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# Design and Analysis of Open Type Differential Gear Box

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***Abstract***—*The main objective of this project is to perform structural analysis of open type differential gears in gear box. We have taken different aluminum alloy and malleable cast iron materials for conducting the analysis. Presently used materials for gears and gears shafts is Cast Iron, Cast Steel. So, in this paper we are checking as the aluminum alloy can be the other material for the differential gear box for light utility vehicles so, we can reduce the weight. The analysis is to be on Abaqus CAE software. It's a product of Solid works. In the present work all the parts of differential are designed under static condition and modelled. Modelling and assembly are done in SOLIDWORKS.*

***Keywords*—*ABAQUS,Open type car differential gear box,SOLIDWORKS, Structural analysis***

## I. INTRODUCTION

A differential is a device, usually but not necessarily employing gears, capable of transmitting torque and rotation through three shafts, almost always used in one of two ways: in one way, it receives one input and provides two outputs this is found in most automobiles and in the other way, it combines two inputs to create an output that is the sum, difference, or average, of the inputs. In automobiles and other wheeled vehicles, the differential allows each of the driving road wheels to rotate at different speeds, while for most vehicles supplying equal torque to each of them. A vehicle's wheels rotate at different speeds, mainly when turning corners. The differential is designed to drive a pair of wheels with equal torque while allowing them to rotate at different speeds. In vehicles without a differential, such as karts, both driving wheels are forced to rotate at the same speed, usually on a common axle driven by a simple chain drive mechanism. When cornering, the inner wheel needs to travel a shorter distance than the outer wheel, so with no differential, the result is the inner wheel spinning and/or the outer wheel dragging, and this results in difficult and unpredictable handling, damage to tires and roads, and strain on (or possible failure of) the entire drive train[3].

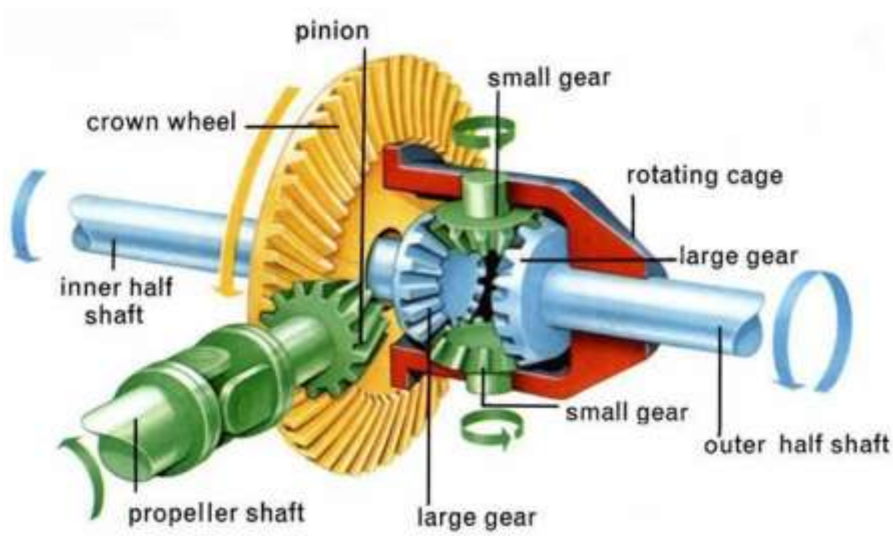


**Figure 1:Open type differential**

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## II. OBJECTIVES

• Creating the frictional contact between two mating gears.

• Structural analysis on gear box by providing the torque to the sun gear in the differential gear box.

• Calculating total deformation and Von-Missesstresses[4].

## III. ABAQUS

ABAQUS/CAE is a software used for both the modelling and analysis of mechanical components and assemblies and visualizing the finite element analysis result. It provides a complete interactive environment for creating abaqus models, submitting and monitoring analysis jobs and viewing and manipulating simulation results.

Important features of abaqus:

- Creating parts using the feature-based modeler.
- Importing parts into abaqus/ CAE.
- Partitioning parts.
- Meshing.
- Defining analysis attributes.
- Submitting and managing abaqus simulations.
- Viewing the results of the simulations.

Every complete finite element analysis consists of 3 separate stages:

- Pre-processing or modelling: This stage involves creating an input file which contains an engineer's design foe a finite element analyzer (also called "solver").
- Processing or finite element analysis: This stage produces an output visual file.
- Post-processing or generating report ,image,animation, etc. from the output file: This stage is a visual rendering stage[7].

## IV. METHOD

### 4.1Specifications of differential gear box

The main aim of the project is 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 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, 5000 rpm and 6400 rpm. Analysis is also conducted by varying the different composites materials for gears. Differential gear is modeled in SOLIDWORKS. The ABAQUS CAE software were used as the analysis tool for determining the structural behavior of various composites under the given loading conditions[6].

Specifications of used axle:-

Gear profile: - 20-degree full depth involute profile (standard)

Pressure angle (α):- 20 degree

Bevel gear arrangement = 90 degree

Pitch cone Angle (φ) = 45 degree

Back cone Angle (β) = 45 degree

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Number of teeth on ring gear = $Z_g$ =60

Module = 5

**4.3Calculations for sun gear and spider gear**

1. Pitch circle diameter (D)

Diameter of sungear =Dg=290mm

Considering diameter of pinion =Dp=70mm

2. Number of tooth on gear

Number of teeth on gear = Zg =20

Number of teeth on pinion = Zp = 20

D=Dg+Dp=360 mm

T= Zg+ Zp = 40

3. Module = M=D/T=360/40=9(according to stds)

4. Velocity Ratio

V.R = Zg/Zp = DG/DP=NP/NG

V.R = Dg/Dp =290/70=4.142

V.R=NP/NG

4.142=2400/NG

NG=576.43rpm

5. Pitch angle

Since the shafts are at right angles therefore pitch angle for the pinion = θp1=tan-1(1/v.r)

=tan-1(1/4.142)

=13.57

Pitch angle of gear θp2=90°-13.57=76.43

6. Formative Number OfTeeeth

For the pinion = Zep = Zp secθp1=20sec(13.57) =37.22

For the gear = Zeg = Zg secθp2= 20sec(76.43) =38.963

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7. Pitch Cone Distance (AO):

AO = 82.7mm

8. Face Width (b): 82.7/3 = 27.5 mm[6]

### 4.4 Material properties

**TABLE 1**
**PROPERTIES OF MALLEABLE CAST IRON**

| Name | Malleable cast iron |
|---|---|
| Model type | Linear elastic isotropic |
| Default failure criterion | Max von mises stress |
| Yield strength | 2.75742e+0.008 $N/m^2$ |
| Tensile strength | 4.13613e+0.008 $N/m^2$ |
| Elastic strength | 1.9e+011 $N/m^2$ |
| Poisson's ratio | 0.27 |
| Mass density | 7300 $kg/m^3$ |
| Shear modulus | 8.6e+010 $N/m^2$ |

**TABLE 2**

**PROPERTIES OF ALUMINIMUM ALLOY**

| Name | Al_alloy7475-1761 |
|---|---|
| Model type | Linear elastic isotropic |
| Default failure criterion | Max von mises stress |
| Yield strength | 1.65e+0.008 $N/m^2$ |
| Tensile strength | 3.0e+0.008 $N/m^2$ |
| Elastic strength | 7e+011 $N/m^2$ |
| Poisson's ratio | 0.33 |
| Mass density | 2600 $kg/m^3$ |
| Shear modulus | 3.189e+010 $N/m^2$ |

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### 4.5 Solid modelling of differential

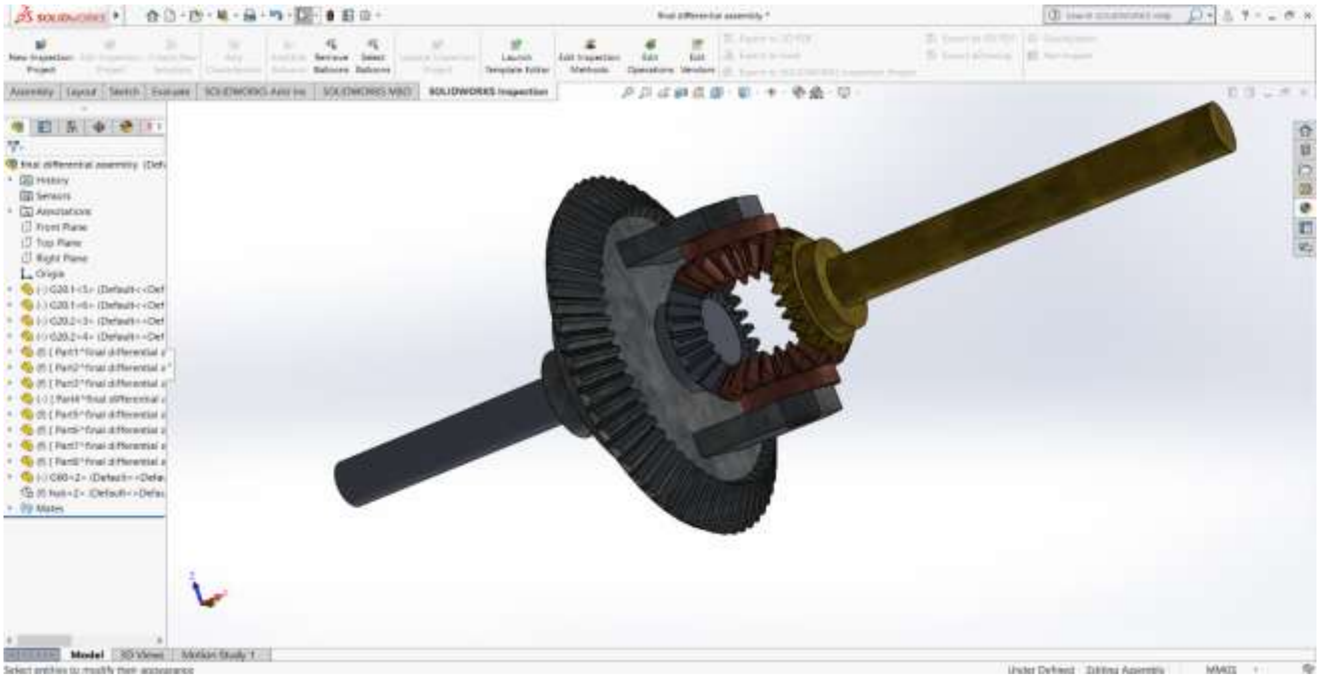

**FIGURE2:Final assembly of Differential Gear box in SOLIDWORKS**

### 4.6 Structural analysis of on ABAQUS software

The assembly of differential is imported on Abaqus software in .igs or .iges format.Its application used for both the modelling and analysis of mechanical components and assemblies (pre-processing)and visualizing the finite element analysis result.

## V.CONCLUSION

Observing the structural analysis results using Aluminum alloy the stress values are within the permissible stress value. The present work relates to differential gear box as an effective alternative to existing metallic open type differential gearbox. Computer aided engineering software is found to be useful tool for various design stages. Reference model of Differential gear box is selected and SOLIDWORKS is used to develop various parametric models. The torque applied to differential gear box would be 140 ,235 ,320 Nm. Different aluminum alloy material is used for gears and are analyzed using ABAQUS for equivalent (Von-Misses) stress, displacement (total deformation). Comparisons of various stress and strain results with different aluminum alloy and metallic materials (Alloy Steel and Cast Iron) and at different rpm are to be performed[3].

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