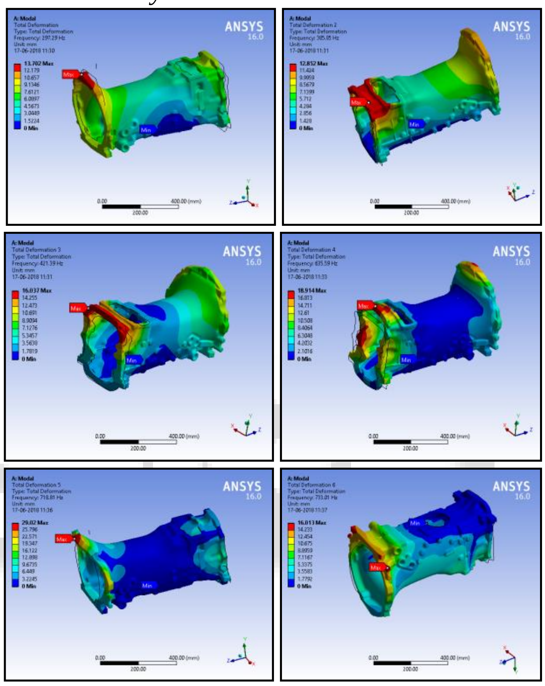


Fig. 11: Mode shapes of aluminum alloy

Grey Cast Iron FG220 (Hz)	Grey Cast Iron FG260 (Hz)	Structural Steel (Hz)	AL Alloys (Hz)
229.34	247.41	296.2	297.29
298.06	321.7	384.76	385.85
326.83	353.29	421.24	421.39
490.21	528.71	633.24	635.59
554.36	597.87	716.11	718.81
567.99	613.45	732.45	733.01

Table 2: Natural frequency variation for tractor transmission housing

	Grey Cast Iron HT200	Grey Cast Iron FG260	Structural Steel	AL Alloys
Total mass	84.524	84.524	92.155	32.518

Table 3: Weight calculation of tractor transmission housing using different materials.

V. CONCLUSION

After reviewing this paper it is clearly understood that the force analysis and forces generated in gearbox housing plays a important role while designing transmission housing. So it's very important to understand design of gearbox housing. In this work transmission housing is analyzed.

From stress analysis of gray cast iron FG220, gray cast iron FG260, structural steel, aluminum alloy it can be concluded that stress distribution in all materials is almost same and their values are 19.68MPa, 19.5MPa, 19.76MPa and 19.59MPa but there is a slight change in their deformation of the transmission housing structure.

By using the properties of gray cast iron FG220 and gray cast iron FG260 the natural frequencies of housing in ANSYS are found to be 229.34 Hz and 247.41 Hz under free-free condition and it is compared with gear mesh frequency which is 35 Hz. Thus the gearbox housing is safe from resonance point of view.

Similarly by using the properties of structural steel and Aluminum Alloy, the natural frequencies of housing in ANSYS are found to be 296.2 and 297.29 Hz, under free-free condition and it is compared with gear mesh frequency which is 35 Hz.

By comparing the properties of all 4 materials, it is concluded that Aluminum is having lighter weight than gray cast iron. So it is recommended to use Aluminum alloy in the manufacturing transmission housing.

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