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STATIC AND MODAL ANALYSIS OF REAR AXLE HOUSING OF A TRUCK

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Abstract: Axle housing is one of the significant components that lead to great performance of the vehicle. It may be available in one-piece or has spilt type construction that is also known as banjo type construction. Axle housings are usually comprised of double lip seals and over size bearings. This results in more capacity and enhanced surface area contact over axle. Both the front and rear openings have center housing. Differential carrier closes the front opening. On the other hand, spherical cover plate is used for closing the rear. This paper analysis the static and modal analysis of the rear axle housing. The geometry of axel housing is created in Pro-E-4.0 software as per the drawing. Then the model is imported to develop a mesh by using HyperMesh-10, through IGES format and then solid elements were created for axel housing. A converged mesh is generated and the meshed component is exported to Ansys-11 to evaluate the product strength and ability to withstand against all forces and vibrations .Finally the stresses, deflections and natural frequencies of the cast iron and mild steel models are carried out and compared.

Keywords: Rear Axle housing, static and modal analysis

1. INTRODUCTION

The axle housing may be of the one-piece or split (banjo) type construction. The former, known as the banjo type because of its appearance, is far more common . Notice that openings, both front and rear, are provided in the center housing [1]. The front opening is closed by the differential carrier, while their ear is closed by a spherical cover plate. Since the assembly must carry the weight of the vehicle, the axle housing in heavy trucks and tractors is a heavy cast unit. In light-duty trucks it may be a combination of cast and steel tube[2]; in general, the center or differential and final drive case is a cast and machined unit, whereas the axle housings themselves may be welded or extruded steel tubing. Items, such as brake backing plates, mounting flanges, spring mounting plates, and accessory units, may be riveted, welded, or cast into the axle housing.

The finite element method [3] and the stress were applied in the study of the stiffness and strength of the rear axle housing of a truck [4], and an analysis of the distributions of the stress and the deformations of the rear axle housing under the actions of corresponding loads when the vehicle was moving in a straight line, swerving or braking while backwards was performed. The influence of the transition arc radius between rear axle gear housing and rear axle tube on the stress of the transition zone and that of the U shaped bolt pre tightening force upon the local structure strength of the housing were analyzed respectively. The results show that, of the above three cases, the stress in the rear axle housing is the maximum when the vehicle is braking[6] in backward, and that in all three cases the transition zone in the housing suffers the highest stress level. Increasing the transition arc radius [10] can't decrease the stress in all parts of the rear axle housing, in some area there is also an increase of the stress level because of the change of its local structure.

2. DESCRIPTION

Length of the axle housing	=	745.50 mm
Maximum load capacity	=	5 tones

Material properties:

(i)Cast Iron:	Young's modulus	=	1.8 x 10^5 MPa
	Poisson's Ratio	=	0.40
	Density	=	7.4 x 10^{-6} Kg/mm^3
(ii)Mild Steel:	Young's modulus	=	2.1 x 10^5 MPa
	Poisson's Ratio	=	0.28
	Density	=	7.86 x 10^{-6} Kg/mm^3

3. MODELLING AND MESHING

The chosen problem is considered as 3-D solid model as shown in Fig 1. The model consists of 88079 elements. Fig. 2 shows the solid 92 element considered for meshing. FE model of the rear axle housing is shown in Fig 3. Appropriate boundary conditions are incorporated in the analysis. The solid 92 is defined by ten nodes having three degrees of freedom (UX, UY and UZ) at each node translations in the nodal x,y and z directions. The element has Plasticity, Creep, Swelling, Elasticity, Stress stiffening, Large deflection, Large strain, Adaptive descent, Initial stress import capabilities.

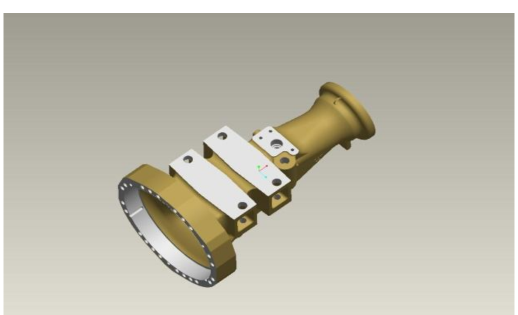

Fig 1: solid model of Rear Axle housing

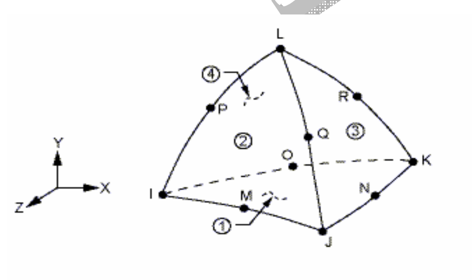

Fig 2: Solid 92 Element

QUALITY PARAMETERS

Aspect Ratio	4
Tet collapse	0.5
Length	5
Min angle of trias	25
Max angle of trias	130

Fig 3: FE Model of Rear Axle housing

4. REAR AXLE HOUSING

Static Analysis:

(i) Cast Iron

Static Analysis of rear axle housing made up with cast iron is performed. Displacements in X, Y and Z directions are shown in Fig.4, Fig.5 and Fig.6 respectively.Fig.7 shows stress in X direction. Stress in Y direction is shown in Fig 8. Fig.9 shows stress in Z direction. The Vonmises stress of the rear axle housing shown in Fig.10

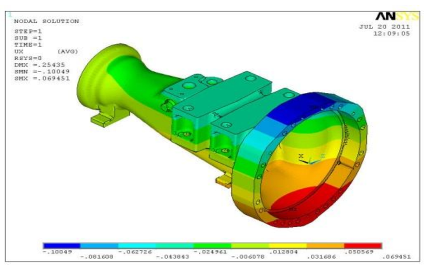

Fig 4:Displacement in X- direction

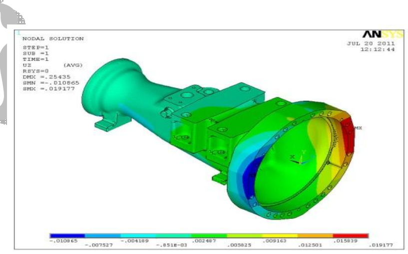

Fig 6:Displacement in Z- direction

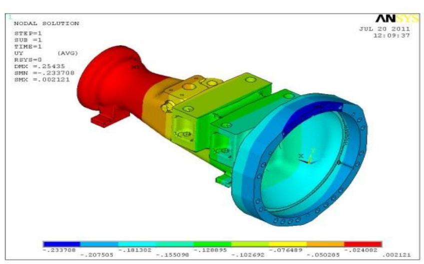

Fig 5:Displacement in Y- direction

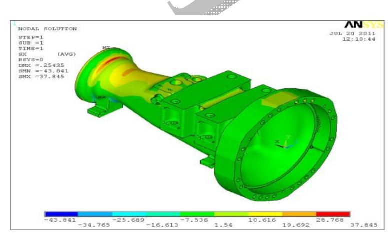

Fig 7:Stress in X direction

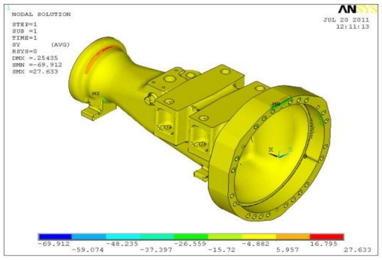

Fig 8:Stress in Y direction

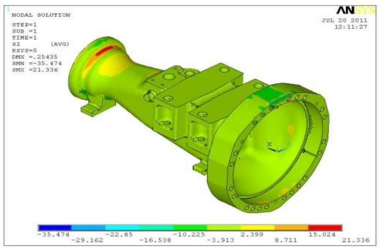

Fig 9:Stress in Z direction

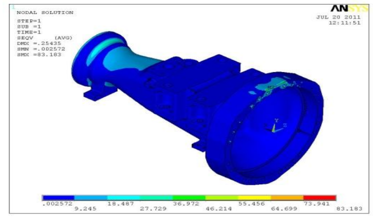

Fig 10: Vonmises Stress

(ii) Mild Steel

Static Analysis of rear axle housing made up with mild steel is performed. Displacements in X, Y and Z directions are shown in Fig.11, Fig.12 and Fig.13 respectively.Fig.14 shows stress in X direction. Stress in Y direction is shown in Fig 15. Fig.16 shows stress in Z direction. The Vonmises stress of the rear axle housing shown in Fig.17

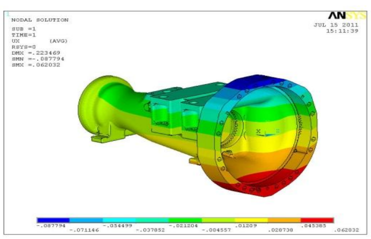

Fig 11: Displacement in X- direction

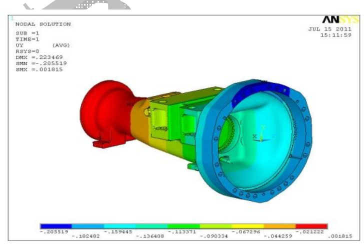

Fig 12: Displacement in Y- direction

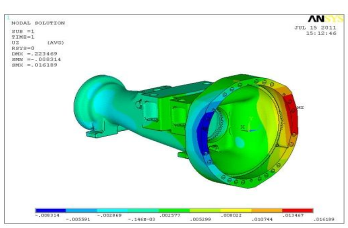

Fig 13: Displacement in Z- direction

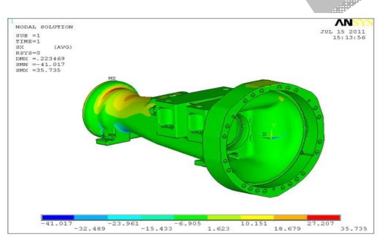

Fig 14: Stress in X direction

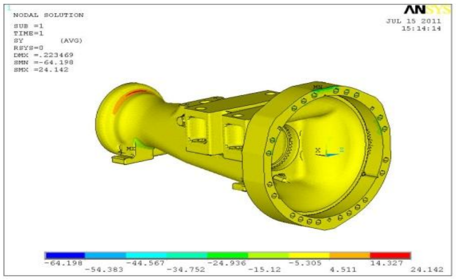

Fig 15: Stress in Y direction

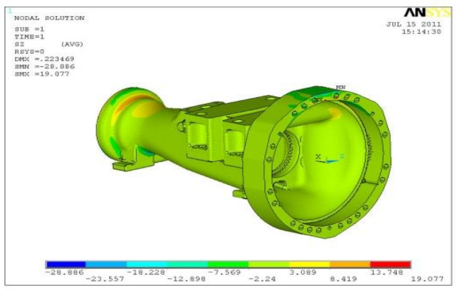

Fig 16: Stress in Z direction

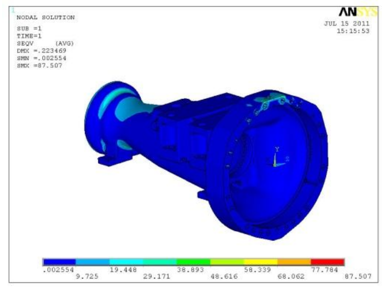

Fig 17: Vonmises Stress

4.2 Modal Analysis:

(i) Cast Iron

Model Analysis of rear axle housing made up with Cast iron is performed. Fig.18 shows Mode Shape 1 of the rear axle housing. Mode Shape 2 of rear axle housing is shown in Fig.19.Mode Shape 3 of rear axle housing made up with cast iron is shown in Fig20.

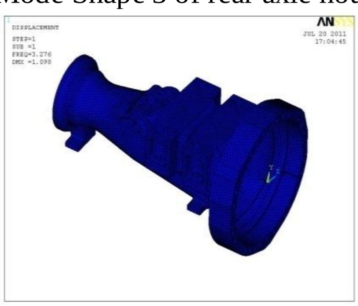

Fig 18: Mode shape 1

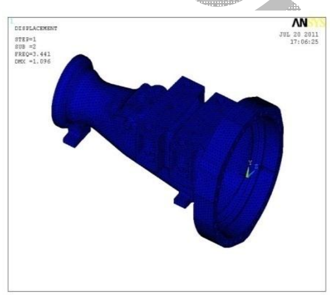

Fig 19: Mode shape 2

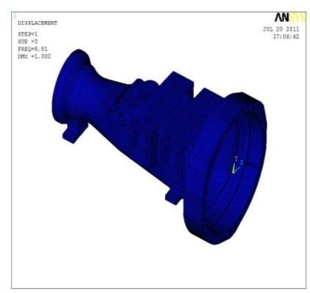

Fig 20: Mode shape 3

(ii) Mild Steel

Model Analysis of rear axle housing made up with Cast iron is performed. Fig.21 shows Mode Shape 1 of the rear axle housing. Mode Shape 2 of rear axle housing is shown in Fig.22.Mode Shape 3 of rear axle housing made up with cast iron is shown in Fig23.

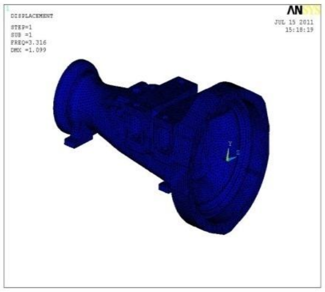

Fig 21: Mode shape 1

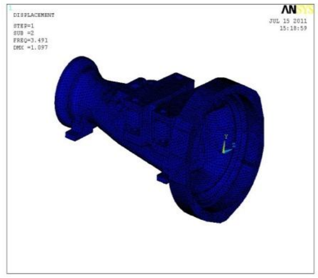

Fig 22: Mode shape 2

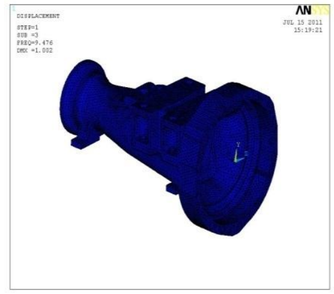

Fig 23: Mode shape 3

5. RESULTS & DISCUSSION:-

Table 1 shows displacement and stresses of the Rear Axle housing made up with Cast Iron by static analysis, which shows displacement in X direction, Y direction and Z direction are 0.10 mm, 0.23 mm, 0.019 mm respectively. Stresses in X,Y and Z directions are found as 43.841 MPa, 69.912 MPa, 35.474 MPa respectively. The vonmises stress found as 83.183 MPa. Table 2 shows displacement and stresses of the Rear Axle housing made up with Mild Steel by static analysis, which shows displacement in X direction, Y direction and Z direction are 0.087 mm, 0.205 mm, 0.016 mm respectively. Stresses in X,Y and Z directions are 41.017 MPa, 64.198 MPa, 28.886 MPa respectively. Vonmises stress is found as 87.507 MPa. Table 3 shows frequencies of the rear axle housing made up with cast iron by modal analysis, which shows frequencies of mode shape 1, mode shape 2 and mode shape 3 are 3.276 Hz, 3.441 Hz, and 8.81 Hz respectively. Table 4 shows frequencies of the rear axle housing made up with Mild Steel by modal analysis, which shows frequencies of mode shape 1, mode shape 2 and mode shape 3 are 3.316 Hz, 3.491 Hz, and 9.476 Hz respectively.

Table 1: Static Analysis of Cast Iron

Name: Static Analysis	**Cast Iron**
Displacement in X- direction ,mm	0.10
Displacement in Y-direction ,mm	0.23
Displacement in Z-direction ,mm	0.019
Stress in X direction, MPa	43.841
Stress in y direction , MPa	69.912
Stress in z direction , MPa	35.474
Vonmises Stress , MPa	83.183

Table 2: Static Analysis of Mild Steel

Name: Static Analysis	Mild Steel
Displacement in X- direction ,mm	0.087
Displacement in Y-direction ,mm	0.205
Displacement in Z-direction ,mm	0.016
Stress in X direction, MPa	41.017
Stress in y direction , MPa	64.198
Stress in z direction , MPa	28.886
Vonmises Stress , MPa	87.507

Table 3: Modal Analysis of cast Iron

Name :modal analysis	Frequency (Hz)
Mode shape 1	3.276
Mode shape 2	3.441
Mode shape 3	8.81

Table 4: Modal Analysis of Mild Steel

Name :modal analysis	Frequency (Hz)
Mode shape 1	3.316
Mode shape 2	3.491
Mode shape 3	9.476

CONCLUSION

The following conclusions are drawn from the present work.

1. The maximum deflection induced is 0.23mm in case of cast iron, which is higher than 0.205mm obtained for mild steel.
2. The maximum stress induced is 83.183 MPa in case of cast iron, which is lower than the maximum stress induced as 87.507 MPa obtained for mild steel.
3. The natural frequencies obtained for cast iron is lesser than the mild steel.
4. Hence comparing all these conditions it may be considered that design of cast iron is better for manufacturing of rear axle housing.

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