Shock and Response Spectrum Analysis of Automobile Rear Axle Housing

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Abstract— Rear axle housing is an important element to house differential mechanism with body loads transferred through support brackets. These members are subjected to various loads during its operation. So a check is required to maintain safety of the problem. In the present work, a rear axle housing is checked for structural safety under leak testing pressures. Initially the structure is built using a three dimensional software based on the autocad representation of the problem. Hypermesh is used for noble excellence meshing. Then it is imported to Ansys for analysis. Initially analysis is carried out to find the optimum constraint to minimize the distortion in the member due to internal leak testing pressures. Initial constraint provided on the top and bottom results, shows failure for safety. Further with the dome region constraint the analysis shows safety for distortion as the deflection developed is less than the allowable deflection. Further the analysis is carried out for the spectrum loads for road vibration based on the mil standards. The spectrum data is given as input which combines the results of modal frequencies for amplified displacements. The results shows safety of the housing for the given loads. Further a transient analysis is carried out for the given load history data based on mil standards. A triangular pulse data is considered as the transient vibration data. The results shows safety of the housing for the given loads. Altogether the results are interpreted with essential graphical plots.

Key words: Automobile rear axle housing, static leak testing, shock and spectrum analysis, road vibrations, finite element analysis

I. INTRODUCTION

A. *Rear Axle Housings*

Working of automobiles is necessary which includes more number of structures in an assembly. If any critical member is weak, it balls up the operation of automobile and leads to loss of money. Hence the design is a serious factor in the design of component. In the present work analysis of a major component called rear axle housing is considered. Rear axle housing are comprised of shell, dome, housing of wheels and brackets of loads. The housing is created in two halves and combined together by welding process. Numerous kind of rear axle housing can be seen according to the applications.

Fig. 1: Rear axle housings

So when the automobiles are in the operation, the components will be exposed to dynamic loads. Particularly spectrum loads are very familiar which occurs due to the vibrations on the road while in the motion. Likewise unexpected humps and pits lead to the random vibrations and more often; these shocks generate greater stresses on the structure. Hence for the right safety, each structure of automobile is needed to be examined for transient and spectrum loads. Owing to the developments in the computer based numerical techniques, more numbers of softwares are existing in the market for engineering analysis and the growth in development of the products. Earlier understanding of the specific field helps in developing the effective products. With the theoretical data, the designer must be having the practical knowledge of the computer aided engineering software aids to the improved development of products. The earlier techniques either destructive or non-destructive methods are done by virtual simulation using computers.. The errors of assembling can also be predicted using the virtual simulation which helps in correcting the mistakes done while designing.

B. *Classification of Rear Axle Housings*

Depends on the usage many types of rear axle housings are available:

1) Split-type
2) Banjo-type
3) Integral-type
4) Split-type

1) *Material Properties*

Properties	Structural Steel
Material of the shaft	Mild steel
Young’s Modulus	190 Gpa
Poison’s ratio	0.303
Yield Stress	328.6Mpa
Density	78E-6Kg/m3

Table1: Material Properties

II. Geometrical Model of the Problem

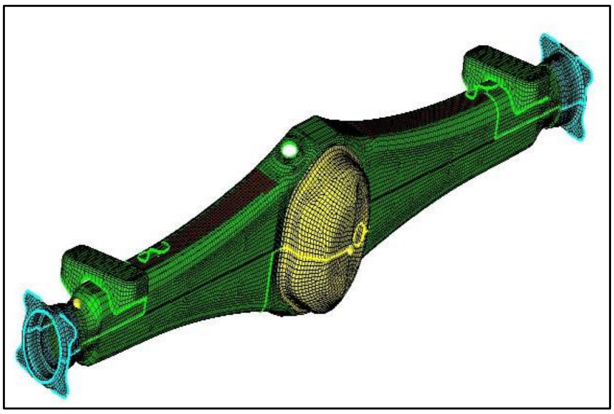

Fig. 2: Geometrical model of the Rear axle housing

The figure2.1 shows built geometry meshed in Hypermesh. The geometry is step file format is exported to hypermesh for meshing. The members are grouped to form components with different thickness. Mid surface option of hypermesh is used for extraction of mid surfaces as the structure is regular. For this problems this is always good for shell meshing. Number of elements used are 24349 and number of nodes 22942. In Ansys shell63 properties are attached to the problem. Various components are created to apply different thickness across the geometry.

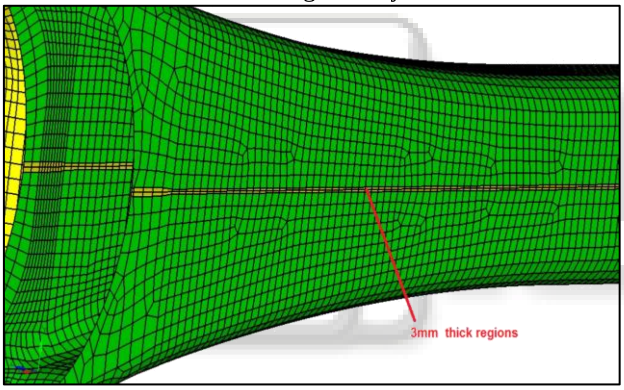

Fig. 3: 3mm thickness regions

The figure2.2 indicates shows weld configuration between the top and bottom shell regions. Here the housing is made by welding the top and bottom portions with 3mm thickness. So it is utmost important to find the safety in this region due to leak testing pressure.

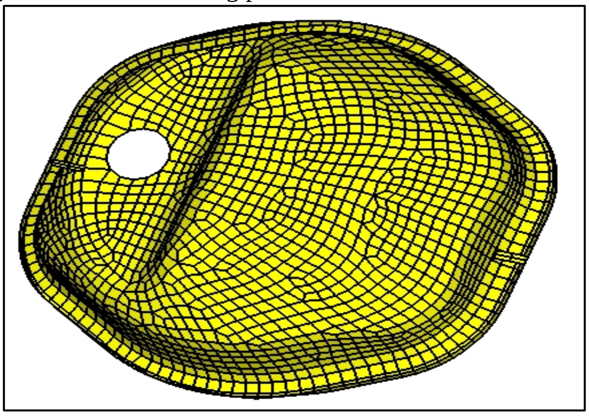

Fig. 4: 2mm Thick Region

The dome region is provided with initial thickness of 2mm. It helps only in covering the differential housing water and dust particles. In addition it provides opening for draining and filling lubricant.

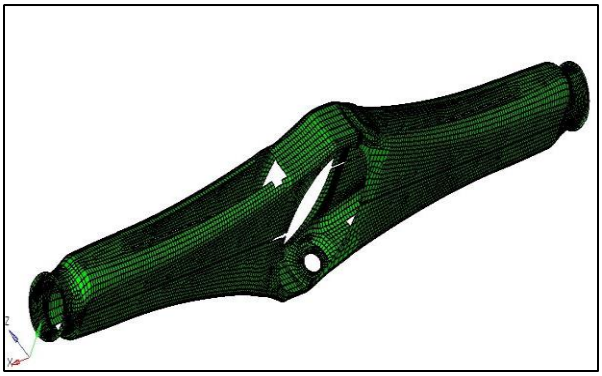

Fig. 5: Constant Thick region (4.5mm thick)

Main region of the housing is the uniform sized shell structure having 4.5 mm thickness. A quality mesh satisfying the skew angle, warpage, aspect ratio, jacobian is created for better results

The components used in the rear axle housing are shown with different thickness. The dome is mainly of 2mm, the shell of 4.5 mm, wheel housing of 6.5mm and 3mm thick weld region joining the top and bottom of the rear axle housing. The main problem is to check the stress generation in this region to prevent any possible failure in the region due to leak testing pressure.

If the width to thickness relation is bigger than ten, then it is a thin structure of shell. Meshing and resolving problems can be condensed by solving the problem in 2D domain where the surfaces in the middle. The results will be more accurate since these elements include the twisting effects for their greater DOFs compared with 3DOF of solids.

A. *Element Assumptions*

Homogeneity and isotropy are the important properties.

- The material is analyzed under the limits of elasticity.
- The solutions can be easily acquired.
- Holds good with the assumptions of the FE solutions.

III. Numerical Analysis and Results

Analysis for rear axle housing has been carried out in 4 stages.

- Distortion of the structure under leak testing pressure
- Analysis for spectrum loads
- Analysis for shock loads.

A. *Case 1: Analysis for Leak Testing Loads*

The imported mesh is analysed for structural strength conditions by constraining at the top and bottom of rear axle housing. Now the objective is whether this constraint is safe for eliminating the distortion in the problem. The figure2.1 represents deformation in the structure after constraining of dome portion. The results show deformation of 88.1 microns as shown in the status bar.

So this deformation is well within the allowable limits of the problem. So applied constraints satisfy the requirement for minimization of distortion in the problem.

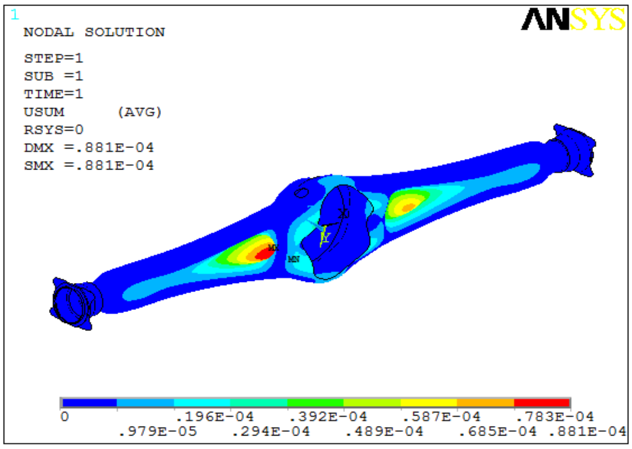

Fig. 6: Deformation in the structure

The figure3.2 represent after proper constraining the stresses in the structure. Max-stress is near 115Mpa as seen in the figure.

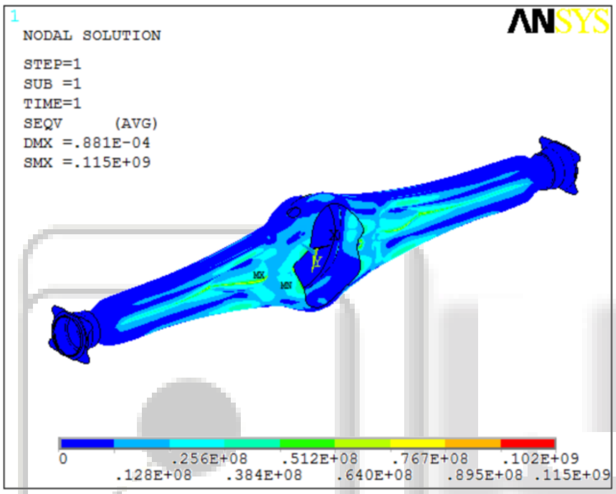

Fig. 7: Vonmises-Stress in Rear axle Housing

The status bar shows variation of stress across the geometry. The developed stress is also lesser to the allowable limiting-stress of material. Hence the structure is determined to be under safety level for leak testing operation.

B. Case2: Spectrum Analysis Results

The rear axle housing is also subjected spectrum loads during transportation and functioning. The spectrum loads are given as follows. In the present analysis single point response spectrum is considered for calculations.

Frequency Range(Hz)	Displacement(m)
4-20	0.001
20-30	0.0008
30-40	0.0003

Table 2: Spectrum data

The table3.1 indicates displacement input for the given frequency range. Each vibration range has different displacements to be applied for spectrum analysis. The constraints are changed to the actual condition of support of rear axle housing. So wheel housing region is constrained and analysis carried out.

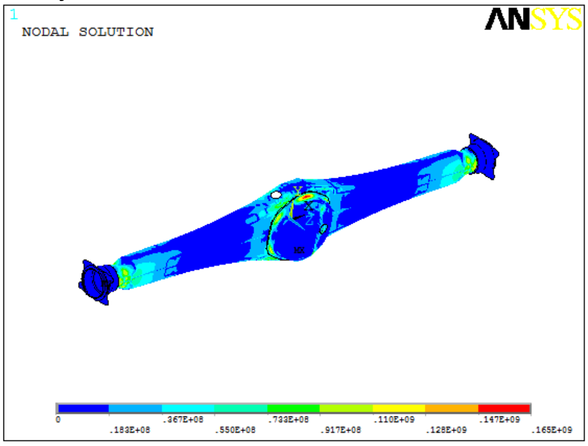

Fig. 8: Vonmises Stress in the Structure

The figure4.15 shows vonmises stress of 165 Mpa for the given problem. This value is lesser to the allowable-limit of problem. Hence this structure can take this load without failure. The maximum stress is shown at the dome region. This can be mainly attributed to lesser thickness of the dome region.

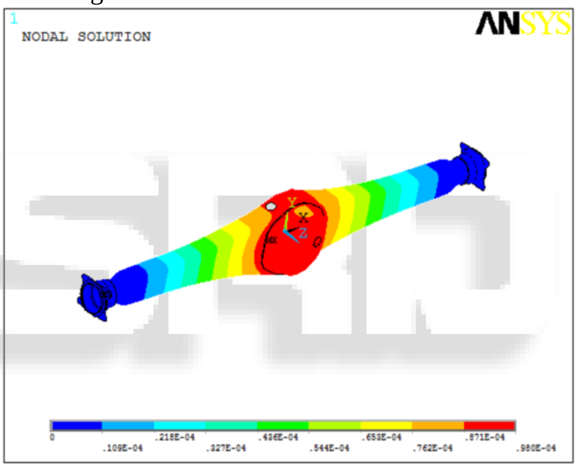

Fig. 9: Deformation plot for spectrum loads

The figure3.4 represents deformation in the structure for given spectrum loads. The deformation value is around 0.098m as shown in the figure. So structure is safe for the given loads. The deformation is uniformly distributed across the geometry.

C. Case3: Analysis for Shock Loads

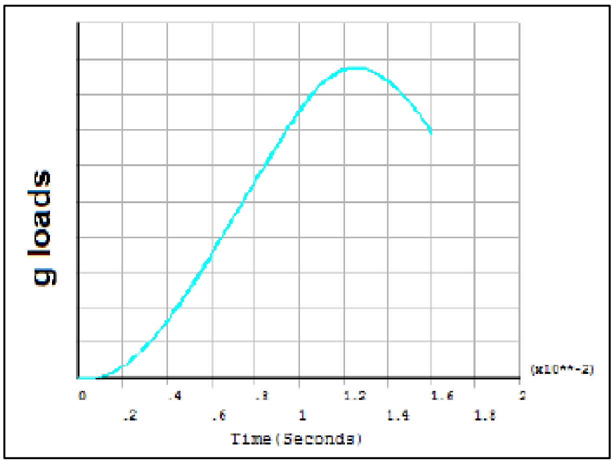

Fig. 10: Shock spectrum input for the problem

The data to be considered is for '6g' loads with triangular wave type load as per the mil standard. The Loading graph is shown in the figure.

Maximum load is 6g loads at .012 seconds. Further it is slopping down. So this load is taken for transient data and split into 4 load steps for application of the load. 2 per cent damping is considered for analysis.

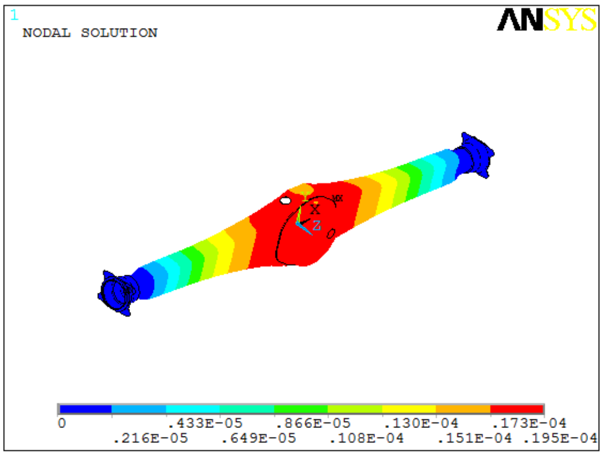

Fig. 11: Deformation plot for Shock Spectrum

The figure3.6 represents deformation level of 19.5 microns in the problem. This deformation is less than the allowable deformation of the problem.

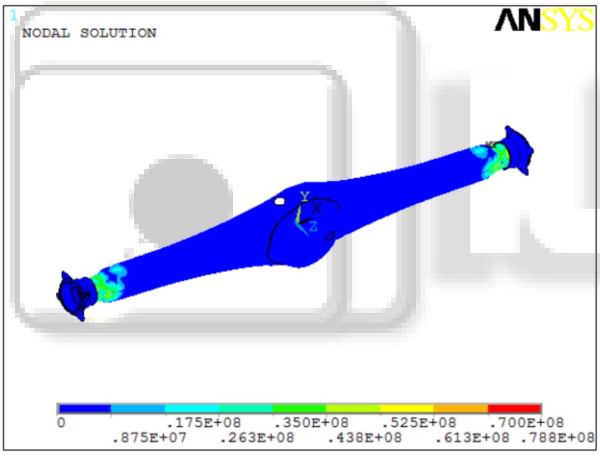

Fig. 12: Vonmises stress for loaded configuration with shock loads

The figure4.21 represents vonmises stress development with shock loads. The results show safety of the structure for the given loads. Maximum stress development is around 78.8Mpa. Maximum stress is taking place near the wheel housing as in the initial unloaded configuration.

The results shows the stress and deflection variation with real housing analysis. Initial leak testing analysis with first type constraints is failing for stress and deformation conditions. So supports are increased by which stress level is coming down to safe limits. Even distortion in the structure is also with in the allowable limit of 100 microns or 0.0001mm or 0.1m. Further analysis of spectrum and shock vibration shows the problem is completely under safety level for the loads given

IV. CONCLUSIONS

- Static analysis is carried to check the safety of the structure for the given leak testing loads where the distortion should be limited to 100microns. The results show no possibility as the obtained natural frequencies are very high compared to the required frequencies. Also with the increased constraints the natural frequencies are increasing which is good for dynamic stability.
- Further analysis is carried out for spectrum loads. The displacements and frequencies are given as input to the system and combined effect of modal and spectrum are obtained. The results show safety of the structure for the given loads.
- Shock data is supplied as transient data for one cycle time and results are obtained.
- Maximum stresses are observed near 0.012 seconds. In all the cases results are obtained for deformation and stress as they are the parameters of failure of design.
- Finally it can be concluded from the analysis; the real axle housing is under safety for the given load-conditions excepting change in the constraints for leak testing conditions

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