

RUBBER COMPOSITE DESIGN OPTIMIZATION USING FEA

Pruthvi Bhalodiya¹, Prof.N.M.Pate², Prof. R.N.Desai³

¹ *Rubber Technology Dept., L. D. College Of Engineering, Ahmedabad, Gujarat.*

² *Chemical Engineering Dept. Vishwakarma Government Engineering College Chandakheda, Gujarat.*

³ *Rubber Technology Dept., L. D. College Of Engineering, Ahmedabad, Gujarat. India -15,*

ABSTRACT

FEA is a powerful tool for analysis the rubber components. FEA is a excellent tool for design engineering to improve the performance of the devices. , It is faster product development tool. It can be used for any phase of the product life styles. It will be provide a best stage to develop an optimum product. Rubber is a very unique material. During processing and shaping, it behaves mostly like a highly viscous fluid. The use of FEA can greatly improve the proces evaluation speed and the quality of product design or reduce the overall cost. In this study we have solve the geometry of object, shape and proprties of rubber mount by using Gmsh and Elmer softwar and also reduce the overall material cost. This all analysis will be depend on stress eigenvektor and convergence history of data.

Keyword: *Gmsh and Elmer software , Rubber mount.*

1. Introduction:

Rubber is viscoelastic material. Rubber is a very unique material. During processing and shaping, it behaves mostly like a highly viscous fluid. After its polymer chains have been cross-linked by vulcanization (or by curing). Proper analysis of rubber components requires special material modeling and nonlinear finite element analysis tools that are quite different than those used for metallic parts. It can large deformations under load. Its load-extension behavior is nonlinear. Because it is viscoelastic, It's behavior is time and temperature dependent.

The finite element method is a computer-aided engineering technique for obtaining approximate numerical solutions to boundary value problems which predict the response of physical systems subjected to external loads. It is based on the principle of virtual work. Finite element analysis in rubber is more difficult. A mostly Finite – element application to design is the determination of stresses and temperatures in rubber component. Many methodes are used to solve the FEA or many software also help to solve it. This analysis can also be diagnostic, also suportrt to solve it's failure prolem. The use of FEA can greatly improve the proces evaluation speed and the quality of product design or reduce the overall cost. So, In this study use the Elmer as for simulate the model. Elmer is computational tool for multi-physics problems. It has been developed by CSC. In collaboration with Finnish universities, research laboratories and industry. Elmer FEM solver is free and open-source software, subject to the requirements of the GNU General Public License (GPL). Elmer includes physical models of fluid dynamics, structural mechanics, electromagnetics, heat transfer and acoustics, for example. These are described by partial differential equations which Elmer solves by the Finite Element Method (FEM). Elmer comprises several different parts :

- Elmer Grid - A mesh conversion tool, which can be used to convert differing mesh formats into Elmer-suitable meshes.

- ElmerGUI - A graphical interface which can be used on an existing mesh to assign physical models, this generates a "case file" which describes the problem to be solved
- Elmer Solver - The numerical solver which performs the finite element calculations, using the mesh and case files.

2. Material behaviour

Viscoelastic Behavior

Any material behavior must be determined experimentally, and the wide varieties of rubber compounds make this experimental determination even more important. Composite behavior is like as following:

Linear and Non-Linear viscoelasticity

Viscoelastic materials such as polymers combine the characteristics of both elastic and viscous materials. There exist many cases in which the material remains elastic everywhere but the stress-strain relationship is nonlinear. They elements of both Hookean elastic solid and pure viscous flow depending on the experimental time scale. Linear viscoelastic materials is that the stress is linearly proportional to the strain history, and it is important to note that the property of linearity of response does not refer to the shape of any material response curve. Linear viscoelasticity is usually applicable only for small deformations and linear materials.

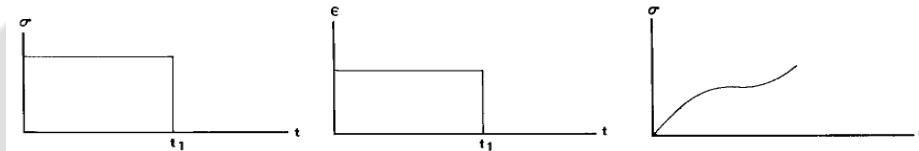


Fig.1 Rubber Elasticity

3. Experiment and Result of Simulation

Details for model development

- Assume a homogenous, elastic Mount object being rigidly supported on one end.
- The gravity affects also the Mount itself. Material properties of the Mount are those of Rubber: Poisson ratio 0.5, Young's modulus $7e5$ pa, and density 1230 kg/m³.
- The problem is to solve the Eigenvalues and stress field of the mount.
- Here the Stress Solve routine based on the linear theory of elasticity is applied.

Solution procedure

Solution procedure of Model-1(Core Model (without hollow)) and Model-2 (Core Model (with hollow))

- Step-1: 3D object generation

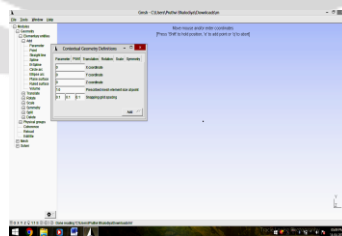


Fig.2 Model 1 &2 (Screenshot of 3D object generation)

- Step: 2 Mesh generation for Core Mount object using Gmsh

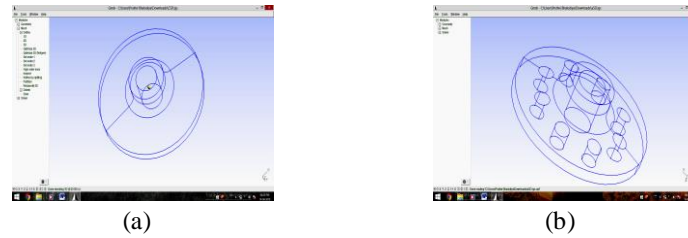


Fig.3 a)Model 1 Mesh generation, b) Model 2 Mesh generation

- Step-3: Go to mesh → define 3D → create 3D → optimize3D → Save to mesh file

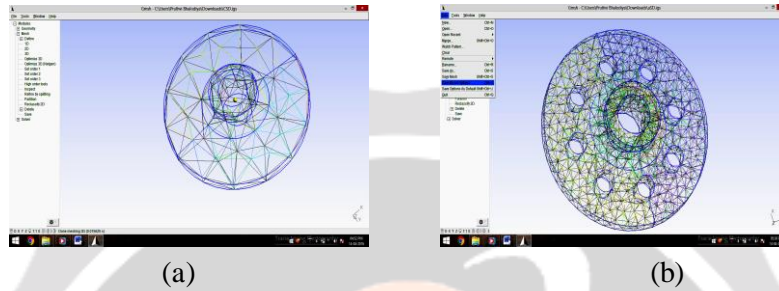


Fig.4 a) Model 1 optimize 3D mesh, (b) Model 2 optimize 3D mesh

The mesh is given in Elmer Grid format in file .msh , load this file in ElmerGUI.

- Step-1: Load the .msh file in Elmer.

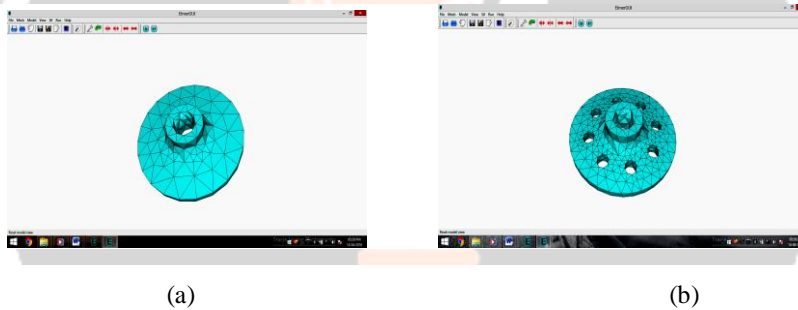


Fig.5 a) Model 1 .msh file, b) Model 2 .msh file

- Step-2: Set the model in Elmer
 - Step-3: Save Project
- After we have successfully saved the files we may start the solver.
- Step-4: Run → Start Solver.

The simulation may take a minute or so depending on the speed of the processor. The Result of simulation is shown in below graph :

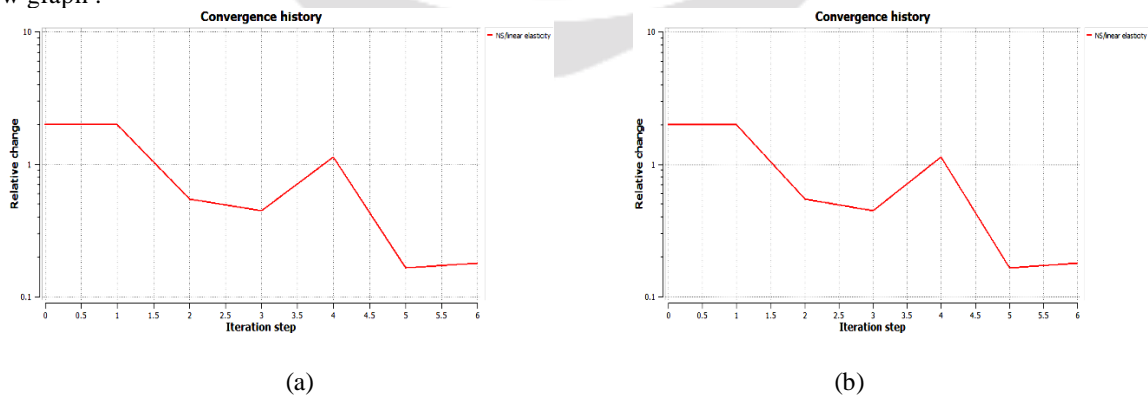


Fig.6 a) Model 1 Convergence history, b) Model 2 Convergence history

Table-1: Simulation analysis data

Model – 1		Model – 2	
at (s): 0.00	0.3410E+00 0.6456E-01 0.8831E-02 0.1404E-02 0.3038E-03 0.5341E-04 0.1136E-04 0.9728E-06 0.8799E-07 0.1335E-07 0.1066E-08 0.6305E-10 Compute Change: NS (ITER=1) <u>(0.18905178E-04 2.0000000)</u>	at (s): 0.00	0.3410E+00 0.6456E-01 0.8831E-02 0.1404E-02 0.3038E-03 0.5341E-04 0.1136E-04 0.9728E-06 0.8799E-07 0.1335E-07 0.1066E-08 0.6305E-10 Compute Change: NS (ITER=1) <u>(0.18905188E-04 2.0000000)</u>
at (s): (1,1)	0.5200E-02 0.6366E-04 0.7278E-06 <u>0.1009E-07</u> 0.1092E-09 0.1271E-11 Compute Change: NS (ITER=2) <u>(145096.56 2.0000000)</u>	at (s): (1,1)	0.5300E-02 0.6366E-04 0.7278E-06 <u>0.1019E-07</u> 0.1092E-09 0.1271E-11 Compute Change: NS (ITER=2) <u>(145186.56 2.0000000)</u>
at(s): (1,2)	0.7103E-02 0.9624E-04 0.1375E-05 <u>0.1688E-07</u>	at(s): (1,2)	0.7100E-02 0.9624E-04 0.1375E-05 <u>0.1690E-07</u>

	<p>0.1779E-09</p> <p>0.2787E-11</p> <p>Compute Change: NS (ITER=3)</p> <p><u>(83010.362 0.54436052)</u></p>		<p>0.1779E-09</p> <p>0.2787E-11</p> <p>Compute Change: NS (ITER=3)</p> <p><u>(83012.362 0.54436152)</u></p>
<p>at(s):</p> <p>(1,3)</p>	<p>0.4428E-02</p> <p>0.5785E-04</p> <p>0.8165E-06</p> <p><u>0.1111E-07</u></p> <p>0.1167E-09</p> <p>0.1787E-11</p> <p>Compute Change: NS (ITER=4)</p> <p><u>(52868.897 0.44365070)</u></p>	<p>at(s):</p> <p>(1,3)</p>	<p>0.4428E-02</p> <p>0.5785E-04</p> <p>0.8165E-06</p> <p><u>0.1113E-07</u></p> <p>0.1167E-09</p> <p>0.1787E-11</p> <p>Compute Change: NS (ITER=4)</p> <p><u>(52870.897 0.44365270)</u></p>
<p>at(s):</p> <p>(2,2)</p>	<p>0.6320E-02</p> <p>0.7973E-04</p> <p>0.9639E-06</p> <p><u>0.1398E-07</u></p> <p>0.1682E-09</p> <p>0.1820E-11</p> <p>Compute Change: NS (ITER=5)</p> <p><u>(190551.00 1.1312313)</u></p>	<p>at(s):</p> <p>(2,2)</p>	<p>0.6320E-02</p> <p>0.7973E-04</p> <p>0.9639E-06</p> <p><u>0.1399E-07</u></p> <p>0.1682E-09</p> <p>0.1820E-11</p> <p>Compute Change: NS (ITER=5)</p> <p><u>(190552.00 1.1312413)</u></p>
<p>at(s):</p> <p>(3,3)</p>	<p>0.4410E-02</p> <p>0.4798E-04</p> <p>0.5049E-06</p> <p>0.5929E-08</p> <p><u>0.8135E-10</u></p> <p>Compute Change: NS (ITER=6)</p> <p><u>(193203.52 0.17898137)</u></p>	<p>at(s):</p> <p>(3,3)</p>	<p>0.4410E-02</p> <p>0.4778E-04</p> <p>0.5049E-06</p> <p>0.5929E-08</p> <p><u>0.8125E-10</u></p> <p>Compute Change: NS (ITER=6) <u>(193205.52 0.17898437)</u></p>

On above table give the comparison of core model(Model-1) and with hollow model(Model-2). All data must be same but little variation is give in highlight. So, as per this data I will concluded the all properties will be same and in second model reduce the material cost.

4. Conclusion

Finite Element Analysis Techniques is important for the to generate the complete model which are material parameters, boundary conditions, change in model easily ,so it getting the final complete model without use of any kind of man power, materials, and machines. In this study I will try to reduce the material cost. On above given the comparison of core model(Model-1) and with hollow model(Model-2).All data must be same but little variation is give in highlight. So, as per this data I will concluded the all properties will be same and in second model reduce the material cost.

Reffereces

Papers

- [1] Dr.H."Jerry" Qi, "Finite Element Analysis", In MCEN 4173/5173, 2006
- [2] Nonlinear Finite Element Analysis of Elastomers, Whitepaper, By MSC.Software,2010.
- [3] H.T.Banks, Shuhua Hu and R.knz , A brief review of elasticity and viscoelasticity , In J. center for resurch in scientific computation, North corlina state university ,Releigh,NC 27695-8212, 2010.
- [4] C.E. Crede and J.E. Ruzicka. Theory of vibration isolation. In C.M. Harris, editor. Shock and vibration handbook, third edition.
- [5] J.A. Harris. Design principles for vibration isolation and damping with elastomers including nonlinearity. Rubber Chemistry and Technology, 62.

Books

- [I] L.R.G.Trelour, " The physics ofrubber elasticity", 3rd ed., clarendon, oxford, 1975.
- [II] Robert O. Ebeuele, " Polymer Science and Technology", CRC press Boca Raton, New York , 1995.