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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: - The differential gears assembly and their housing are analyzed for the vibrational effect on a device in which the life of the gears is calculated over a wide frequency range using the Ansys-14.0 platform and Solidworks modeling. The gear housing is also influenced by vibration in the casing that surrounds the gearbox in this form of study. Gear's main goal is to protect and provide a secure platform for successful gear transmission. It also protects moving parts and shields them from the elements. The differential couples the propeller shaft to the pinion, which runs on the differential's ring gear or crown gear, which also helps to reduce gearing friction. As well as extending the gear's lifespan. As a result, the differential gear housing will be subject to vibration, and it will be necessary to measure the response of the differential gear housing in various vibration situations, as well as to determine their natural frequencies. This may be the most effective method in developing a differential gear housing that is free of resonance-induced fatigue failures. The gear housing should be built using an acceptable methodology for allocating vibration-causing causes, promoting scientific methods, and minimizing the effects of frequencies. This vibration analysis is carried out using the ANSYS 14.0 program as a computational technique, with SOLIDWORKS being used for validation and modeling of the differential gearbox.

Keywords: *differential gears, natural frequency, Ansys 14.0.*

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I INTRODUCTION

The differential in automobiles and other wheeled vehicles allows the outer drive wheel to rotate faster than the inner drive wheel during a turn. This is necessary when the vehicle makes a turn, causing the wheel on the outside of the turning curve to roll further and faster than the one on the inside. The input rotational speed of the drive shaft is equal to the average rotational speed of the two driving wheels. A rise in one wheel's speed is counterbalanced by a decrease in the other wheel's speed.

Under excitation conditions, heavy vehicle transmission systems are exposed to noise and vibration. One of the most common causes of excitation is internal excitation forces, meshing forces, load and speed variation, and gear defects. A differential gearbox in an automobile is a collection of gears designed to divide the speed of the wheel in turning conditions based on torque variation. The input shaft's speed is the highest, and the output shaft's speed is the lowest, resulting in a higher torque value. The torque is transferred to the drive shaft in large amounts. Since noise and vibration are the two causes of transmission failure, noise and vibration reduction in heavy vehicle transmission systems is a continuous work in progress. The vibration signature pattern is influenced by the material's mechanical properties. The simulation results show that as the materials are modified, natural frequencies and mode shapes take on different characteristics. Since grey cast iron has a damping property that reduces vibration, it is used as a casing material for automobiles, whereas structural steel has a high density and is used as a casing material for heavy static machinery in industrial applications.

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.

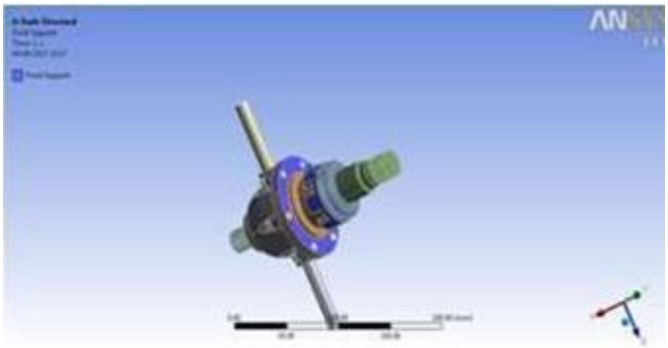
Analysis work

The project is divided into two domains:

1. Modal Analysis
2. Stress analysis

Modal Analysis: Under the right excitation conditions, the natural frequencies of a device are those frequencies at which the resonant response occurs. Knowing these important dynamic frequencies is crucial for designing or evaluating a device that is subjected to dynamic loading.

Stress Analysis: Stress analysis is a part of the static analysis of the model in ansys 14.0 and modeled in SOLIDWORKS using boundary conditions and forces determined from the instructor's data.



Fixed support

Moment

Model analysis: It's a concept that refers to the methods for extracting a structure's modal properties (natural frequencies, modal damping factors, and mode shapes) from data about the structure that can be presented in various formats.

Gear mesh frequency: This frequency is most often associated with gears, and it is proportional to the number of teeth on the gear multiplied by the shaft's running speed. Multiple gears and, as a result, multiple gear meshing frequencies are common in gearboxes. A normal gear mesh signature with a low amplitude of gear mesh frequency and a sequence of symmetrical sidebands on each side of the mesh components spaced at the exact running speed of the shaft. If the gearbox is operating normally, the spacing and amplitude of these side bands are likely symmetrical. Any change in the symmetry of the gear mesh signature indicates the presence of impending gear issues.

Modeling of gear

Modeling is a system of principles that can be used to model three-dimensional solids mathematically and computationally. The emphasis on physical accuracy distinguishes solid modeling from similar fields such as geometric modeling and computer graphics. The geometric and solid modeling principles, which are at the heart of computer-aided design, support the development, sharing, visualization, animation, interrogation, and annotation of digital models of physical objects.

II CALCULATIONS OF A CROWN GEAR AND PINION

The project's main goal is to determine the best material for gears in gearboxes at higher speeds by examining stress, displacement, and weight reduction, with an emphasis on mechanical design and contact analysis on gearbox assembly as they transmit power at different speeds of 2400 rpm, 5000 rpm, and 6400 rpm. Variable frequencies are also used in the study. Solidworks is used to model differential gear. The structural behaviour of various composites under the given loading conditions was determined using the ANSYS 14.0 fem software as the analysis method.

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

Pitch Cone Distance (AO):

AO=((d1/2)2+(d2/2)2)1/2

AO=250mm

Face width (b) b=AO/3

or } which is lesser

b=10

CALCULATION OF GEAR AND PINION

Pitch circle diameter (D) Diameter of sungear =

Dg=150mm Diameter of pinion =

Dp=70mm

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

Module

= M=D/T

=220/33

=6.66

=7(according to stds)

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

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

Formative Number Of Teeeth

For the pinion = Zep

= Zp secθp1=15sec25.025

=16.554

For the gear = Zeg

= Zg secθp2

= 8sec64.974

=42.55

Pitch Cone Distance (AO):

AO=((D1/2)2+(D2/2)2)1/2

AO = 82.7mm

8.Face Width (b):

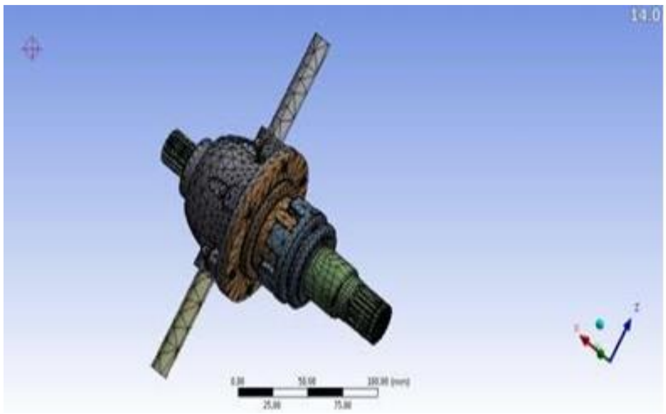
82.7/3 = 27.5 mm

FEM ANALYSIS OF THE GEAR

The finite element method (FEM) is a mathematical technique for solving engineering and mathematical physics problems. Finite element analysis is another name for FEM (FEA). Structure analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential are all complex problem areas of concern. For partial differential equations, the analytical approach of solution usually necessitates the solution of boundary problems. The problem is expressed as a system of algebraic equations using this approach. The results in estimated unknown values at a discrete number of points around the domain.] To solve these problems, complex problems are subdivided into smaller, simpler pieces known as finite elements. These simple equations are then combined into a larger system of equations that models the entire problem. FEM then approximates a solution by minimizing a related error function using variational methods from the calculus of variations.

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

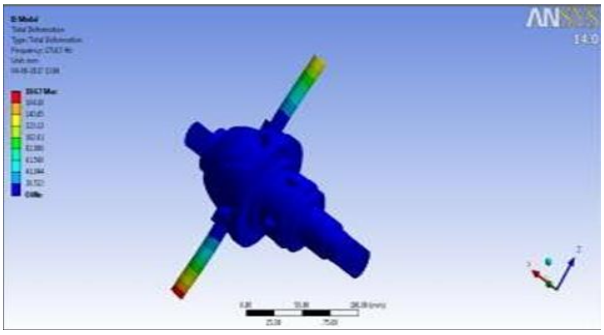
Problem formulation

The characteristics of the component or subassemblies of a required product have a natural frequency, which is exemplified by resonance. This is noticeable when evaluating the output of applications where the component's human comfort is essential to the function. Vibrations caused by the engine, for example, are experienced by automobiles. This phenomenon must be analyzed in the components that make up the subassemblies. The component's design should provide a mode for dealing with factors that cause unwanted levels of vibration, or endorse any scientific method of problem-solving that reduces the harmful effects of resonance.

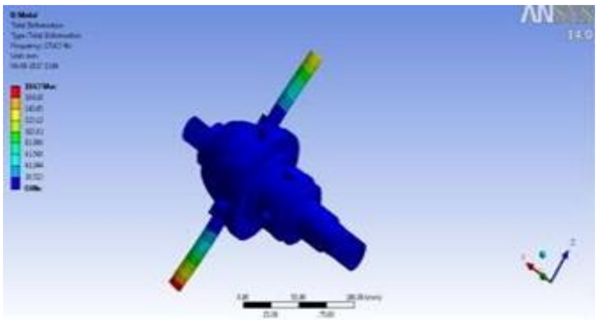
III RESULT

Modal analysis

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



Total deformation 1



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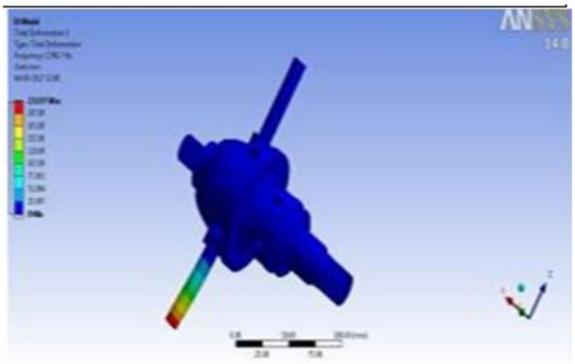
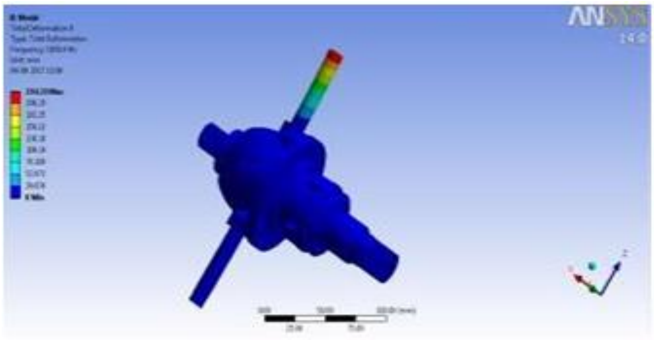
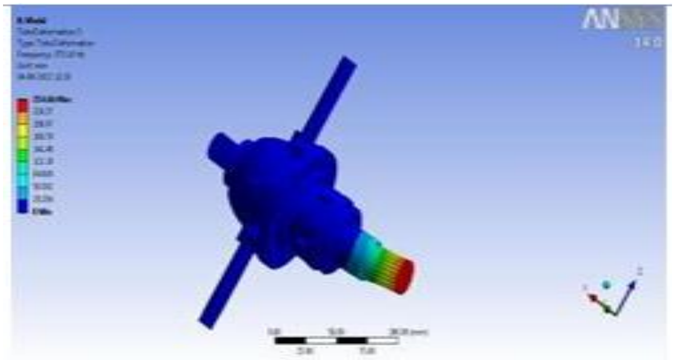


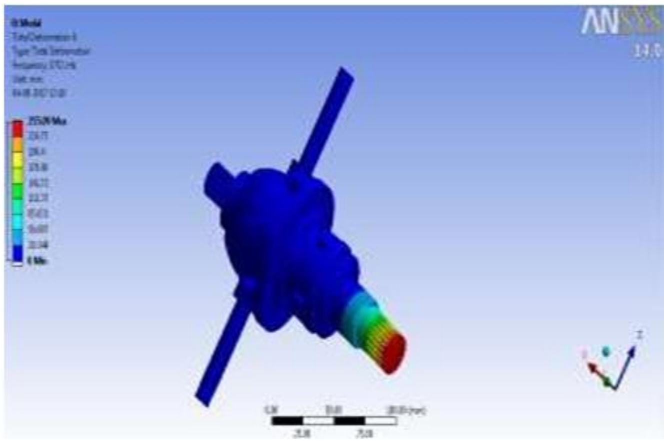
Total deformation 3



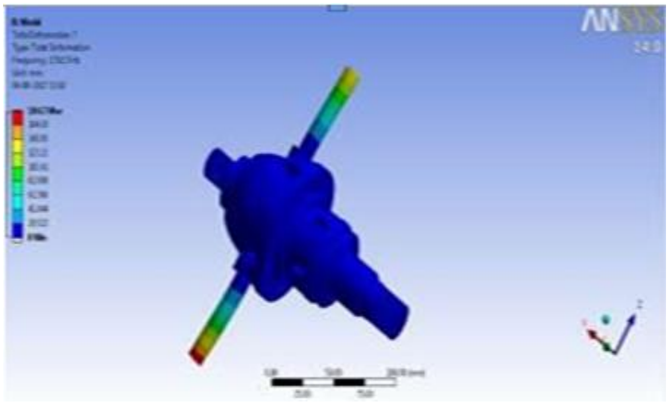
Total deformation 4



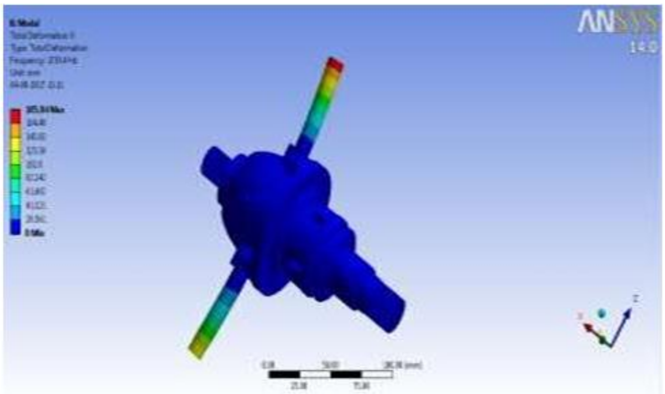
Total deformation 5



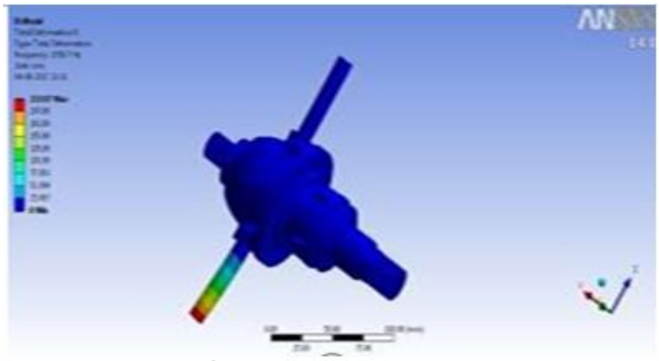
Total deformation 6



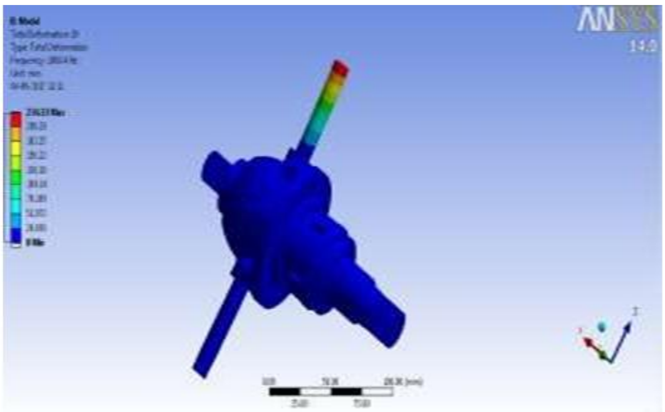
Total deformation 7



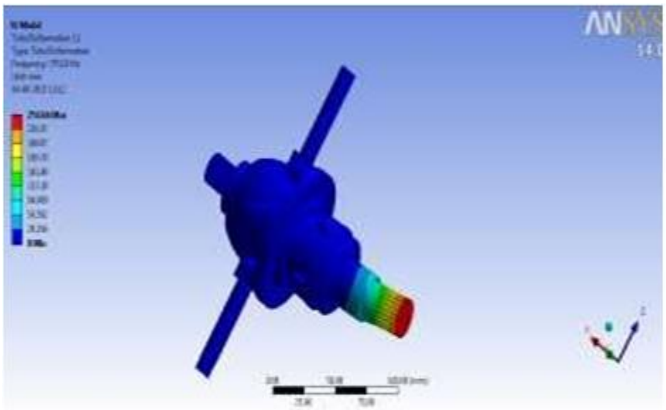
Total deformation8



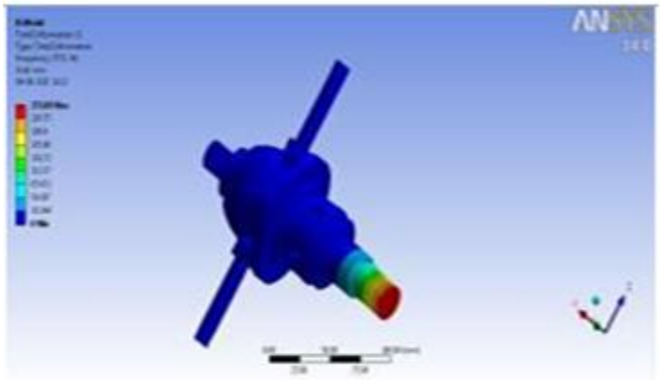
Total deformation 9



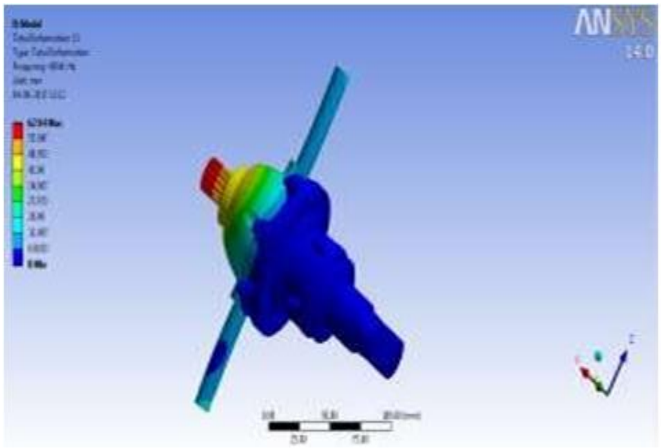
Total deformation 10



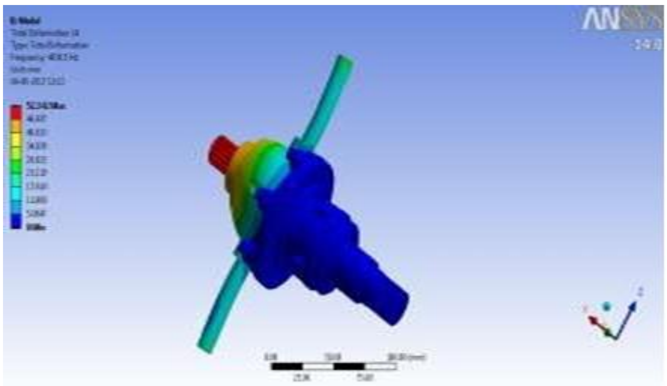
Total deformation 11



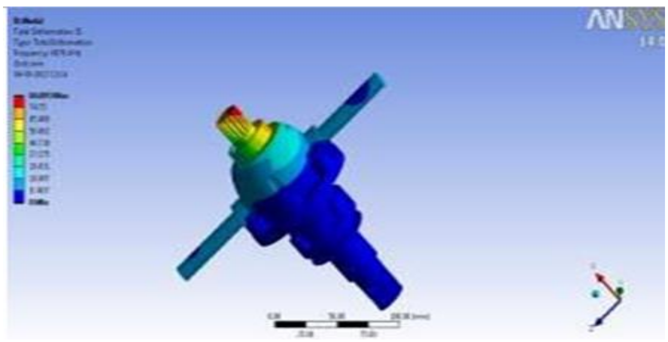
Total deformation 12



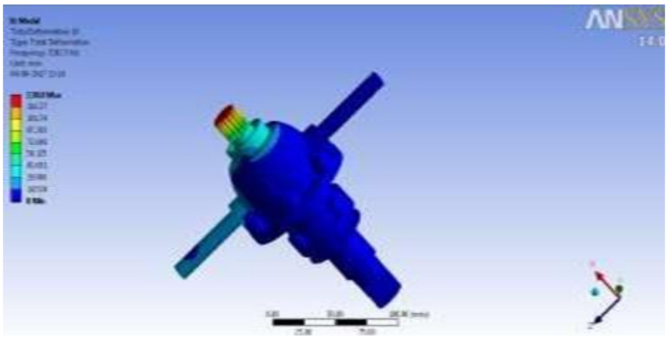
Total deformation 13



Total deformation 14



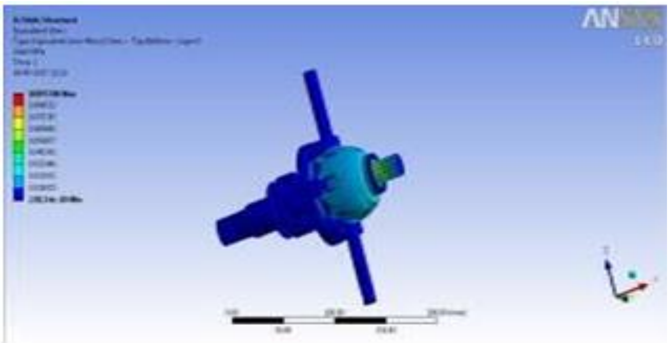
Total deformation 15



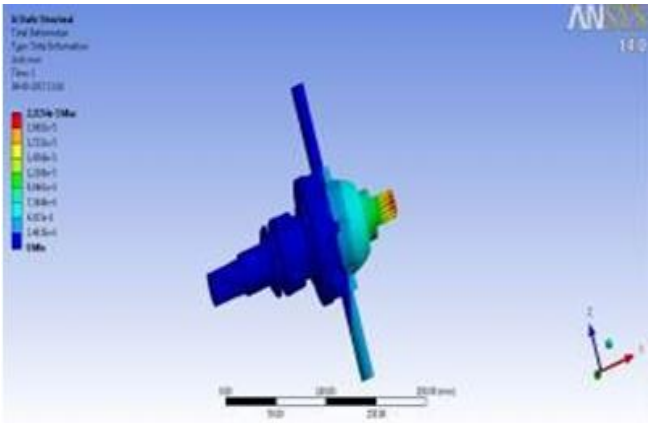
Total deformation 16

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



Deformation due to torque

IV 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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