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Design and Analysis on Rear Axle Housing of a Truck

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Abstract - **Axle housing is one of the main component to play vital role in the various automobiles which is placed to rear end at the vehicle and carries different loads and stresses both static and dynamically at the same time transmit the power. Both the front and rear axle openings have centre housing. This project analyzing the static and model analysis of rear axle housing on different materials like steel, aluminium alloy, carbon/epoxy, jute-glass fibre composite. This results may give von-misses, deformation in static analysis and also find frequency in model analysis by using various software's. These both analysis are find out the performance on materials it means which material is withstand the loads and estimate the deformation ,stresses and vibrations while working conditions. The design safety is ensured was based upon the strength and rigidity.**

Keywords: Axle housing, static analysis, model analysis, maximum displacements, maximum stresses and natural frequencies.

I. Introduction

Now a day's automobiles are major platform and play key role in the world to serving the various services like import, export the goods and transport the passengers from one to another locations. And many companies invest their profits in automobile industries. While during these transportations various failures may occur and acting various loads on the various components like self-weight, passengers weight, chassis and body weight and many companies looking to increase the vehicle performance by their modifying the various parts and change the design and modeling and adding the various composite materials to their parts.

In automobile each and every part is very important with standard specifications and calculations like weight ratios, damping capacity of the composite materials, tolerances and stresses etc. In that way axle-housing is the most precious part in automobiles. Axle means it is fixed shaft and it is fixed between the two wheels and supports the body weight and the housing is in symmetrical shape which is carries and cover axle mounting parts. The axles are commonly made from chrome-molybdenum steel and carbon-steel and it is actually located at centre of the shaft at rear end of the vehicle. It is used to transmit the power, supports the heavy loads and it gives the smooth wheel turning experience to the driver without slippage on the road.

The axle-housing is mostly constructing by banjo type and their parts that are needed for structural capability as well as for carrying the drivelines parts, bearings and sealing's of the axle. In this axle housing completely remain stationary, do not move with the wheels. In axle housing there are different types of mounts their which is help to the shafts, wheels for smooth turning. The bearing and bushings are mounting parts which is centrally fit in to the axle-housing to help the rotate wheel proper way.

II. OBJECTIVES

The main objective of this work to analysis the automobile rear axle housing of a truck. It achieves through following set of objectives:

- Modelling of axle housing using CREO parametric 3.0 and use of ANSYS workbench 14.5 for analysis.
- To study of static analysis of rear axle housing to understand the maximum stress and deformation.
- To find out the natural frequencies of the optimized rear axle housing.

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III. METHODOLOGY

- Creating 3D model of rear axle housing by using CREO Parametric 3.0
- Model is imported to ANSYS workbench 14.5 for the analysis.
- Apply meshing by using HYPERMESH.
- Static analysis to understand the maximum stress and deformation.
- To optimize the rear axle housing in model analysis.

IV. MODEL OF REAR AXLE HOUSING

The 3D model of the rear axle of a truck is modelled by using CREO parametric 3.0. Figure shows 1.

Figure 1: 3D model of rear axle housing

4.1 MESH GENERATION FOR 3D MODEL

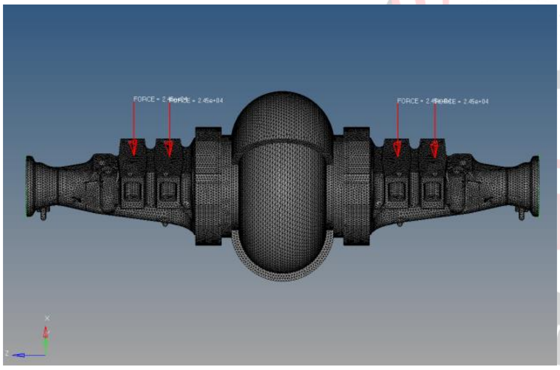

Figure 2: Meshed model

The above figure shows load analysis by using hyper-mesh software . Basically the hyper-mesh software is pre-processor of finite element model which is used to divide the particular area of surface turns into no. of nodes and after their calculate on each node to importing the 3D model from CREO parametric 3.0 software while selecting the auto meshing after their converting 2D model. Finally select the tetra mesh to the 3D component. In this analysis stress distribution on each nodes and applying 10 tons of load which is divided by 4 parts(2.45e+0.4) on both surfaces at the edge of this result to analyse the jacobian aspect ratio which is 1.00.

V. RESULT AND DISCUSSION

Static Analysis:

Static analysis is used to determine the stress, deformation, strain, forces of steady (static) condition of the structural components and also calculate the complex, linear, geometry calculations. The analysis results give and identify the weak areas with low strength and durability.

Material Properties of steel:

Table 1 : Properties of material

Material Type	Steel
Poisson's ratio (μ)	0.3
Young's modulus (E)	200 GPa
Density (ρ)	7850 Kg/m^3

Displacements in 3 directions X,Y&Z

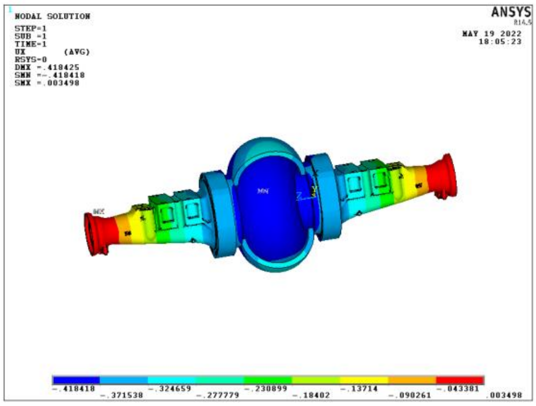

Figure 3: Displacement in X-direction

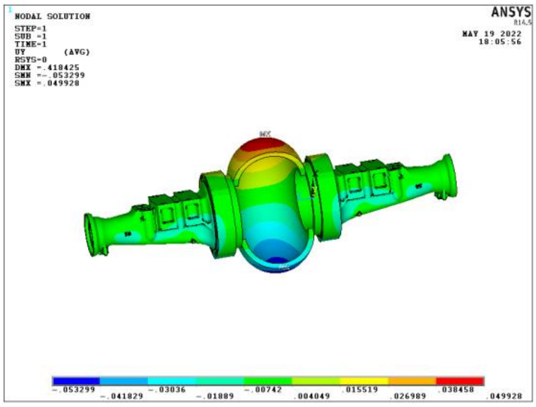

Figure 4: Displacement in Y-direction

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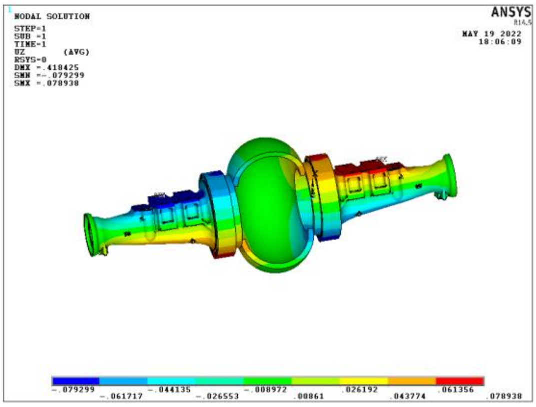

Figure 5: Displacement in Z-direction

The above figures represents the static analysis (symmetric structure) results of rear axle housing of steel material with length 2011mm , load acting 10 Tons at 4sections. Structural analysis is performed in ANSYS workbench 14.5 in 3 directions of displacement X=0.0034mm, Y=0.049mm & Z=0.078mm.

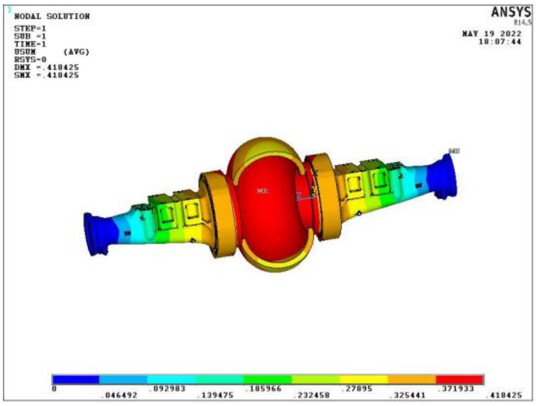

Figure 6: Maximum displacement of axle housing

The above figure represents the maximum displacement of axle housing is 0.418mm.

Stresses in 3 directions X,Y&Z

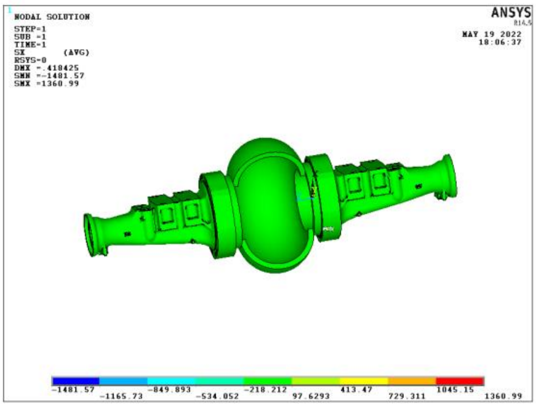

Figure 7: Stress in X-direction

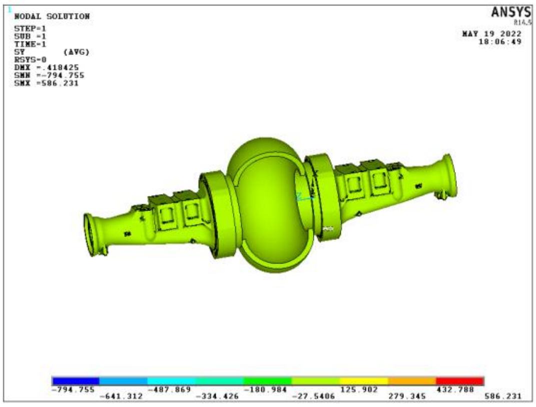

Figure 8: Stress in Y-direction

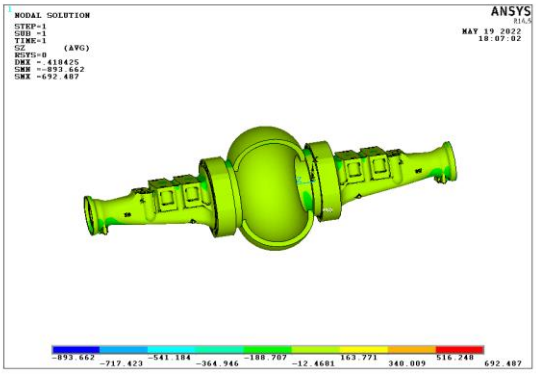

Figure 9: Stress in Z-direction

The above figures represents the static analysis in 3 directions of stresses X=1360.99MPa, Y=586.23 MPa & Z= 692.48 MPa

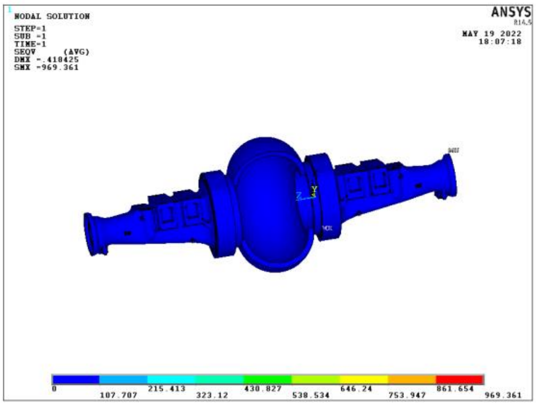

Figure 10: Von-misses stress

The above figure represents the von-misses stress is 969.36 MPa.

Material Properties of Aluminium:

Table 2: Properties of Material

Material Type	Aluminium
Poisson's ratio (μ)	0.33
Young's modulus (E)	71GPa
Density (ρ)	2770 Kg/m^3

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Displacements in 3 directions X,Y&Z

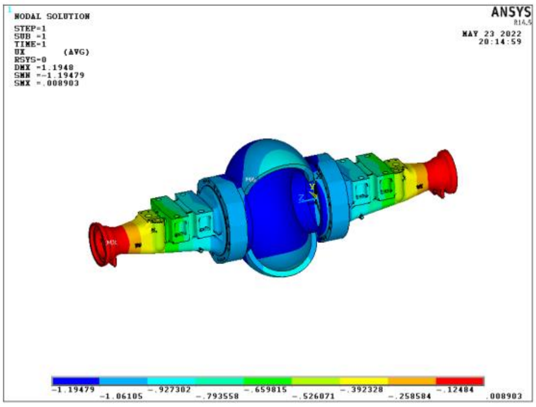

Figure 11: Displacement in X-direction

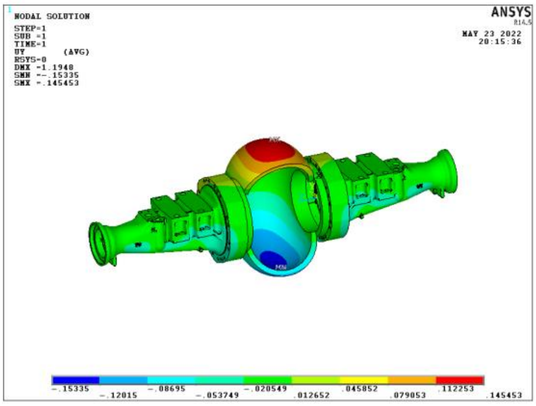

Figure 12: Displacement in Y-direction

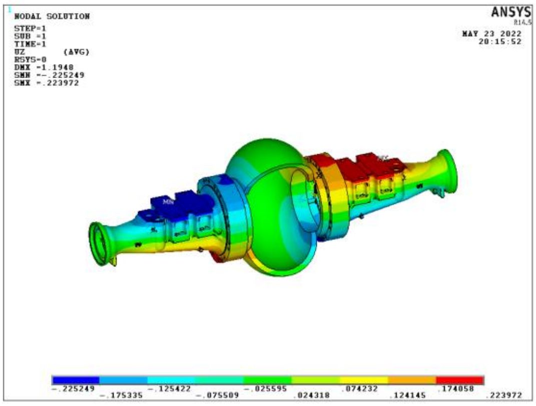

Figure 13: Displacement in Z-direction

The above figures represents the static analysis (symmetric structure) results of rear axle housing of steel material with length 2011mm , load acting 10 Tons at 4sections. Structural analysis is performed in ANSYS workbench 14.5 in 3 directions of displacement X=0.0089mm, Y=0.145mm & Z=0.223mm.

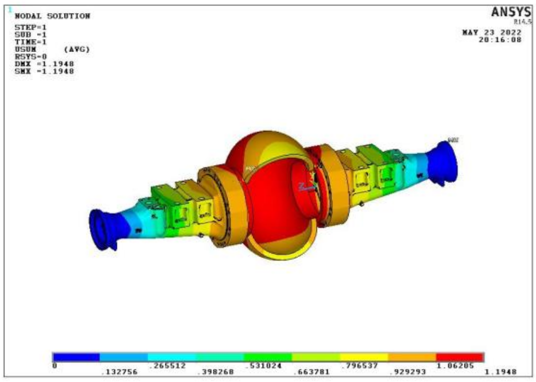

Figure 14: Maximum displacement of axle housing

The above figure represents the maximum displacement of axle housing is 1.194mm.

Stresses in 3 directions X,Y&Z

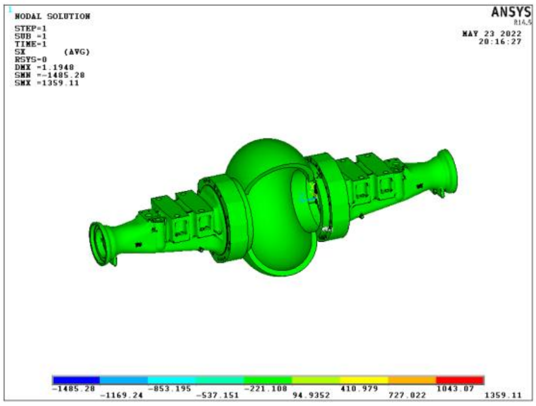

Figure 15: Stress in X-direction

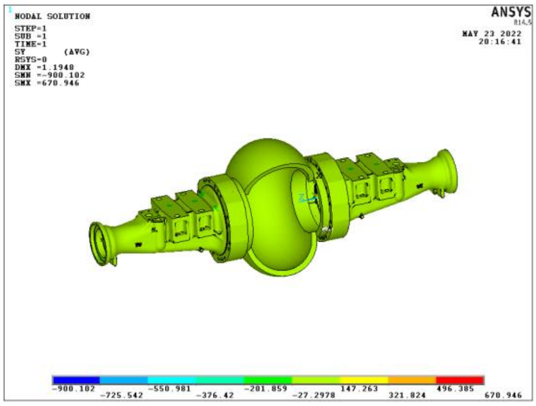

Figure 16: Stress in Y-direction

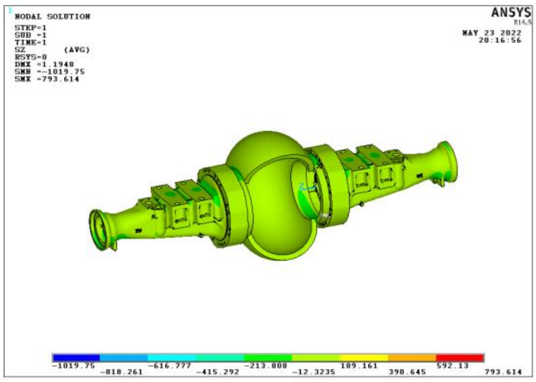

Figure 17: Stress in Z-direction

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The above figures represents the static analysis in 3 directions of stresses X=1359.11MPa, Y=670.94 MPa & Z= 793.61 MPa

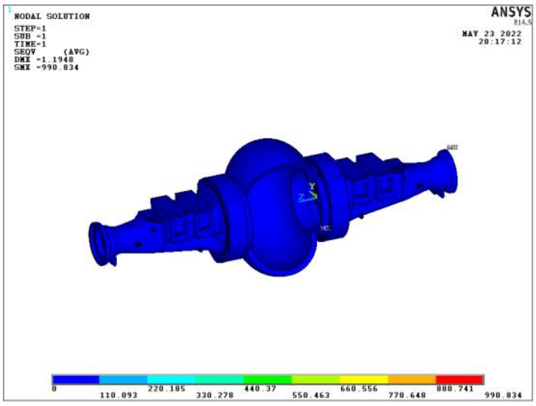

Figure 18: Von-misses stress

The above figure represents the von-misses stress is 990.83 MPa.

Material Properties of Carbon/Epoxy:

Table 3: Properties of Material

Material Type	Carbon/Epoxy
Longitudinal Modulus (E_x)	190GPa
Transverse Modulus(E_y)	7.7GPa
Shear Modulus (G_{xy})	4.2GPa
Shear Modulus (G_{yz})	4.2GPa
Shear Modulus (G_{xz})	4.2GPa
Poisson's Ratio (μ)	0.3
Density (ρ)	1600 Kg/m^3

Displacements in 3 directions X,Y&Z

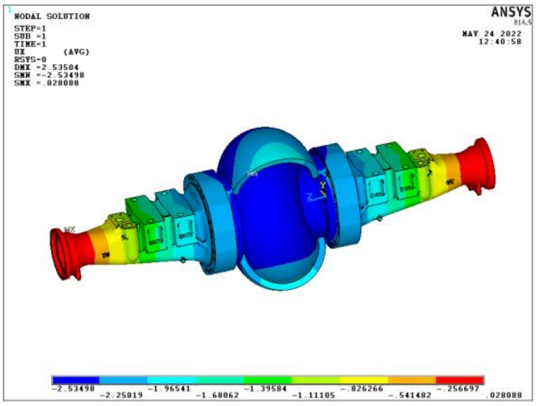

Figure 19: Displacement in X-direction

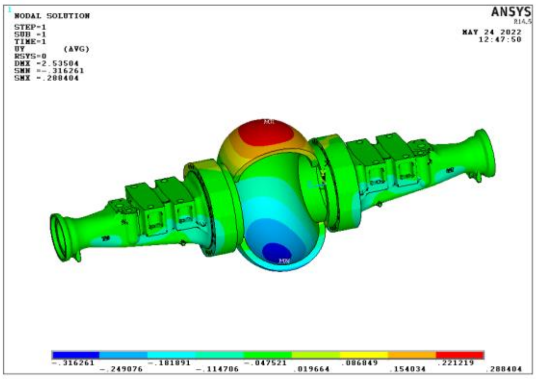

Figure 20: Displacement in Y-direction

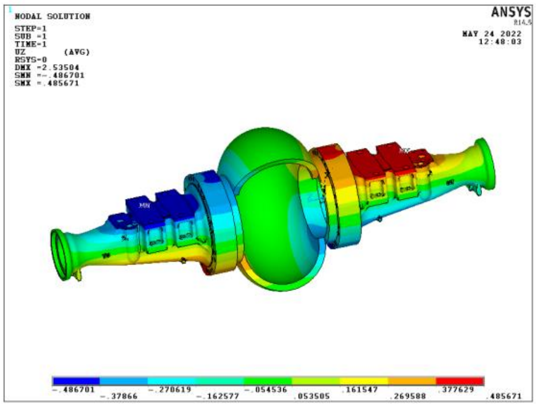

Figure 21: Displacement in Z-direction

The above figures represents the static analysis (symmetric structure) results of rear axle housing of steel material with length 2011mm , load acting 10 Tons at 4sections. Structural analysis is performed in ANSYS workbench 14.5 in 3 directions of displacement X=0.0280mm, Y=0.2884mm & Z=0.4856mm.

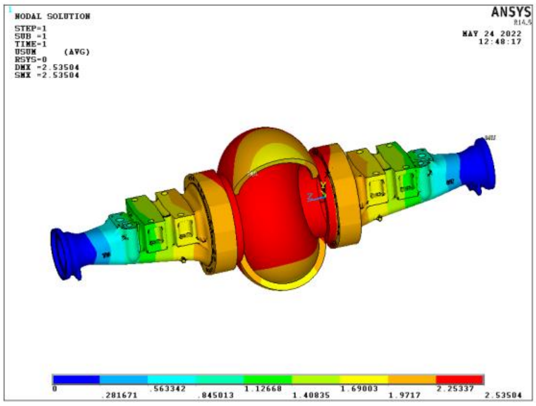

Figure 22: Maximum displacement of axle housing

The above figure represents the maximum displacement of axle housing is 2.535mm.

Stresses in 3 directions X,Y&Z

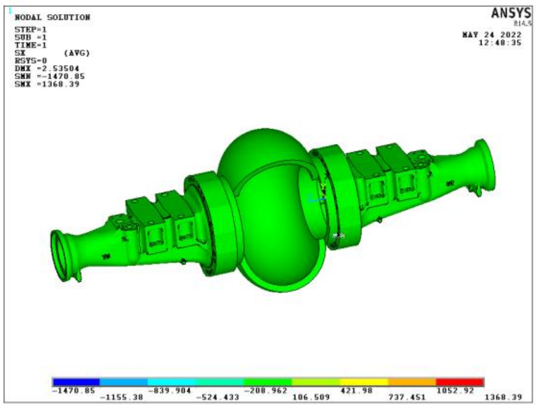

Figure 23: Stress in X-direction

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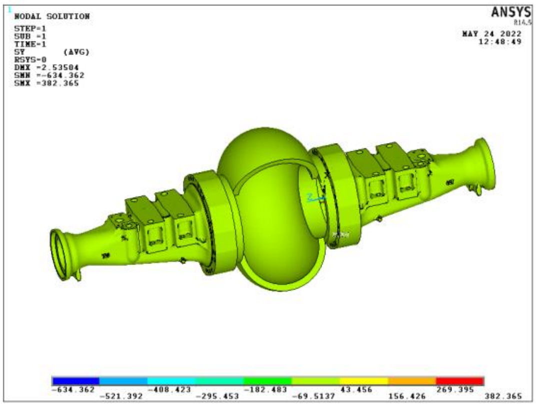

Figure 24: Stress in Y-direction

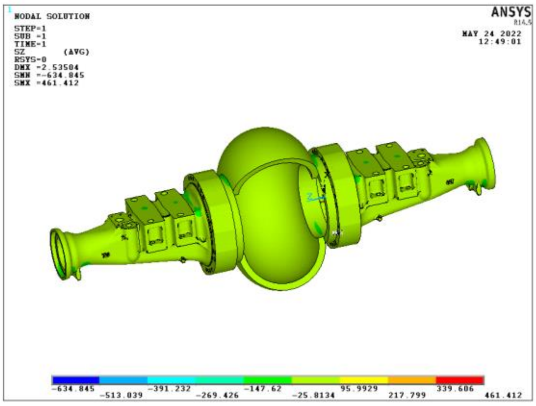

Figure 25: Stress in Z-direction

The above figures represents the static analysis in 3 directions of stresses X=1368.39MPa, Y=382.36 MPa & Z=461.41MPa

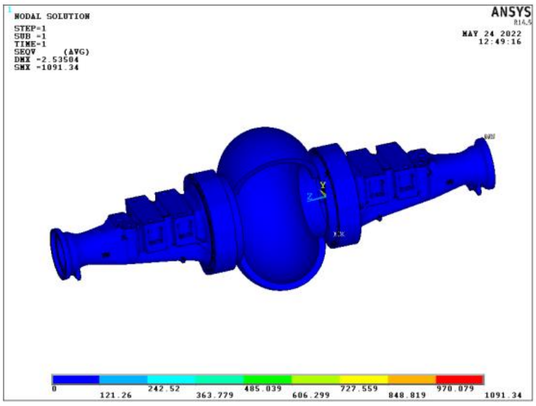

Figure 26: Von-misses stress

The above figure represents the von-misses stress is 1091.34MPa.

Material Properties of Jute-Glass:

Table 4: Properties of material

Material Type	Jute-Glass
Poisson's ratio (μ)	0.32
Young's modulus (E)	26.5GPa
Density (ρ)	1400 Kg/m^3

Displacements in 3 directions X,Y&Z

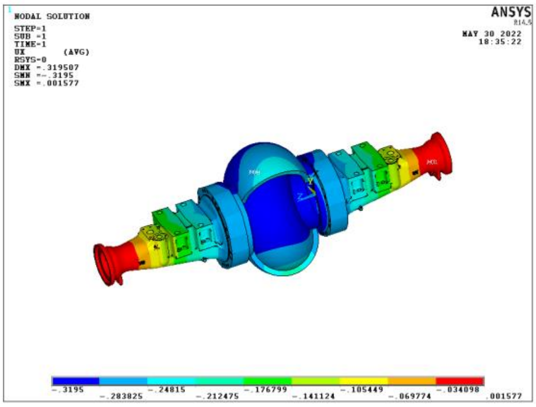

Figure 27: Displacement in X-direction

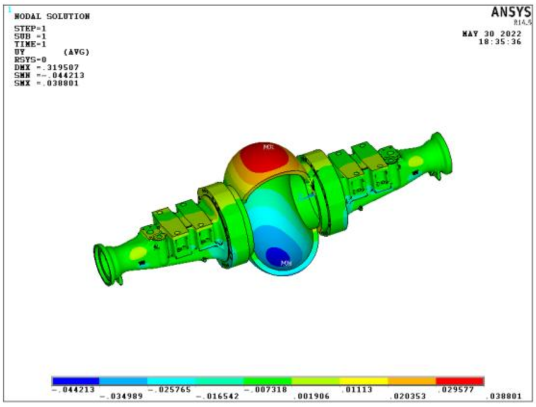

Figure 28: Displacement in Y-direction

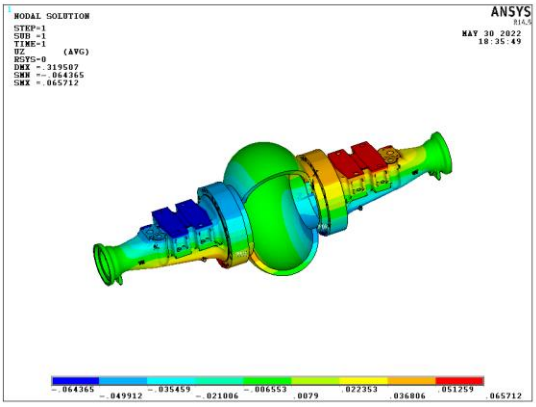

Figure 29: Displacement in Z-direction

The above figures represents the static analysis (symmetric structure) results of rear axle housing of steel material with length 2011mm , load acting 10 Tons at 4sections. Structural analysis is performed in ANSYS workbench 14.5 in 3 directions of displacement X=0.0015mm, Y=0.0388mm & Z=0.0657mm.

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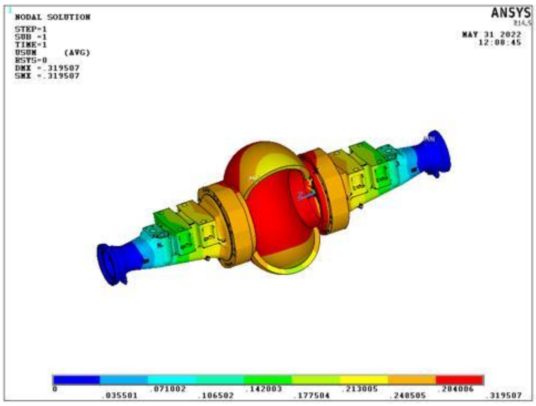

Figure 30: Maximum displacement of axle housing

The above figure represents the maximum displacement of axle housing is 0.3195mm.

Stresses in 3 directions X,Y&Z

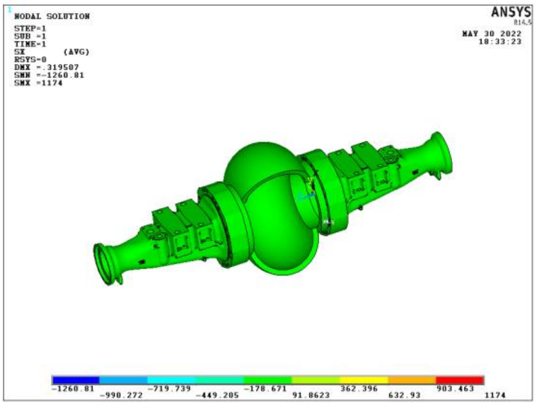

Figure 31: Stress in X-direction

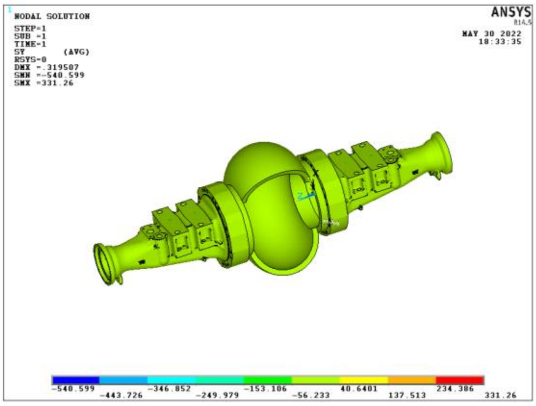

Figure 32: Stress in Y-direction

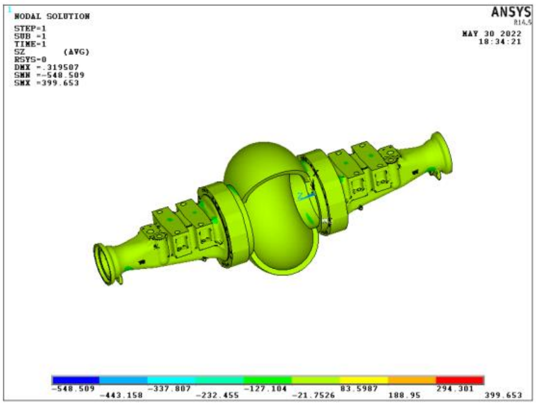

Figure 33: Stress in Z-direction

The above figures represents the static analysis in 3 directions of stresses X=1174MPa, Y=331.26 MPa & Z=399.65MPa.

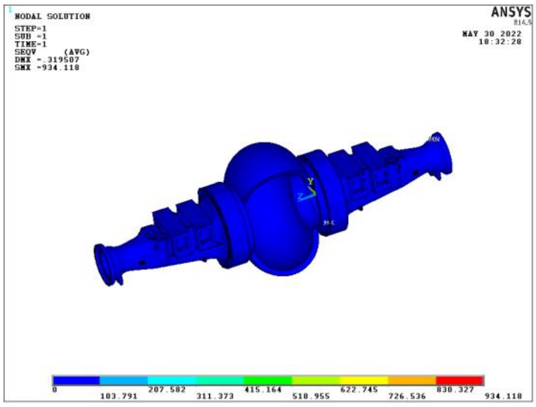

Figure 34: Von-misses stress

The above figure represents the von-misses stress is 934.118MPa.

Table 5: Displacements obtained during analysis

S .No	Material Name	Displacements (mm)			
		X	Y	Z	Max
1	Steel	0.0034	0.049	0.078	0.418
2	Alumini-um	0.0089	0.145	0.223	1.194
3	Carbon/ Epoxy	0.0280	0.288	0.4856	2.535
4	Jute-Glass	0.0015	0.038	0.0657	0.319

Table 6: Stresses obtained during analysis

S .No	Material Name	Stresses (MPa)			
		X	Y	Z	Max
1	Steel	1360.99	586.23	692.48	969.36
2	Alumini-um	1359.11	670.94	793.61	990.83
3	Carbon/ Epoxy	1368.39	382.36	461.41	1091.34
4	Jute-Glass	1174	331.26	399.65	934.11

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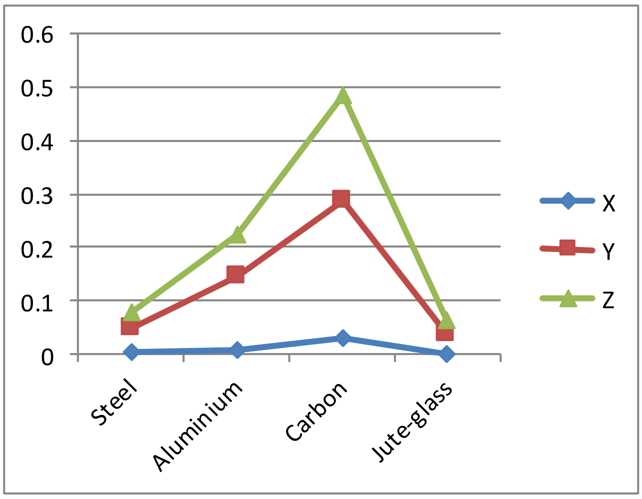
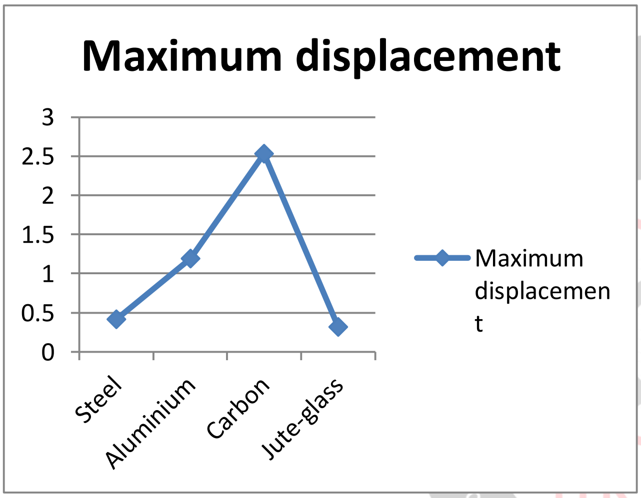


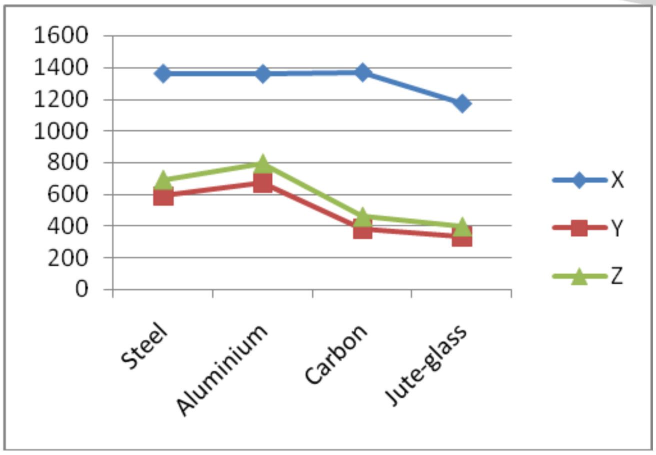
Graph 1: Materials v/s Displacements

In this graph, the jute-glass material has the less displacements in 3 directions (X,Y,Z) has compared to remaining materials.



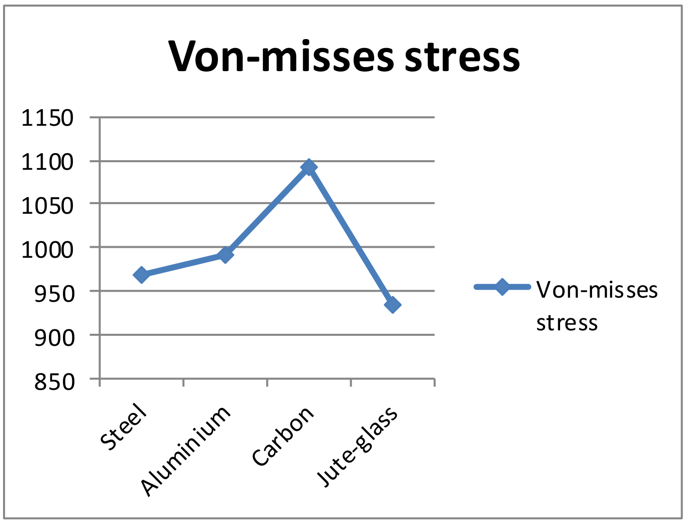
Graph 2: Materials v/s Max Displacements

In this graph, the maximum displacement of jute-glass is less compared to remaining materials.



Graph 3: Materials v/s Stress

In this graph, the stresses in 3 directions (X,Y,Z) the jute-glass material is less compared to steel, aluminium,, carbon/epoxy.



Graph 4: Materials v/s Von-misses stress

In this graph, the maximum stress of jute-glass is less and considered.

Model Analysis:

Model analysis is used to determining the dynamic characteristics in various engineering fields like natural frequencies, damping factors and mode shapes of the suspension parts etc. For the various automobiles and also used to determining the mathematical calculations of dynamic behavior.

These factors may affect the part it's lead to tend the fatigue damage by this analysis to use reduce the vibrations.

Steel Material:

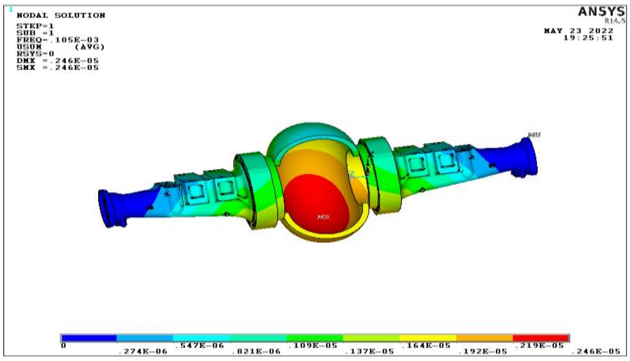


Figure 35: Mode shape

Aluminium Material:

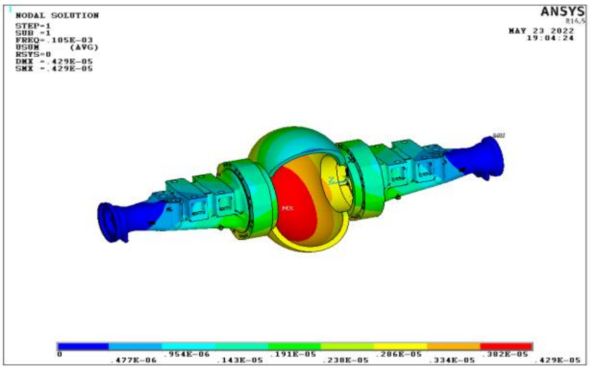


Figure 36: Mode shape

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Carbon/Epoxy:

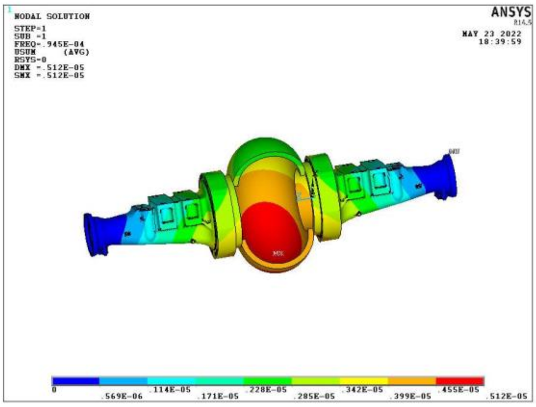


Figure 37: Mode shape

Jute-Glass:

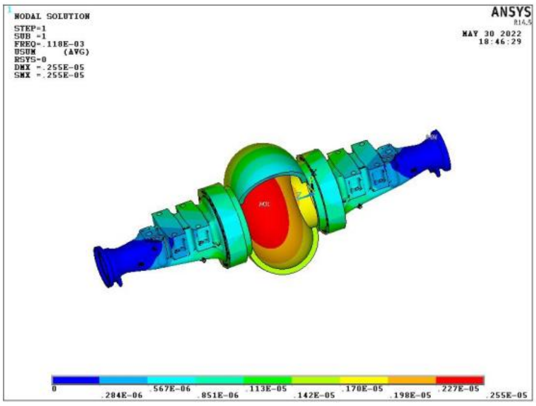
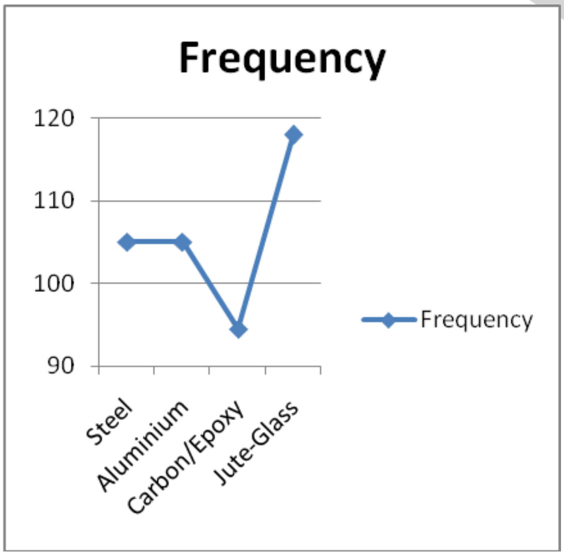


Figure 38: Mode shape

Table 7: Frequency of rear axle housing

S.No	Material Name	Frequency(Hz)
1	Steel	105
2	Aluminium	105
3	Carbon/Epoxy	94.5
4	Jute-Glass	118

The frequency values are listed in the table the carbon-epoxy material has less.



Graph 5: Material v/s Frequency

In this graph, the carbon material has the value is 94.5 hz has to be less compared to stel, aluminium, jute-glass.

VI. CONCLUSION

- The maximum displacement induced in steel is 0.418mm are followed by the aluminium material is 1.194 mm followed by carbon/epoxy material is 2.535mm followed by jute-glass material is 0.319mm. Compared the four materials the jute-glass material is lesser than the compared materials.
- The von-misses stress induced in steel is 969.36MPa, followed by aluminium is 990.83MPa, followed by carbon/epoxy is 1091.34 MPa, followed by jute-glass is 934.11MPa, the jute material is lesser than the compared materials.
- The natural frequencies is obtained for carbon/epoxy is lesser than the steel, aluminium, jute-glass materials.

- Compare the four materials in static and model conditions the design of jute-glass fibre composite material is better for manufacturing of rear axle housing of truck.

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