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MODELING, DESIGN & ANALYSIS OF DIFFERENTIAL GEAR BOX AND ITS HOUSING THROUGH FEM, SOLIDWORK & ANSYS BENCHWORK 14.0

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ABSTRACT
In this paper the differential gears assembly and its housing are analyzed for the vibrational effect on a system in which the life of the gears is detrmined 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 effected 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. 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 & it is also helps as the reduction in gearing friction. And enhance the life of the gear. Hence will subjected to vibration so it becomes compalsary to calculate the response of differential gear housing in different vibration conditions and it is also finding there natural frequencies. 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. This vibration analysis is done by using ANSYS 14.0 software as a computational technique and validation and the modeling of differential gear box is done by using of SOLIDWORKS.

KEYWORDS: differential gears, natural frequency, Ansys 14.0.

I. INTRODUCTION
In automobiles and other wheeled vehicles, the differential permit the outer drive wheel for rotating faster than the inner drive wheel on the time of a turn. This is must when the vehicle makes a turn, making the wheel when that is traveling around the outside of the turning curve roll farther and faster than the other. The average rotational speed of the two driving wheels which is 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 wheel.

Heavy vehicle transmission systems are subjected to noise and vibration under excitation condition. Internal excitation forces, meshing forces, load and speed variation and gear defects are one of the major sources of excitation. Automobile differential gearbox is an assembly of gears to meet the torque variation for dividing the speed of the wheel on turning conditions. The speed at the input shaft is maximum which is minimise at output shaft to increase torque value. High value of torque is transmitted to drive shaft. Noise and vibration reduction in heavy vehicle transmission system is a constant development, because noise and vibration are the two reasons for transmission failure. Mechanical properties of material influence the vibration signature pattern. The simulation results show that natural frequencies and mode shapes show different characteristics as we change the materials. Grey cast iron have damping property to reduce the vibration effect so it is used as automobile casing materials but structural steel have high density, it is used as casing material for heavy static machinery in industrial application.

Research Aim
- To design a gear box housing under the plateform of solodwork.
- To findout the natural frequencies of gearbox under different condition through ansys 14.0.
- To findout the stress and torque gererated in gearbox under different conditions.

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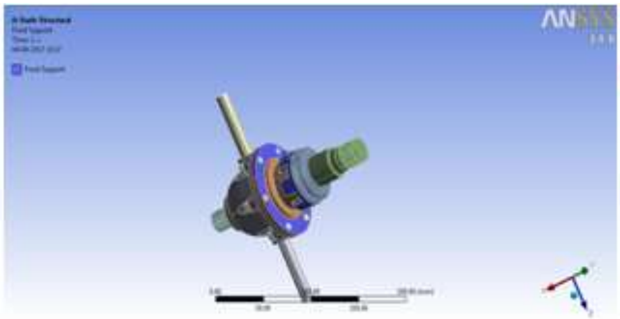
Analysis work

The project is divided into two domains:

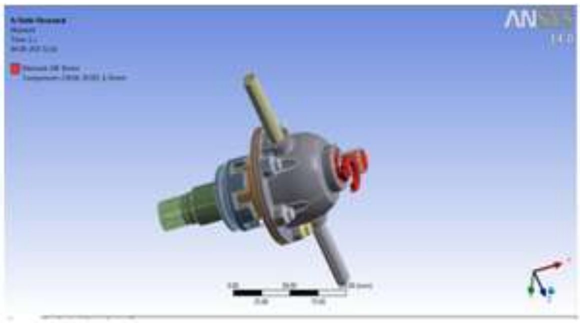
1. Modal Analysis
2. Stress analysis

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 14.0 and modeled in SOLIDWORKS by applying boundary conditions and forces which are calculated by the data provided by the instructor .



Fixed support



moment

1.1 **Model analysis** it is a term used to described the processes employed to extract a structure's modal properties (natural frequencies, modal damping factors, and mode shapes) from information about the structure that can be presented in a different form of formats. When these properties are extracted from a theoretical analysis of the dynamic behavior

1.2 **Gear mesh frequency** This type of frequency most commonly used with the gears & it is equal to the number of teeth on the gear multiple of the running speed of its shaft. A typical gearbox will have multiple gears and therefore multiple gear meshing frequencies. A normal gear mesh signature having low amplitude of gear mesh frequency with a series of symmetrical sidebands, spaced at the exact running speed of the shaft, on each side of the mesh components. The spacing and amplitude of these side bands is likely symmetrical if the operation of gearbox is normal. Any deviation in the symmetry of the gear mesh signature is an indication of incipient gear problems.

Modeling of gear

Modeling is a consistent set of principles for mathematical and computer modeling of three dimensional solids. Solid modeling is distinguished from related areas of geometric modeling and computer graphics by its emphasis on physical fidelity. Together, the principal of geometric and solid modeling from the foundation of computer aided design and in general support the creation, exchange, visualization, animation, interrogation, and annotation of digital models of physical objects.

II. CALCULATIONS OF A CROWN GEAR AND PINION

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 frequencies. Differential gear is modeled in Solidwork . The ANSYS 14.0 fem software were used as the analysis tool for determing the structural behaviour of various composites under the given loading conditions.

Specifications Of Used Heavy Vehicle

ASSUMPTIONS:

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

- bevel gear arrangement = 90 degree
- Pitch cone Angle (φ) = 45
- Back cone Angle (β) = 45
- Module (M) = 10
- Number of teeth on gear = Zg =50
- Number of teeth on pinion = Zp = 8

Velocity Ratio (V.R)
V.R=TG/TP= DG/DP=NP/NG
V.R=TG/TP=50/8=6.25
V.R=NP/NG
6.25=2400/NG
NG=384rpm
Minimum no. of teeth on pinion (Zp)
For satisfactory operation of bevel gears the number of teeth in the pinion must not be less than
hence the assumed value of the pinion is in safe condition
Pitch circle diameter (D)
Pitch circle diameter for the gear (Dg) = M*Zg
Pitch circle diameter for the pinion (Dp) = M*Zp
Pitch angle (θ)
Since the shafts are at the right angles , the pitch
angle were given as:
For the pinion = θp1=tan-1(1/v.r)
Pitch angle of gear θp2=90°-9=81
formative number of teeth (Te)
for the pinion Zep= Zpsecθp1=8sec9 =8
for the gear = Zeg=Zgsecθp2=50sec81 =319.622

1. Pitch Cone Distance (AO):
   $AO=((d_1/2)^2+(d_2/2)^2)^{1/2}$
   AO=250mm
2. Face width (b)
   b=AO/3

or } which is lesser
b=10

III. CALCULATION OF GEAR AND PINION

1. Pitch circle diameter (D)

Diameter of sungear =Dg=150mm
Diameter of pinion =Dp=70mm

2. Number of tooth on gear

Number of teeth on gear = Zg =18
Number of teeth on pinion = Zp = 15
D=Dg+Dp=220
T= Zg+ Zp = 33

3. Module = M=D/T=220/33=6.66=7(according to stds)

4. Velocity Ratio

V.R = Zg/Zp = DG/DP=NP/NG
V.R = Dg/Dp =150/70=2.142
V.R=NP/NG
2.142=2400/NG
NG=1120.448rpm

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5. Pitch angle

Since the shafts are at right angles therefore pitch angle
for the pinion = θp1=tan-1(1/v.r)
=tan-1(1/2.142)=25.025
Pitch angle of gear θp2=90°-25.025=64.974

6. Formative Number Of Teeeth

For the pinion = Zep = Zp secθp1=15sec25.025 =16.554
For the gear = Zeg = Zg secθp2= 8sec64.974 =42.55

7. Pitch Cone Distance (AO):

$AO=((D_1/2)^2+(D_2/2)^2)^{1/2}$
AO = 82.7mm
8.Face Width (b): 82.7/3 = 27.5 mm

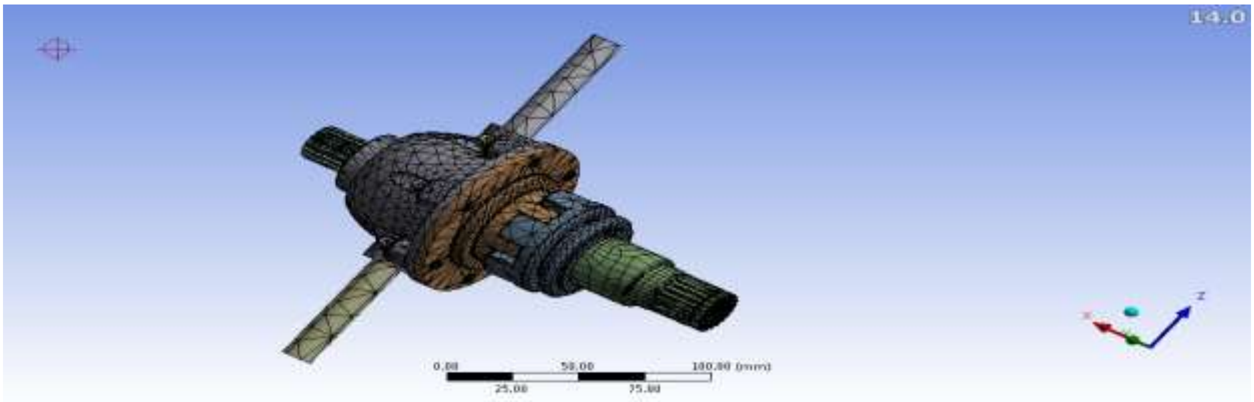
IV. FEM ANALYSIS OF THE GEAR

The finite element method (FEM) is a numerical method by which we can solve problems of engineering and mathematical physics. FEM is also known as finite element analysis (FEA). Complex problem areas of interest that contain structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The analytical method of solution generally requires solution to boundary problems for partial differential equations. This method is formulation of the problem results in a system of algebraic equations. The yields approximate values of the unknowns at discrete number of points over the domain.] To solve these problem, it is subdivides large problem into smaller and simpler parts that are called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. FEM then uses variational methods from the calculus of variations to approximate a solution by minimizing an associated error function.

V. MESHING OF GEAR ASSEMLY

A mesh is the Discretization of a component into a number of small elements of defined size. Finite element analysis is dividing the geometry into various small number of elements. These elements are connected to each other at a point called nodes. Each node may have two or more than two elements connected to it. A collection of these elements is called mesh.

Meshing is very important part of pre-processing in any FEA software. In ANSYS workbench there are many tools and option available to help for create an mesh.



Mesh model

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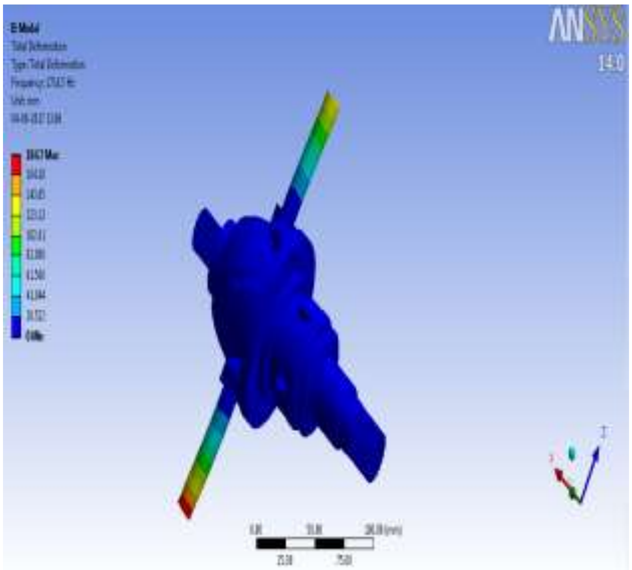
Problem formulation

A natural frequency, epitomize by resonance is the characteristics of the part or subassemblies of a required product. This becomes noteable 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 od 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

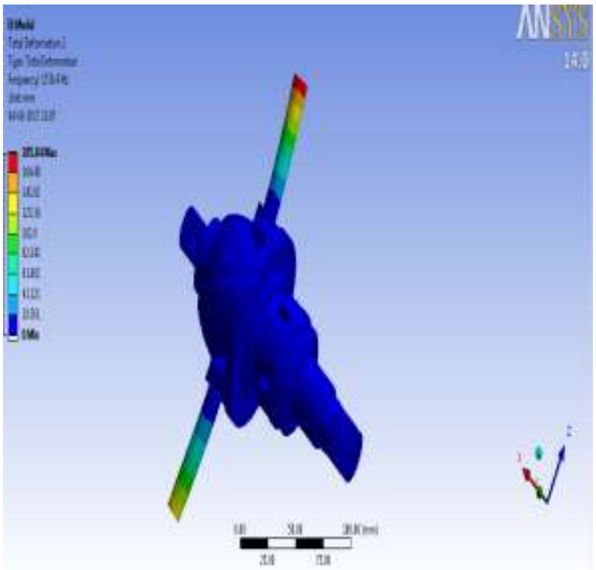
VI. RESULT

Modal analysis

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



Total deformation 1



Total deformation2

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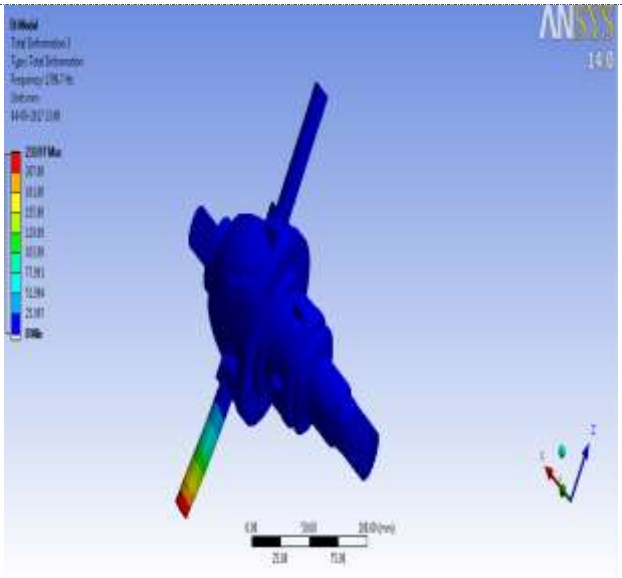
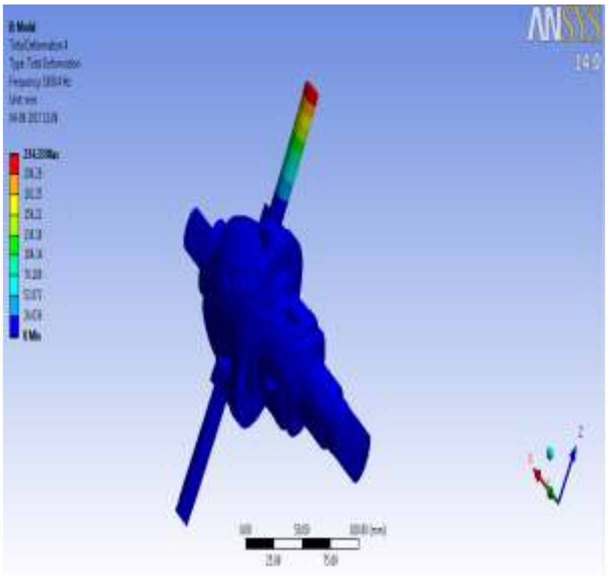


Total deformation 3



Total deformation 4

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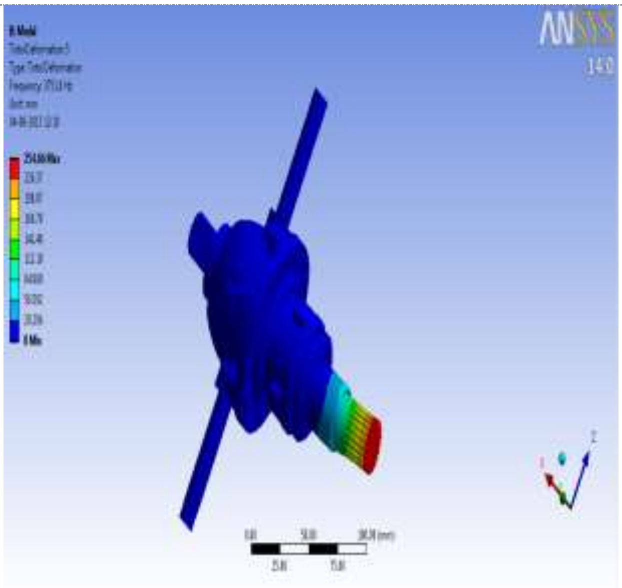
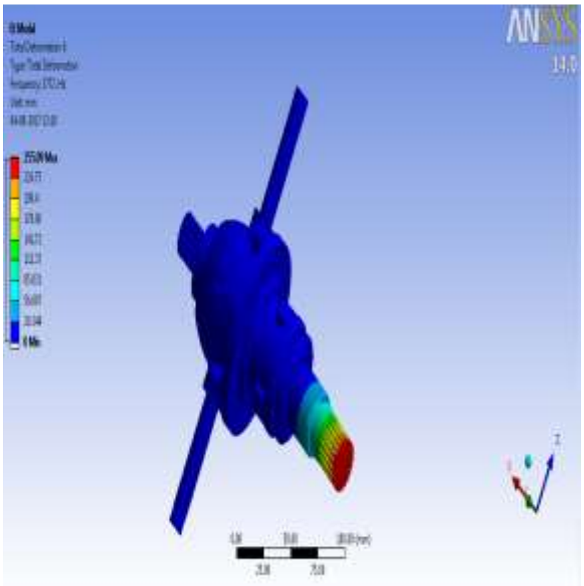


Total deformation 5



Total deformation 6

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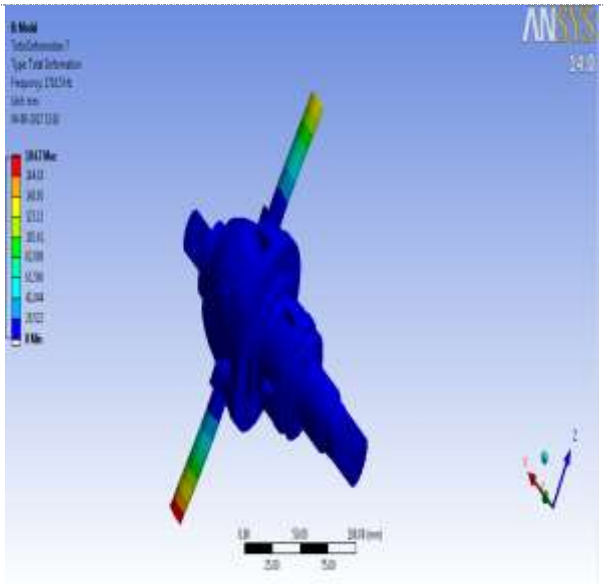
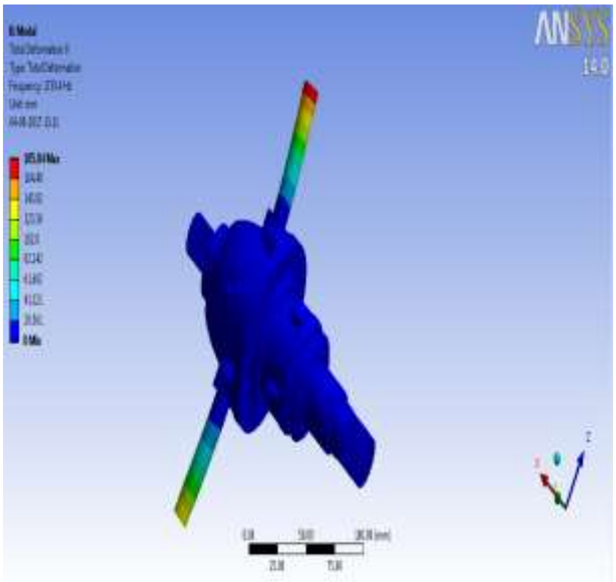


Total deformation 7



Total deformation8

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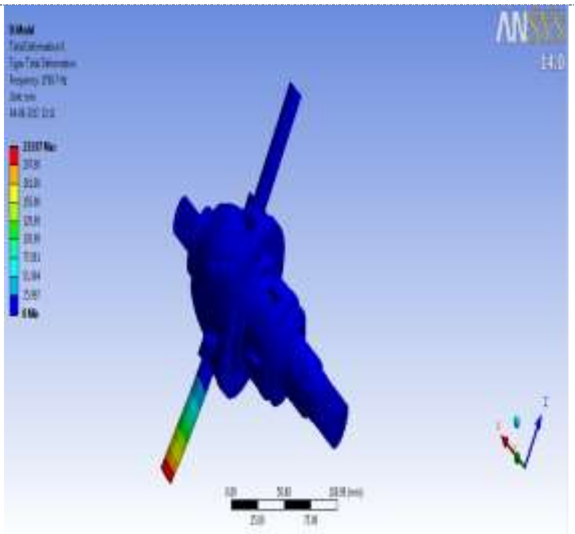
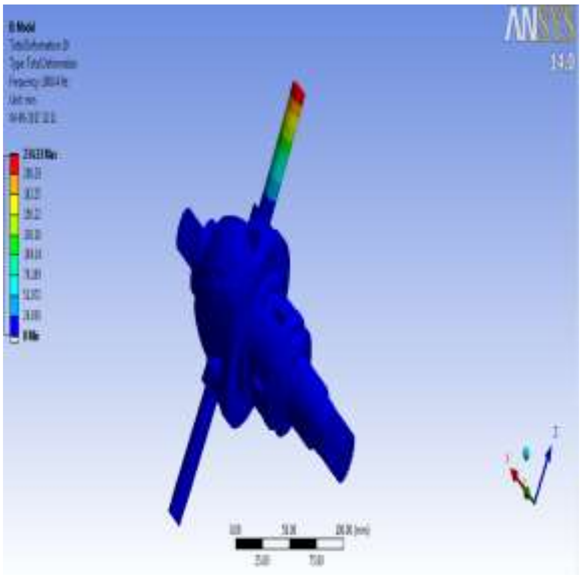
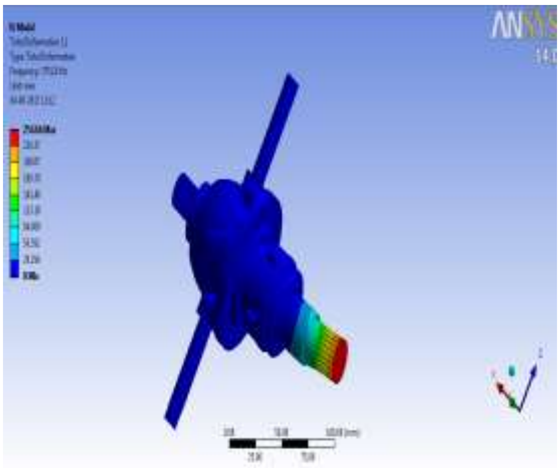


Total deformation 9



Total deformation 10



Total deformation 11

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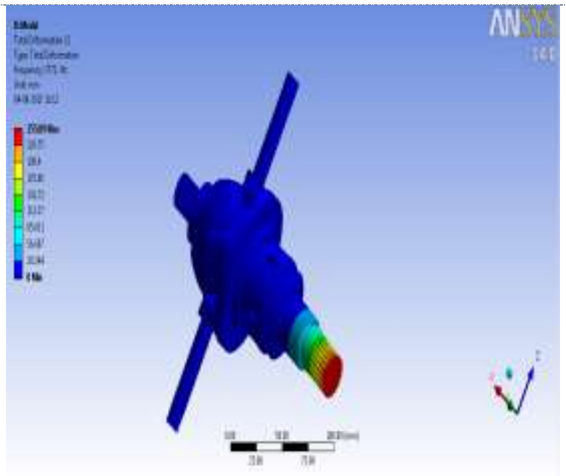
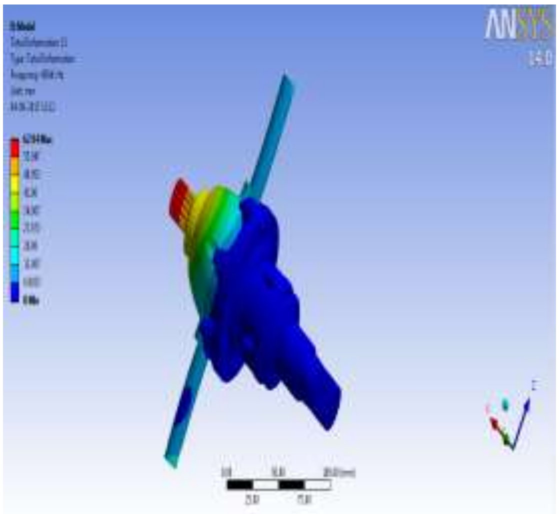
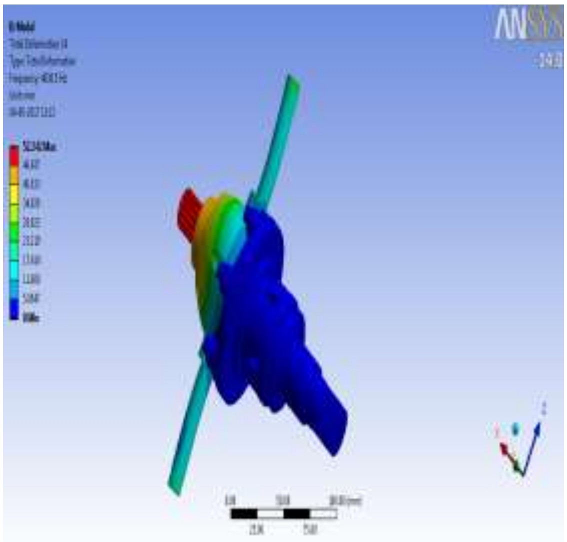


Total deformation 12



Total deformation 13



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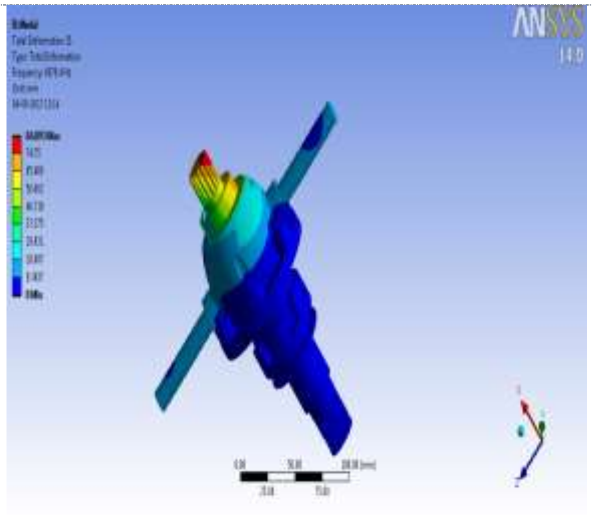
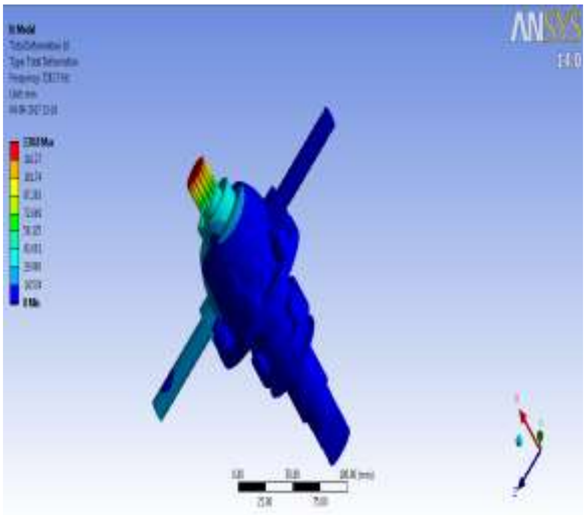


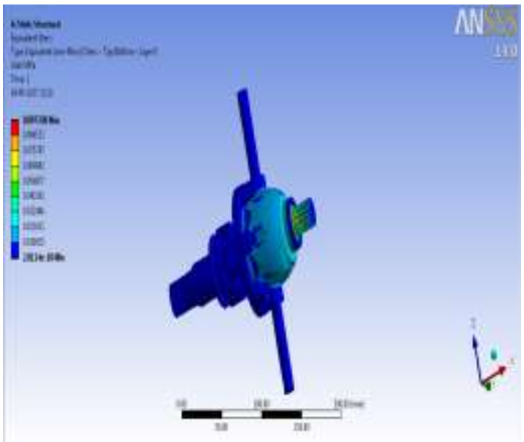
Total deformation 15



Total deformation 16

VII. STRESS ANALYSIS

As we know high contact stresses are results in pitting failure of the gear tooth, it is compulsory to keep contact stresses within the limit. After analysis of the differential gear assembly the stress and moment on different modes it has been obtained which are as follows



Deformation due to stress

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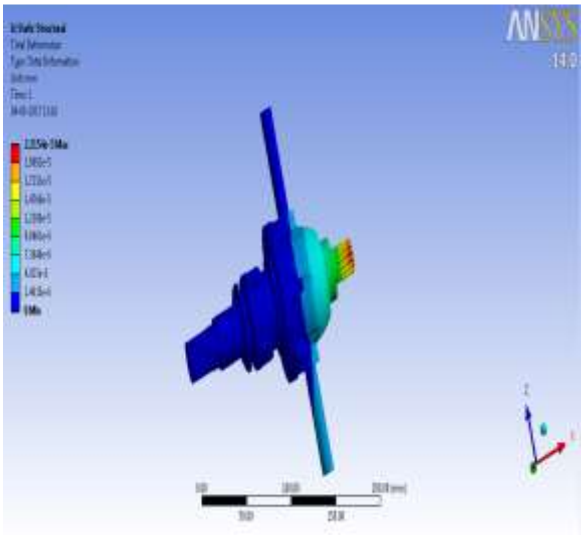

deformation due to torque

VIII. CONCLUSION

In this research 3-D deformable-body model of differential gearbox and its housing was developed through SOLIDWORKS. The results obtained were then compared with the AGMA theoretical stress values. The results are in good congruence with the theoretical values, which suggest that the model designed is correct. after the analysis the following frequencies are obtained:-

Mode	Frequency [Hz]
1.	1716.5
2.	1730.4
3.	1790.7
4.	1800.4
5.	3751.8
6.	3772.
7.	4594.
8.	4630.5
9.	6979.4
10.	7282.7

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