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Modeling, Analysis and 3D Printing of Gearbox

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Abstract - A gearbox is a mechanical device that transmits power and adjusts the speed and torque of an engine or motor. It consists of a series of gears that can change the output speed and direction of rotation. Gearboxes are essential in various applications, from automobiles to industrial machinery, ensuring efficient performance. They come in various types, including manual, automatic, and planetary gear systems, each designed for specific operational needs.

The main aim of this paper is to focus on the mechanical design on assembly of gears in gear box when they transmit power at different speeds. The metals selected for the gears is Aluminium Alloy by utilized materials for riggings and apparatus shafts is cast steel. In this paper to supplant the materials with Aluminium material for diminishing weight of the item. Stress, uprooting is investigated by considering weight diminishment in the rigging box at higher speed. Gear box assembly model is created by using Solid works software and a prototype of gear box is created by using 3D printing technology to check with design changes.

***Key Words*:** Gearbox, Gear assembly, Powe transmission, Aluminium alloy, cast steel, stress analysis, Displacement analysis, Weight reduction, 3D printing, Mechanical design, High-speed operation.

1. INTRODUCTION

SolidWorks and ANSYS are two essential software tools widely used in engineering design and analysis. SolidWorks is primarily used for 3D modeling, allowing engineers to create precise parts, assemblies, and technical drawings. It offers parametric design, motion simulation, and visualization features that aid in product development. On the other hand, ANSYS specializes in advanced engineering simulations, including structural, thermal, fluid, and electromagnetic analysis. It is used to predict how products will perform under real-world conditions, reducing the need for physical prototypes. While SolidWorks focuses on design and drafting, ANSYS emphasizes testing and validation through finite element analysis (FEA) and computational fluid dynamics (CFD). Both tools support innovation by improving design accuracy and reducing development time. SolidWorks models can also be imported into ANSYS for deeper simulation and stress testing. Together, these tools form a powerful combination in modern engineering workflows. Their integration helps ensure both functional design and structural reliability in various industries.

2. Problem Identification, Objectives, Scope, and Benefits

Problem Identification:

Traditional gearboxes often use heavy materials like cast steel, which increase the overall weight of mechanical systems such as automobiles and industrial machines. This added weight can lead to reduced efficiency, higher fuel consumption, and increased manufacturing costs. Additionally, the mechanical behavior of these components under high-speed conditions needs to be thoroughly analyzed to ensure performance and durability.

Purpose:

The purpose of this study is to explore the mechanical design and assembly of gearbox components with a focus on replacing conventional heavy materials with lighter

alternatives, specifically aluminum alloy. The study aims to analyze the stress and displacement behavior of the gearbox at various speeds using CAD modeling and simulation tools to evaluate the effectiveness of the material substitution.

Scope:

1. Design and modelling of a gearbox assembly using SolidWorks software.
2. Material substitution analysis by replacing traditional cast steel with aluminium alloy for gears.
3. Structural analysis focusing on stress and displacement under high-speed conditions.
4. Development of a 3D printed prototype to validate design changes.
5. Applicability to automotive and industrial gear systems.

Benefits:

1. Weight reduction of the gearbox, leading to improved efficiency and reduced energy consumption.
2. Lower manufacturing costs due to the use of lightweight materials.
3. Enhanced understanding of gear behaviour under stress through simulation.
4. Acceleration of product development through 3D prototyping.
5. Contribution to the development of more sustainable and high-performance mechanical systems.

3. EXPERIMENTAL PROCEDURE

Modeling procedure of Gear Box

1. To create a new file, click on file - new or click the new file icon in the main toolbar.
2. To design the body go to solid works software and open it. In solid work, select part module in new file then it will enter into part module.
3. Later select that plane the click on sketch tools and create circle
4. After that extrude tool and select circle as a profile and z line as a path.
5. To design the body, go to solid works software and open it. In solid work, select part module in new file then it will enter into part module.
6. Latr gog to tool import in library and select aisi standards and select in transmission
7. Then select helical gear and specify as require in terms of ratios
8. Drive Assembly
9. To design the body, go to solid works software and open it. In solid work, select part module in new file then it will enter into part module.
10. Import bodies one by ones as shown in figure
11. Driven Assembly
12. To design the body, go to solid works software and open it. In solid work, select part module in new file then it will enter into part module.
13. Import bodies one by ones as shown in figure
14. To design the body, go to solid works software and open it. In solid work, select part module in new file then it will enter into part module.
15. Import bodies one by ones as shown in figure
16. Later go to pattern and select circular pattern and select above circle as a pattern item.
17. Select above plane as a reference for pattern, specify 12 in number of patterns then ok

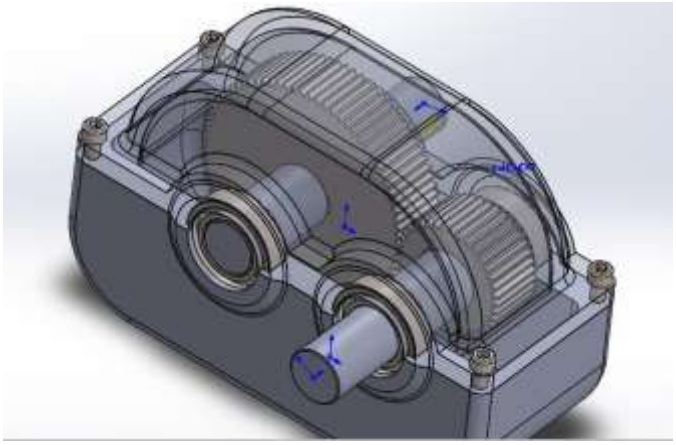


Fig -1: Assembly of Driver Transmission

Gear box Analysis

To conduct the finite elements analysis, you need to follow certain steps that are given next.

1. Set the type of analysis to used.
2. Create model
3. elements type
4. material properties
5. boundary conditions
6. Interpret the results

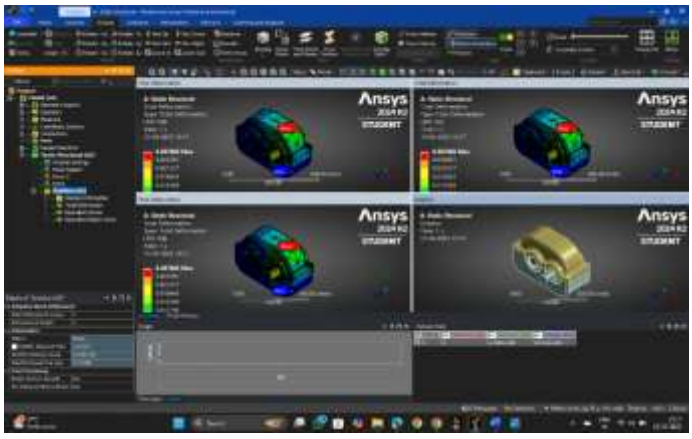
The first step is to start a new project in the workbench window.

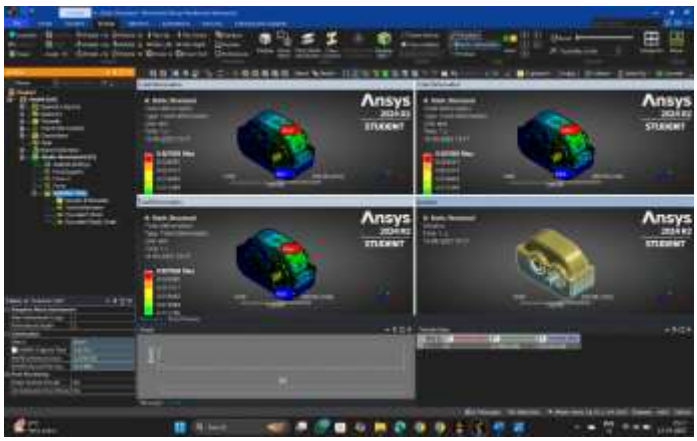
Start Ansys workbench.

1. Double-click on Static structural in the toolbox window; Double-click on the geometry cell; the design modeler window
2. After importing the geometry form the SolidWorks step file the design modeler window to display the workbench window.
3. After the model is created in the design modeler window, you need to generate the mesh to convert the unknown geometry to known geometry.
4. Double-click on the model cell in the static structural analysis system; the mechanical window is displayed. Choose the mesh and click generate mesh tool.
5. After the mesh is generated, you need to set the boundary and loading conditions under which the analysis will be performed.
6. Select the Static structural in tree outline; right click over it and select the fixed support tool from the supports; fixed support is attached to the tree outline.
7. Select the Static structural in the tree outline, choose the loads button to display Choose the force tool; in force is attached under the Transient structural in the tree outline. Also, the details of "force" window are displayed.
8. Force is known as the rate of change of force, you can apply force load by choosing the force tool from the loads.

After the boundary and loading conditions are specified for the analysis, you need to evaluate the results that are of importance in the case of a analysis. The various results that can be evaluated are: deformation, stress, strain. **Fig -2**: Analysis of gear box with gray cast iron

9.





10. **Fig -3**: Analysis of gear box with Aluminium

Table-1: Comparison of Materials

	Aluminium alloy	Gray cast iron
Total Deformation	0.027665 mm	0.017959
Equivalent Stress	87.927 mpa	93.618 mpa
Equivalent Strain	0.0012738	0.00087561

3D PRINTING OF GEAR BOX

1. Create Gear box a 3D model
2. Export the design as an STL (.stl) or OBJ (.obj) file – standard formats for 3D printing.
3. Use slicing software to:
4. Import the STL file.
5. Insert all gear components and place n heat bed
6. Use PLA as Material for strength and durability
7. Layer height as 0.18 mm
8. Perimeter shells as outside wall linings or thickness
9. Infill Density as 50%
10. Slicing

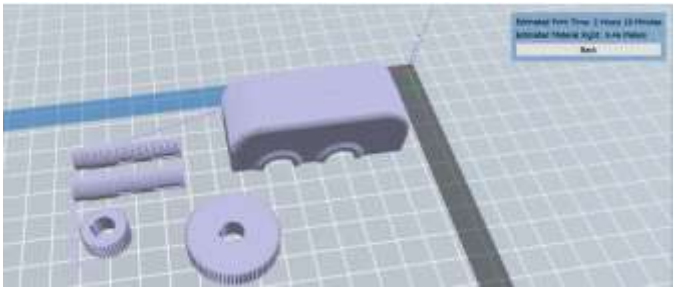


Fig -4: 3D Printing of Gear box

4. CONCLUSION

Gears are used to transfer motion from one object to another in a mechanism. There are many important design considerations with respect to gears. The most fundamental calculation for gears is the gear ratio. This ratio describes the relative motion of the gears involved. A high gear ratio corresponds to a high torque output and a low gear velocity. The gear ratio can be used to determine the proper number of teeth for the gears. The output speed of the vehicle depends on the overall gear ratio.

In this paper modelling of gear box was completed by using SolidWorks software analysis was done on two metals aluminum alloy and Gray cast iron and compared. A prototype gearbox was created by using 3D printing to check the design changes.

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