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DESIGN AND ASSEMBLY ANALYSIS OF A DIFFERENTIAL GEAR BOX

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ABSTRACT

Differential is used when a vehicle takes a turn, the outer wheel on a longer radius than the inner wheel. The outer wheel turns faster than the inner wheel that is when there is a relative movement between the two rear wheels. If the two rear wheels are rigidly fixed to a rear axle the inner wheel will slip which cause rapid tire wear, steering difficulties and poor load holding.

Differential is a part of inner axle housing assembly, which includes the differential rear axles, wheels and bearings. The differential consists of a system of gears arranged in such a way that connects the propeller shaft with the rear axles.

The following components consists the differential:

- Crown wheel and pinion.
- Sun gears
- Differential casing

In the present work all the parts of differential are designed under static condition and modeled. The required data is taken from journal paper. Modeling and assembly is done in Pro/Engineer. The detailed drawings of all parts are to be furnished.

The main aim of the project is to focus on the mechanical design and contact analysis on assembly of gears in gear box when they transmit power at different speeds at 2500 rpm, 5000 rpm. Presently used materials are Cast iron and Cast steel. For validating design Structural Analysis is also conducted by varying the materials for gears, Cast Iron and of Aluminum Alloy.

The analysis is conducted to verify the best material for the gears in the gear box at higher speeds by analyzing stress, displacement and also by considering weight reduction.

The analysis is done in ANSYS WORKBENCH software. Modeling is done in the Catia v5.

Chapter-1

1. INTRODUCTION TO GEAR BOX

A transmission or gearbox provides speed and torque conversions from a rotating power source to another device using gear ratios. In British English the term transmission refers to the whole drive train, including gearbox, clutch, prop shaft (for rear-wheel drive), differential and final drive shafts.

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In American English, however, the distinction is made that a gearbox is any device which converts speed and torque, whereas a transmission is a type of gearbox that can be "shifted" to dynamically change the speed: torque ratio, such as in a vehicle. The most common use is in motor vehicles, where the transmission adapts the output of the internal combustion engine to the drive wheels. Such engines need to operate at a relatively high rotational speed, which is inappropriate for starting, stopping, and slower travel. The transmission reduces the higher engine speed to the slower wheel speed, increasing torque in the process. Transmissions are also used on pedal bicycles, fixed machines, and anywhere else rotational speed and torque needs to be adapted. Often, a transmission will have multiple gear ratios (or simply "gears"), with the ability to switch between them as speed varies. This switching may be done manually (by the operator), or automatically. Directional (forward and reverse) control may also be provided. Single-ratio transmissions also exist, which simply change the speed and torque (and sometimes direction) of motor output.

In motor vehicle applications, the transmission will generally be connected to the crankshaft of the engine. The output of the transmission is transmitted via driveshaft to one or more differentials, which in turn drive the wheels. While a differential may also provide gear reduction, its primary purpose is to change the direction of rotation.

Conventional gear/belt transmissions are not the only mechanism for speed/torque adaptation. Alternative mechanisms include torque converters and power transformation (e.g., diesel-electric transmission, hydraulic drive system, etc.). Hybrid configurations also exist.

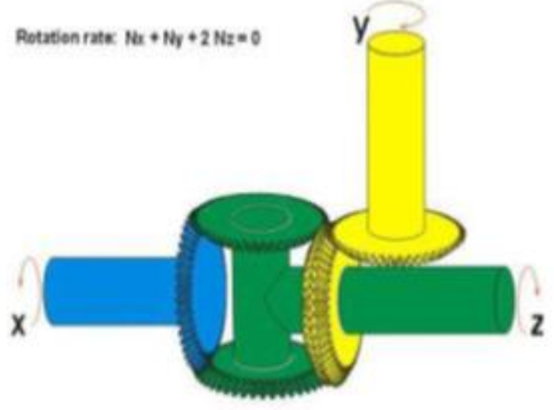

Fig 1 Differential gear box

2. AIM OF THE PROJECT

The main aim of the project is to focus on the mechanical design and contact analysis on assembly of gears in gear box when they transmit power at different speeds at 2400 rpm, 3500 rpm. Analysis is also conducted by varying the materials for gears, Cast Iron, and Aluminum Alloy.

The analysis is conducted to verify the best material for the gears in the gear box at higher speeds by analyzing stress, displacement and also by considering weight reduction.

Design calculations are done on the differential of Ashok leyland 2516M by varing materials and speeds. Differential gear is modeled in Pro/Engineer. Analysis is done on the differential by applying tangential and static loads. Frequency analysis is also done on the differential. Analysis is carried out using ANSYS WORKBENCH.

Chapter-2

2. LITERATURE SURVEY

1. Iresh Bhavi1,Vinay Kuppast, Shivakant Curbed –2017 Finite Element Analysis Of Spiral Bevel Gears Pair Used In An Automobile Differential Gear Box-

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This paper describes the experimental destructive testing of spiral bevel gears used in automotive differentialgear box. The experimental testing is aimed at early detection of failure of spiral bevel gears during operation by continuously recording and comparing the sound and vibration characteristics during testing. For this purpose, especially fatigue test rig has electric motor been developed which can apply dynamic rotational loads with the help of a three phase AC.

2. Zeping Wei., 2004"Stresses and Deformations in Involute gears by Finite Element method," M.S, Thesis, College of Graduate Studies and research, University of Saskatchewan, Saskatchewan.

The main objective of this paper is to perform mechanical design of gear box and analysis of gears in gear box. Presently used materials for gears and gears shafts is Cast Iron, Cast Steel. So, in this paper we are checking as the aluminum can be the other material for the differential gear box for light utility vehicles so, we can reduce the weight.

Chapter-3

3. INTRODUCTION TO CAD

Computer-aided design (**CAD**), also known as **computer-aided design and drafting** (**CADD**), is the use of computer technology for the process of design and design-documentation. Computer Aided Drafting describes the process of drafting with a computer. CADD software, or environments, provide the user with input-tools for the purpose of streamlining design processes; drafting, documentation, and manufacturing processes. CADD output is often in the form of electronic files for print or machining operations. The development of CADD-based software is in direct correlation with the processes it seeks to economize; industry-based software (construction, manufacturing, etc.) typically uses vector-based (linear) environments whereas graphic-based software utilizes raster-based (pixelated) environments.

The main modules are

Part Design

Assembly

Drawing

3.2 MODEL OF DIFFERENTIAL GEAR

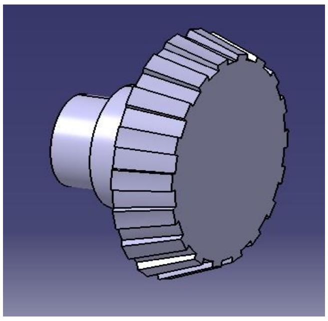

Fig 3.1 DRIVE PINION

Fig 3.2 RING GEAR

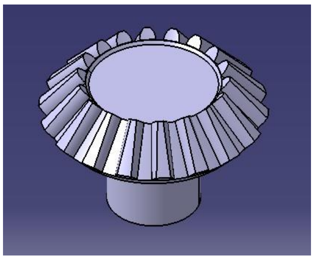

Fig 3.3 DIFFRENTIAL PINION

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Fig3.4 DIFFRENTIAL PINION

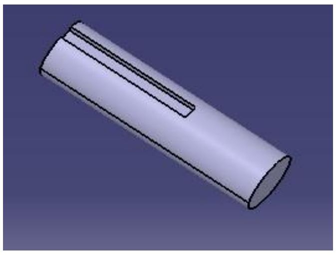


Fig 3.5 SHAFT

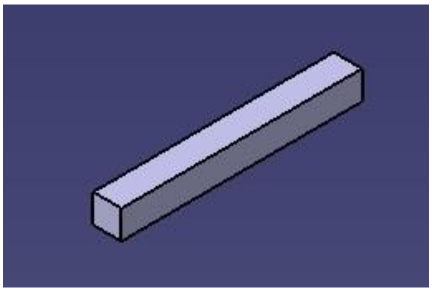
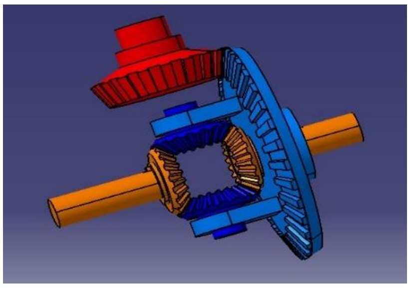


Fig 3.6 KEY



3.7 FULL ASSEMBELEY

Chapter-4

4.1 INTRODUCTION TO FEA

Finite element analysis (FEA) is a fairly recent discipline crossing the boundaries of mathematics, physics, engineering and computer science. The method has wide application and enjoys extensive utilization in the structural, thermal and fluid analysis areas. The finite element method is comprised of three major phases: (1) **pre-processing**, in which the analyst develops a finite element mesh to divide the subject geometry into subdomains for mathematical analysis, and applies material properties and boundary conditions, (2) **solution**, during which the program derives the governing matrix equations from the model and solves for the primary quantities, and (3) **post-processing**, in which the analyst checks the validity of the solution, examines the values of primary quantities (such as displacements and stresses), and derives and examines additional quantities (such as specialized stresses and error indicators).

Model

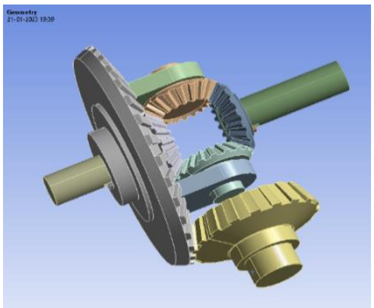


Fig 4.1 Importing Geometry into ansys

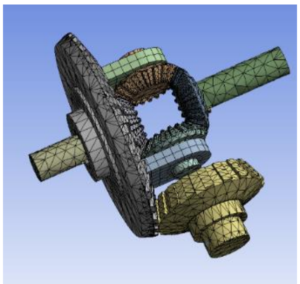


Fig 4.2 Meshing Body

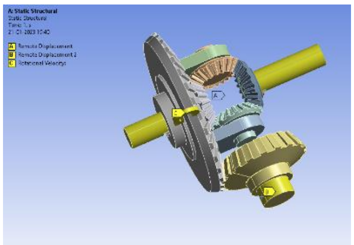


Fig 4.3 Boundary Conditions

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4.2 MODAL SHAPES OF TOTAL DEFORMATIONS WITH MATERIAL STRUCTURAL STEEL :

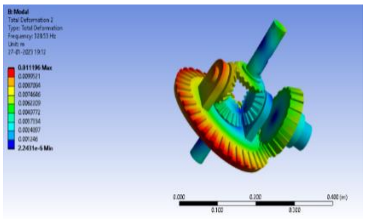

Fig 4.2.1 mode-1;Frequency: 328.53Hz

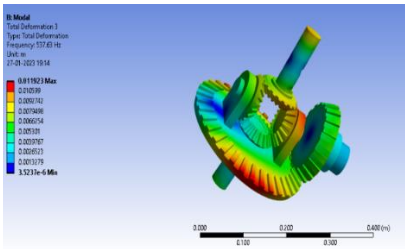

Fig 4.2.2 Mode-2; Frequency: 537.63Hz

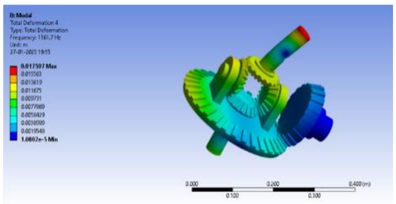

Fig 4.2.3Mode-3; Frequency:1161.7Hz

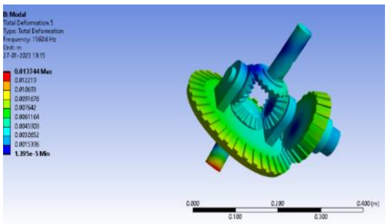

Fig 4.2.4 Mode-4; Frequency:1560.6Hz

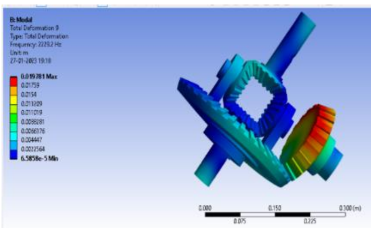

Fig 4.2.5 Mode-8; Frequency:2229.2Hz

4.3 SOLUTIONS WITH MATERIAL STRUCTURAL STEEL

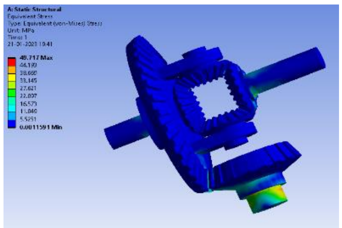

Fig 4.3.1 Vonmises stress: 49.717mpa

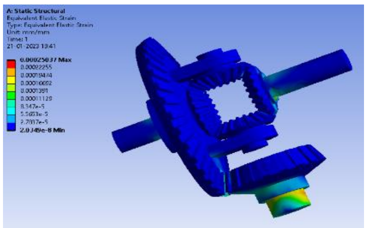

Fig 4.3 2 Vonmises starin:0.00025E-5mm/mm

4.4 MODAL SHAPES OF TOTAL DEFORMATIONS WITH MATERIAL GREY CAST IRON:

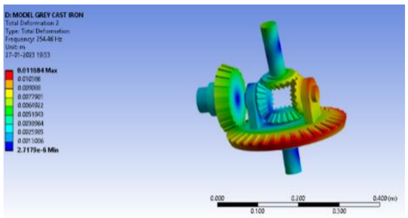

Fig 4.4.1 Mode-1; Frequency: 254.46Hz

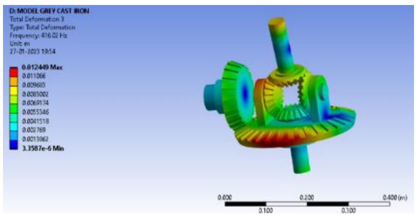

Fig 4.4.2 Mode-2; Frequency:416.02Hz

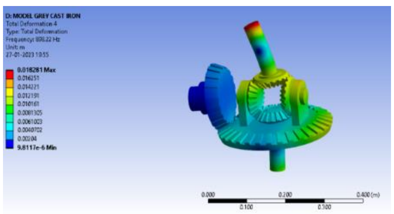

Fig 4.4.3 Mode-3; Frequency:898.22Hz

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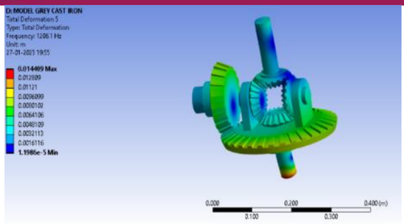

Fig 4.4.4 Mode-4; Frequency:1206.1Hz

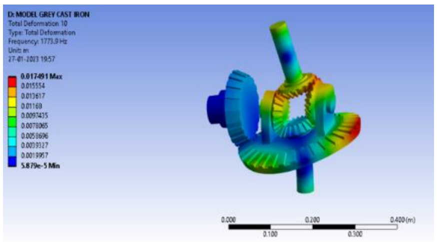

Fig 4.4.5 Mode-9; Frequency:1773.9Hz

4.5 SOLUTIONS WITH MATERIAL GRAY CAST IRON

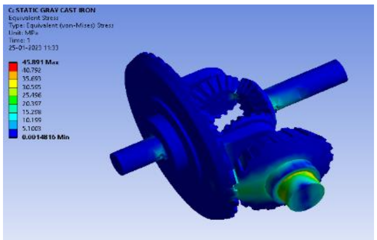

Fig 4.5.1Vonmises stress: 45.891MPA

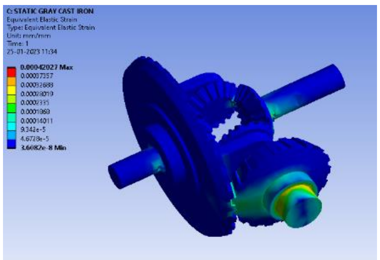

Fig 4.5.2Vonmises starin:4.2E-4mm

4.6 MODAL SHAPES OF TOTAL DEFORMATIONS WITH MATERIAL ALUMINUM ALLOY:

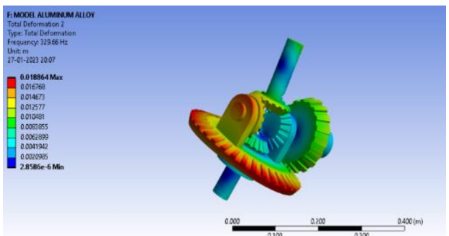

Fig 4.6.1 mode-1; Frequency:329.66Hz

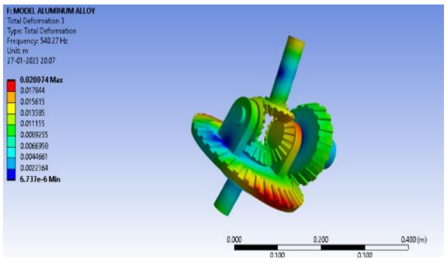

Fig 4.6.2 Mode-2; Frequency:540.27Hz

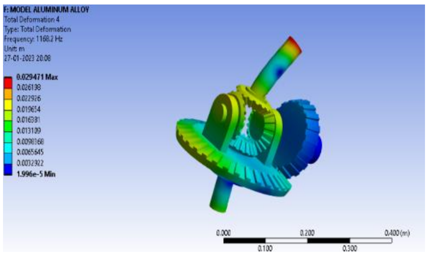

Fig 4.6.3 Mode-3; Frequency:1168.2Hz

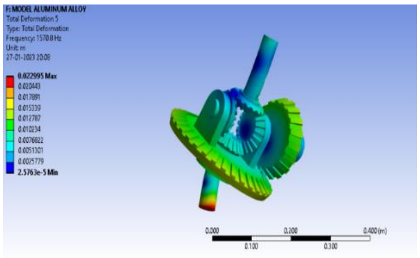

Fig 4.6.4 Mode-4; Frequency:1570.8Hz

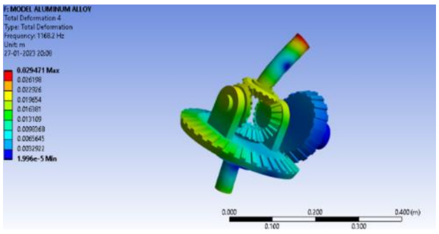

Fig 4.6.5 Mode-3; Frequency:1168.2Hz

4.7 SOLUTIONS WITH MATERIAL ALUMINIUM ALLOY

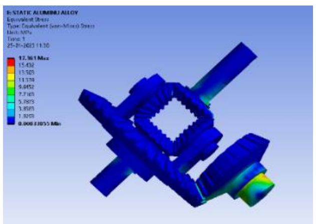

Fig 4.7.1 Vonmises stress :17.36MPA

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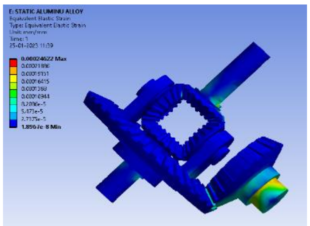

fig 4.7.2 Vonmises starin:2.4E-4mm/mm

Chapter-5

5.1 PROPERTES OF MATERIAL:

S.NO.	MATERIAL	STRESS (MPA)	STRAIN (MM/MM)
1	STRUCYRAL STEEL	49.717	2.50E-04
2	GRAY CAST IRON	45.89	4.20E-04
3	ALUMIUM ALLOY	17.36	2.40E-04

Fig 5.1 PROPERTES OF MATERIAL

GRAPHS

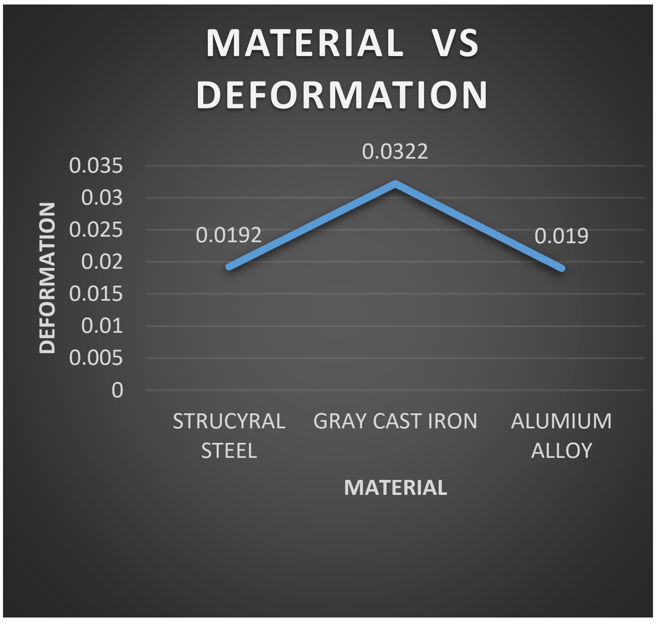

Fig 5.1 GRAPH FOR MATERIAL VS DEORMATION

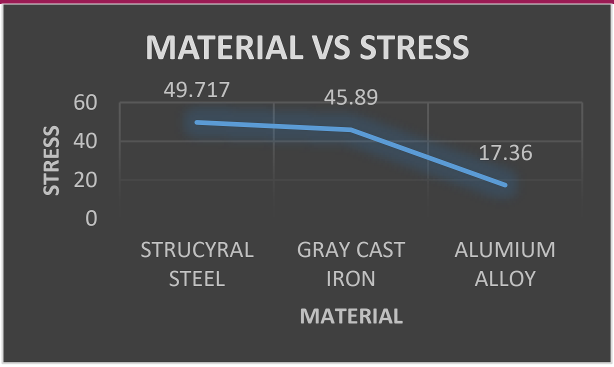

Fig 5.2 GRAPH FOR MATRIAL VS STRESS

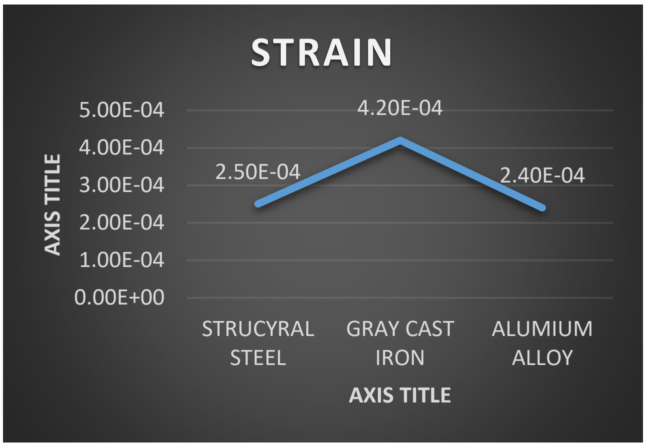

Fig 5.3 GRAPH FOR MATRIAL VS STRAIN

Chapter-6

6. CONCLUSION

In our project we have designed a differential gear box for Ashok Leyland 2516M. Loads are calculated when the gears are transmitting different loads 2400N and 3500N and different materials Aluminum Alloy, Stainless Steel & Brass.

Structural and Frequency analyses are done on the differential gear box to verify the best material by taking in to account stresses, displacements, weight etc.

By observing the structural analysis results using Aluminum alloy the stress values are within the permissible stress value. So using Aluminum Alloy is safe for differential gear.

When comparing the stress values of the three materials for all speeds 2400rpm and 5000rpm, the values are less for Aluminum alloy than Cast Iron.

And also weight of the Aluminum alloy reduces almost 3 times when compared with Grey Cast Iron since its density is very less. Thereby mechanical efficiency will be increased.
By observing analysis results, Aluminium is best material for Differential.

Chapter-7

7. References

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