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Design and Analysis of Gearbox on ANSYS

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Abstract:- *Transmission of torque from the rotating power source to an another device by the use of gears or gear trains. Providing speed and torque conversion from a rotating source to an output shaft for this conversion gearbox is use. Multispeed gearboxes are used in the application where frequent changes occur in speed or torque for this changes output shaft is required. The transmission of motion and power from a input to the output source is possible due to the meshing of teeth in the gears. This paper consists of gearbox designing, modal analysis on the both gearboxes and the procedure for calculating the strength on structural gear of the both gearboxes. For analysis purposes an assembly of gearboxes is created in SOLIDWORK and the IGS file is need to be exported into the ANSYS. Gear efficiency is depending on the deformation, so the result showing deformation and maximum stresses are under the limits.*
Key word:- *Computer Aided Design and Finate Element Analysis.*

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I. Introduction:-

Gearbox frequently alluded as a transmission unit that help us in gear and gear train to provide speed or torque transformations through a rotating energy inception to another device. Gearboxes are used in conversion of high speed power inception to low speed power(ex-Lift, cranes and pulverizing machine) into a large number rates (Machine, Processing machine and Automobile). A gearbox that convert a high speed input to a single output is known as a single stage gearbox. It usually has two gear and shaft. A gearbox that changes over a high speed input to various different speed output it is known as a double stage gearbox. Double stage reduction gear box has a multiple gears and shafts. A double stage reduction gear confine diminishes its speed on various stages.

A. There are two type of reduction gearbox:

1. Single stage reduction gearbox: Single stage reduction gearbox is a type of reduction in which it's reduce the gear and comprising with the two gears.

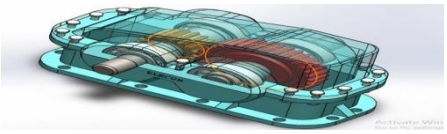


Figure: 1. Single Reduction Gearbox

2. Double stage reduction gearbox: This Double stage reduction gearbox is also help inreducing the two stage worm reduction unit and comprises with three gears.

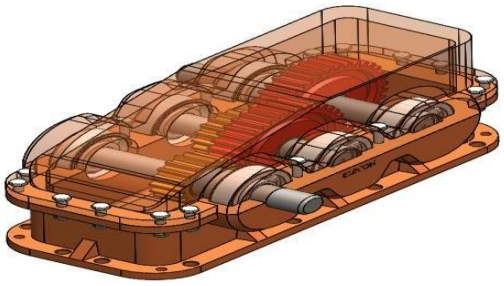


Figure: 2. Double Reduction Gearbox

II. Objectives:

The aim of this project work is to determine the strength and vibration of gearbox reducer.

- The purpose of this simulation is to validate the structural strength and modal analysisof gears on the both

reduction gearboxes.

- To analyze the motion analysis in reduction gearbox.
- To analyze the vibration analysis in reduction gearbox.
- To measure torque and force designing in reduction gearbox.

III. Material selection:

Table: I. "Material properties of Steel S275"

Parameter	Values
Material selected	Steel(S275)
Young's Modulus, E	$2x10^{05}$MPa
Passion's Ratio	0.3
BHN	400-425
Tensile strength	460Mpa
Yield strength	250Mpa
Density	7850Kg/m^3

IV. Methodology:

A: CAD Modeling: Basically a CAD modeling is a software that helpful in making design. It is used in creating all the component which is required in the gearbox and also in assembling.

It also generate motion in the gearbox. All the model components are made in three planes that are front plane, side plane and top plane. CAD software is highly advance version of Auto Cad software. Its model components are:-

a. Casing: casing is a fixture that fixes all the shafts and assembles all gears into an assembly without any interference. Casing also contains the mounting points to mount it in a power train assembly.

b. Gears: A gear is a rotating machine part having a cutting tooth like appearance is a mesh which binds to an another toothedpart for transmitting torque. Geared devices can change the speed, torque and the direction of power source. Gears always producing a change in torque through their ratio.

c. Shafts: The input driven shaft is a solid circular part in which the spacer is placed. The input gear will be mount on the shaft and the angular bearing will be placed between the input gear and the spacer. The driven drive connecting rod is also known as propeller shaft. This shaft is used for an output gear and mounted on the driven drive shaft .

d. Bearing: Angular contact ball bearing have internal or external ring raceways. It should displaced comparative with one another toward bearing pivot. Angular contact balls bearing are planned in such manner that to oblige joined burdens acting spiral and hub loads.

B. **MOTION ANALYSIS IN SOLIDWOKRS**:- The ABB foot mount motor which has some parameters.

- Power =10 kw

-Speed = 1440 rpm

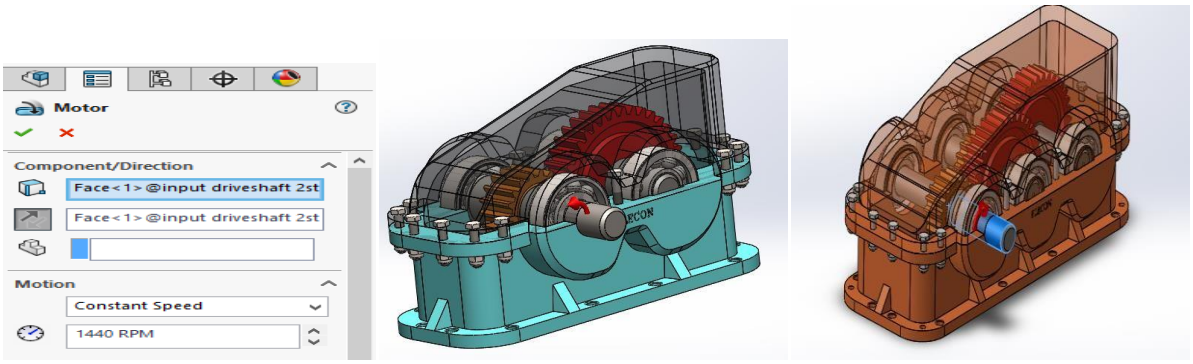


Figure: 3. Motion analysis speed of both gearbox

C. **Static Structure Analysis:** A pressure avoidance investigation is performed utilizing finite element analysis (FEA). The total technique of investigation has been finished by utilizing ANSYS. The overall course of FEA is partitioned into three principle stages

- Preprocessor
- Solution
- Postprocessor

1 Pre processor:- Pre processor is an ANSYS programming in which input information is process to achieving an output.

Type of analysis:

- Geometric modal
- Material selection
- Meshing component
- Loading Conditions
- Boundary Conditions

2 Solution: FEA programming produces component grids, figures modal qualities or subordinates, stored as the outcome information in records.

3 Post processor:- In Postprocessor the result from the solution stage is in the mathematical structure or comprises modal upsides of the range fluctuating and subsidiaries.

4 Geometry: Following assumptions and simplifications are considered for the finite element analysis in structural assembly.

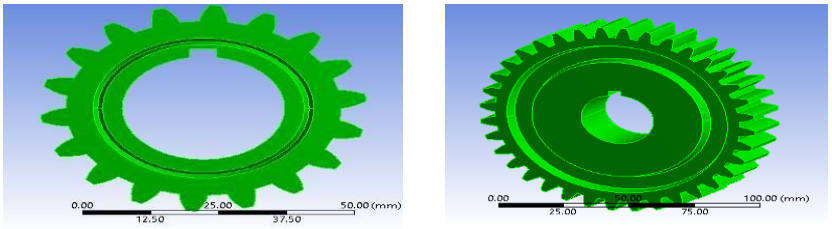


Figure: 4. Single Stage Reduction Gearbox

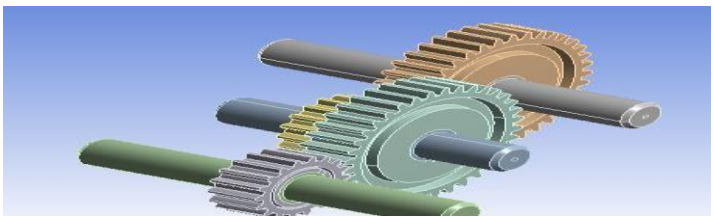


Figure: 5. Double Reduction Gearbox

5 Meshing: Meshing is the cycle where geometry is spatially parts into components and nodes. Mass distribution and stiffness of material is used mathematically in meshing and it is created automatically.

For Input Gear For Output Gear:

- Element size = 3mm - Element size = 3mm,

-Number of element:- 120336, -Number of element:- 59239,

-Number of node:- 183975-Number of node:- 89070

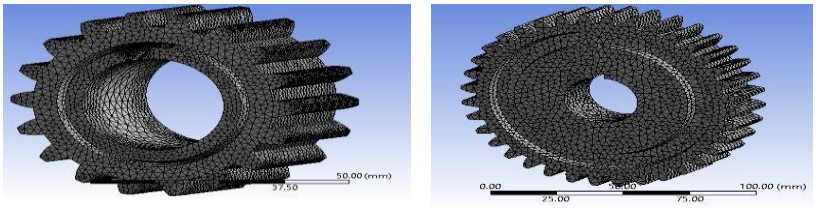


Figure: 6. Single Stage Reduction gearbox MeshingDouble stage reduction gearbox

- Element size = 3mm
- Number of element:- 22568,
- Number of node:- 41942

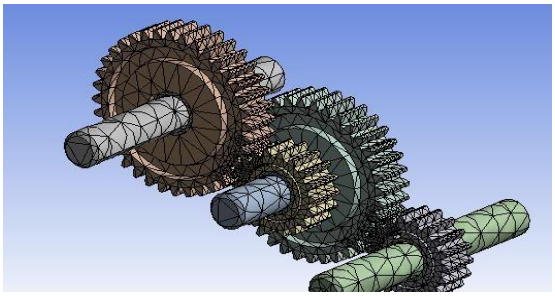


Figure: 7. Double Reduction Gearbox Meshing

6 Boundary Conditions: The boundary condition is the group of various forces, stress, speed and supports is applying as a limit action for one of the better normal cycles investigation.

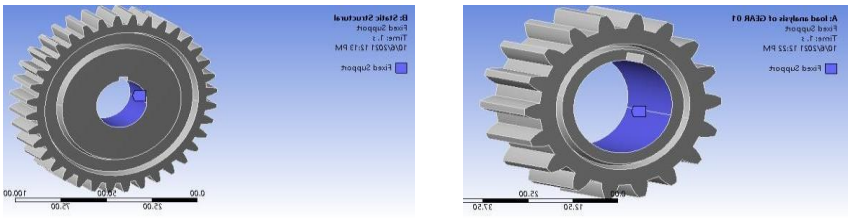


Figure: 8. Single Stage Reduction gearbox

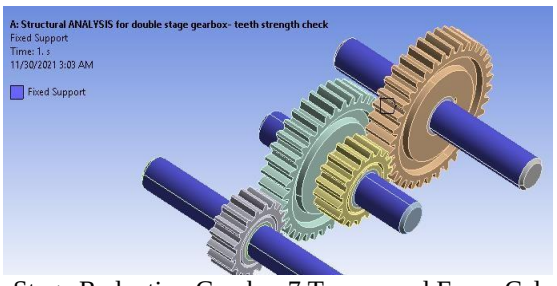


Figure: 9. Double Stage Reduction Gearbox7 Torque and Force Calculation:

- Power = 10kw
- Speed = 1440rpm
- Small gear outer radius =30mm =0.03m

- Output gear outer radius =57mm =0.057mFormulas:

Torque(Nm) = power(kw)x9549/speed(rpm)Force(N) = torque(Nm)/radius(m)

Table: II. Calculation of Single Stage Reduction Gearbox

Input Gear	Output Gear
Torque(Nm)=10x9549/1440	Torque(Nm)=10x9549/720
= 66.3125Nm	= 132.625Nm
Force(N)=66.3125(Nm)/0.03m	Force(N)= 132.625(Nm)/0.057m
= 2210.416 N	= 2326.75 N
= 2211N	= 2327N

Figure: 10. Load Applied On Single Stage Reduction GearboxTable: III. Calculation of Double Stage Reduction Gearbox

Input Gear (small)	Middle Gear(Big)
Torque (Nm)= 10 x 9549/1440	Torque (Nm)= 10 x 9549/720
= 66.3125 Nm	= 132.625 Nm
Force(N) = 66.3125(Nm)/0.03m	Force(N) =132.625(Nm)/0.057m
= 2210.416 N	= 2326.754 N
= 2211 N	= 2327 N
Middle Gear (small)	Output Gear
Torque (Nm)= 10 x 9549/720	Torque (Nm)= 10 x 9549/360
= 132.625 Nm	= 265.25 Nm
Force(N) = 132.625(Nm)/0.03m	Force(N) =265.25(Nm)/0.057m
= 4420.83 N	= 4653.5 N
= 4421 N	= 4654 N

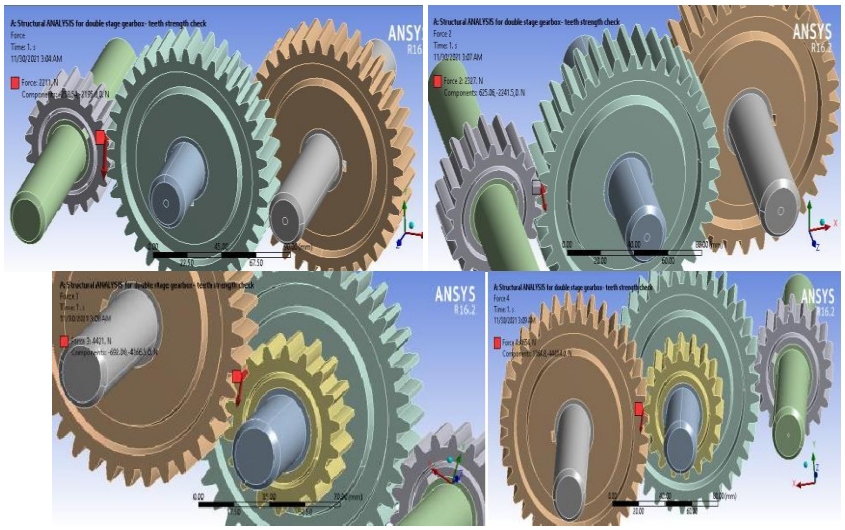


Figure: 11. Load Applied On Double Stage Reduction Gearbox

D. **Modal Analysis Of Reduction Gearbox :** Modal analysis is a natural frequency of a system in which the resonant reaction happens under the appropriate excitation condition. Information on this basic dynamic frequencies is a fundamental phase of plan or development of a framework exposed to dynamic loading. The modal investigation is utilized to compute the vibration qualities.

1 Pre processor:- Pre processor is an ANSYS programming in which input information is process to achieving an output.

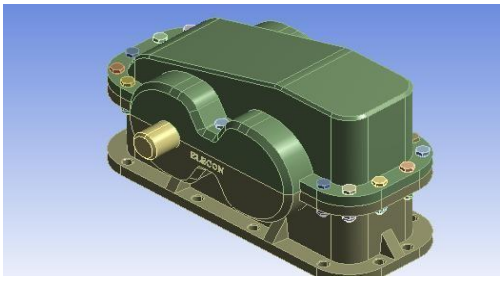
Type of analysis:

- Geometric modal
- Material selection
- Meshing component
- Boundary Conditions

2 Solution: FEA programming produces component grids, figures modal qualities or subordinates, stored the outcome information in records.

3 Post processor:- In Postprocessor the result from the solution stage is in the mathematical structure or comprises modal upsides of the range fluctuating and subsidiaries.

4 Geometry: Following assumptions and simplifications are considered for the finite elementanalysis in structural assembly.



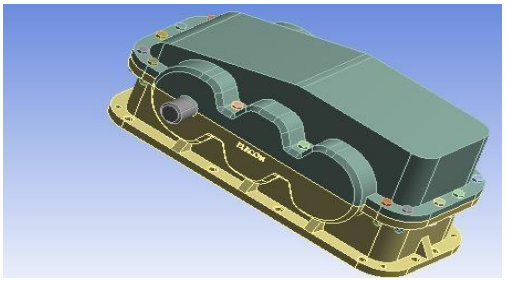
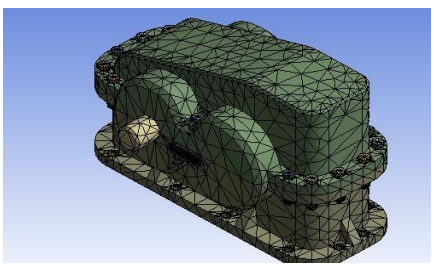


Figure:12. Single Reduction Gearbox Figure:13 .Double Reduction Gearbox

5 Meshing: Meshing is the cycle where geometry is spatially parts into components and nodes. Mass distribution and stiffness of material is used mathematically in meshing and it is created automatically.

Single Stage Reduction Gearbox : Double Stage Reduction Gearbox:

- Element size =3mm - Element size :- 3mm
- Number of element:- 241835 - Number of element:-291112
- Number of node:- 136050 - Number of node:-163272



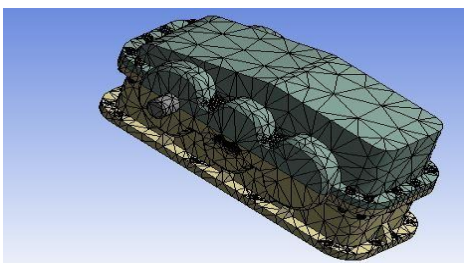


Figure:14. Single Stage Reduction Gearbox F igure:15. Double Stage Reduction Gearbox:

V. Result:

1. Static Structural analysis results of Single and Double Stage Reduction Gearbox:

Create simplified 3D model of Gearbox in Solid works. Create and save above model .IGS format and bringing in ANSYS. Allow is to give model material properties as shown as table I. To give material properties create meshing. To give meshing input limit action as applying the load on teeth of both gear individually. Subsequent settling the model for fixed structural analysis equivalent stress and total deformation as shown in figure 16 and 17. Output shaft velocity of single stage reduction gearbox is constant for 4320 degree/sec or 720 RPM . It clearly shows that this magnitude is one half of the input velocity (1440rpm). To give meshing input limit action as applying load on a teeth of both gear individually. Output shaft velocity of double stage reduction gearbox is a constant for 2160 degree/sec or 360 RPM . It clearly shows that this magnitude is one fourth of the input velocity (1440rpm).

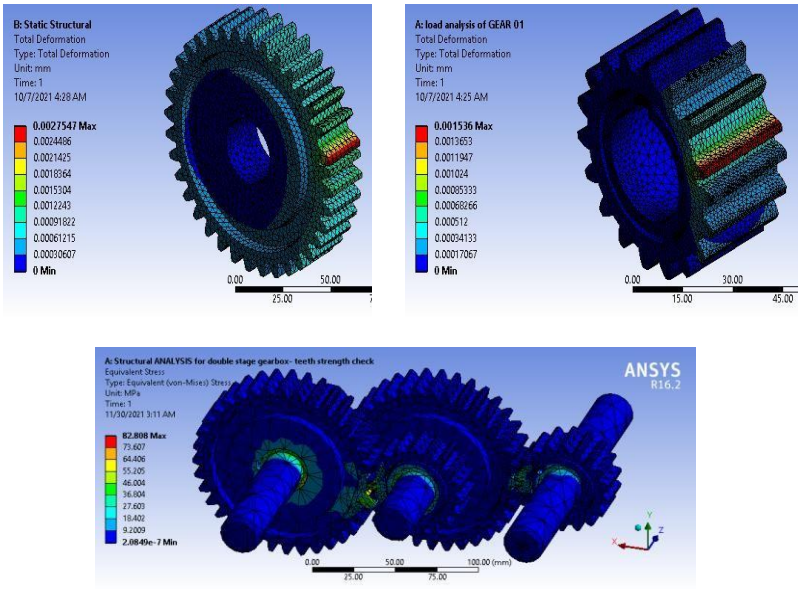


Figure:16. Equivalent stress(Mpa) on Single and Double Stage Reduction Gearbox

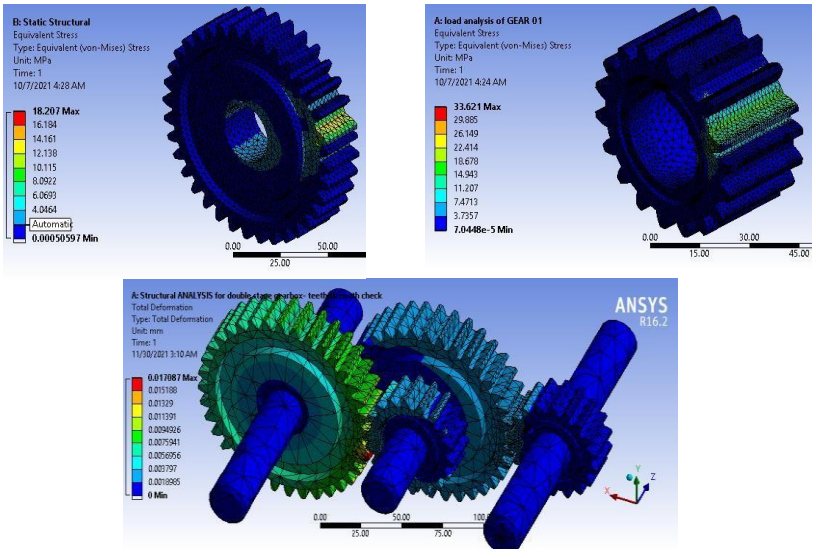


Figure: 17.Total Deformation(mm) on Single and Double Stage Reduction Gearbox

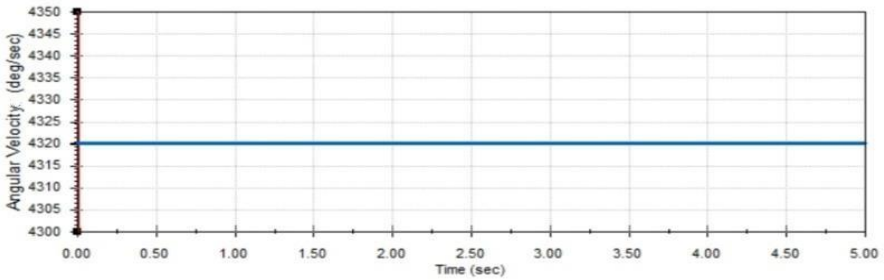


Figure: 18. Graph between Angular velocity and Time on both Gearbox Reduction

2. Vibration of Total Deformation :

Table: IV. Different Modes Shape

MODES(Deformed shape)	FREQUENCY[Hz]	FREQUENCY[Hz]
1	1123.9	1073.6
2	2392.5	1913.6
3	2772	2122
4	2887.2	2211.4
5	3145.9	2496.6
6	3420	2561.6

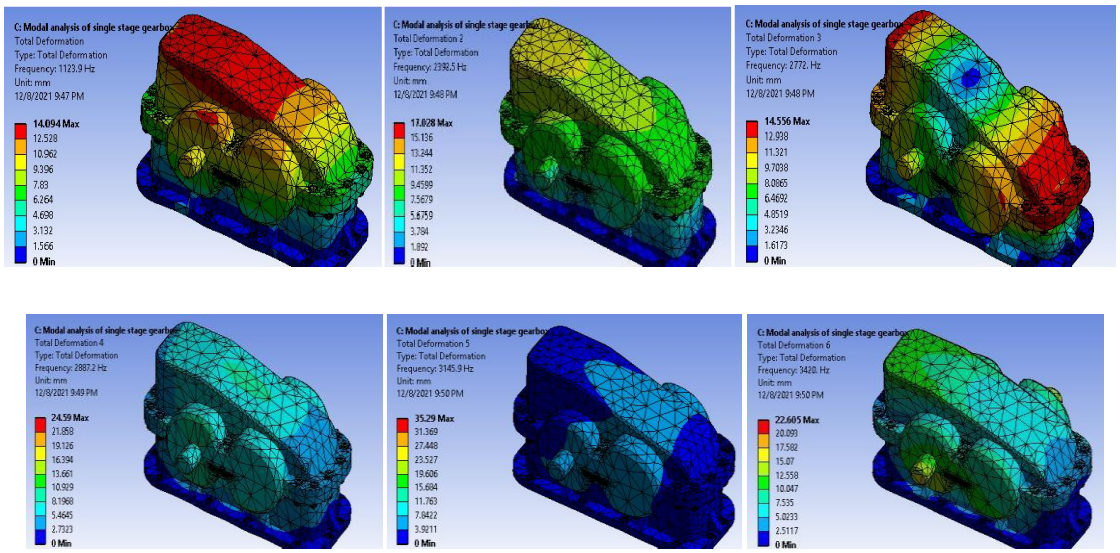


Figure:19. Total Deformation on different Mode Shape of Single Stage Reduction Gearbox

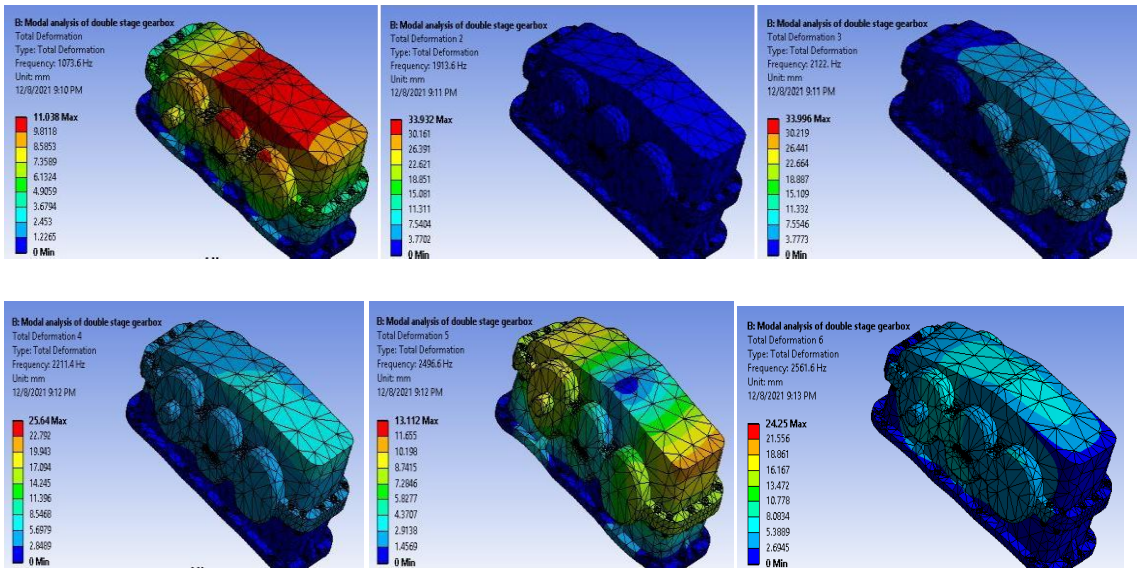


Figure:20. Total Deformation on different Mode Shape of Double Stage Reduction Gearbox

VI. Conclusion:

- It can be seen from the result of stress analysis on single stage reduction gearbox is that the maximum stress is 18.207MPa and deformation is only 0.0027547mm.
- It can be seen from the result of stress analysis on double stage reduction gearbox thatmaximum stress is 82.808MPa and deformation is only 0.017087mm.
- The output shaft velocity of single stage reduction gearbox is constant of 4320 degree/sec or 720 rpm but the output shaft velocity of double stage reduction gearbox is constant of 2160 degree/sec or 360 rpm. Single stage gearbox provide more speed than Double stage reduction gearbox.
- The magnitude of single stage reduction gearbox is one half of the input velocity(1440 rpm) but the magnitude of double stage reduction gearbox is one fourthof the input velocity.
- As per our load condition there is no such area which is over the stress limit. Maximum stress area is a point stress area which can be neglected.
- Hence the structure of single stage reduction gearbox is safe for low medium automobile and the structure of double stage reduction gearbox is safe for high medium automobile.
- Table:4. Modal analysis result for both single and double stage reduction gearbox.
- According to modal analysis result conclude that maximum total deformation of frequency give failure of gearbox.
- It is concluded from above two gearbox analysis that maximum total deformation of single stage reduction gearbox have 35.29 mm with frequency have 3145.9 Hz and maximum total deformation of double stage reduction gearbox have 33.996 mm with frequency have 2122 Hz. Double stage reduction gearbox is better than Single stage reduction gearbox in modal analysis

Future Scope:

- Fatigue Analysis for Life calculation.
- Structural Analysis To used composite material for gears.
- Manufacturing of Gearbox.
- Experimental results for gearbox

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