SK. Abdulla et al., International Journal of Research in Engineering, IT and Social Sciences, ISSN 2250-0588, Impact Factor: 6.565, Volume 14 Issue 06, June 2024, Page 387-390

DESIGN AND ANALYSIS OF DIFFERENTIAL GEARBOX USING VARIOUS MATERIALS

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Abstract:

The differential gear box is a crucial component in automotives, its primary function is to allow the wheels to rotate at different speeds while maintaining power transmission from the engine to the wheels. This study aims into the material selection for optimizing the differential gearbox in automotive applications. Presently used materials for gears and gear shafts is cast iron and cast steel. Using advanced design software such as SolidWorks and conducting comprehensive analysis using ANSYS, we evaluate the performance of different materials through parametric modelling and finite element analysis (FEA). Specially, we conduct total deformation and von Mises stress tests in ANSYS to analyze material response, the study aims to identify the material that provide best balance of properties for the differential gearbox's requirements.

I. INTRODUCTION:

A differential gearbox is a critical component in automotive drive trains. Its primary function is to allow the wheels to rotate at different speeds while maintaining power transmission from the engine to the wheels, essential for smooth and stable vehicle operation, especially during turns or when navigating uneven terrain. The differential accomplishes this by utilizing a combination of gears, including the ring gear and pinion gear, which transfer power from the driveshaft to the differential assembly, and the spider gears, which allow the wheels to rotate at different speeds relative to each other. The side gears, connected to the axle shafts, rotate with the wheels, all housed within the differential case that provides structural support.

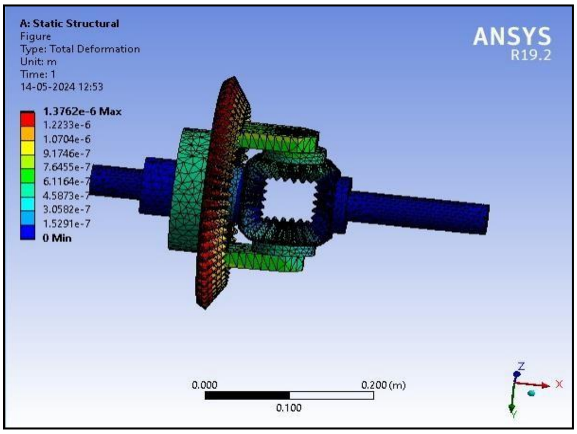
II. METHODOLOGY:

- Modelling of differential gearbox using design software SolidWorks.
- Import the model into analysis software Ansys, the format for importing the file is 'STEP'.
- Gather the material properties of the materials like density, yield strength, young's modulus and poisons ratio.
- Selection of required materials for the study.
- Analyse the differential gearbox step by step using different materials at different load conditions.
- Collect the results like total deformation and equivalent stress values obtained in analysis.
- Finalise the best sustain material for the differential gearbox based on the results obtained.

III. RESULTS AND DISCUSSIONS:

3.1. Static Structural Analysis:

3.1.1. Total Deformation:



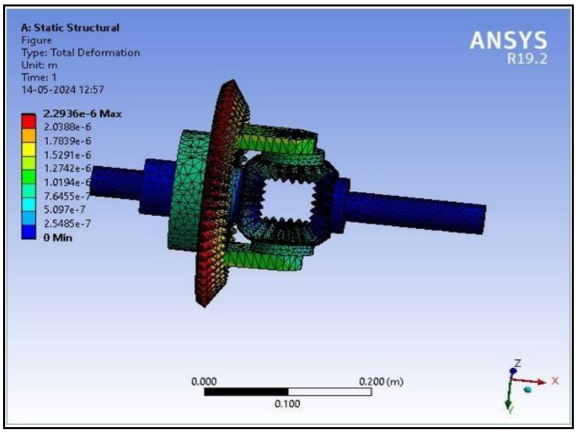
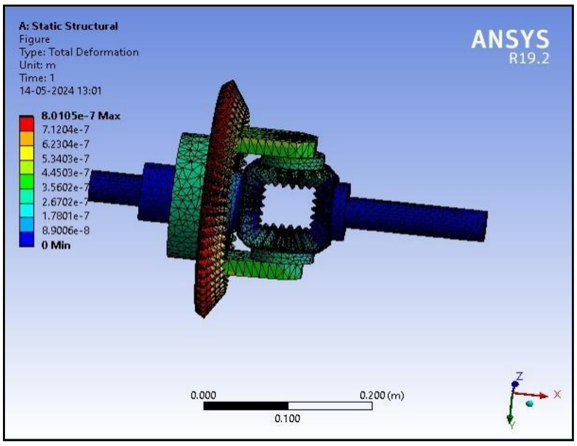


Fig-1.1 Total deformation of the cast iron at moment of 150 N-m

Fig-1.2 Total deformation of cast iron at moment of 250 N-m



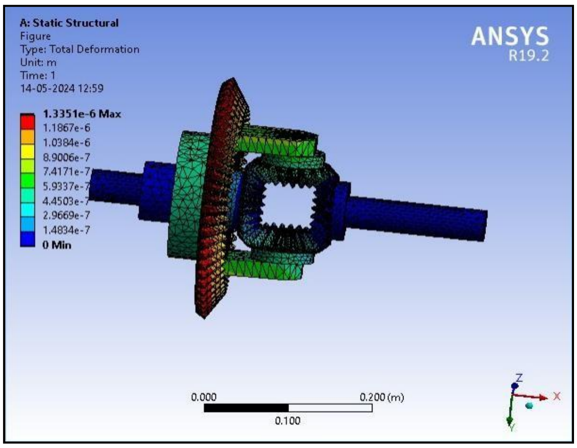
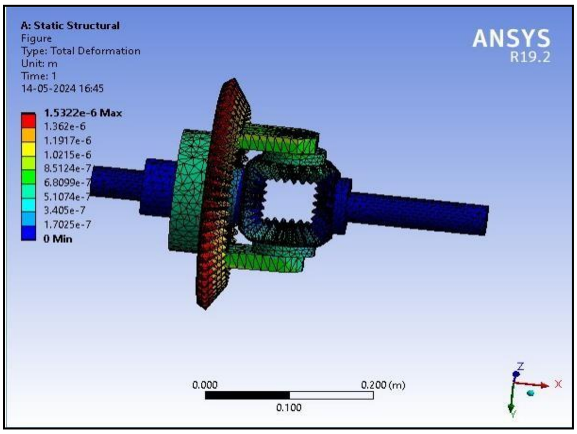


Fig-1.3 Total deformation of Medium Carbon Steel at moment of 150 N-m

Fig-1.4 Total deformation of Medium Carbon Steel at moment of 250 N-m



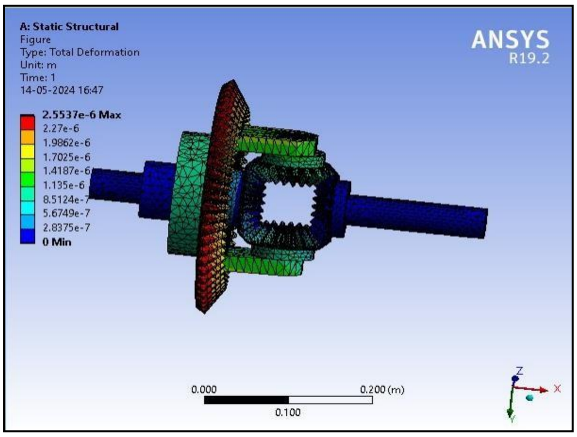


Fig-1.5 Total deformation of Ti-15Mo-5Zr-3Al at moment of 150N-m

Fig-1.6 Total deformation of Ti-15Mo-5Zr-3Al at moment of 250N-m

Total deformation values for various materials at different moments are tabulated below.

Table 1.1: Total Deformation

Sl. no	MATERIAL	MOMENT	TOTAL DEFORMATION
1	Cast iron	150 N-m	1.3762e-006
		250N-m	2.2936e-006
2	Medium Carbon Steel	150 N-m	8.0105e-007
		250N-m	1.3351e-006
3	Ti-15Mo-5Zr-3Al	150 N-m	1.5322e-006
		250N-m	2.5537e-006

3.1.2. Equivalent stress:

Fig-1.7 Equivalent stress of the cast iron at moment of 150 N-m

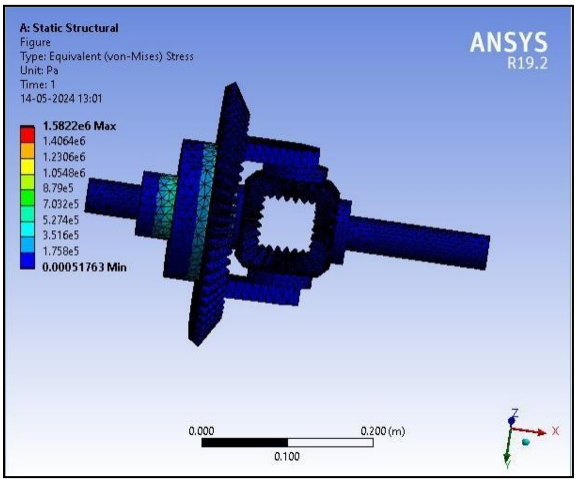


Fig-1.8 Equivalent stress of cast iron at moment of 250 N-m

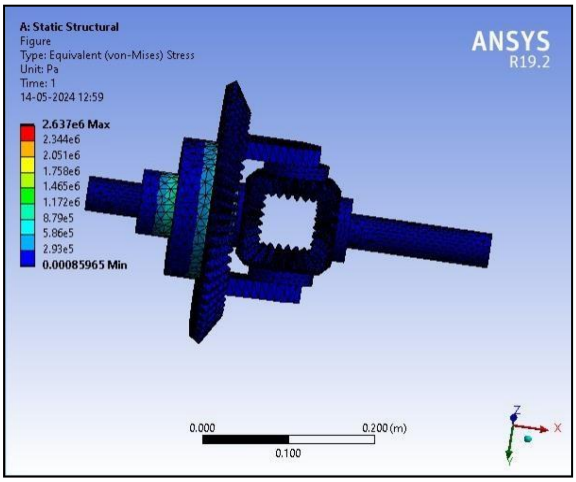


Fig-1.9 Equivalent stress of Medium Carbon Steel at moment of 150 N-m

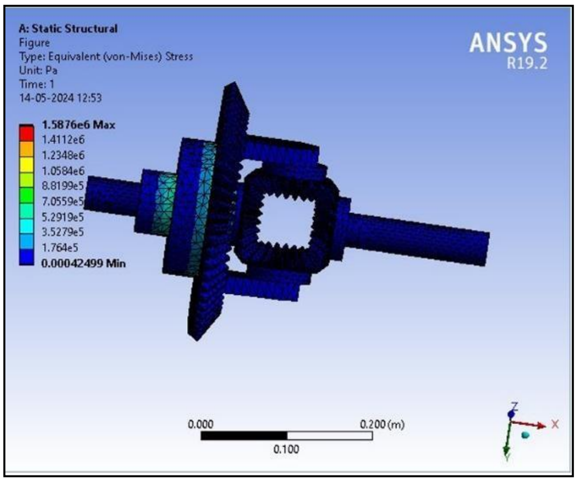


Fig-1.10 Equivalent stress of Medium Carbon Steel at moment of 250 N-m

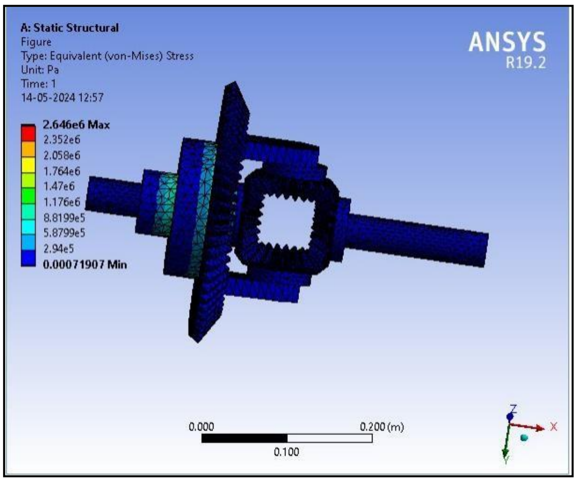


Fig-1.11 Equivalent stress of Ti-15Mo-5Zr-3Al at moment of 150N-m

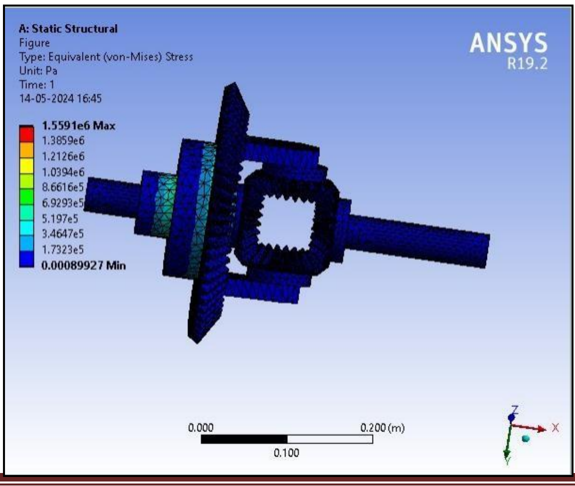
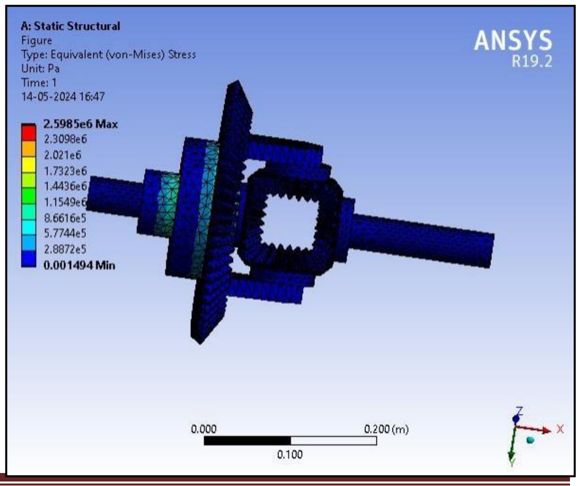


Fig-1.12 Equivalent stress of Ti-15Mo-5Zr-3Al at moment of 250N-



Equivalent stress values for various materials at different moments are tabulated below:

Table-1.2 Equivalent Stress

Sl.no	MATERIAL	MOMENT	EQUIVALENT STRESS
1	Cast iron	150 N-m	1.5876e+006
		250N-m	2.646e+006
2	Medium Carbon Steel	150 N-m	1.5822e+006
		250N-m	2.637e+006
3	Ti-15Mo-5Zr-3Al	150 N-m	1.5591e+006
		250N-m	2.5985e+006

IV. Conclusion:

The static structural analysis of different materials for the differential gearbox revealed that medium carbon steel exhibited the least deformation and moderate stress levels, making it structurally robust under typical load conditions. Titanium alloy demonstrated intermediate deformation, the lowest equivalent stress, and the highest tensile yield strength, indicating superior mechanical performance but with higher cost and manufacturing complexities. Cast iron showed the most deformation, highest stress concentrations, and the lowest tensile yield strength, suggesting susceptibility to failure and reduced durability over time. Despite titanium alloy's mechanical advantages, its higher cost limits its practical use, whereas medium carbon steel provides an optimal balance of strength, durability, and cost-effectiveness, making it the recommended choice for differential gearbox applications.

References:

1. Shashank Pandey, Nikhilesh N. Singh2 & Dr. Prabhat Kumar Sinha, “Modeling, design & analysis of differential gear box through fem, SolidWorks & Ansys workbench 14.0”, International Journal of Engineering Sciences & Research Technology (IJESRT) 2017, ISSN:2277-9655.
2. Patoju Sai Sankar, Pudi Teja Kumar, Gude Raghu, Kallapalli Ranjith Kumar, Sunkara g s Meher teja. “Design and analysis of differential gear box”, International Journal of Engineering Sciences & Research Technology (IJESRT), 2018.
3. R. Karthick, V. Mohankumar, S. Mohanprabhu & V. Manoj, “Design and analysis of differential gear box”, International Journal of Engineering Sciences & Research Technology (IJESRT) 2018.
4. N. Siva teja, “Design and analysis of differential gear box”, International journal of Mechanical Engineering and technology (IJMET), 2017.