Design and Analysis of Differential Gear Box

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Abstract

Differential is an essential part of any four wheeled vehicle. A differential allows wheels of a vehicle to rotate at different speeds. This is necessary when the vehicle turns. The Differential gear is a part for all four wheelers, wheel reserved the power from engine to gear box then by drive shaft to differential gear. Differential innovation was created hundreds of years prior and is viewed as a standout amongst the most astute developments human reasoning has ever delivered the car differential enables a vehicle to turn a corner while shielding the wheels from sliding. In automotive mechanics, gear arrangement that permits power from the engine to be transmitted to a pair of driving wheels, dividing the force equally between them but permitting them to follow paths of different lengths, as when turning a corner or traversing an uneven road. On a straight road the wheels rotate at the same speed; when turning a corner, the outside wheel has farther to go and will turn faster than the inner wheel if unrestrained.

The Wheels are taking the force power from the engine by a drive shaft. The wheels that get power and make the vehicle push ahead are known as the drive wheels. The fundamental capacity of the differential rigging is to permit the drive wheels to turn at diversely RPMs while both are getting power from the motor engine, Power from the engine is flowed to the wheels via a drive shaft.

The main objective of this paper is to perform mechanical design of differential gear box and analysis of gears in gear box. We have taken grey cast iron and aluminium alloy 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 aluminium can be the other material for the differential gear box for light utility vehicles so, we can reduce the weight.

Keywords: *Differential gear box, cast iron, Cast steel.*

1. 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 reflect available information about the market and 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.

2. NEED OF DIFFERENTIAL

Car wheels spin at different speeds, especially when turning. Each wheel travels a different distance through the turn, and that the inside wheels travel a shorter distance than the outside wheels. Since speed is equal to the distance travelled divided by the time it takes to go that distance, the wheels that travel a shorter distance travel at a lower speed. Also note that the front wheels travel a different distance than the rear wheels. For the non-driven wheels on your car --the front wheels on a rear-wheel drive car, the back wheels on a front-wheel drive car --this is not an issue. There is no connection between them, so they spin independently. But the driven wheels are linked together so that a single engine and transmission can turn both wheels. If your car did not have a differential, the wheels would have to be locked together, forced to spin at the same speed. This would make turning difficult and

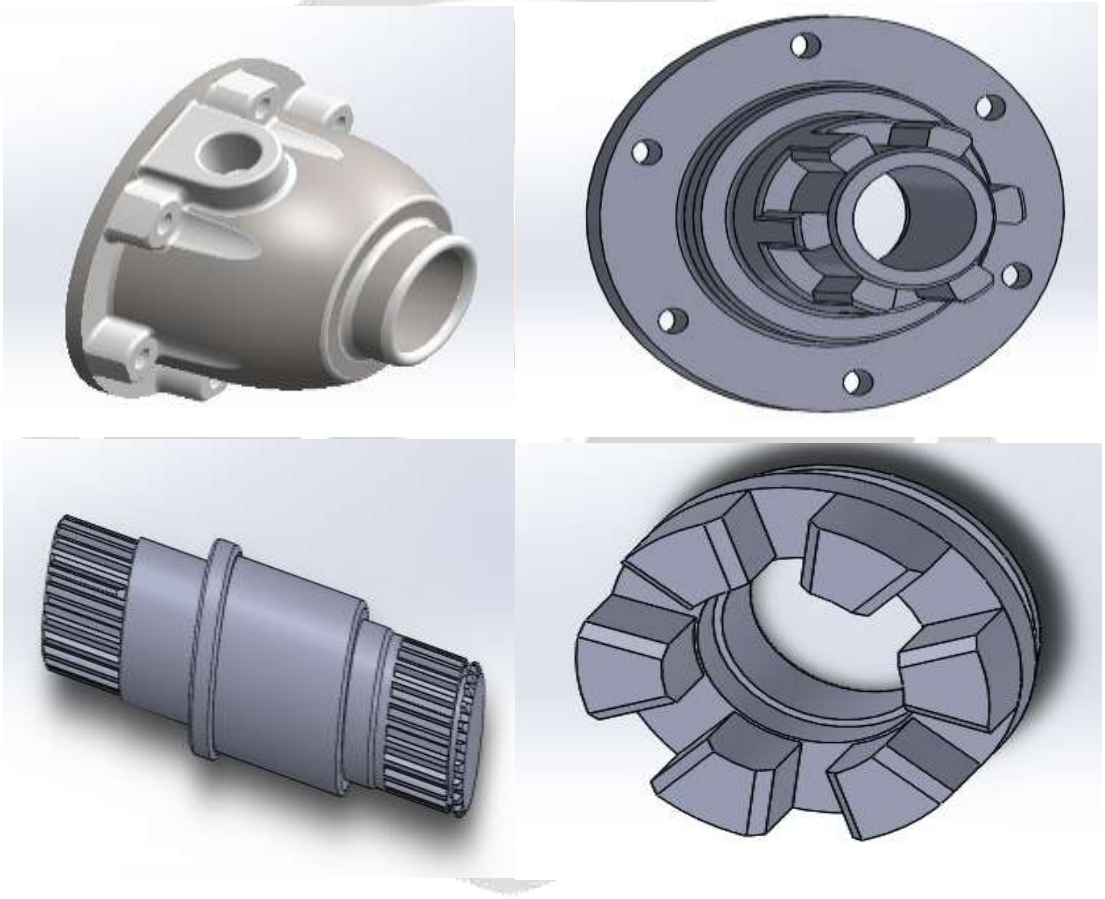
hard on your car: For the car to be able to turn, one tire would have to slip. With modern tires and concrete roads, a great deal of force is required to make a tire slip. That force would have to be transmitted through the axle from one wheel to another, putting a heavy strain on the axle components.

3. APPLICATIONS

A gearbox is precisely bored to control gear and shaft alignment. It is used as a housing/container for gear oil. It is a metal casing for protecting gears and lubricant from water, dust and other contaminants. The automotive differential is designed to drive a pair of wheels 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.

4. DESIGNING OF DIFFERENTIAL

Designing of differential is done on solidworks software. The dimensions are taken according to requirement. Differential is made up of different parts which is merged later. The different parts are shown in figure 1.



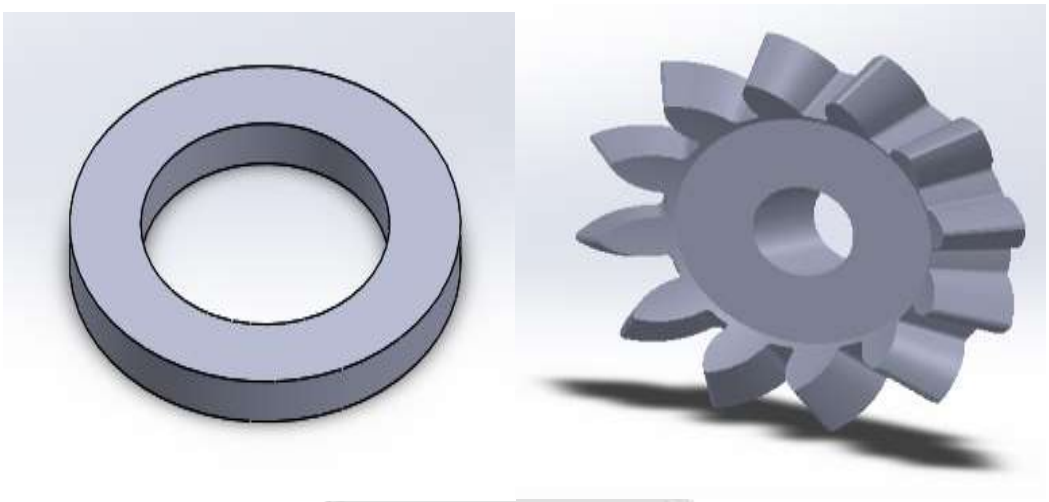


Fig.1 Differential parts

And the whole differential assembly is as shown in figure 2.

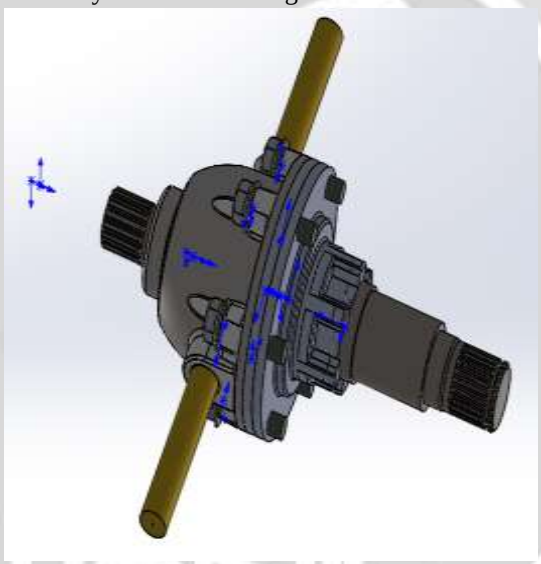
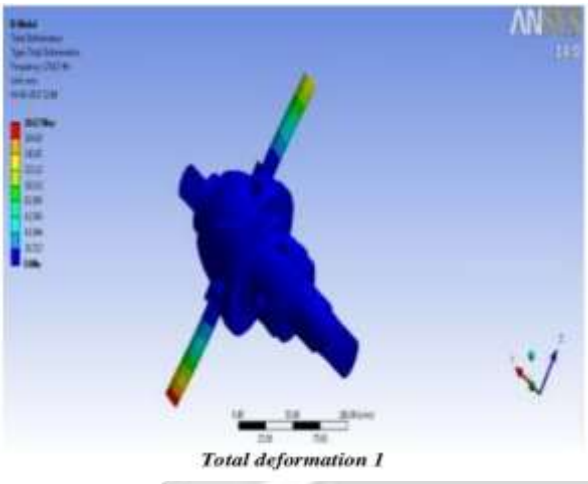


Fig.2 Differential assembly

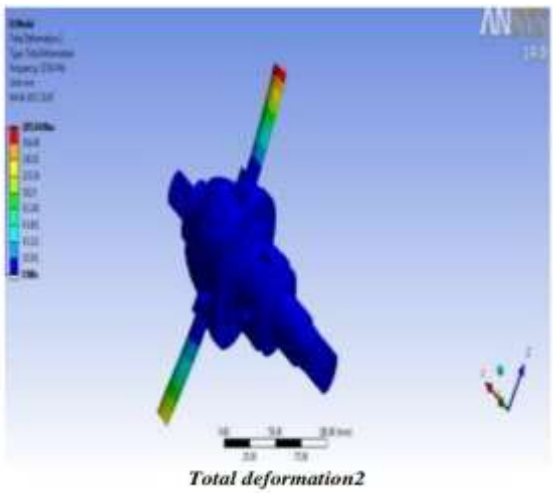
5. ANALYSIS

In any designing of differential is done is to improve efficiency by increasing its strength decreasing its weight and by changing its structure either chain differential or spur gear differential. This development of differential improves its efficiency from cracking expired it load acting on it. The differential gears assembly and its housing are analyzed for the vibrational effect on a system in which the life of the gears is determined within different frequency range in the platform of Ansys-14.0 with use of solidworks modeling. In this type of analysis, the gear housing is also affected by vibration in casing that surrounds the gear box. The main objective of gear is to protect and to provide a safe platform to get good gear transmission. The main aim of this analysis id to focus on the mechanical design and analysis on assembly of gears in gear box when they transmit power at different speeds i.e- 2500 rpm, 5000 rpm and 7500 rpm. Analysis is also conducted by varying the materials for gears, Cast Iron, Cast Steels and Aluminum Alloy. Presently used materials for gears and gear shafts is Cast Iron, Cast steel. In this paper to replace the materials with Aluminum material for reducing weight of the product.

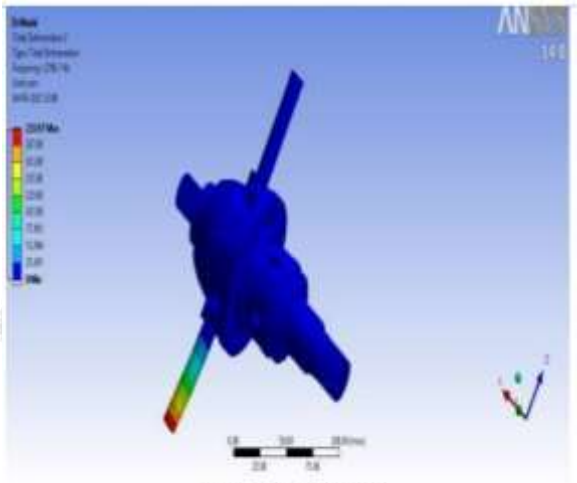
MODAL ANALYSIS: After analysis of all the stresses and formulation the following natural frequencies are obtained as shown in figure 3.



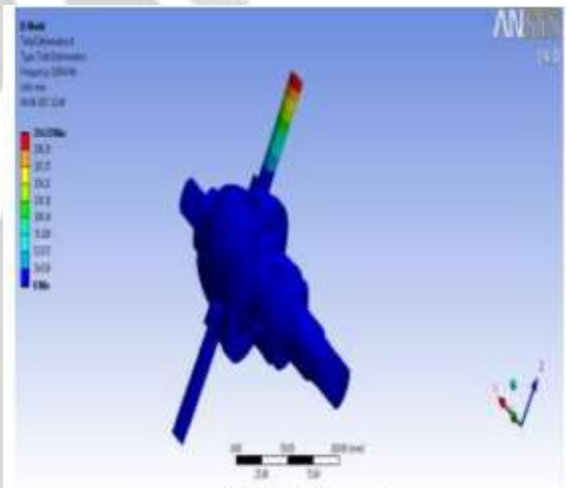
Total deformation 1



Total deformation2



Total deformation 3



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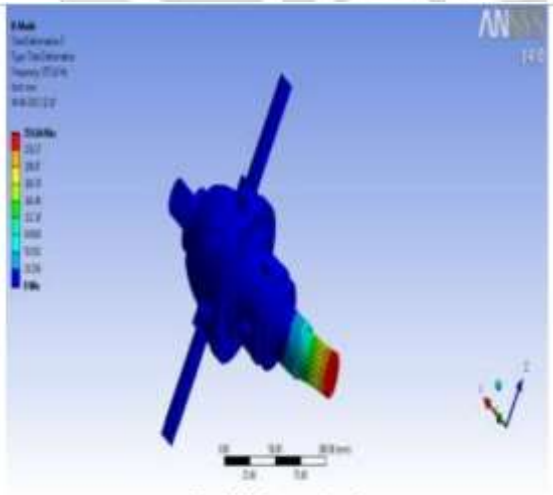

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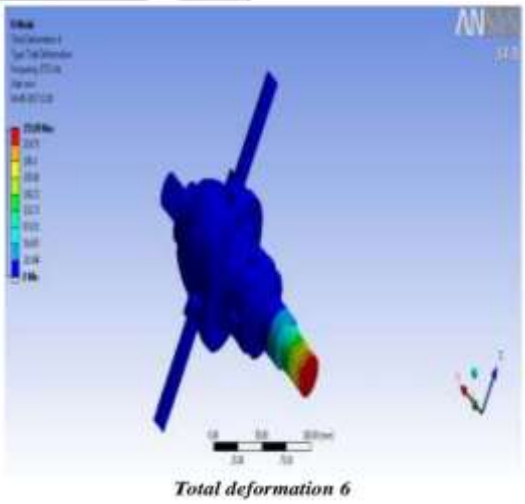

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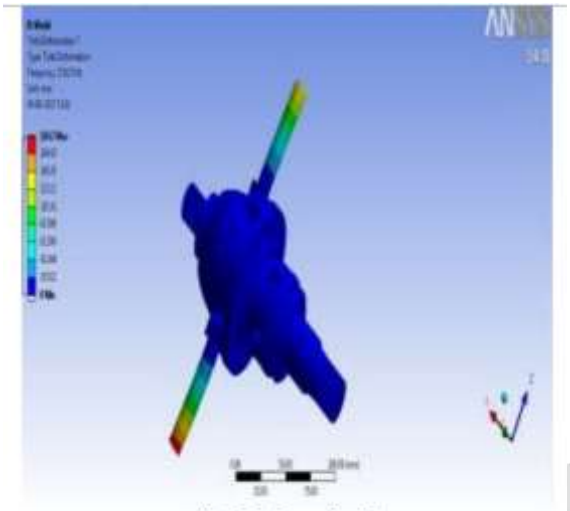

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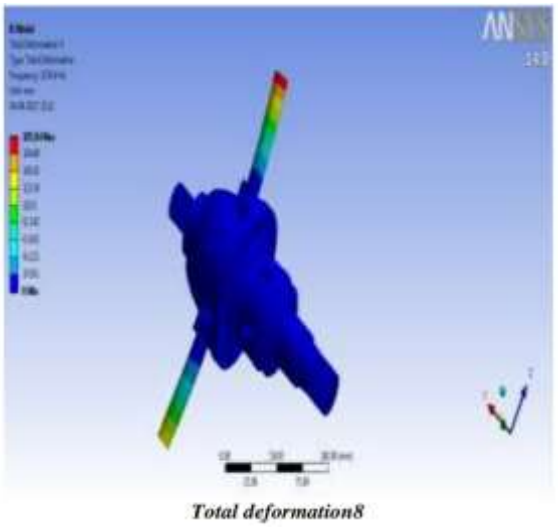
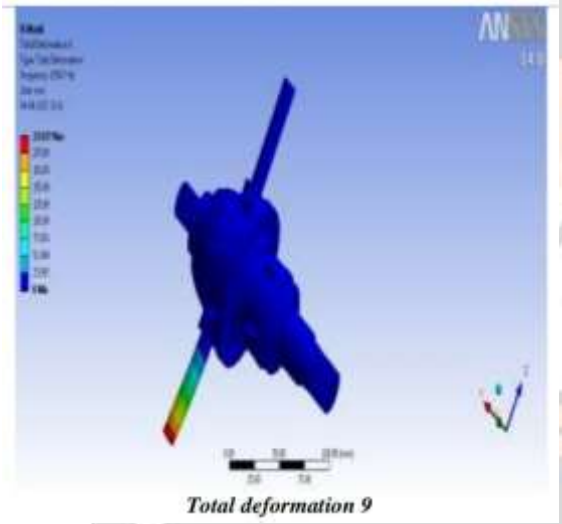


Total deformation8



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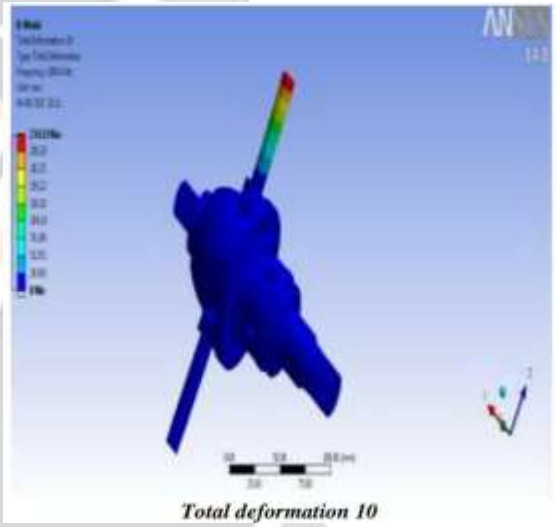

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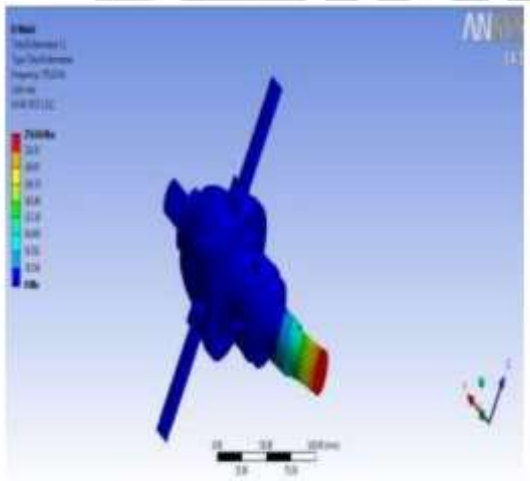

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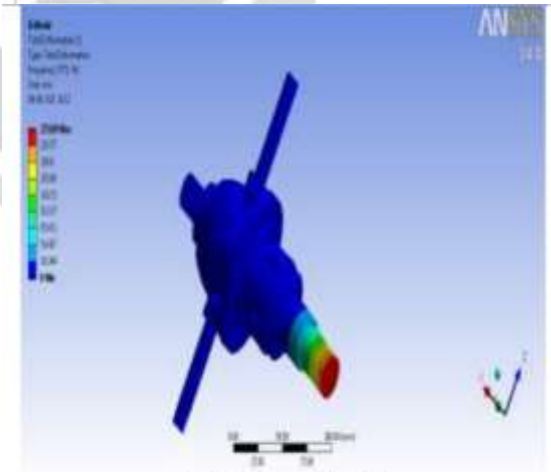

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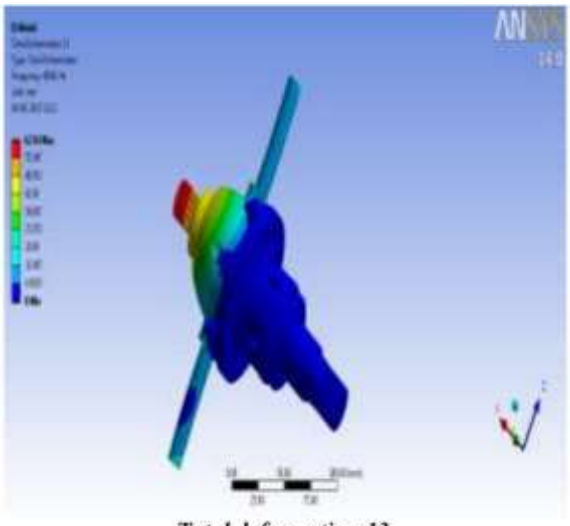

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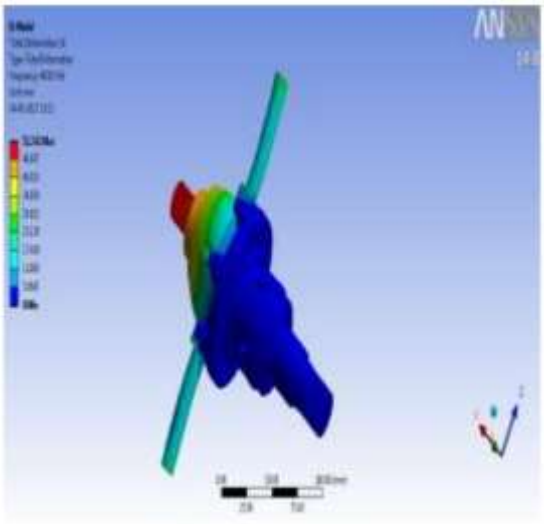

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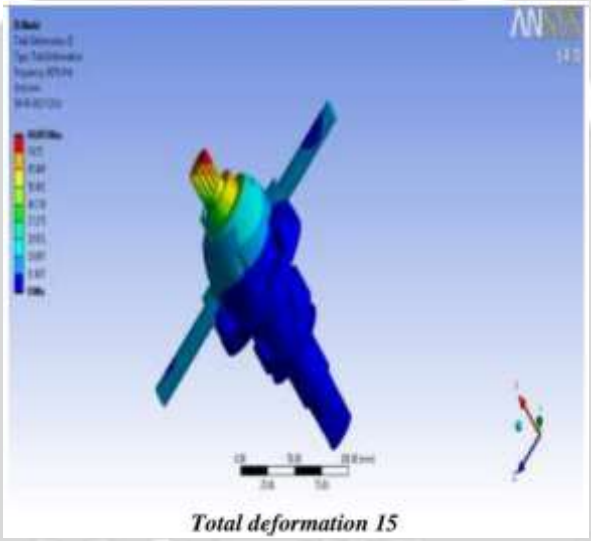

Total deformation 15

Fig.3. Natural frequencies and deformations

6. LIST AND DISCUSSION:

Table 1 shows material specification used for FEA analysis.

Table 1: MATERIAL SPECIFICATION

SR 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

7. RESULTS AT DIFFERENT RPM:

Table 2, 3 and 4 show stress and strain pattern at different RPM.

TABLE 2: 5000 RPM

TANGENTIAL	NI CR ALLOY STEEL	ALUMINIUM ALLOY	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

TABLE 3: 6400 RPM

TANGENTIAL	NI CR ALLOY STEEL	ALUMINIUM ALLOY	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

TABLE 4:2400 RPM

TANGENTIAL	NI CR ALLOY STEEL	ALUMINIUM ALLOY	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

8. 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.

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