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Non Linear Analysis of Constant Velocity Joint Rubber Boot in a Car

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***Abstract*— Rubber boots are used in many vehicles to protect the constant velocity joint (cv joint). The cv boot should be stiff enough to retain its shape but flexible enough to adapt itself for the range of swing angle at the joint. The cv joint is usually sealed with rubber boot to keep dirt and moisture out. The objective of this paper is to determine the stress results and displacement behavior for two models of the rubber boot with different thickness. Since a rubber boot is symmetric, a half symmetry model is considered for the analysis. The analysis is performed in two steps:**

a) Compression of rubber boot

b) Tilting of the drive shaft

***Keywords*— Rubber boot, Finite element method, Constant velocity joint.**

INTRODUCTION

In the automotive industry, rubber boots are used as a covering for the cv joints to shield it from dirt, debris on the road, moisture etc., and to keep the lubricant oil within the joint, to maintain smooth functioning of the joint.

CV joint (also known as universal joint) in a front wheel drive car enables it to flex with the suspension and also helps it to transmit power to the wheel at an angle with constant speed of rotation.

The boot constantly undergoes expansion, compression and bending during running of the vehicle.

Rubber boots are made of specialized rubber materials called elastomers which can withstand very large strains.

For elastomers used in rubber boots the ratio of stress to strain continuously varies, the material behaviour is non-linear. The boot shows both material and geometric non- linearity.

It is imperative that the boot should never fail before the CV joint itself.

I. ANALYSIS OF RUBBER BOOT

A. Rubber boot modelling

Fig1 shows 2D model of the rubber boot created first using key points in Ansys and extruded to get a solid 3D model as shown in fig3.

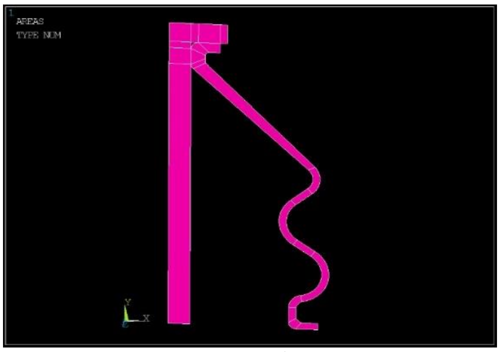

Fig1.1: 2D Model of rubber boot

Rubber boot being a symmetric model, half of its geometry is considered for analysis.

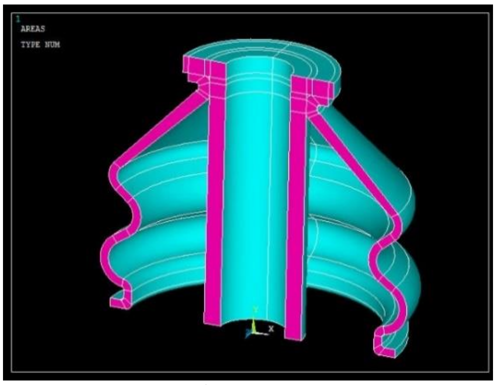

Fig1.2: Half symmetric 3D model

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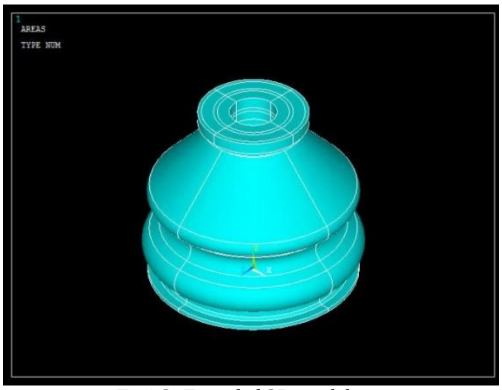


Fig1.3: Extruded 3D model.

B. Element type

Three elements are used in this analysis:

1. Solid 8noded 185-Shaft
2. Shell 4node 181-Rubber boot
3. Beam 2node 188-Dummy beams (For tilting of shaft)

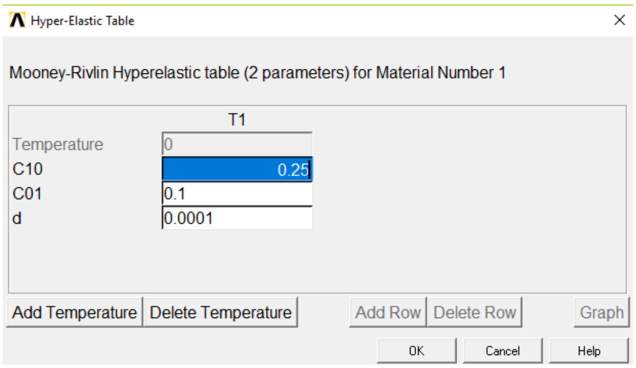
C. Material types

Neoprene, the material of the boot is expressed by hyper elastic material model. The mechanical properties of the material are expressed using the Mooney- Rivlin model.

Mooney-Rivlin Models

Mooney-Rivlin models are popular for modeling the large strain non-linear behaviour of elastomers. It is also used for approximating the material behaviour of biological tissues. Strain energy density function is used to describe hyperelastic materials.

It is suitable for upto 200% of strain that a component is subjected to. This hyperelastic material model gives a reasonably accurate result at lower computational cost.



D. Meshing

Meshing is the process of descretizing the given component into a finite number of elements so as to ensure that the applied load is uniformly distributed. The model is meshed using mapped type of meshing. Mapped meshing results in regularly shaped elements in a regular pattern which improves the accuracy of the result.

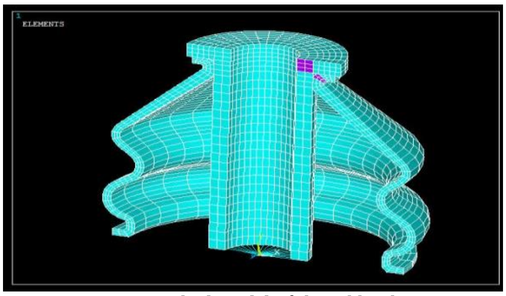


Fig1.4: Meshed model of the rubber boot

E. Defining Loads

Symmetric boundary condition is applied to the model.

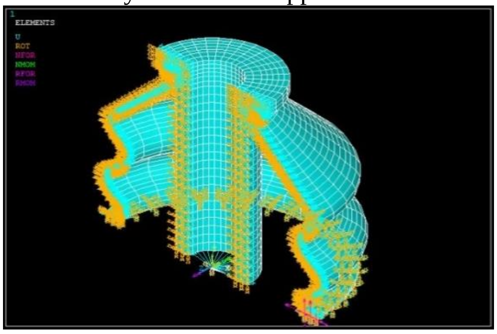


Fig.1.5: Symmetric boundary condition

Load is defined on the factors of displacement and rotation of rubber boot using different load steps.

Load step 1:

The end node at the base of centre axis of the shaft is constrained in all directions. A displacement of 4mm upward is given to the rubber boot in Y direction. In this load step we have 40 sub-steps.

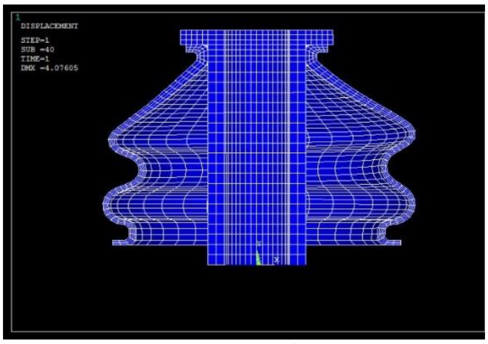


Fig. 1.6: compression of rubber boot

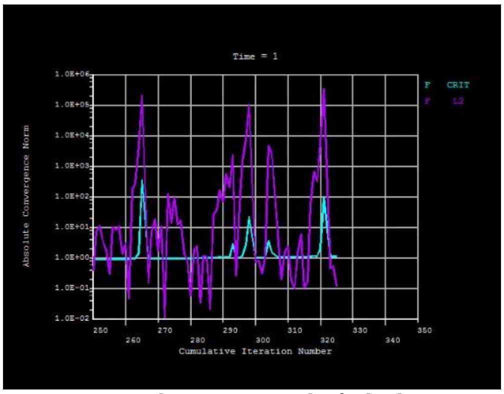


Fig.1.7: The convergence plot for load step 1

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Load step 2:

After compression of rubber boot in upward direction, the rotation of the shaft is made about Z axis by an angle of 15deg. This will continue after load step 1. We have 37 sub steps in this load step.

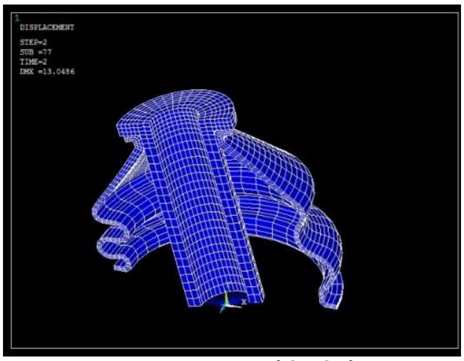

Fig.1 .8: Rotation of the shaft

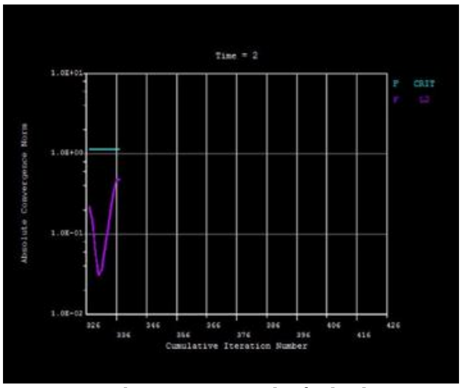

Fig.1.9: The convergence plot for load step 2

II. RESULTS

1. Displacement plot

For model 1 with thickness 1mm.

The maximum deformation in the rubber boot is 12.224mm.

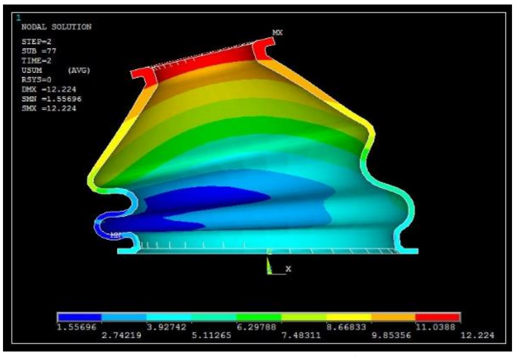

Fig. 2.1.1: Displacement plot for model 1

For model 2 with thickness 1.5mm

The maximum deformation in the rubber boot with thickness 1.5mm is 11.96mm

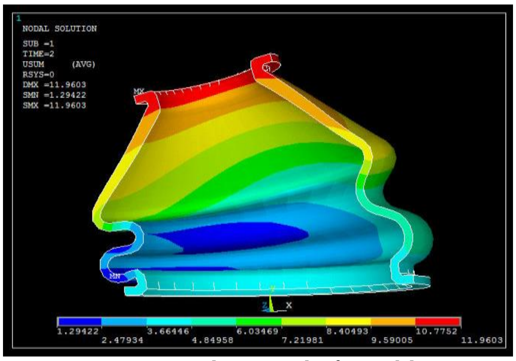

Fig.2.1.2: Displacement plot for model 2

2. Stress plot

For model 2 with thickness 1.5mm. The maximum stress in the boot is 0.2559 N/mm^2

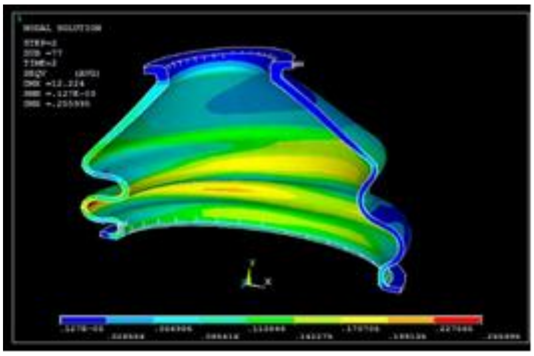

Fig.2.2.1: Stress plot for model 1

For model 2 with thickness 1.5mm the maximum stress is 0.2526 N/mm^2

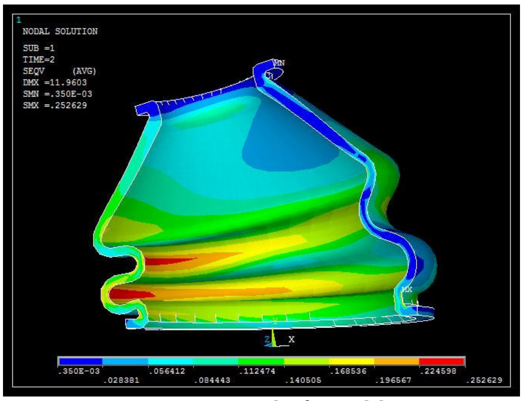

Fig.2.2.2: stress plot for model 2

TABLE 2 .1:

SL.NO	MODEL	DISPLACEMENT in mm	STRESS in N/mm^2
1	MODEL 1 (1mm thickness)	12.224	0.2559
2	MODEL 2 (1.5mm thickness)	11.96	0.2526

The maximum permissible stress for Neoprene is 1.8N/mm^2. It is observed that the stresses obtained in two models are within the permissible limit and maximum stress concentration are found at the compression side of the rubber boot. It is observed from the Table the stress obtained in model 2 is almost similar to the stress obtained in model 1.

III. CONCLUSION

The non-linear analysis of rubber boot has been conducted using the ANSYS15 validation. The analysis is done for swing angle of 15 degree and fixed displacement of 4mm.The analysis is carried out for two models with thickness of 1mm and 1.5mm. After trials and errors the following results are obtained.

- The results are compared and obtained stress values for both models are found to be within the allowable limits.
- Also, the deformation was found to be appreciable.
- We conclude that reducing the thickness from 1.5 to 1mm, we are able to save nearly33% of the rubber material

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