



ISSN : 2321-9416

Indo - American Journal of Mechanical Engineering



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Design and optimization of four-wheeler gear box panel using different materials

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ABSTRACT

Structural modelling commonly depends on a range of geometric factors. Given that every component has a distinct lifespan, it is crucial to compute its fundamental parameters. In order to ascertain the longevity of a component, it is necessary to utilise it as an input parameter for Finite Element Analysis (FEA). Finite Element Analysis (FEA) is a computational technique used to solve complex engineering and mathematics issues. This project involved doing a real-time analysis of a gear box casing using ANSYS software. The casing was made of structural steel and aluminium alloy. Stress and deformation evaluations were conducted by applying different boundary conditions. The findings from these investigations aided in the reconfiguration of the gear casing. The redesign process was executed utilising ANSYS, integrating diverse criteria derived from real-world applications. Analysed under various boundary conditions, the new model was evaluated for both structural steel and aluminium alloy materials. An assessment was conducted to analyse the stress, deformation, structural supports, and overall structural outcomes of the modified gear box shell, in order to ensure compliance with safety regulations. Furthermore, a thorough examination of the materials revealed the superior choice for the gear box casing.

Keywords: gear box casing (Problems, Objectives and Analysis), Structural Analysis

1. Introduction

The gearbox casing is an essential element in the gearbox system of automobiles and industries. The main purpose of the housing is to safeguard the gears and other parts that enable the transfer of power from the engine to the wheels or machines being driven. The choice of design and materials for gearbox casings has a substantial influence on the

performance, longevity, and effectiveness of the gearbox system. Gearbox casings are produced using techniques such as casting, forging, and machining. The selected technique impacts the precision of the casing's dimensions, the quality of its surface, and the cost of manufacture. The design must ensure that the casing can withstand the mechanical strains and vibrations experienced during operation. This requires a thorough use of finite element analysis (FEA) to anticipate and address possible areas of weakness.

This refers to the process of creating an airtight seal and applying lubricant to reduce friction and improve the performance of a mechanism or system. Efficient sealing solutions are important to avert oil leaks and the introduction of contaminants. In addition, the casing design should be optimised to ensure effective lubrication of gears and bearings, hence reducing friction and minimising wear. With the help of Siddharth Kumar Singh, B. Sreenivasa Theja [1], Different geometric functions are often the basis for structural modelling design. Because of the restricted lifespan of any part, it is essential to determine its fundamental characteristics. A component's expected lifespan may be determined using Finite Element Analysis, which requires the component itself as an input parameter. **Amit Yadav**, Lalit Bhardaj, and Deepak Chhabra [2] as authors Static study of the rear dead axle using a CAE tool is the focus of this paper. An study was conducted using finite elements to determine the loading conditions and design considerations for the rear dead axle. A rear axle's component components and assembly were created using Creo elements programme. In their work, Ahire and Munde [3] provide a car's front axle does double duty as it supports the vehicle's front end, allows for easier steering, and cushions impacts from uneven road surfaces. Dong Fang, Hu, and Wen Hui Liu [4] In this article, we see the results of a static strength study conducted on the front axle housing of a tractor using the finite element analysis programme ANSYS. We also see the distribution of stresses and strains, as well as the vertical displacements, graphically shown in the housing. In addition, it displays the model processing analysis findings, accuracy and reliability metrics, and structural weaknesses. Patil et al. [5] With weight reduction and vehicle adaptability as primary goals, this research aims to identify the optimal alternative to traditional steel front drive axles. To round up the research, we want to recommend a good composite material and production method for the suggested axle. H. Günal, M.M. Topac, and N.S. Kuralay [6] An investigation of a prototype rear axle housing's early failure during vertical fatigue testing is conducted. This failure happens before the anticipated load cycles. In all of these

tests, the cracks on the samples started in the same spot. G. R. Baggerly's [7] The quality of a weld may be greatly affected by even small variations in the chemical composition of the steel. When designing a process for welding in a factory, it is common practice to start with the material specification's specified steel composition. This is done to ensure that the weld characteristics are continuously satisfactory, without creating a high hardness heat-affected zone (HAZ) in the base metal close to it. Wang Xi, Song Xun [8] Through the use of single tooth bending, the effects of low-amplitude loads below the fatigue limit on the gearbox cylindrical gear are studied under both programme loading and continual low-amplitude loading.

2. Materials and Methods

Structural steel is highly regarded in the field of building and construction materials due to its exceptional adaptability and strength. The fact that it is widely used worldwide is evidence of its exceptional characteristics and versatility. In this chapter, we will thoroughly examine structural steel, analysing its characteristics, categorizations, compositions, and many uses. The construction industry mostly utilises structural steel due to its durability and excellent strength-to-weight ratio. Structural steel is chosen for a variety of reasons, including its flexibility, greater strength, cost-effectiveness, capacity to be constructed quickly, simplicity of repair or modification, outstanding quality, and steadfast dependability.

Carbon is the main component of commercial steel alloys, and its amount determines both the mechanical qualities of the material and its applicability for different uses. Higher carbon content improves hardenability, hardness, and strength, but it also leads to brittleness and reduces weldability because of the production of martensite. Therefore, the amount of carbon present in structural steel plays a crucial role, offering both benefits and difficulties. Aluminium alloys consist primarily of aluminium and contain a wide range of alloying elements, including copper, magnesium, manganese, silicon, tin, and zinc. These alloys are widely used in numerous industries due to their outstanding features, such as a high strength-to-weight ratio, resistance to corrosion, and superior thermal and electrical conductivity. They play a crucial role in driving technical developments and industrial success.

2.1 Numerical Method and its Applications

Numerical Analysis is a crucial field of mathematics that employs numerical methods to effectively solve complex mathematical problems. Frequently, issues stemming from research and engineering display significant intricacy, hindering straightforward analytical resolutions. Therefore, numerical methods are essential in simplifying and overcoming these issues. Thanks to substantial advancements in computational technology, numeracy has become increasingly popular and is now widely recognised as a valuable tool for both scientists and engineers. As a result, numerous software programmes, including Matlab, Mathematica, and Maple, have been created, enabling users to efficiently and directly address complex problems. These software suites are equipped with features that utilise commonly used numerical procedures, enabling users to easily handle difficult problems and acquire solutions with a single command, without needing to delve into the details of numerical subtleties. The scope and significance of numerical analysis refer to the extent and importance of the field that deals with the development and use of algorithms for solving mathematical problems using numerical methods.

Numerical Analysis is mostly used in mathematics and computer science to develop, analyse, and use methods designed to solve numerical problems commonly found in continuous mathematics. These issues usually arise from practical uses of algebra, geometry, and calculus, generally including variables that show continuous change. They appear in various fields, including natural sciences, social sciences, engineering, medicine, and business. In the last 50 years, the increasing number of digital computers, along with improvements in computational capacity, has led to the widespread use of realistic mathematical models in scientific and technical fields. This path highlights the increasing significance and applicability of numerical methods in tackling intricate problems in several fields.

Statistical methods, however, focus on analysing data to reveal patterns, correlations, and trends. These methods are crucial in domains such as economics, psychology, and epidemiology, where making decisions based on data is of utmost importance. Statistical tools encompass a wide range of techniques, including descriptive statistics (such as mean and variance) and inferential statistics (such as hypothesis testing and regression analysis). The Finite Element Method (FEM) is a numerical technique used to solve engineering problems by dividing a complex system into smaller, simpler elements and analysing them individually. The Finite Element Method (FEM) is a robust

numerical approach used to solve partial differential equations (PDEs) and functional minimization problems. It is extensively used in engineering, namely in the fields of structural analysis, heat transport, and fluid dynamics. Here is a more comprehensive exploration of Finite Element Method (FEM).

3. Results and Discussions

SpaceClaim's 3D direct modelling technology is widely recognised for its user-friendly nature and is primarily demonstrated through its easy user interface, which features four core tools: Pull, Move, Fill, and Combine. Each of these tools is specifically engineered to simplify the process of creating models and offer substantial adaptability in designing and modifying them. The Combine tool executes Boolean and dividing actions, such as merging components and removing one component from another. These actions are essential in complex modelling activities that involve the integration or modification of numerous components in relation to each other. The fundamental modelling capabilities are based on the ACIS modelling kernel, which has been licenced to SpaceClaim by Dassault Systems. The ACIS kernel serves as a strong base for SpaceClaim's direct modelling capabilities, guaranteeing accuracy, dependability, and adaptability in the construction and alteration of 3D models. SpaceClaim allows engineers and designers to quickly create and improve intricate models by incorporating user-friendly tools into a unified interface. This optimises the design process, boosts efficiency, and offers a robust solution for various engineering and design obstacles as shown in Figures [1-3].

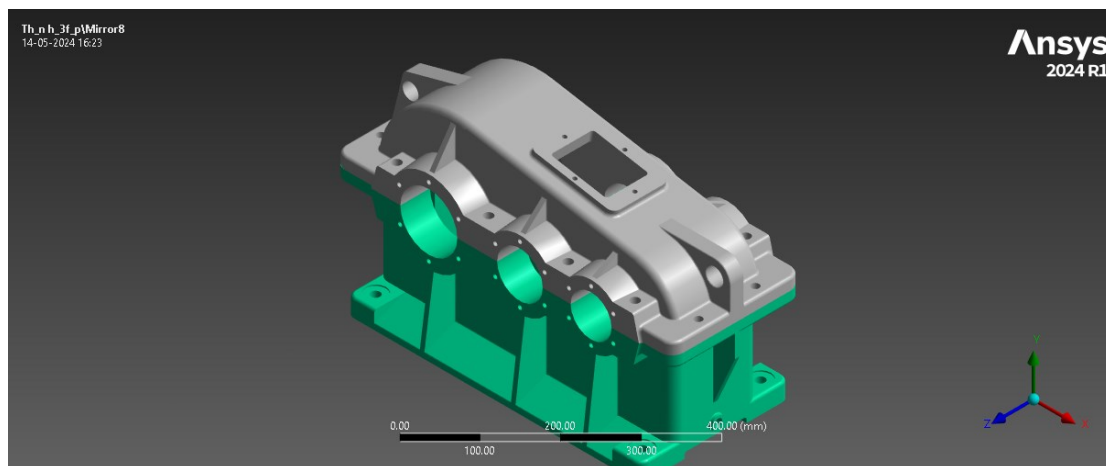


Figure 1. Geometry of the gear box casing

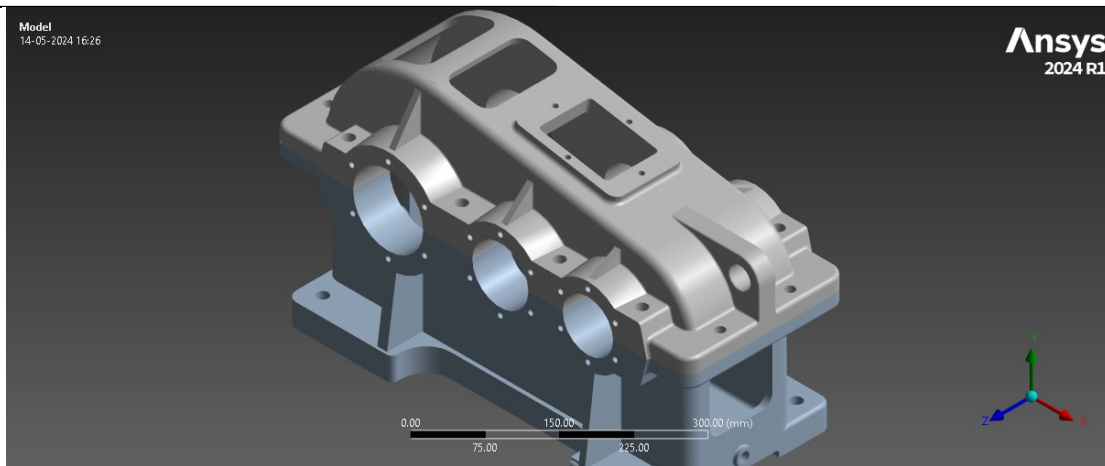


Figure 2. Geometry of the Modified model gear box casing

Although the process of faceting CAD models for drafting purposes involves the ability to add vertices, its objective is distinct. Facetting seeks to achieve an accurate representation of the shape by minimising the number of triangles used, without giving importance to the shape of individual triangles. In contrast, the objective of mesh generation for simulations is to construct cells that enable precise and efficient calculations. Mesh generating software commonly integrates with CAD systems to define input geometry and with simulation applications to utilise the result. The input to these systems can vary greatly, typically encompassing formats such as solid modelling, geometric modelling, non-uniform rational basis splines (NURBS), boundary representation (B-rep), stereolithography (STL), or point clouds.

Engineers and scientists can make accurate predictions and assessments of physical systems by developing meshes that effectively reflect the complexities of the input domain. These meshes allow for thorough simulations and visualisations. This method is crucial for the progress of various industries, such as structural engineering and computer graphics. It helps convert intricate real-world geometries into manageable computational models as shown in figures [3-4].

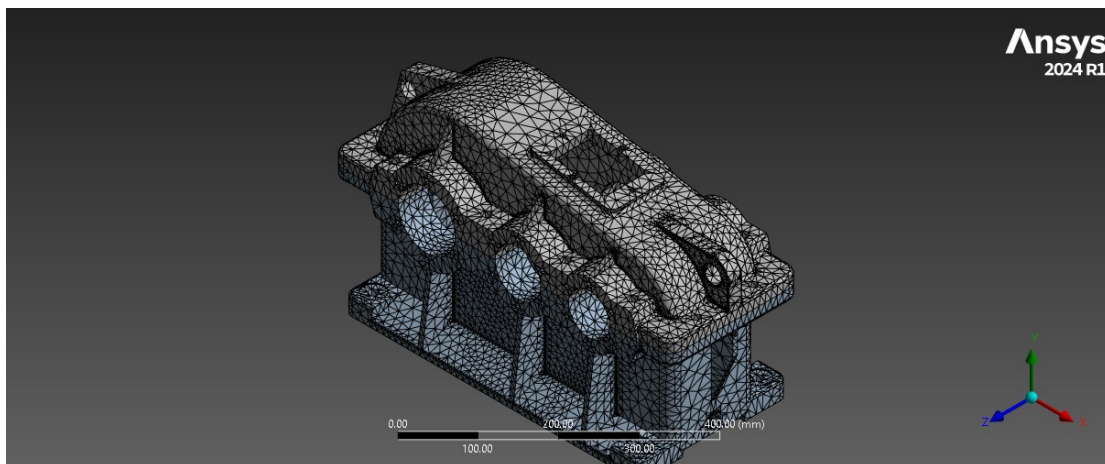


Figure 3. Meshing of gear box Casing

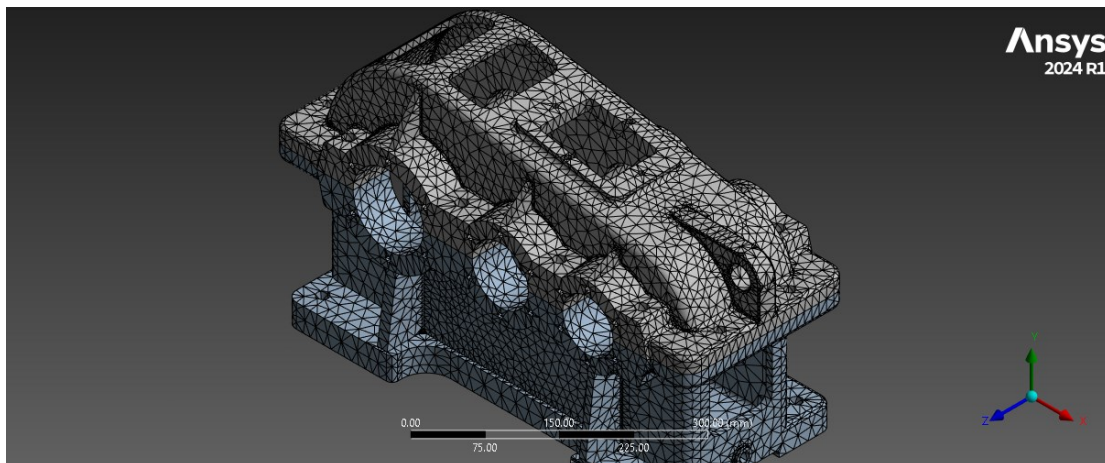


Figure 4. Meshing of Modified model gear box casing

Boundary Conditions in Finite Element Analysis

Executing a FEA simulation is rather simple, but, achieving precise and logical outcomes from the simulation might be difficult. An inappropriate application of boundary conditions is a frequent cause of erroneous FEA results. FEA often deals with physical processes that can be described by ordinary differential equations (ODEs) or partial differential equations (PDEs) as shown in figures [5-7].. The majority of these issues are categorised as boundary value difficulties. A boundary value problem entails the solution of a system of differential equations inside a defined region when the circumstances at the boundaries are already known. Boundary conditions are necessary limitations for determining solutions to boundary value problems.

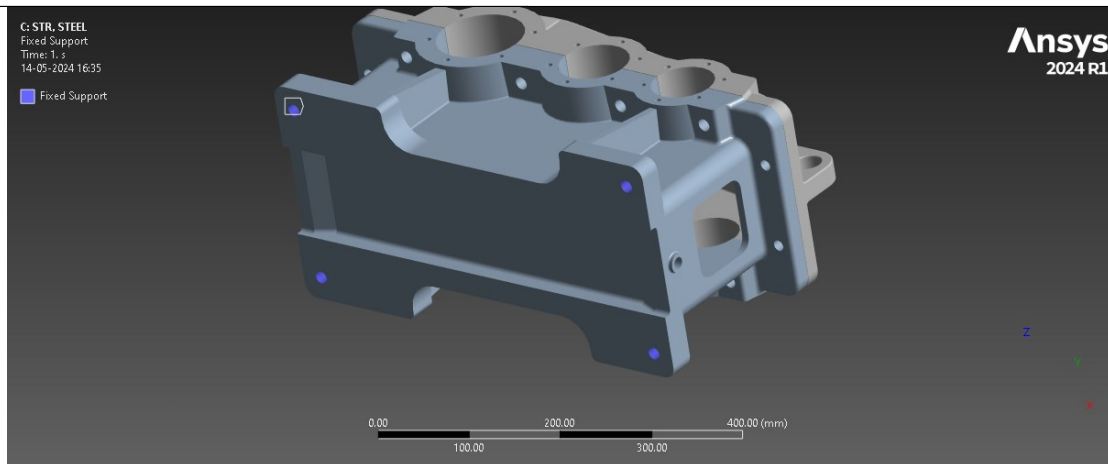


Figure 5. Fixed support

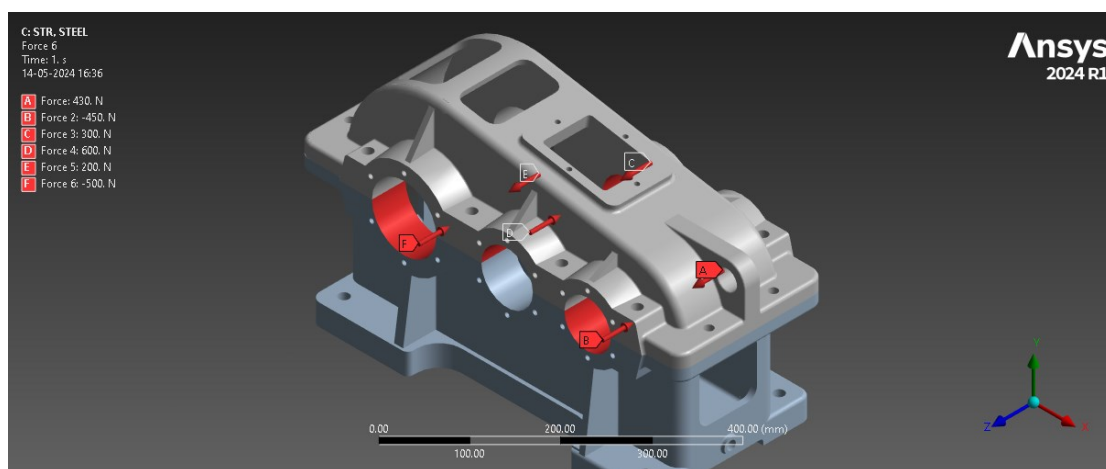


Figure 6. Force

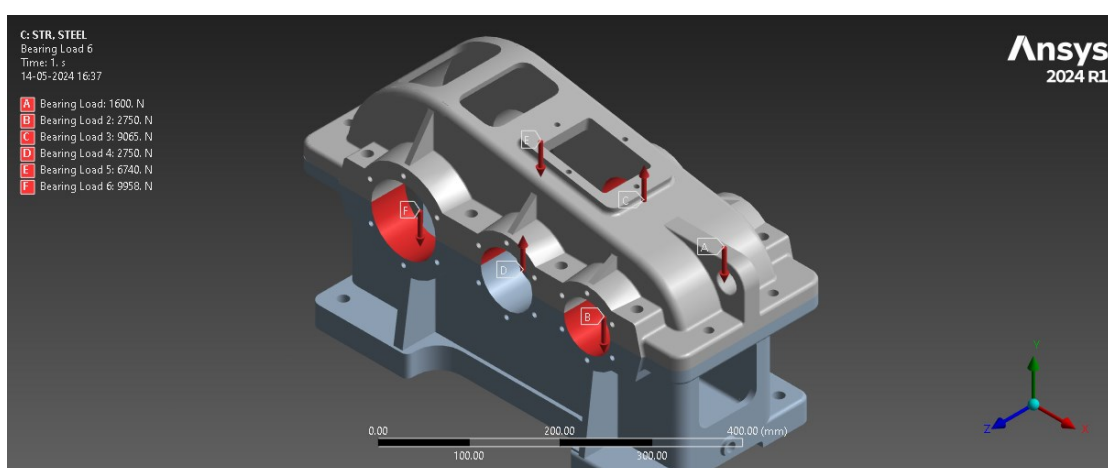


Figure 7. bearing load

Upon conducting a structural analysis on the gearbox casing in its original state, using structural steel as the designated material, the subsequent findings were obtained. Figures 8 and 9 depict the overall deformation and the comparable stresses, respectively.

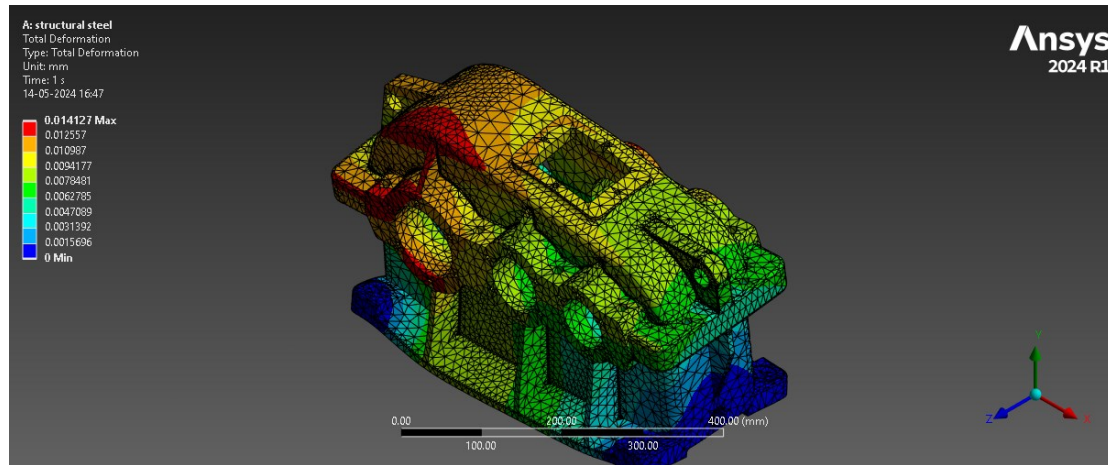


Figure 8. Total deformation of Modified model

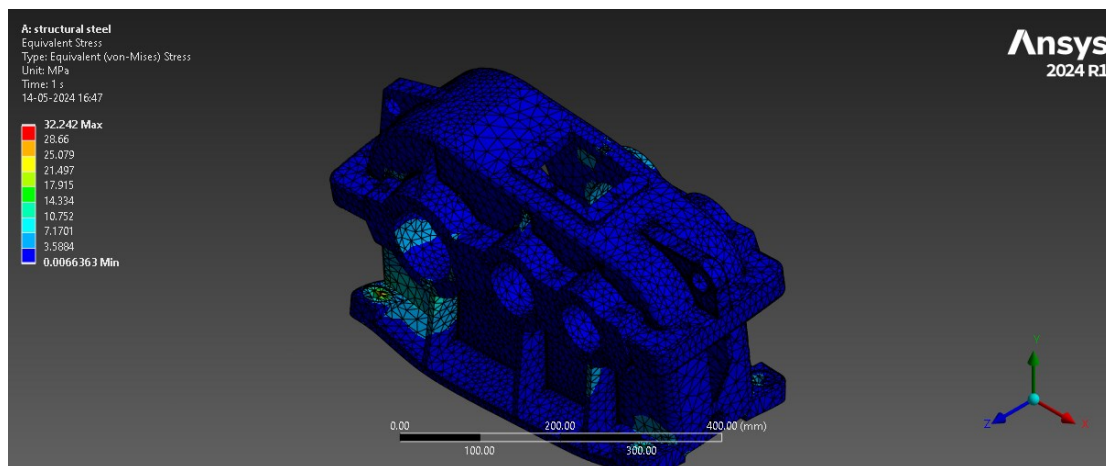


Figure 9. Equivalent Stress of Modified model

Static structural analysis is performed on modified model -1. The modified model -1 uses GCI (ASTMA48) material. By classifying the material as GCI (ASTM A48), a structural study was conducted on the redesigned gear box casing. Figures [10-13] display the measurements of total deformation and equivalent stresses, respectively along with the tables[1].

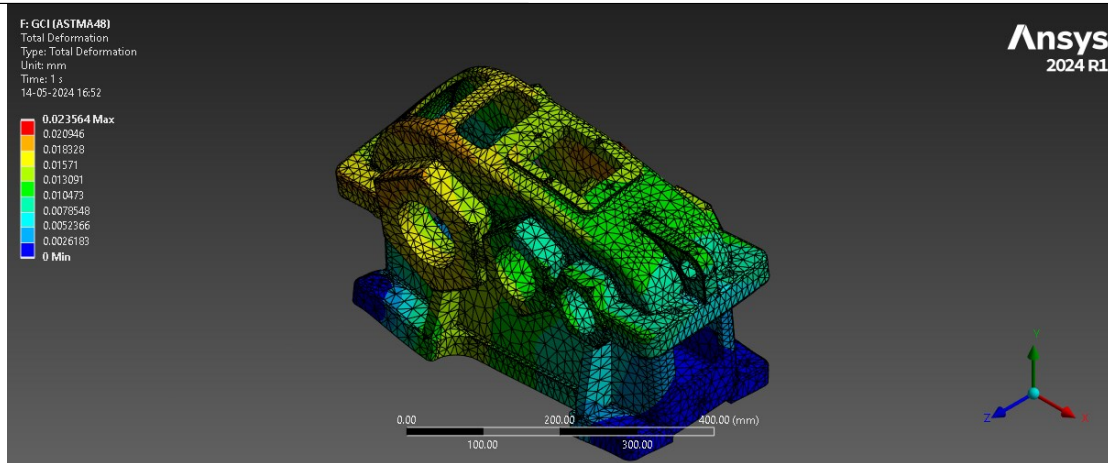


Figure 10. Total deformation of Modified model

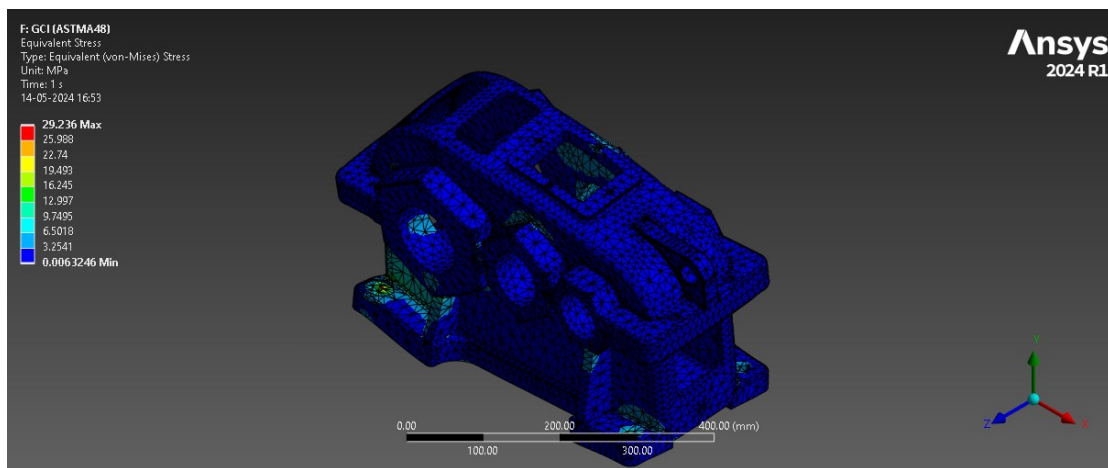


Figure 11. Equivalent Stress of Modified model

Table 1. Deformations and equivalent stress for different materials

	Material			
Original model	Structural steel		Aluminium alloy	
Deformation [mm]	0.014		0.039	
Equivalent stress[MPa]	32.242		31.541	
	Material			
Modified model	Structural steel	Aluminium alloy	CFRP	GCI[ASTMA48]
Deformations [mm]	0.011	0.040	0.117	0.023
Equivalent stress [MPa]	31.845	28.469	28.469	29.236

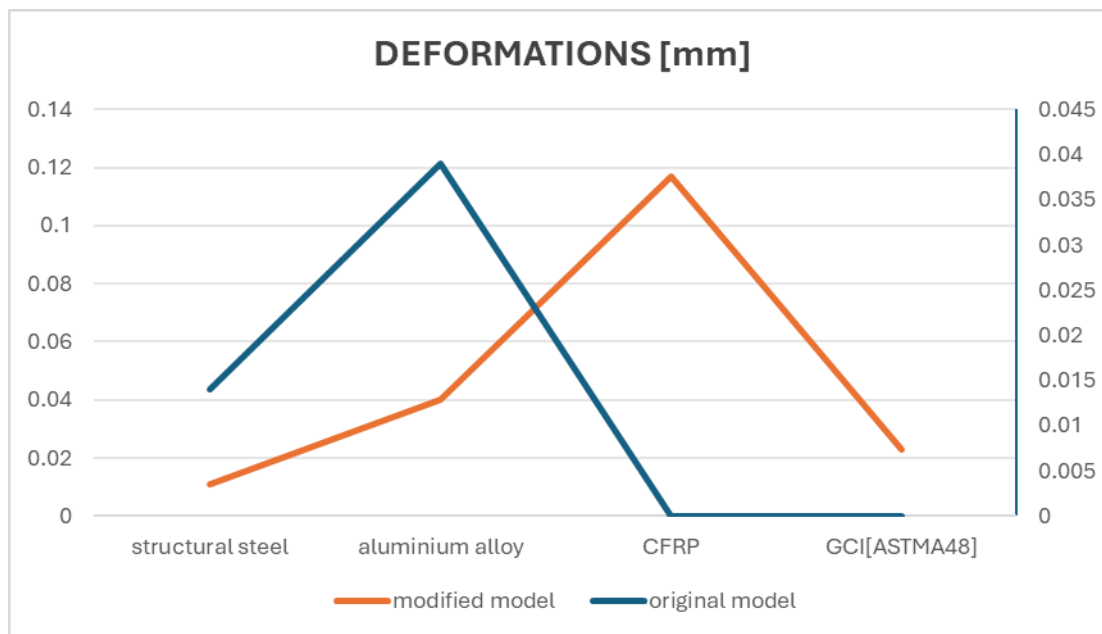


Figure 12. graphs between the original and modified model

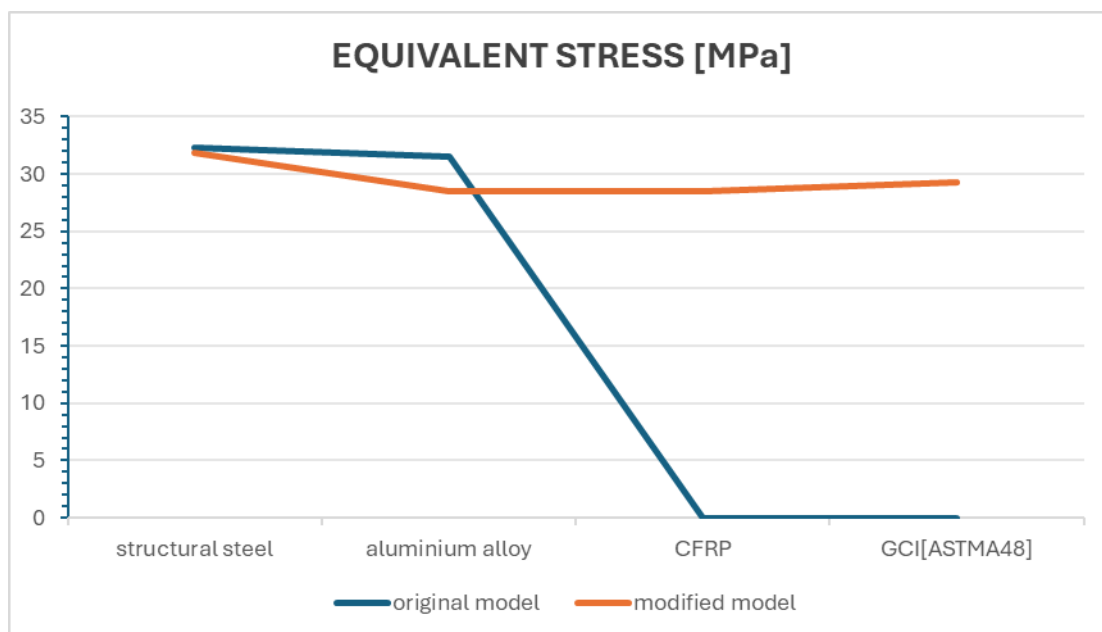


Figure 13. graphs of equivalent stress between the original and modified model

4. Conclusions

The ANSYS software was effectively utilised to successfully achieve the redesign of the full-floating rear axle casing component. The component underwent a detailed structural study, which determined that the stress, total deformation, and frequency values were all within the allowable Factor of Safety for the material. The results were compared to those

of the current model, validating the safety and resilience of the modified model.

The investigation clearly demonstrates that the revised model surpasses the previous one in terms of performance and safety. The selection of structural steel for the gearbox casing of the tractor has demonstrated clear benefits compared to using an aluminium alloy. Structural steel not only improved stress management and deformation properties, but also maintained the overall integrity of the gearbox casing when subjected to different loading situations. Furthermore, the redesign effectively resolved and corrected past issues with the casing, guaranteeing improved dependability and efficiency. The manufacturing accessories were efficiently recovered and integrated into the revised model, ensuring a smooth transfer from design to production. This research offers the designer significant insights into how the product behaves in various environmental settings, enabling informed decision-making for future designs. The thorough assessment highlights the modified model's ability to endure operational pressures, thus confirming its appropriateness and dependability for real-world use.

REFERENCES

1. Theja, B. Sreenivasa, and Siddharth Kumar Singh. "Structural Analysis of gear box casing of Tractor." *Applied Mechanics and Materials*. Vol. 592. Trans Tech Publications Ltd, 2014.
2. Bhardaj, Lalit, Amit Yadav, and Deepak Chhabra. "Design & Static Analysis of rear axle."
3. Ahire, Pravin R., and K. H. Munde. "Design and analysis of front axle for heavy commercial vehicle." *International Journal of Engineering and Computer Science* 5.7 (2016): 17333-17337.
4. Hu, Dong Fang, and Wen Hui Liu. "Finite Element Analysis of the Tractor Front Axle Housing Based on ANSYS." *Applied Mechanics and Materials*. Vol. 105. Trans Tech Publications Ltd, 2012.
5. Patil, P. J., et al. "Experimental and Finite Element Analysis of Reinforced Composite Front Drive Axle." *Indian Journal of Science and Technology* 15.42 (2022): 2230-2239.
6. M.M. Topac, H. Günal, N.S. Kuralay, Engineering Failure Analysis, In Press, Corrected Proof, Available online 25 September 2008, Fatigue failure prediction of a rear axle housing prototype by using finite element analysis.

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7. R. G. Baggerly, Engineering Failure Analysis, Volume 11, Issue 1, February 2005, Failure of steel castings welded to heavy truck axles.
 8. Lu Xi, ZhengSonglin, International Journal of Fatigue, Volume 31, Issue 2, February 2009, Strengthening and damaging of gear box casing under low-amplitude loads below the fatigue limit.