MODELING AND ANALYSIS OF DIFFERENTIAL GEARBOX

A Project Report

Submitted to

Jawaharlal Nehru Technological University, Kakinada

In partial fulfillment of the requirements for the

award of the degree of

BACHELOR OF TECHNOLOGY

in

MECHANICAL ENGINEERING

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CERTIFICATE

This is to certify that the Project entitled **"MODELING AND ANALYSIS OF DIFFERENTIAL GEARBOX**" submitted by R. ESWAR PRASAD NAIDU (19L65A0343), B. LAKSHMI VISWANADHAM (19L65A0397), K. PYDI VENKATA SAI CHANDRA (19L65A0390), T. SAIRAM (19L65A03A0), D.ASHOK (19L65A0361), M. BHAVANI PRASAD (19L65A0399) in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **MECHANICAL ENGINEERING** from Jawaharlal Nehru University, Kakinada for the academic year 2021-22 is a record of bonafide work carried out under our guidance and supervision.

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DECLARATION

We are, hereby declare that the Project entitled **"MODELING AND ANALYSIS OF DIFFERENTIAL GEARBOX**" done by us under the guidance of **Dr. G. SATISH BABU, M.E, Ph.D,** which is submitted in the partial fulfillment of the requirement for the award of the **B.Tech** degree in **Mechanical Engineering** at **Chaitanya engineering college** for Jawaharlal Nehru Technological University, Kakinada is our original work.

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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 away that connects the propeller shaft with the rear axles.

The main objective of this project is to perform mechanical design of differential gear box and analysis of gears in gear box. Nickel Chromium steel, Aluminium alloy, and Malleable Cast iron materials are to be considered for conducting the analysis. Presently used materials for gears and gears shafts is Cast Iron, Cast Steel. So, on this project work, different materials are considered for the analysis and comparision is to be done based on stresses and weight reduction.

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 software and Modelling is done in Solidworks.

Research Aim

- To design a gear box housing under the platform of Solidworks 2021.
- To find out the stress and deformation generated in gearbox under different conditions through Ansys 2021 R2.
- To find out the best material suitable for differential gearbox.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

A differential is a gear train with three shafts that has the property that the angular velocity of one shaft is the average of the angular velocities of the others, or a fixed multiple of that average. A gear box provides speed and torque conversions from a rotating power source to another device using gear ratios.

Fig 1.1: Differential Gearbox

In automobiles and other wheeled vehicles, the differential allows the outer drive wheel to rotate faster than the inner drive wheel during a turn. This is necessary when the vehicle turns, making the wheel that is traveling around the outside of the turning curve roll farther and faster than the other. The average of the rotational speed of the two driving wheels equals the input rotational speed of the drive shaft. An increase in the speed of one wheel is balanced by a decrease in the speed of the other. When used in this way, a differential couple the input shaft (or prop shaft) to the pinion, which in turn runs on the

ring gear of the differential. This also works as reduction gearing. On rear-wheel-drive vehicles, the differential may connect to half-shafts inside an axle housing, or drive shafts that connect to the rear driving wheels. Front wheel drive vehicles tend to have the pinion on the end of the main-shaft of the gearbox and the differential is enclosed in the same housing as the gearbox. There are individual drive-shafts to each wheel.

1.2 Functions Of Differential Gear Box:

When a four-wheeler (car) takes a turn, the outer wheel turns faster than the inner wheel. Thus, there is relative movement between the inner and outer wheel.

The function of the differential is to permit the relative movement between inner and outer wheels when vehicle negotiates (takes) a turn. The torque transmitted to each rear wheel is equal in this case, although their speed is different.

The differential is made up of a system of gears that connect the propeller shaft and rear axles. It is a part of inner axle housing assembly. The assembly consists of differential, rear axles, wheels, and bearings.

1.3 Need of Differential Gearbox:

When a vehicle travels in a straight line, the two rear wheels turn on the road exactly at the same speed and there is no relative movement between two rear wheels.

But when vehicle takes a turn the outer wheel travels on a longer radius than the inner wheel. The outer wheel turns faster than inner wheel i.e, there is relative movement between two rear wheels. If two rear wheels are rigidly fixed to a rear axle, the inner wheel will slip, which will cause rapid tire wear, steering difficulties and poor road holding. Therefore there must be some device, which will divide the input torque of the transmission system between two rear axles. Differential serves this purpose.

1.4 Differential Gearbox Location:

Location in a different type of vehicle layouts-

1. In Front-engine front-wheel-drive layout – differential is located at the front next to gearbox.
2. In Rear engine rear-wheel-drive layout – differential is located at the rear next to gearbox.
3. Four wheels drive layout – differential is located at the front as well as rear.
4. Front engine rear-wheel-drive layout – it is located at the rear in between two half shafts.

1.5 Principle of Differential:

If a vehicle travels in a straight line, the two rear wheels turn exactly at the same speed, and there is no relative movement between them. But when the vehicle takes a turn the outer wheel travels a longer radius than the inner wheel i.e. there is relative movement between the two rear wheels. The outer wheel turns faster and covers a larger distance than the inner wheel. The inner wheel makes a larger angle than the outer wheel. thus the vehicle negotiates the turn safely.

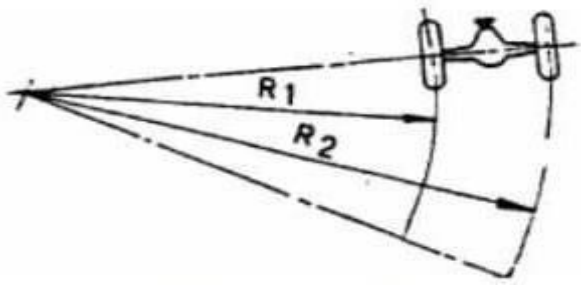


Fig.1.2: Principle of Differential

1.6 What is Differential?

The ***Differential*** is a mechanism that differentiates the power transmission ratio to the wheels. The final drive is also integrated with differential. The Final drive is the last stage in power transmission from the engine to the powered wheel. It reduces the gearbox's output shaft speed for harmonizing with the powered wheels.

As you can see below in the image, the differential gear hub is located in the rear axle.

Where this is a rear-drive axle vehicle's layout.

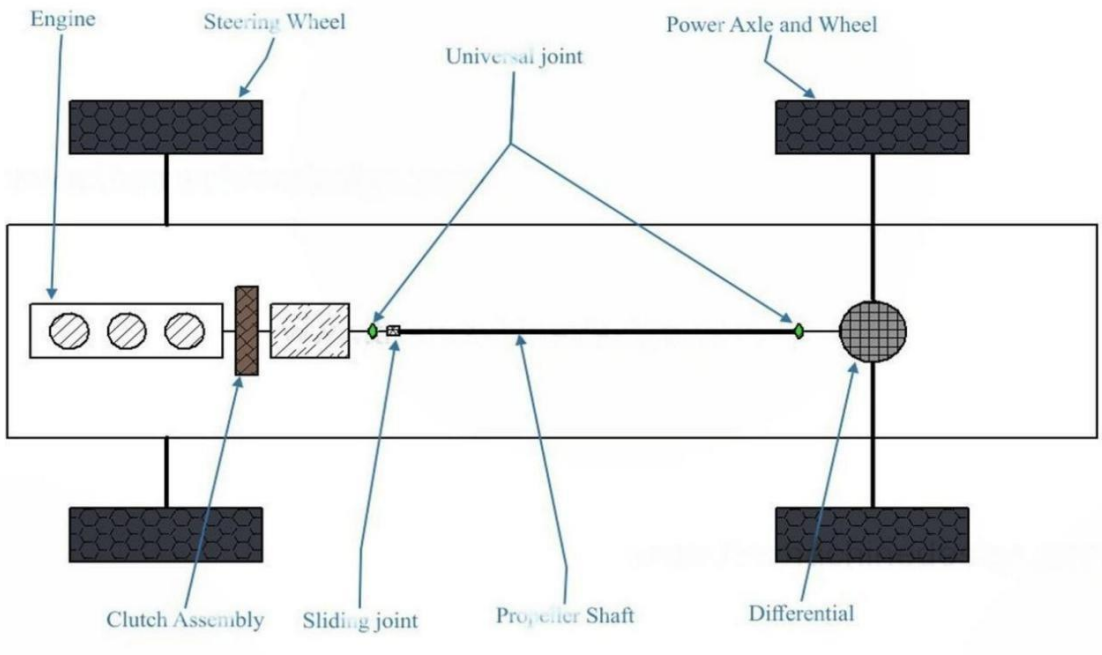


Fig1.3 : The differential in Automobile: Vehicle Layout

Basically, the differential gear consists of three shafts. One shaft is the power input shaft, that is connected with the propeller shaft. Another two shafts are the output shafts, that transfers motion to the powered wheel. These shafts are connected with the bevel gears assembly in the housing. The differential allows higher rpm to the outside wheel and reduces the inside wheel's speed during turning the vehicle.

Without a differential, it is not possible to take a quick turn at a higher speed.

1.7 Construction of Differential:

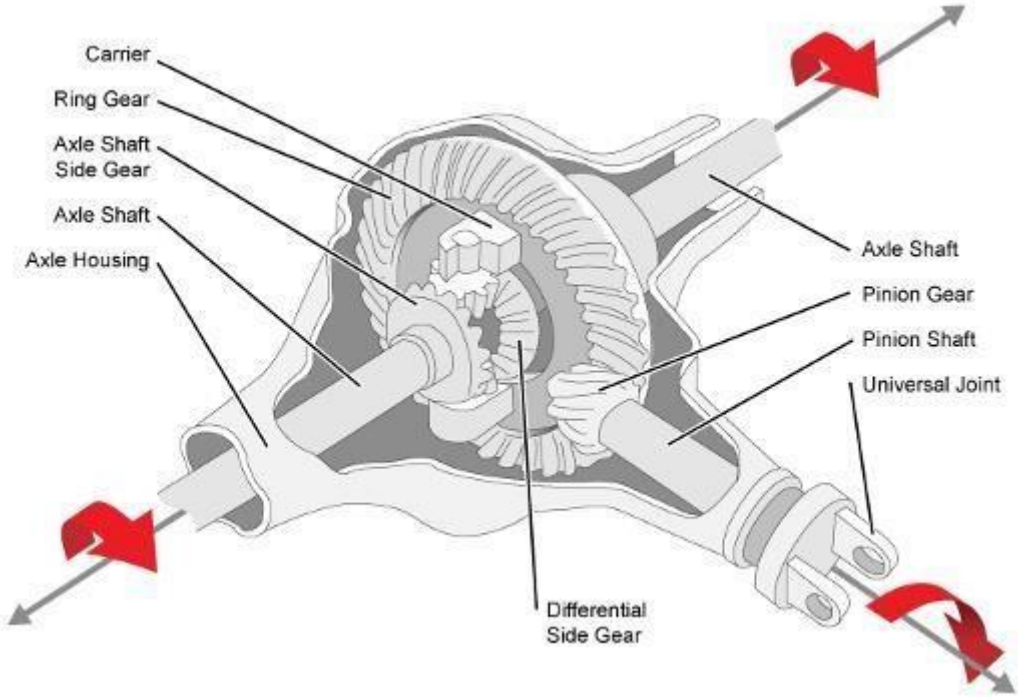


Fig.1.4: Differential Construction

As shown in the above image, there are various parts in this differential unit. This is an open differential. A pinion gear is mounted on the pinion shaft. Actually, this pinion shaft is a propeller shaft. This pinion gear rotates the big ring gear. A Carrier unit mounted on the ring gear. It consists of two bevel pinions (planet pinions) and two bevels (sun) gears. The sun bevel gears are connected with the half shaft of the rear axle. A differential housing covers this whole assembly. And axle housing covers the half shaft.

1.8 Major Components of Differential:

The following main components are used in the differential assembly.

l. Drive pinion or Bevel pinion

2. Ring gear or Crown wheel

3. Differential case

4. Differential side gear or Sun gears

5. Differential pinions (or) Planet gears

6. Axle shafts or Half shafts

7. Pinion shaft or Cross pin (or) spider.

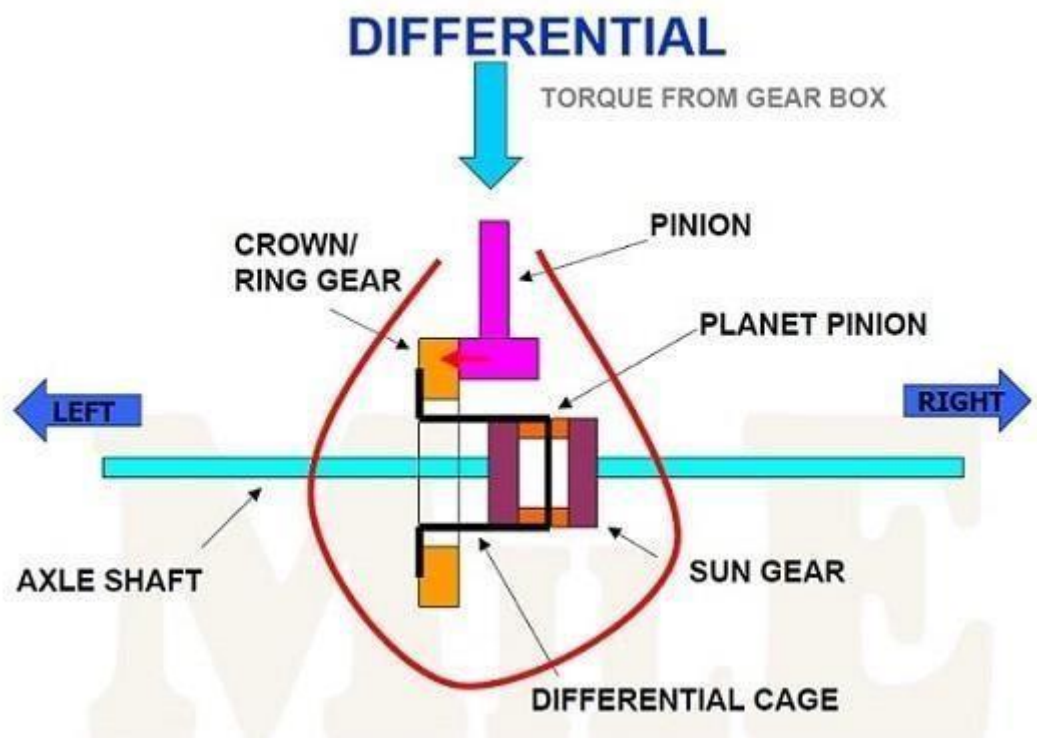


Fig.1.5: Differential Parts

Figure1.5. shows the basic parts of the type of differential used in rear-wheel-drive cars. On the inner ends of each axle a smaller bevel gear called differential side gear is mounted. Two bevel gears are put together to mesh both driving and driven shafts at an angle of 90°. The differential case is mounted with two-wheel axles and differential side gears. The differential case has bearings that rotate two axle shafts. Then, the two pinion gears and their supporting shaft, called pinion shafts, are fitted into the differential case. Then, the pinion shaft meshes with the two differential side gears connected to the inner ends of the axle shafts.

The ring gear is bolted to a flange on the differential case. The' ring gear rotates the differential case. Finally, the drive pinion is mounted. The drive pinion is assembled with the differential housing called differential case or carrier. The driver shaft is connected with the drive pinion by a universal joint and it meshes with the ring gear. So, the drive pinion is rotated when the drive shaft turns. Thus, the ring gear is rotated.

1.9 Working of Differential:

What happens in the differential case when the vehicle moves straight?

When a vehicle moves on a straight path, the differential gear assembly (whole assembly) turns as a unit. The ring gear, both differential side gears and both axles are in this unit. The two planet pinion do not rotate with the pinion shaft. Because they apply the same force on the sun pinions. Therefore, both sun pinions rotate at the same rpm with the ring gear.

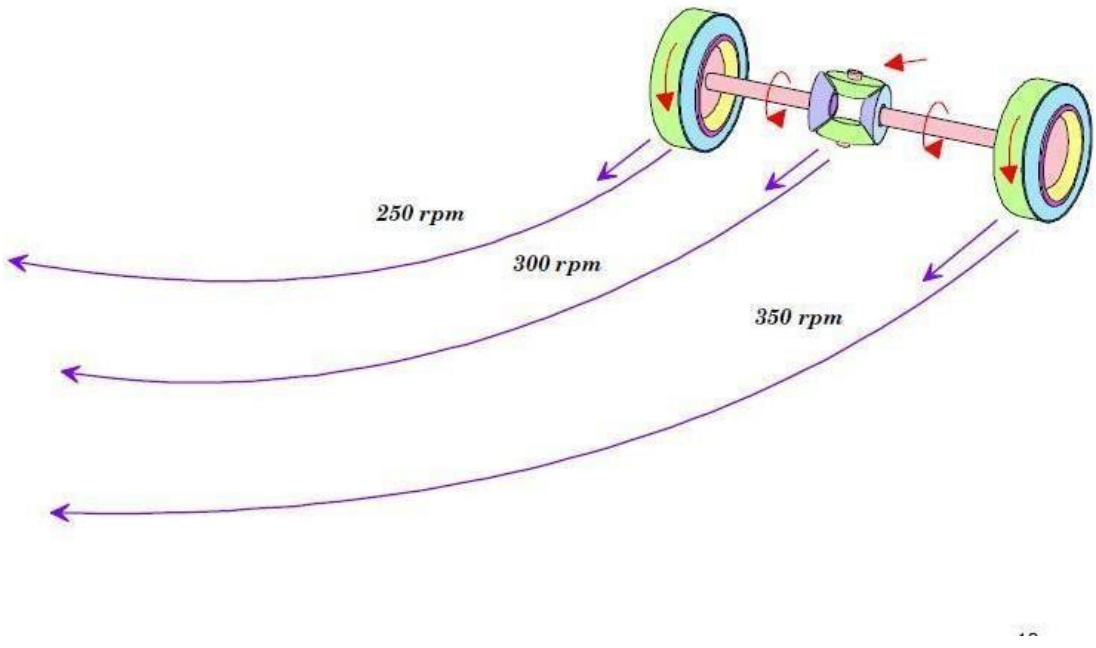


Fig.1.6: Differential Wheels Path at different speeds

What happens in the differential case when the vehicle turns right?

During the right turn, the vehicle right (inside) wheel rotates slower than the left (outside) wheel. Inside of the differential case, the planet pinion rotates on its self axis along with the ring gear. This allows the independent rotation to both side wheels. As the carrier rotates with ring gear, the planet pinion rotates at same rpm. But, due to pinion's spinning on the self axis, it reduces the rpm of the right sun gear and increases the rpm of the left sun gear. The vice-versa action happens while the vehicle turns left. the plane pinion reduces the rpm of the left side sun gear and increases the right side sun ears rpm. For better understanding please go through this video.

1.10 TYPES OF DIFFERENTIALS

There are three types of differentials:

(a) Conventional type,

(b) Non-slip or self-locking type, and

(c) Double reduction type.

(a) Conventional Type

Conventional type differential described in Section 5.6 delivers the same torque to each rear wheel. If any of the wheels slips due to any reason the wheel does not rotate and the vehicle does not move.

(b) Non-slip or Self-Locking Type

Non-slip or self-locking type differential overcomes this drawback. It construction is similar to that of conventional type differential. But, two sets of clutch plates are provided additionally. Also, the ends of planet shafts are left loose in notches provided on the differential cage.

(c) Double Reduction Type

Double reduction type differential provides further speed reduction by additional gear. This type of differential is used in heavy-duty automobiles which require larger gear reduction between engine and wheels.

*O*ther uses of Differential:

The differential gear helps during turning and cornering at continues speed. It's also having other uses. Like,

1. It transfers power at 90° with independent rpm when required.
2. Reduces the pinions rpm at the ring gear. As a result, reduced rpm and higher torque at wheel.

1.10.1 Advantages of Differential Gearbox:

1) Both driving wheels can rotate in the same direction at the same speed.
2) Both driving wheels can rotate in the same direction at different speeds.
3) Both driving wheels can rotate in the opposite direction at the same speed.
4) Both driving wheels can rotate in the opposite direction at a different speed.

CHAPTER 2

LITERATURE REVIEW

Author Utkarsh Patil et al. [1] discussed in this paper the transmission system of the vehicle but they mainly focused on the different type of the differential gearboxes. As the vehicle gets stucked in the potholes, mud, slippery road, snow or the obstacle etc. the torque provided to the stucked wheel is more and the vehicles tyre rotate on the same place and does not move forward so to minimize this limitation the authors discussed various modification in the differential gearboxes such as helical gear driven differential, limited slip differential, clutch pack differential, cykro gear differential, electronic controlled differential, belt driven differential, locking differential by centrifugal force etc. this many differentials are designed for special purposes operations and these are unable to eliminate all the limitations so, we can use the combination of it and eliminate the limitation and use in the vehicle for our required operation.

The Author Harsha Bhandaru et al. [2] discussed about the differential gearbox and gearbox to reduce the transmission system using differential gear and he also discussed about various transmission system such as gear array, toroidal CVT, CVT, Lock differential instead of differential. This all type of differential gears are shown in below figures. He also discussed about the problems related to the parking faced by the people in the metropolitan areas to solve this he discussed the design in which the wheel directly turns in 90° or we can say in longitudinal axis so that the parking problem in the compact spaces is solved. He also discussed the alternative transmission system components and smart parking system is fabricated friction losses in the transmission components can be reduced by using oil which is used in CVT. The transmission component can be used in the passenger car. The smart parking can be easily implemented in cars.

Bridjesh P et al. [3] proposed that the design, modelling and the structural analysis of chain differential. They found the results using solidworks on the different materials. He analysed the differential stub axle, sprocket and involute bevel gear by aluminium alloy, plain carbon steel and grey cast iron. They observe the stress, strain and displacement value and

concluded that the aluminium alloy is safe for differential body, grey cast iron for sprocket and for the gear steel is the safe material.

Chandrakant Singh et al. [4] gives the information about vehicle differential system. When one wheel of the vehicle is stucked in the snow or mud and does not have enough traction i.e, stationary then the other wheel rotates twice its normal speed, so he studied and gave the solution of it by introducing differential locking system which is sensor based. Sensor senses the difference in speed of the vehicles wheels and locks the differential so that the wheels have same traction. This mechanism produces a stabilization force acting though the rear axle, that resist a vehicle rotation. In this paper the differential is going to locked and the shifter mechanism used to move dog ring engage both wheel shaft with drive and equal power is given to the both.

The Author Silvia Medvecka-Benova et al. [5] discussed and have done optimization of the differential heavy truck without a wheel reduction. The unique constructions concept solution has a heavy truck because the distribution of the drive torque is placed in the central distribution tube, as shown in Fig. 5 The modified differential gearbox consists of the Axial axle, bevel pinion, Bevel gear, half axle, Drive shaft of the rear axle, Ring gear, Internal ring gear etc as shown in fig. 5 & fig. 6. the modified differential gearbox is cylindrical type. By doing the analysis the author found that the result that the original differential gearbox there was increased stress with the value exceeding the yield strength of the material gearbox in the place of the notch at the head of the gearbox, so by modification of the differential gearbox the value of the stress will be reduced at the notch by 34% and this is adjusted gearbox is useful for larger load carrying vehicles such as heavy trucks.

Joseph Gerald et al. [6] give the idea about the light weight spur gear differential system by introducing a spur gear at half shaft of the vehicle which transmit the power to the wheel. The carrier is mounted on the propeller shafts which rotates the pinion in opposite direction. This pinion is connected to the half shaft of the vehicle which rotate in the same direction as propeller shaft. These differential claims 30% lighter than the bevel spur differential and 70% free space available because of its slim design for this reason it increases efficiency and reducing the cost compared with others conventional differential. This is used for light duty and commercial vehicles.

Gregory Antoni et al. [7] discussed in thus paper about various mechanical losses in differential gearbox. In differential gearbox friction losses is the major problem it damages the surface of the gear tooth. The friction loss is developed because of the lack of lubrication between mechanical element or by defect in the gear design. He discussed on the friction losses occurred using various relationship graphs. In order to test the influence of these parameters and determine the ability of model to predict any mechanical losses a sensitivity analysis was conducted using numerical approach and experimental study he calculated realistic values for some parameters

The Author Amir Khan et al. [8] discussed about the fourwheel drive. It cannot work without central differential. They studied the phenomenon of windup which is there in small difference in between front and rear wheel produce extra torque applied across the transmission. This case study is for Maruti Suzuki Zypsy. It transfers torque ratio 50:50 for front and rear axle but the torque develop by engine should ratio 60:40 which is ideal ratio for better handling. So, it need to replace gearbox to modified central differential having two different side gears. FEM method is used for analysis and creo-2 is used for calculating design. They concluded that modified central differential is better is better than transfer gearbox.

C Veeranjaneyulu et al. [9] discussed and studied on the on the design and analysis of differential gearbox. They analyse using different material such as cast iron, cast steel and aluminium alloy. The design is done with help of the cosmos software which is used for the finite element method to stimulate the working condition of design of design and it also predict the behaviour of the material. From this paper he concluded that aluminium alloy has the stress value within the permissible limit. So aluminium alloy is safe for differential gearbox. After comparing stress value for speed, they concluded that the value of permissible stress of aluminium alloy is less than the other material. They also observed the frequency analysis of the material. The vibrations are less in the aluminium alloy rather than the other cast iron and cast steel. They concluded that aluminium alloy has three times reduction in weight than other two material which increases the mechanical efficiency of the differential so aluminium alloy is the best material used for it.

Nitin Kapoor et al. [10] design and developed a model of differential gearbox with a material of glass filled polyamide composite material by using CATIA-V5 under the different speed and static loading condition. The stress and strains result of glass filled polyamide composite and metallic materials. glass filled polyamide have the better tensile strength, recyclability, low density, high creep resistance fatigue strength, low von-misses stress, less friction and low cost. by relating composite material different gearbox with conventional it is found to be stress and strains are lower for the composite material which increases mechanical efficiency.

G. Shrikant Reddy et al. [11] designed and analyzed the gear assembly in the differential gearbox. the problem of the failure at the contact regions minimized by modifying gear material in static and dynamic condition. This modification was done by using stresses and displacement at the point the material used by them are Ni-Cr steel and steel and compared it in the ANSYS workbench. So, they got that Ni-Cr steel is the best material in differential gearbox manufacturing as it gives high strength also the material Ni-Cr has long life compared to steel.

Daniel Das.A ,2013 [12], When comparing the stress values of the three materials for all speeds 2000rpm, 4500rpm and 6000 rpm, the values are less for Aluminum alloy than Alloy Steel and Cast Iron. By observing the frequency analysis, the vibrations are less for Aluminum Alloy than other two materials since its natural frequency is less. And also weight of the Aluminum alloy reduces almost 3 times when compared with Alloy Steel and Cast Iron since its density is very less. Thereby mechanical efficiency will be increased. By observing analysis results, Aluminum Alloy is best material for Differential.

Shashank Pandey et al., 2017,[13],The main objective of gear is to protect and to provide a safe platform to get good gear transmission. It is also gives a supports for moving parts and protected it from outside condition. The differential couples and the propeller shaft on the pinion, which is runs on the ring gear or crown gear of the differential & itis also helps as the reduction in gearing friction. And enhance the life of the gear. This can be most important tool in designing the differential gear housing free from fatigue failures caused by the resonance. The design of the gear housing should be appropiate a methodology for allocated with factors causing vibrations and to promote scientific means and to minimize the effects of frequencies.

N.Vijayababu#1, Ch.Sekhar#2 2015 [14] In our project we have designed a differential gearbox for Ashok Leyland 2516M. Loads are calculated when the gears are transmitting different speeds 2400rpm, 5000rpm.Structural analyses are done on the differential gearbox 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, 5000rpm the values are less for Aluminum alloy than Alloy Steel and Cast Iron. By observing analysis results, Aluminum Alloy is best material for Differential.

KUNAL CHITALE1 et.al 2021 [15] 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, 5000rpm and 6400 rpm, the values are less for Aluminum alloy than Alloy Steel and Cast Iron. By observing the frequency analysis, the vibrations are less for Aluminum Alloy than other two materials since its natural frequency is less. And also weight of the Aluminum alloy reduces almost 3 times when compared with Alloy Steel and Cast Iron since its density is very less. Thereby mechanical efficiency will be increased. By observing analysis results, Aluminum Alloy is best material for Differential.

CHAPTER –3
METHODOLOGY

3.1 Methodology of Differential Gearbox

Initially we decided the domain in which we are planning to work on based on the interest of the team members. So we finalized on automobiles When a detailed study was done on the various aspects of automobiles. The process of work and comparison between Aluminium, Nickel and Cast iron is carried out. Weight reduction, stress, deflection strain energy, modulus of elasticity such parameters are calculated through the theoretical calculation and compare using software through modelling and analysis

3.2 Work Flow of Static Analysis in Differential Gearbox

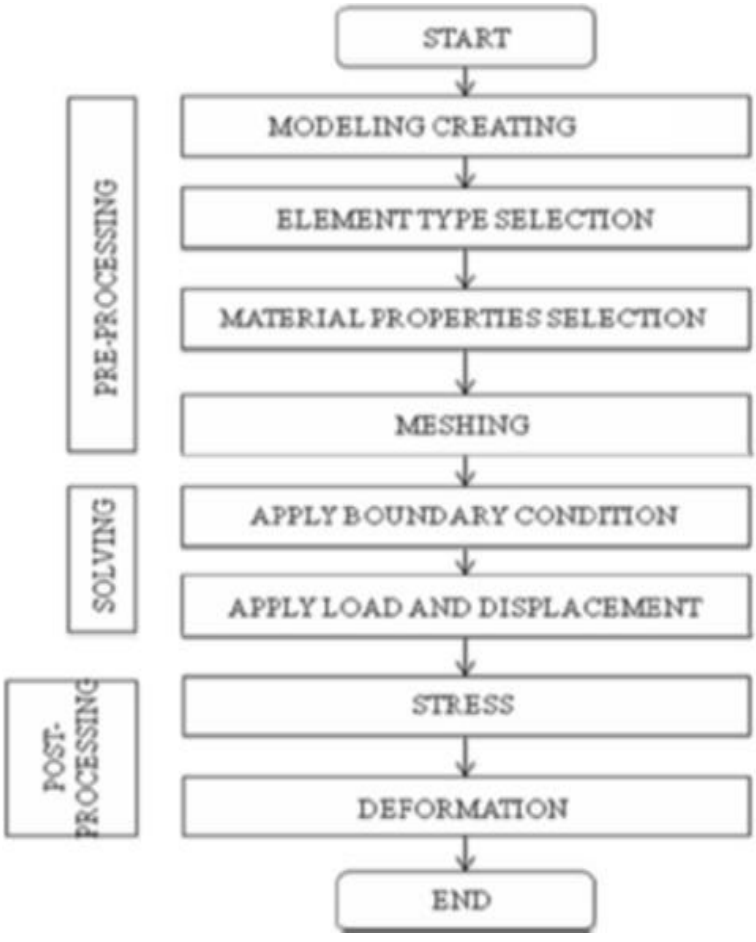


Fig. 3.1: Work flow of static analysis in Differential Gearbox

3.3. Properties of the Material

Table: 3.1: material specification used for FEA analysis

Sl NO.	MATERIAL		
	NICKEL CHROMIUM	**ALUMINIUM ALLOY**	**MALLEABLE CAST IRON**
YIELD STRENGTH(N/m2)	5137.35	4918.58	8219.75
TENSILE STRENGTH(N/m2)	12329.63	3289.89	12329.62
ELASTIC MODULUS(N/m2)	119748.28	154185.26	113760.87
POISON'S RATIO	0.28	0.33	0.27
MASS DENSITY(Kg/m3)	7800	2600	7300
SHEAR DENSITY(N/m2)	159603.78	9506.27	189427.60

CHAPTER -4

MODELLING OF DIFFERENTIAL GEAR BOX

4.1 Software

CAD Software are used to virtually visualize a component, before it is being manufactured. Now a day's there are so many modeling software's available in the market, for example AUTOCAD, Pro/E or Creo, CATIA, Unigraphics & SOLIDWORKS etc. Each software has its own importance, based on user interface in-built modules and so on. In this project, we use Solid works for modelling the Component.

4.1.1. SOLIDWORKS

Solid works is a suite of design software supporting product design developed by Dassault systems. It consists of apps, each with a distinct set of capabilities for a user role within product development. It runs on MS-Windows and provides apps for 2D design. 3D CAD feature modeling, 3D direct modeling, finite Element Analysis and simulation, schematic design, technical illustrations, and viewing and visualization.

1. Solidworks is a 3D app for designing.
2. Solidworks is a standalone design app for interact directly with the geometry with a direct modeling approach.
3. Solidworks drawing is a design app for engineers who want to create concept layout.
4. Work in 2D, with the intention of ultimately evolving the design to 3D.
5. Solidworks sketch is a design app to quickly freehand a design idea in 2D.

Solidworks is a 3D design app for designing. The reason of using among all the list of software is the easy to understand user interface and also because of the ease of extracting the core and cavity with the help of manufacturing module with minimum steps. Thus, we could create and design the component and mould with case and by saving a lot of time an effort.

This app of the Solidworks software package consists of different modules based on the area of software usage and are as follows:

a. Sketch

b. Part
c. Assembly
d. Drawing
e. Simulation
f. Flow Simulation
g. Sheet Metal
h. Mould tools
i. Surface
j. Mechanism

Along with these modules, there are also sub-types in each modules. For example, in part module there are Solid, Composite, Sheetmetal and bulk.

4.2 Model of Differential Gearbox

4.2.1 PARTS OF DIFFERENTIAL GEARBOX

1. Differential Case

Fig.4.1: Differential Case

2. Crown Wheel

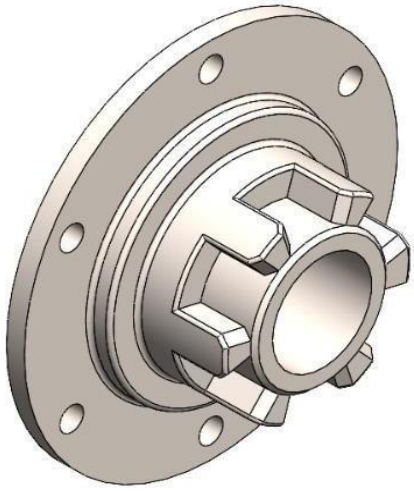


Fig.4.2: Crown Wheel

3. Splined Shaft

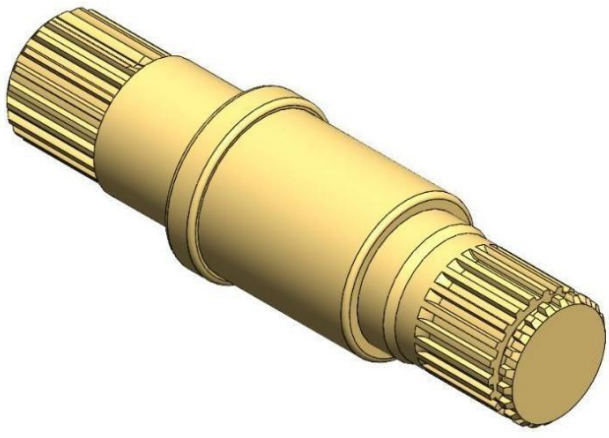


Fig.4.3: Splined shaft

4. Bevel Gear

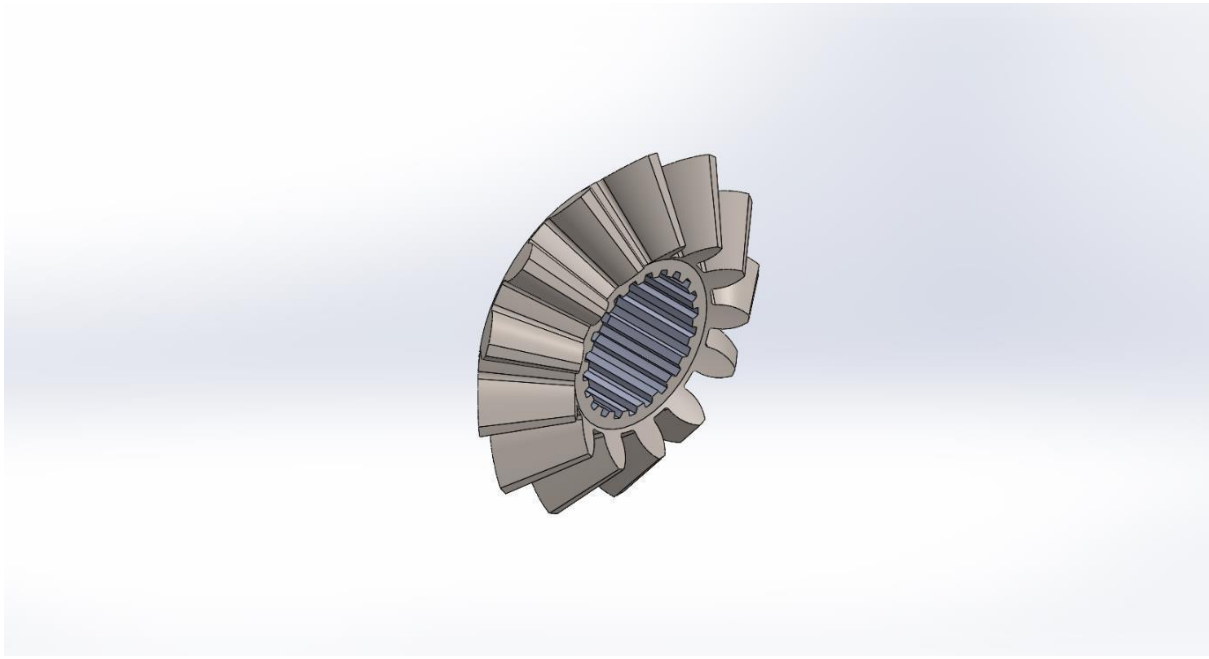


Fig4.4: Bevel gear

5. Pinion

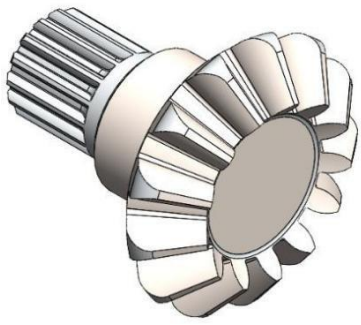


Fig4.5: Pinion

6. Cover

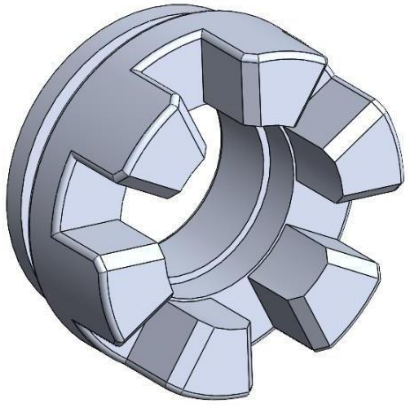


Fig.4.6: Cover

7. Washer

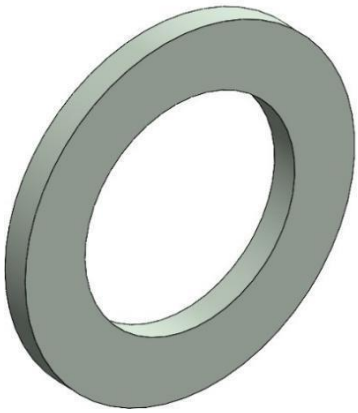


Fig 4.7: Washer

4.3 ASSEMBLY OF DIFFERENTIAL GEARBOX

1. Assembled view of Differential

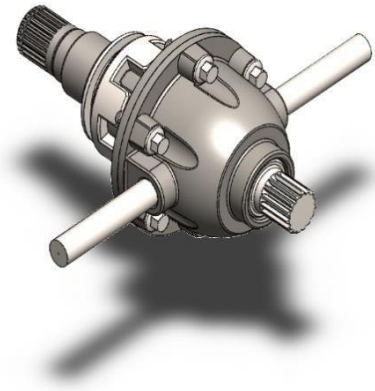


Fig 4.8: Assembly view

2. Exploded view of Differential

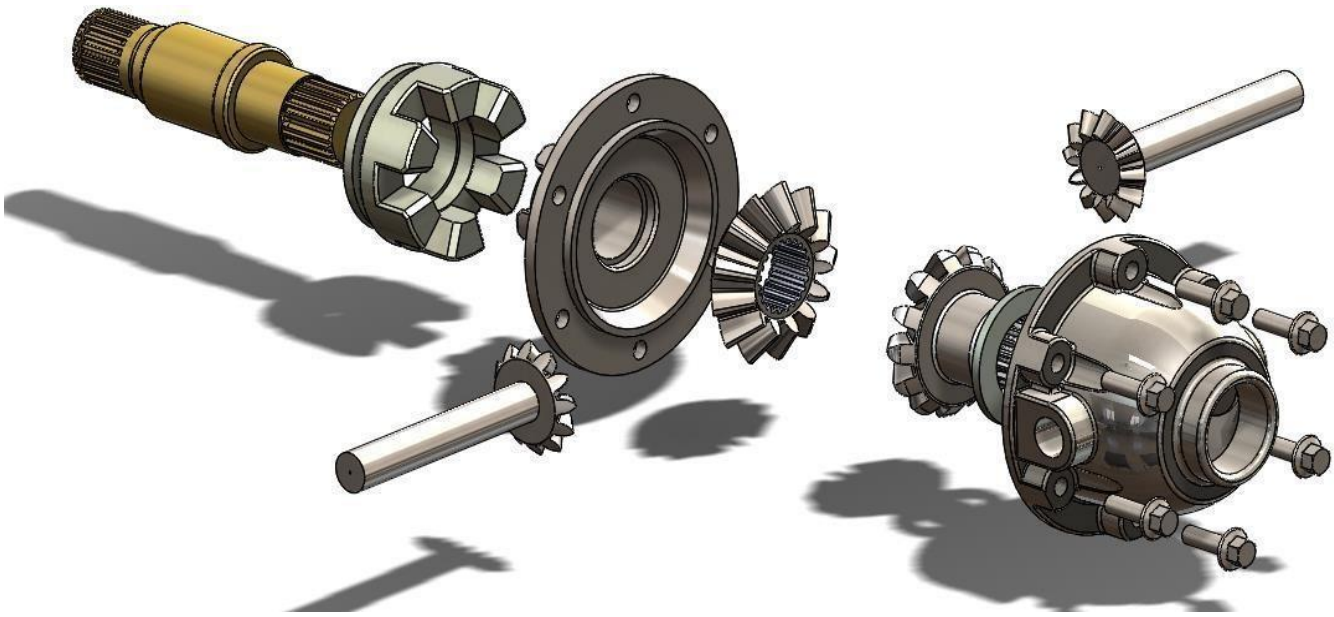


Fig 4.9: Exploded view

3.Transparent Gear View

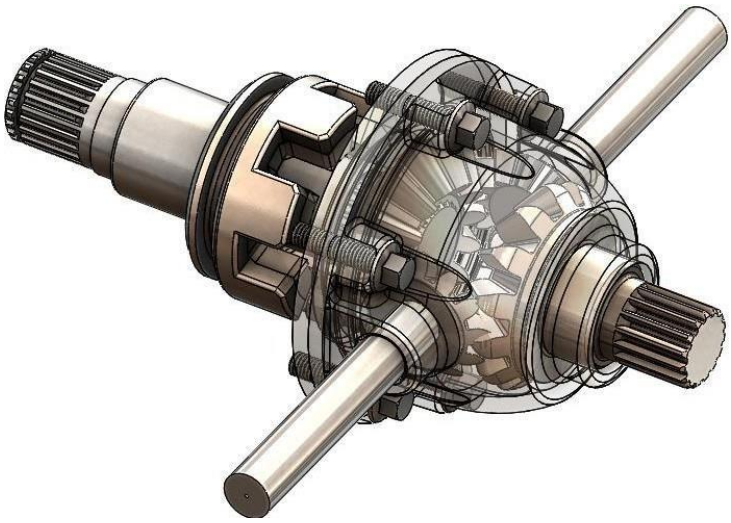


Fig 4.10: Transparent view

4.Front View of Differential

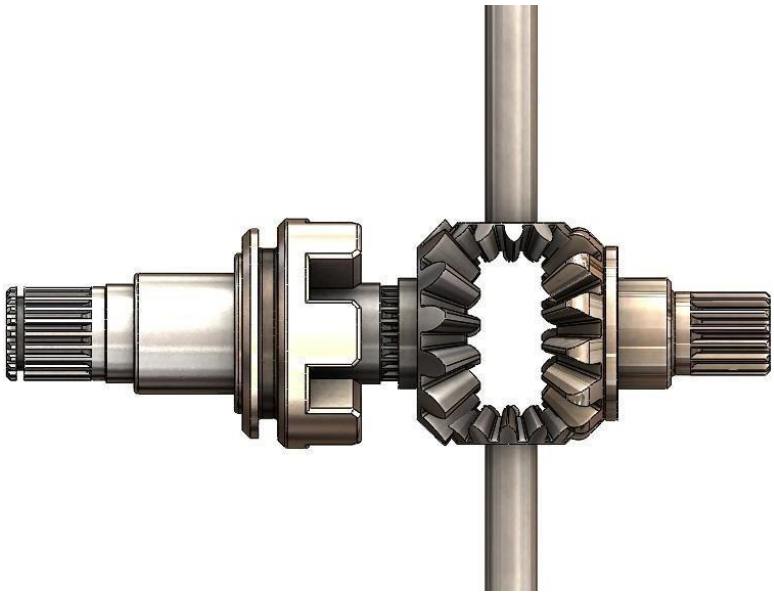


Fig 4.11: Front View of Differential

CHAPTER-5

Analysis of Differential gear box

Ansys is general purpose finite element analysis (FEA) software package. Finite element numerical method of a deconstructing a complex system into very small pieces (user designated size) called element. The software implements equations that governs the behaviour of these elements and solve them all; creating a comprehensive explanation of how the system acts as a whole. These results that can be presented in tabulate or graphical forms.

This type of analysis is typically used for the designed and optimization of system for too complex to analyse by hand. Systems that make fir into this category are too complex due to their geometry or governing equations.

Ansys is the standard FEA teaching tool within the engineering department at many colleges. Ansys is also used in civil and Electrical engineering, as well as physics and chemistry department.

Ansys provide a cost effective way to explore the performance of the products and processes in a virtual environment. This type of product development is termed as virtual Prototyping.

With virtual prototyping techniques users an iterate various scenarios to optimize the product long before manufacturing is started. This enables a reduction in level of risk, and in the cost of ineffective designs. The multifaceted nature of Ansys also provides a means of ensure that

users are able to see the effect of designs on the whole behaviour of the product, be it electromagnetic, thermal, mechanical etc.

Analysis work

The project is divided into two domains:

1. Modal Analysis
2. Stress analysis

Modal Analysis: Natural frequencies of system are those frequencies at which the resonant response occurs under the right excitation conditions. Knowledge of these critical dynamic frequencies is an essential step in the design or evaluation of a system subjected to dynamic loading.

Stress Analysis: Stress analysis is a part of static analysis of the model in Ansys 2021 R2 and modeled in SOLIDWORKS by applying boundary conditions and forces which are calculated by the data provided by the instructor .

5.1 ANALYSIS OF DIFFERENTIAL

5.1.1 IMPORTED MODEL IN ANSYS 2021 R2

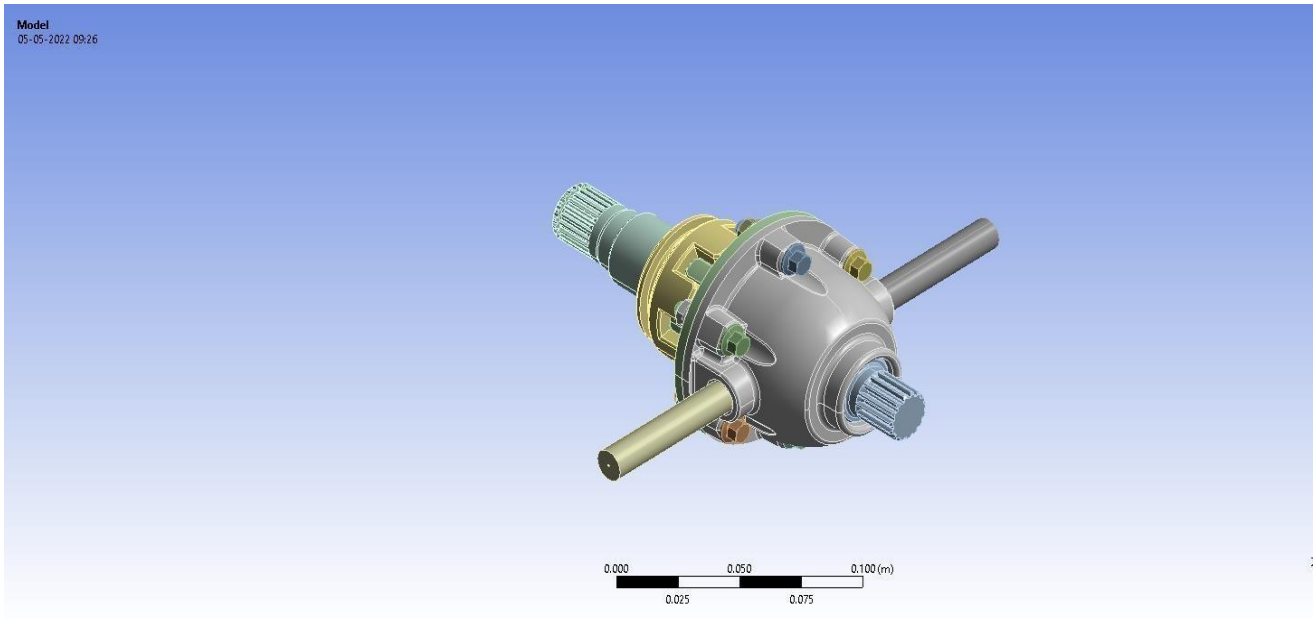


Fig 5.1: Imported Model in Ansys

5.2 MESHING OF DIFFERENTIAL

In the analysis of the gear assembly, it is mandatory to study of its structural behavior at different load and condition. 3–D model of the gear assembly were made in solidwork and were carried out in ansys analysis software as an iges file format. Thereafter importing the model in ansys with the suitable material was applied to the model and then meshing were done in ansys by which the whole body is divided into small tetrahydral element connected by nodes . The total node and element for the two were given.

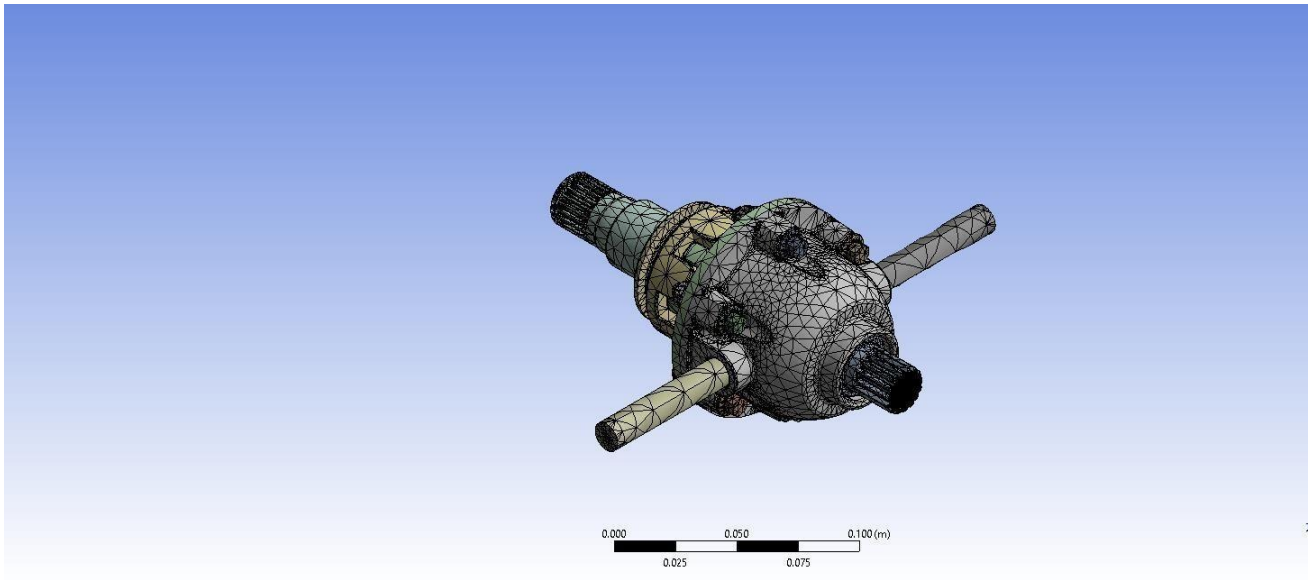


Fig 5.2: Meshing in Ansys

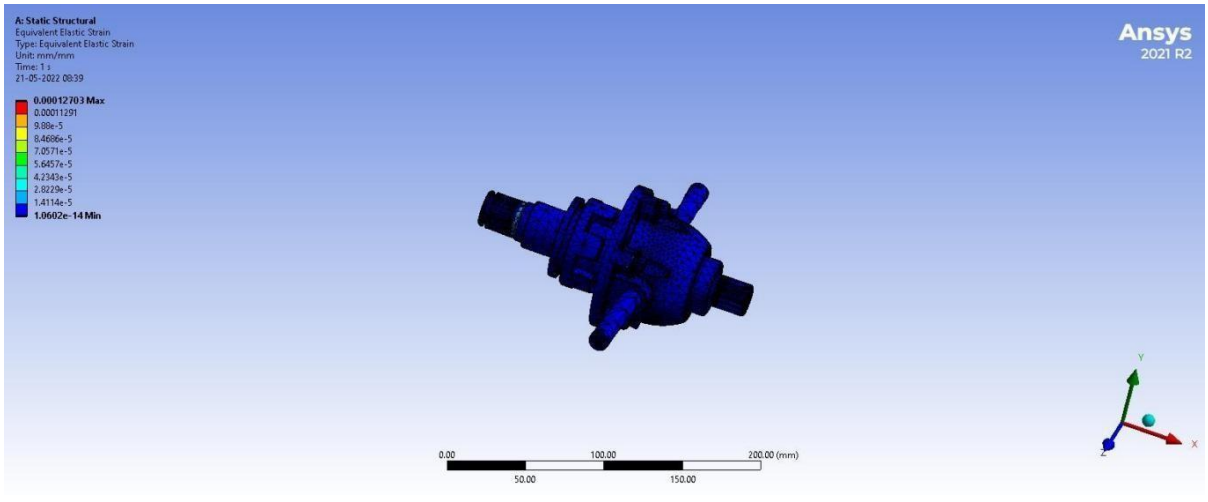
5.3 Structural Analysis

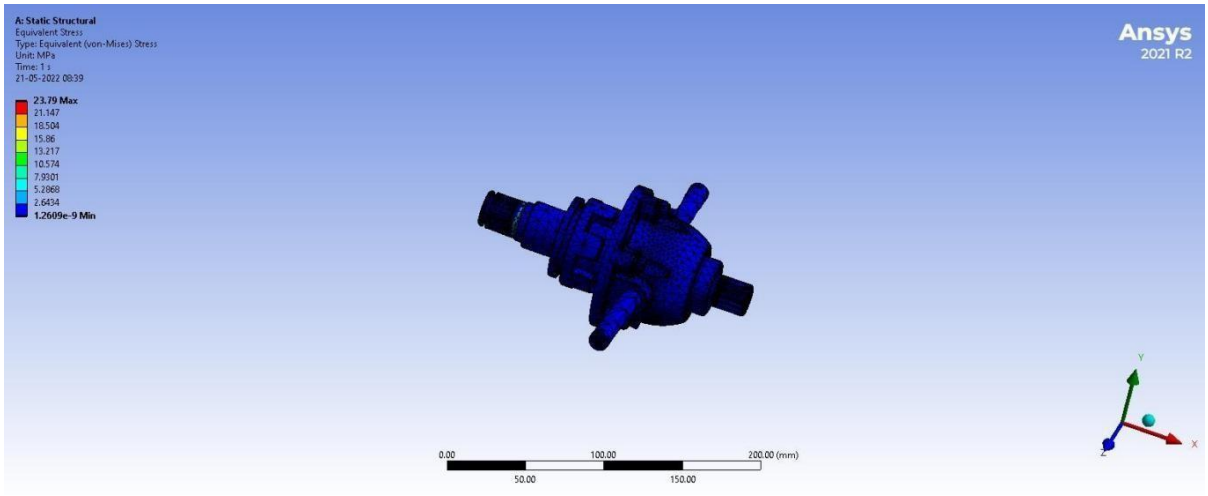
Problem formulation

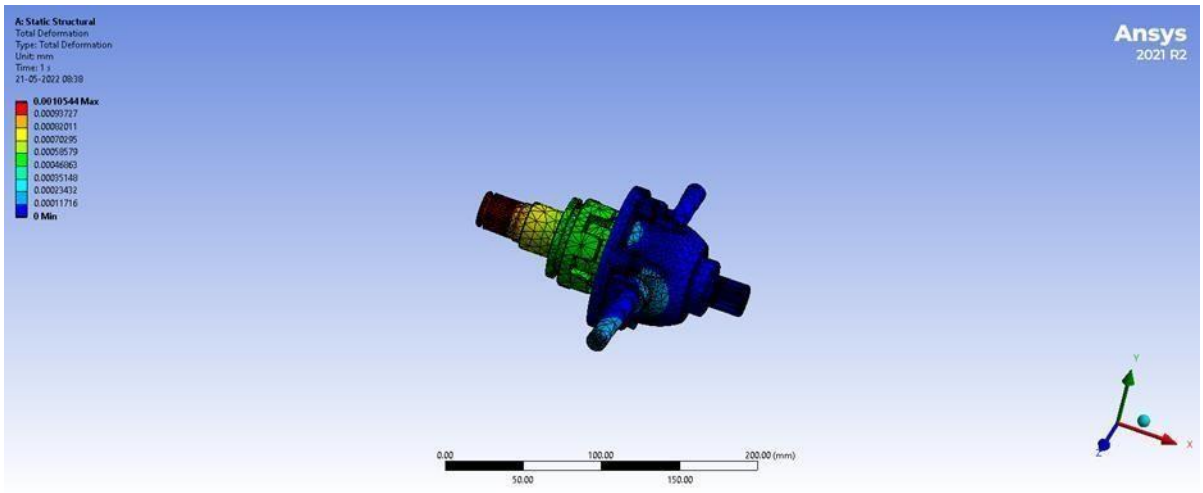
A natural frequency, epitomize by resonance is the characteristics of the part or subassemblies of a required product. This becomes notable while assess performances of applications where human comfort of the component life has a prominence on the function. Automobiles for example, are subjected to vibrations in terms of caused by the engine. The components making up the subassemblies need to be evaluated for this phenomenon. The design of the component should incorporate a mode for dealing with factors causing undesirable levels of vibration or to support any scientific means of problem solving that would decrease the harmful effects of resonance.

After analysis of all the stresses and formulation the following natural frequencies are obtained

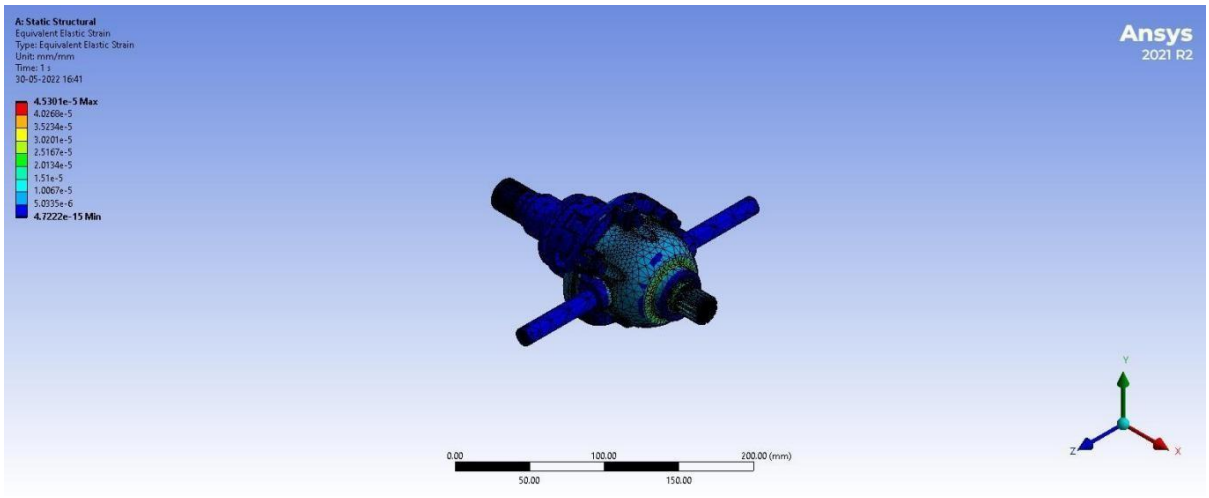
5.4 NICKEL CHROMIUM STEEL

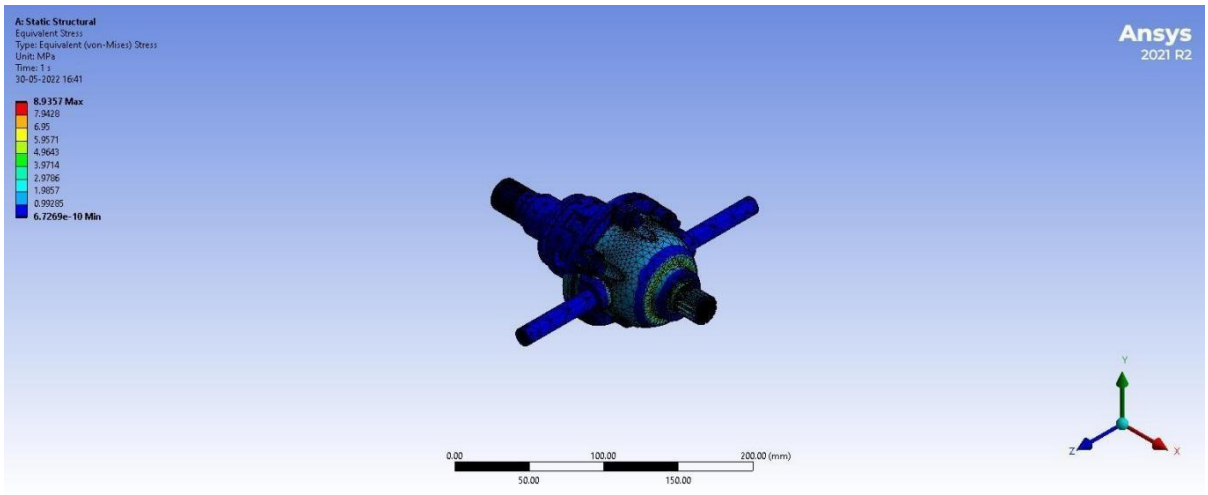


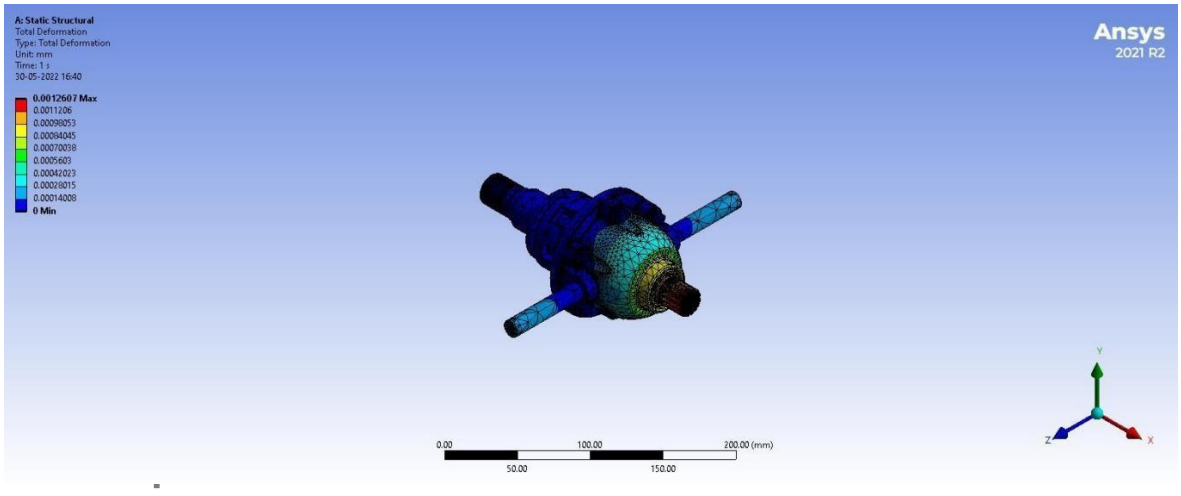

A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1 s
21-05-2022 08:39
23.79 Max
21.147
18.504
15.86
13.217
10.574
7.9301
5.2868
2.6434
1.2609e-9 Min
Ansys
2021 R2
0.00
100.00
200.00 (mm)
50.00
150.00
Y
X
Z


A: Static Structural
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1 s
21-05-2022 08:38
0.0010544 Max
0.00093727
0.00082011
0.00070295
0.00058579
0.00046863
0.00035148
0.00023432
0.00011716
0 Min
Ansys
2021 R2
0.00
100.00
200.00 (mm)
50.00
150.00
Y
X
Z

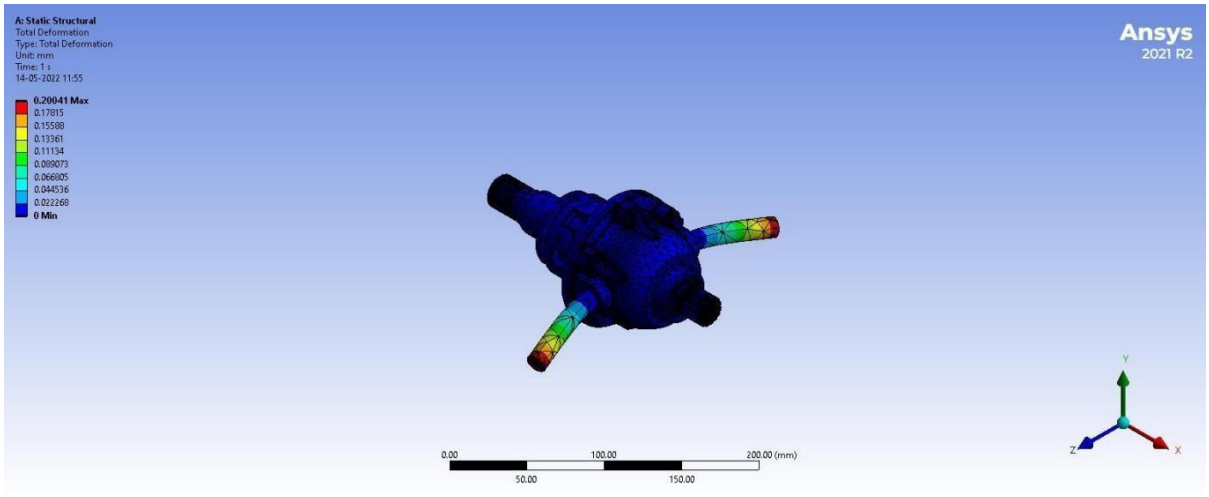
5.5 ALUMINIUM ALLOY

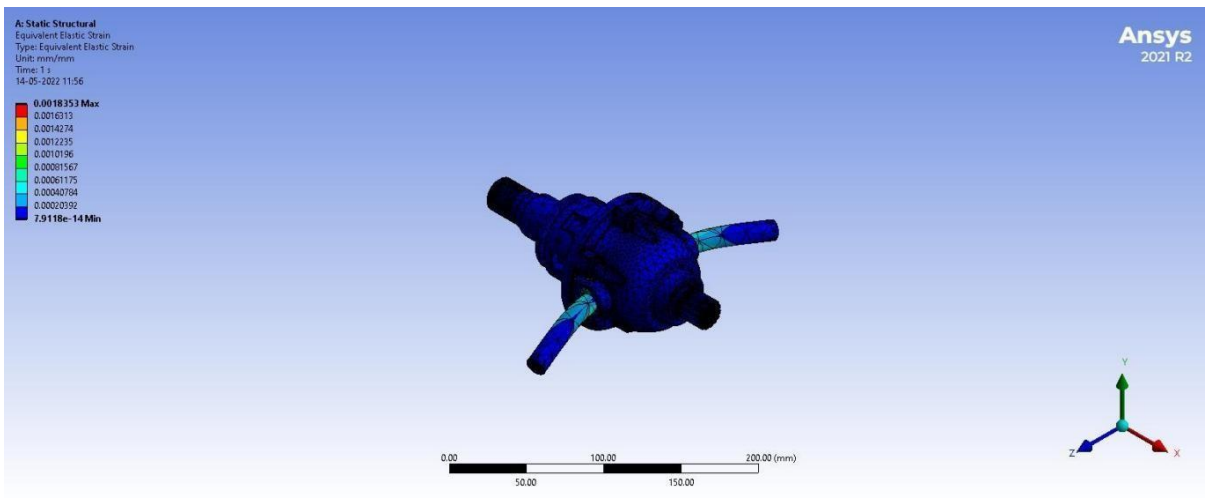


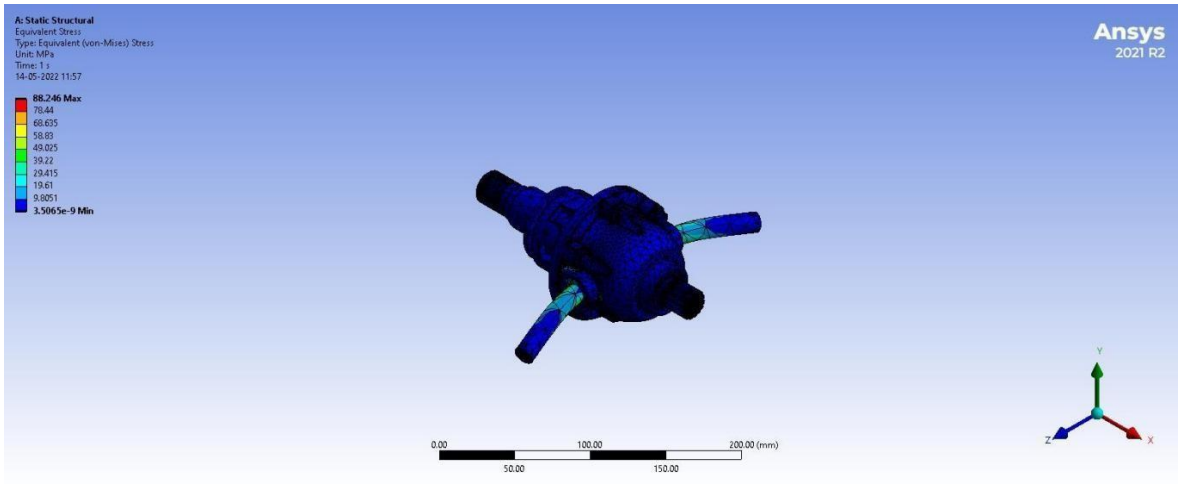




5.6 MALLEABLE CAST IRON







CHAPTER- 6

RESULT AND DISCUSSION

6.1 RESULTS AT DIFFERENT RPM

Tables shows the stress, strain and deformation of 3 materials at different speeds

1.5000 RPM

TANGENTIAL	**NI CR ALLOY STEEL**	**ALUMINIUM ALLOY**	**MALLEABLE CAST IRON**
LOAD(N)	1818.54	15195.22	1770.24
DISPLACEMENT (mm)	0.0054118	0.0131944	0.00548866
STRESS(N/mm2)	2.584	1.70369	2.01578
STRAIN	0.007072	0.01519	0.02311
STATIC			
LOAD(N)	5614.19	18143.3	37933.7
DISPLACEMENT (mm)	0.164853	0.150036	0.117614
STRESS(N/mm2)	74.4963	22.6949	43.1949
STRAIN	0.000309415	0.000274774	0.000199826

2. 6400 RPM

TANGENTIAL	NI CR ALLOY STEEL	ALUMINIUM ALLOY	MALLEABLE CAST IRON
LOAD(N)	915.177	1276.19	1416.19
DISPLACEMENT (mm)	0.00268949	0.01555	0.00439091
STRESS(N/mm2)	1.03521	1.36296	1.61261
STRAIN	0.01134	0.01215	0.01849
STATIC			
LOAD(N)	56141.9	18143.3	37933.7
DISPLACEMENT (mm)	0.146873	0.11763	0.117614
STRESS(N/mm2)	61.8853	19.3772	41.8212
STRAIN	0.000290205	0.000256567	0.000198329

3.2400 RPM

TANGENTIAL	NI CR ALLOY STEEL	ALUMINIUM ALLOY	MALLEABLE CAST IRON
LOAD(N)	2093.8	2922.51	3243.08
DISPLACEMENT (mm)	0.0071615413	0.0241696	0.0100566
STRESS(N/mm2)	2.29414	3.19018	3.575744
STRAIN	0.00700	0.02802	0.01142
STATIC			
LOAD(N)	56141.9	18143.3	37933.7
DISPLACEMENT (mm)	0.164988	0.150063	0.11763
STRESS(N/mm2)	63.5052	19.8068	41.8212
STRAIN	0.000280882	0.000258239	0.000198329

CHAPTER – 7

APPLICATIONS, CONS & PROS

7.1 Advantages

- Compact
- Light weight
- Reduction ratio of even 20:1 is possible by this method.
- Worm shaft is placed higher in this arrangement near the underbelly of the chassis thus less prone to damage.
- Entire structure is centralized in terms of mass & since C.G. is in the center the positioning is easier.
- The entire differential offers rotational flexibility about the drive axle axis thus the worm shaft can be tilted at any angle without any trouble or complications. This will not affect the design calculations nor increase design complexity.
- The entire enclosure floats around the mechanism. Once disconnected from its mounting, both the shells can come apart offering maintenance worker complete access to the mechanism from any angle.
- Design is very simple and has good serviceability.

7.2 Disadvantages

- Limited efficiency at best up to 95%.
- Due to poorer efficiency, temperature rise must be within permissible limits or else seals may get damaged. Also excessive temperature could lead to tooth failure due to seizure.
- The entire system is made of two metals. The worm wheel normally has to be made of a more conformable metal (such as Phosphor Bronze).This may increase costs.

- If the gearing size requirement is larger (for increased torque transmitting capacity), height increases.
- Since the worm wheel is made out of phosphor bronze, whose wear strength is not as high as that of alloy steels, the frequency of replacement of
  worn out parts may be greater.

7.3 APPLICATIONS

- Gear assembly that permits the shafts to turn in different speed while continuing transmit torque.
- Differential applications
    1. rear drive axle – front engine rear wheel drive vehicles.
    2. transaxles – front engine front wheel drive and rear engine rear wheel drive vehicles.
    3. front drive axles and rear drive axles – four wheel drive vehicles.
    4. transfer case of some four wheel drive vehicles.

CHAPTER – 8
CONCLUSION AND FUTURE SCOPE

8.1 CONCLUSION

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, 5000rpm and 6400 rpm, the values are less for Aluminum alloy than Alloy Steel and Cast Iron. By observing the frequency analysis, the vibrations are less for Aluminum Alloy than other two materials since its natural frequency is less. And also weight of the Aluminum alloy reduces almost 3 times when compared with Alloy Steel and Cast Iron since its density is very less. Thereby mechanical efficiency will be increased. By observing analysis results, Aluminum Alloy is best material for Differential.

8.2 FUTURE SCOPE

In future very large scope for the different material property for the Triple reduction gearbox casing and also for this design improvement. In future modification in design can be made in order to minimize the weight and size of the casing. Also, one can test the same model for more materials and obtained the better results deformation and stores

The efficiency mainly gets influenced by the velocity ratio as well as the worm Pitch Circle Diameter (P.C.D.). The lower the velocity ratio and greater the size of the worm P.C.D. the more efficient the system becomes. This in turn reduces power lost as heat as well as the overall heat dissipation requirements of the system. Since phosphor bronze is an expensive alloy and it has a greater tendency to wear, the best way to save money would be to cast only the outer half of the worm wheel from phosphor bronze and then bolt it onto a cheaper cast iron inner wheel. The miter gears will then be pivoted on the pin shaft made of grey cast iron which is much cheaper. This way less phosphor bronze is consumed per unit of production, reducing material cost. But at the same time the mating surface will have to be machined so this increases production time and cost slightly. The pivoted bevel gears need not be of the same dimensions as those mounted on the drive axles. They can be of smaller size, thus reducing weight even further &/or making system more compact.

CHAPTER – 9

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