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Modeling, Design & Analysis of Straight Bevel Gear and Pinion by FEM, Solid works & Ansys Benchwork 14.0

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ABSTRACT

In this research developing an analytical approach, modeling and analysis to evaluate stress distribution, natural frequencies and predict the life of the gear and pinion under the plateform of ANSYS 14.0 with the help of solid works modeling. The function of gears to provide proper gearing for transmission. These gears must typically operate at extremely high rotational speeds and carry high power level Bevel gears are used to transmit the power between two intersecting shafts at almost any angle or speed. Various forces acting on the gear has been calculated.

The purpose of this work is to analyze and validate the stress distribution in bevel gears using contemporary FEM program and ANSYS 14.0 the design of the gear housing should incorporate a methodology for dealing with factors causing vibrations and to promote scientific means to minimize the effect of frequencies. This vibration analysis is done by using ANSYS 14.0 software as a computational technique and validation Keywords natural frequencies, stress distribution, ANSYS 14.0

Keywords-- Modeling, ANSY, BEVEL

I. INTRODUCTION

Bevel gears are gears which is widely used for the axes of the two shafts intersects each other and the tooth of the bearing faces with the gears themselves are conically shaped. Bevel gears, mostly mounted on those shaft which are angled at 90 degrees apart, but it can be designed as to work on other angles and the pitch surface of the bevel gears is a cone.

Pitch surface and pitch angle are the most important concepts for gearing. The pitch surface for a gear is hypothetically imaginary toothless surface that we would have for averaging out the peaks and valleys of the own teeth. The pitch surface of an ordinary gears is like a shape of the cylinder. The pitch angle for a bevel gear is a angle among the face of the axis and the pitch surface.

The most known kinds of bevel gear has a pitch angle are less than 90 degrees and therefore they are cone-shaped. This type of bevel gear is called external because the gear teeth point outward. The pitch surfaces of meshed external bevel gears are coaxial with the gear shafts; the apexes of the two surfaces are at the point of intersection of the shaft axes are cone-shaped. This type of bevel gear is called external because the gear teeth point outward. The pitch surfaces of meshed external bevel gears are coaxial with the gear shafts; the apexes of the two surfaces are at the point of intersection of the shaft axes.

Bevel gears which have pitch angle greater than ninety degrees having teeth that point inward and are called internal bevel gears.

Bevel gears which having pitch angles of exactly 90 degrees which have teeth thatis to point outward parallel with the axis and resemble the points on a crown. That's why this type of bevel gear is called a crown gear.

II. AIM OF THE RESEARCH

- To design and modeling of bevel gear and pinion assembly.
- To find out the natural frequency of bevel gear and pinion mechanism.

III. DESIGN OF BEVEL GEARS

Bevel gears are designing for which calculating the required traction force and for keeping a system compact, bevel gears are designed by minimum requirement number of teeth. therefore the necessary required amount of power can be transmit without compensating the size of object. Bevel gear is designed for 20º pressure angle. The different kind of forces acting on the gears are calculated and eventually determined the bending strength. Bending stress in gear tooth is analyzed

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by using Lewis equation. Some of the equations used in straight bevel gear design are mentioned here.

Nomenclature

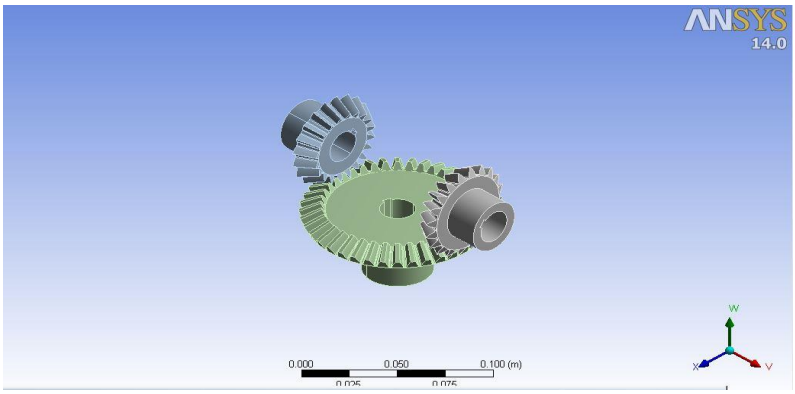
σb - Bending Stress
Pt - Tangential Force
m - Module
b - Face Width
Ko - Overload Factor
Km - Mounting Factor
J - Geometry Form Factor
Kv - Velocity Factor
Sb - Beam Strength
Y - Lewis Form Factor
Ao - Cone Distance
σm - Permissible Bending Stress

IV. MATERIAL PROPERTIES

In this research, material used for both the gears is Alloy Steel. Case hardened 20MnCr5 is used for forming of gear pairs. It is alloy steel with 0.17-0.22% of Carbon and Case-hardening process belongs to enhancing the strength and wear properties of the gears made from relatively inexpensive worked materials. The treatments for a high-hardness wear resistant surface also maintain fatigue strength. As a bevel gears are small in size and torque transmitted are comparatively high so to withstand case hardening process is needed. So strength and resistance to stress are the criteria for the selection of material.

Modeling of gear

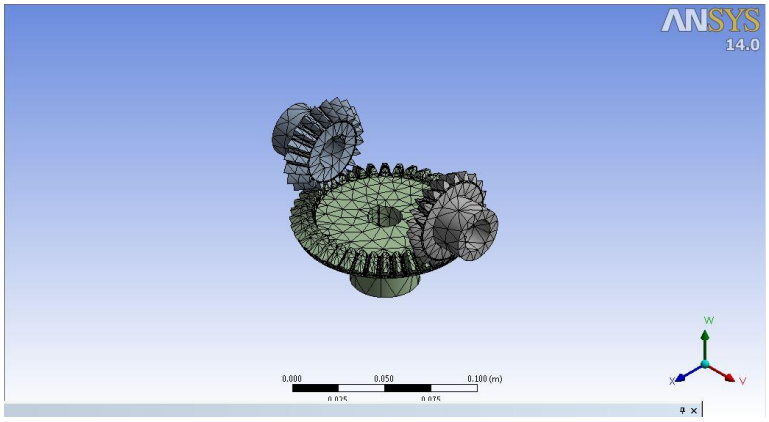
Modeling of gear is dine under the plateform of solidworks and these are imported in ansys through IEGS file



MODEL

V. FINITE ELEMENT MODEL

The bevel gear and pinion mechanism solid model is imported in ANSYS as a IEGS file and analysis is performed by FEM through ansys Workbench 14.0. Firstly, the 3-D solid model is assembly of three mating gear as shown in figure. Then we get solution of this model.



Mesh model

Analysis work

The project is divided into two parts

- Model analysis
- Stress analysis

Modal analysis

In model analysis we can calculate the deformation thorugh naturat frequency(vibration). In this process natural frequencies of the model are calculated and finding out failure occurs in model on different frequency modes given by the instructor.

Structural analysis

In static structure analysis different mechanical properties is to be determined. This type of analysis contains the stress analysis, strain analysis, bending moment, torque etc.

VI. CALCULATIONS OF A CROWN GEAR AND PINION

The main objective of the project is to verify the best material for the gears in at higher speeds through analyzing stress generation, displacement and also considered weight reduction focus on the mechanical design and contact analysis on assembly of gears in gear box when it transmit more power at different speeds at 2400 rpm, 5000 rpm and 6400 rpm. Analysis is also conducted by varying the natural frequencies. Differential gear is designed in Solidwork . The ANSYS 14.0 used like the analysis tool for determined the structural behaviour of many composites within the given loading situations.

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

VII. 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
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

VIII. PROBLEM FORMULATION

A natural frequency, gaind by resonance is the characteristics of the subassemblies of a required product. This becomes remarkable while assess performances of applications where human comfort of the component life

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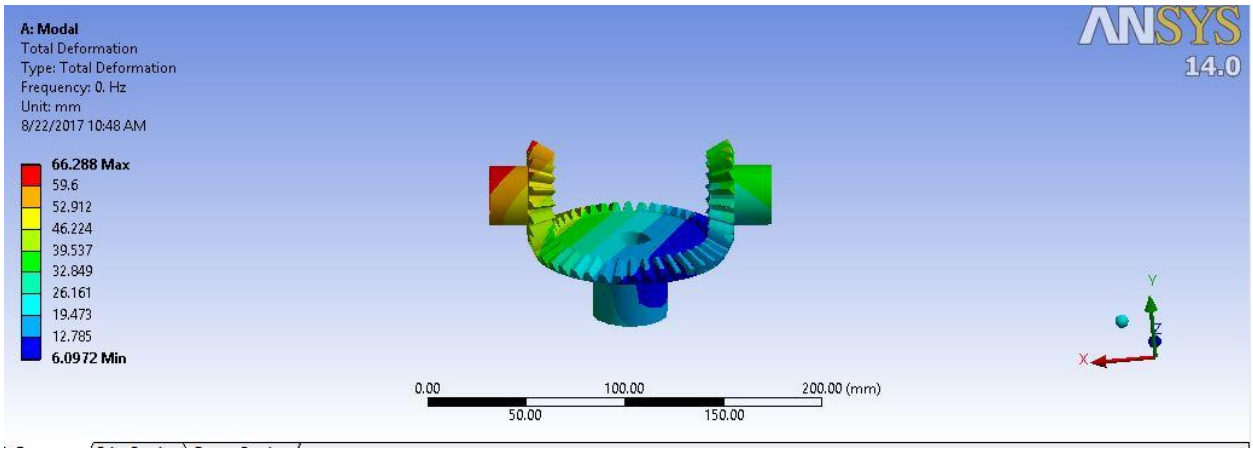
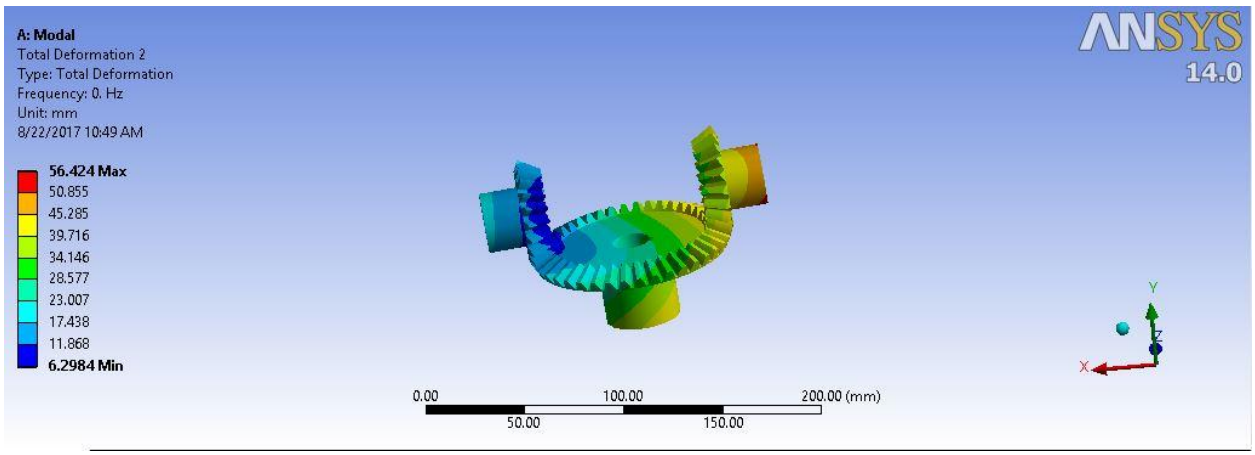
has a prominence on the function. Automobiles example, are example subjected to vibrations in terms deformation caused in the engine. The components making the assemblies need to be evaluated for this phenomenon. The design of the component should incorporate a mode for dealing with factors causing undesirable levels of vibration or to support any scientific means of problem solving that would decrease the harmful effects of resonance

IX. RESULT

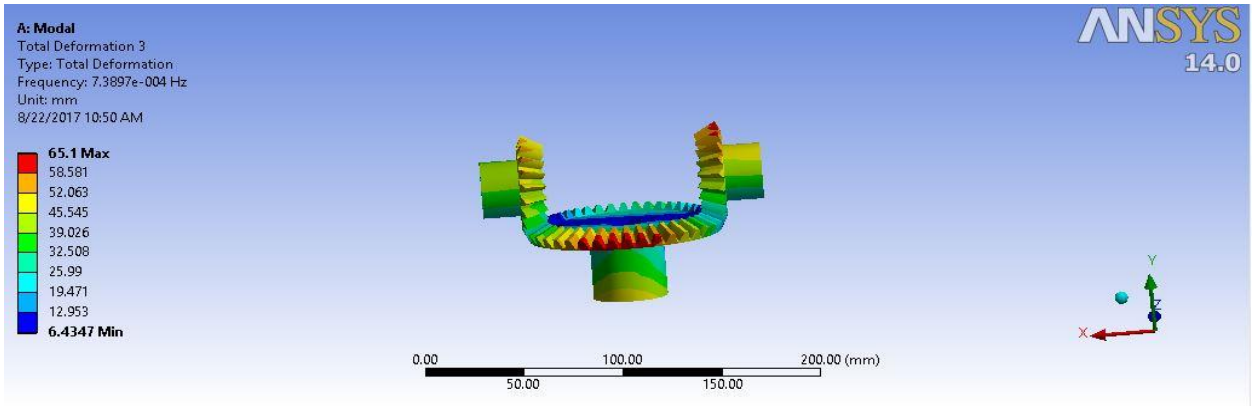
After the calculation of all the stresses following natural frequencies are obtained.



Total deformation 1



Total deformation 2



Total deformation 3

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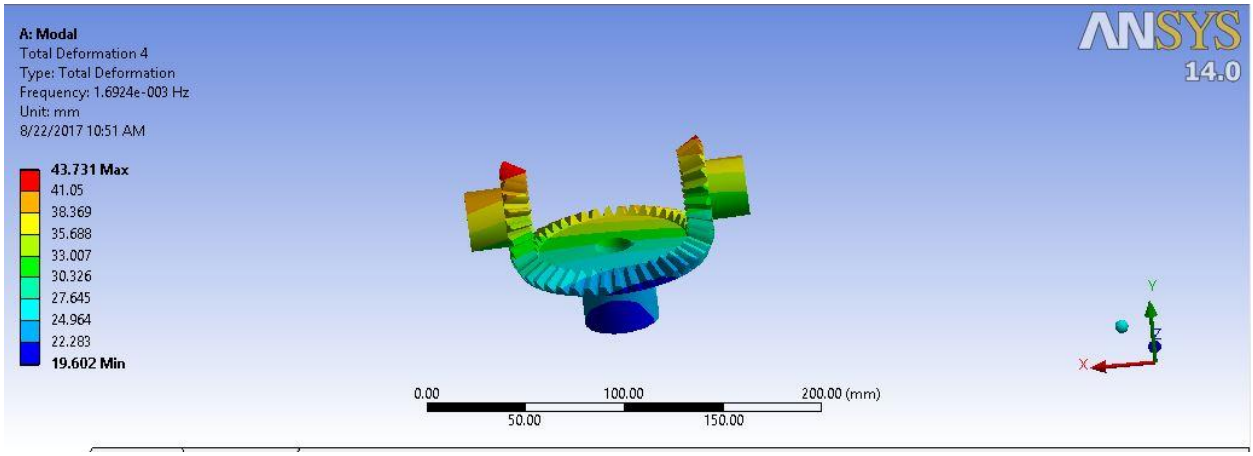
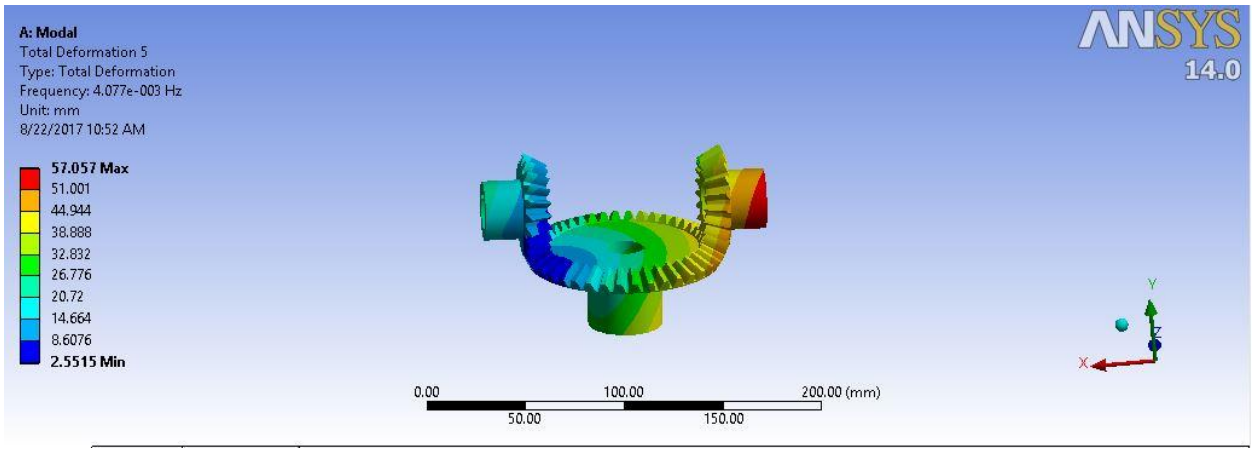
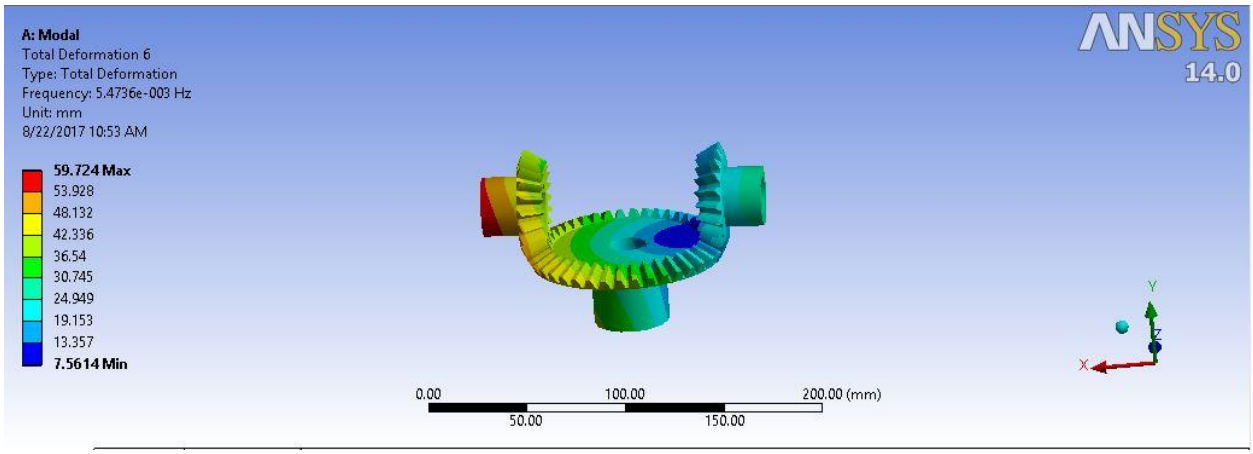


Total Deformation 4



Total deformation 5



Total deformation 6

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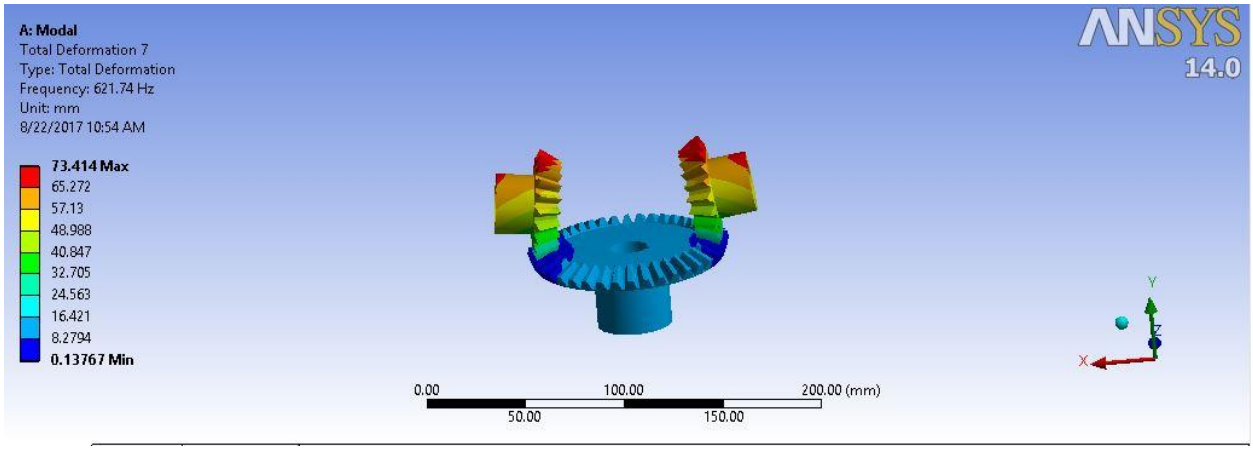
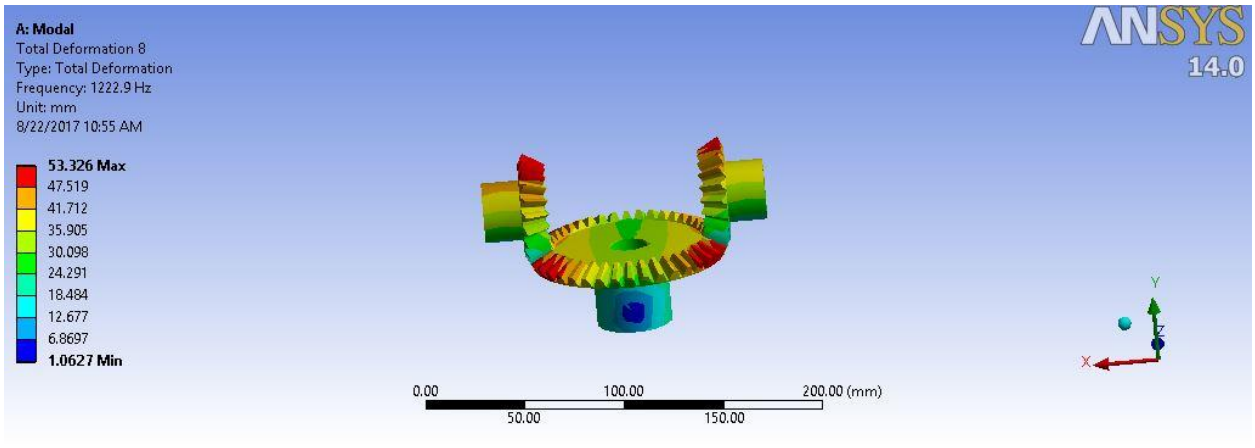
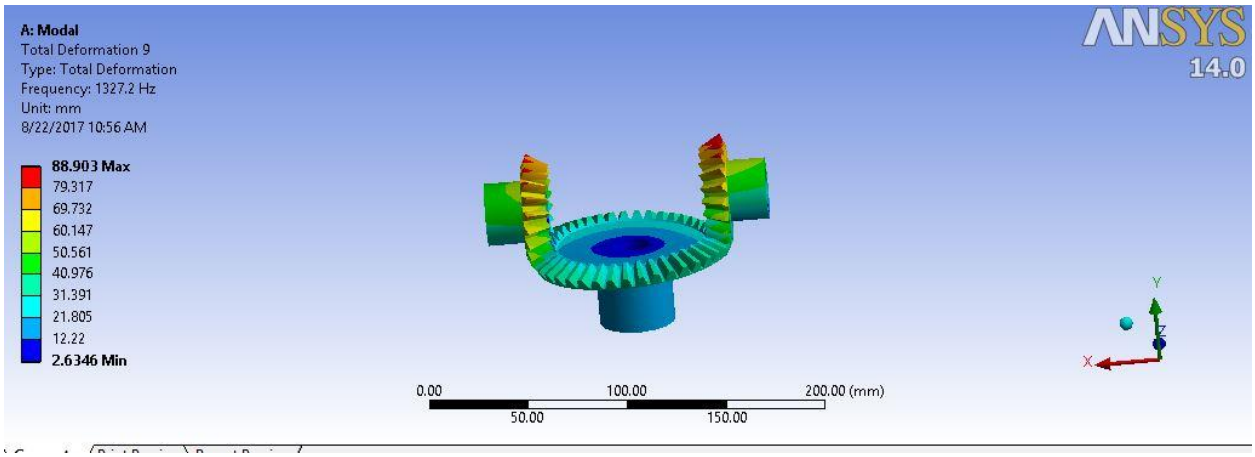


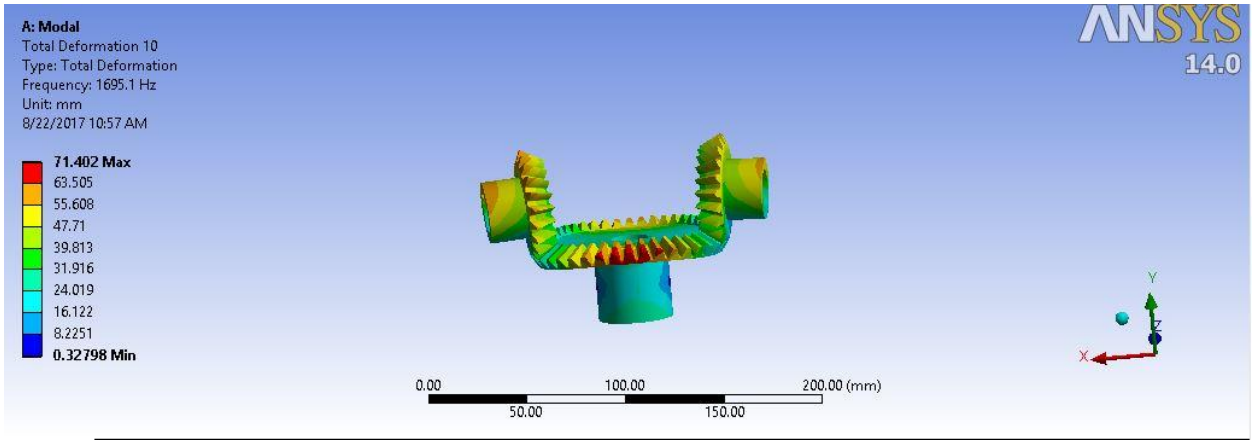
Total deformation 7



Total deformation 8



Total deformation 9



Total deformation 10

X. CONCLUSION

From analysis of the bevel gear and pinion assembly the natural frequencies on different modes it has been obtained which are as under :-

Mode	Frequency [Hz]
1.	0.
2.	
3.	7.3897e-004
4.	1.6924e-003
5.	4.077e-003
6.	5.4736e-003
7.	621.74
8.	1222.9
9.	1327.2
10.	1695.1

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