Grenze International Journal of Engineering and Technology, July 2018

Design and Thermal Analysis of Tractor Boot

Dr. P Ravi Chander[1], Mr. Y Madhu Maheswara Reddy[2], R Manish[3] and G SaiRam[4]
[1-2] Methodist College of Engg. & Tech./ Department of Mech. Engg., Hyderabad, India
Email: vira755@gmail.com[1], mm315@gmail.com[2]
[3-4] Student, Methodist College of Engg. & Tech./Mech. Engg. Department, Hyderabad, India

Abstract— **In today's modern world, Farmers use advanced farm equipment for the better yield and good quality products. In order to meet the increasing demand of Tractors in the Industry, the Production time has to be reduced satisfying the quality issues at the same time. The need for good quality products and 'Zero defect operations' are pivotal for any industry. One such defect to be eliminated is the damage caused to the rubber boot of tie rod in Dhruv tractors. Tie rod is a vital component in the steering system of any automobile. It helps in steering and handling of a vehicle. The problem arose is due to high temperature in the paint shop causing it to transmit the heat to the Polyurethane material.**

In order to cease the damage, various experiments were conducted which are as follows:

- **Masking the entire surface of rubber boot.**
- **Covered the steel ring with an 'O' ring**
- **Used a thick rubber as a covering.**

The specimens were examined and observed that the rubber boot lacked thickness around the steel ring which is not able to sustain such high temperatures. Hence, the tie rod rubber boot is redesigned in NX-CAD with varying thickness and analysed the thermal stress and optimized the thickness of the rubber boot.

Index Terms—**Farmers, Tractor, Tie rod, Steering, Rubber Boot and NX-CAD.**

I. INTRODUCTION

A tractor is the farm equipment division of Mahindra and Mahindra. Mahindra has begun the manufacturing tractors in the early 1960's, almost 50 years back. At present it is the top manufacturer in India and also one of the best manufacturers in both automotive and Farm Equipment division. Sales of Mahindra Tractors are predominant in the states of Gujarat, Haryana, Punjab, Maharashtra and the Southern States. Mahindra has taken over the Gujarat Tractors which were under the government control and then they took over Swaraj in Punjab.

Mahindra& Mahindra considers Dhruv model as its crown jewel as it is sold all across the world and is accepted worldwide due to it's quality and performance of the vehicle. One vital part of the vehicle is the front axle which is connected to the transmission and the engine in the skid region. The front axle sub assembly includes tie rod which has a rubber boot which is made of Polyurethane (PU) material and is held in its position by a couple of steel rings. Due to high temperature in the paint shop, the steel rings transmit the heat onto the polymer causing it to melt and damage the material. A proper solurtion is to be applied to prevent any damage to the rubber boot. Even though, Bhoomiputra, model too involves a rubber boot tie rod, the problem does not exist in the latter type of model.

It was founded in 1945 as a steel trading company, and entered automotive manufacturing in 1947 to bring the iconic Willy's Jeep onto Indian roads. Over the years, it diversified into many new business ventures in order to meet the needs of the customers. It follows a unique business model of creating empowered companies that enjoy the best of entrepreneurial independence and group-wide synergies. This principle has led its growth into a US $16.7 billion multinational group with more than 200,000 employees in over 100 countries across the globe. Today, operations span 18 key industries that form the foundation of every modern economy: aerospace, aftermarket, agribusiness, automotive, components, construction equipment, consulting services, defense, energy, farm equipment, finance and insurance, industrial equipment, information technology, leisure and hospitality, logistics, real estate, retail, and two wheelers.

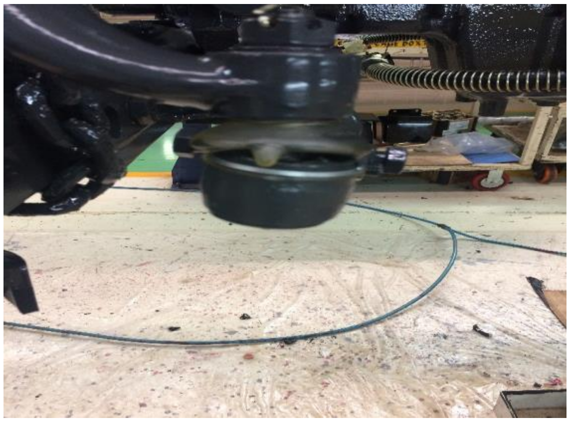


Fig 1.1: Damaged Rubber Boot

Fig 1.2: Masked Tie Rod

Fig 1.3: Rubber O Ring

Fig 1.4: Rubber Cap on Rubber Boot

Its federated structure enables each business to chart its own future and simultaneously leverage synergies across the entire Group's competencies. In this way, the diversity of its expertise allows it to bring the customers the best in many fields. And though we operate across vast geographies, our governing spirit of **"Rise"** binds us as one Mahindra, dictating that we empower people everywhere to not only chart new frontiers, but to conquer them too.

II. OBJECTIVE & METHODOLOGY

The basic objective of the project is to eliminate the melting of tie rod rubber boot in the Dhruv tractor by analysing the entire work line, finding the root cause of the problem and provide an inexpensive but effective solution to the defect.

It involves testing of the rubber boot with different types of materials like a masking tape, an rubber O-ring or an combination of thick rubber cap and masking tape if required to cover and provide an insulative layer to the material to be tested. The final condition of the specimen tested is observed in various workstations for better understanding to provide an accurate solution to the problem present. Also consequently third should lead to the following:

1. Reduction in replacement cost.
2. Minimizing the rework cost and time associated with it
3. Eliminating the rework labor cost.

The results obtained through this project shall improve the quality of the produced vehicles and have very good benefits to the industry in terms of achieving the required target similarly reducing the unwanted cost and expenditure incurred by the industry for rework and replacement.

The 3D model of the **RUBBER BOOT** is created using UNIGRAPHICS NX software from the 2d drawings. UNIGRAPHICS NX is the world's leading 3D product development solution. This software enables designers and engineers to bring better products to the market faster. It takes care of the entire product definition to serviceability. NX delivers measurable value to manufacturing companies of all sizes and in all industries.
The CAD model of the RUBBER BOOT is shown below
A 2D drawing is used to design a 3D model for our component using Unigraphics NX 7.5 CAD software

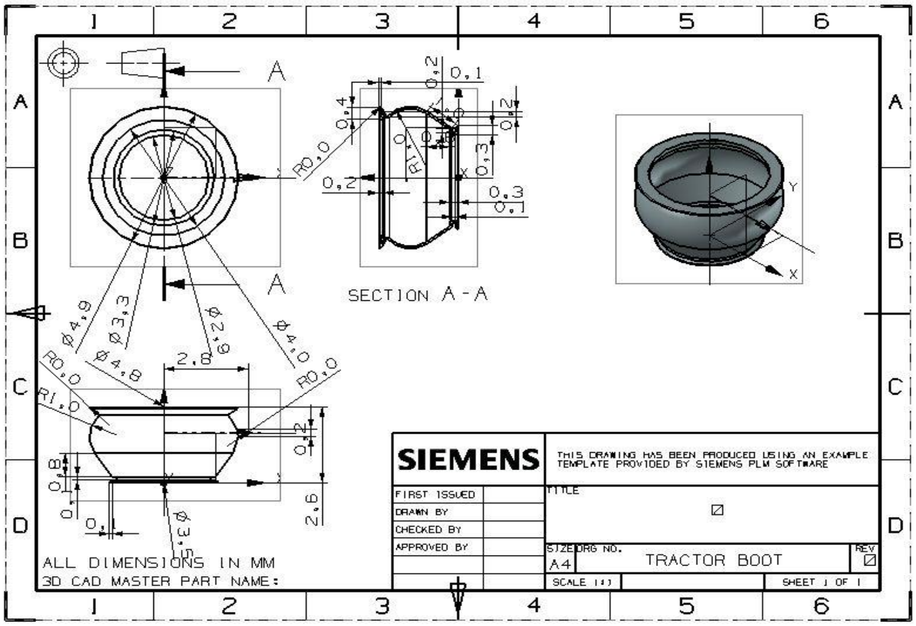


Fig 2.1: 2D Dimensions of rubber boot

Sketching is one of the most powerful tools available in UG. The basic idea of sketching is to create a 2D shape that is controlled by numerical values and geometric constraint rules. The sketch process involves creating a new sketch by choosing "Insert / Sketch / create".

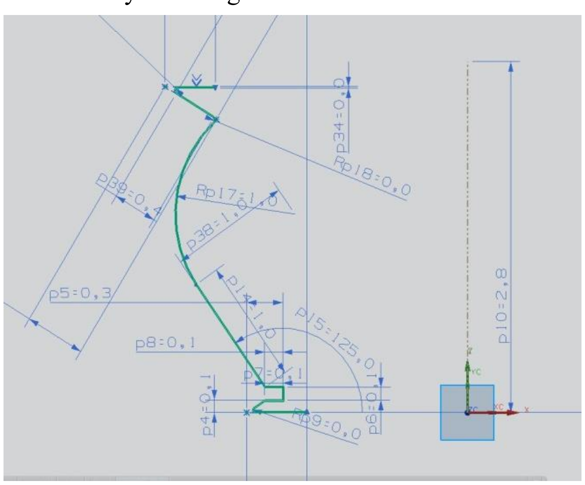


Fig 2.2: 2D sketch for the rubber boot

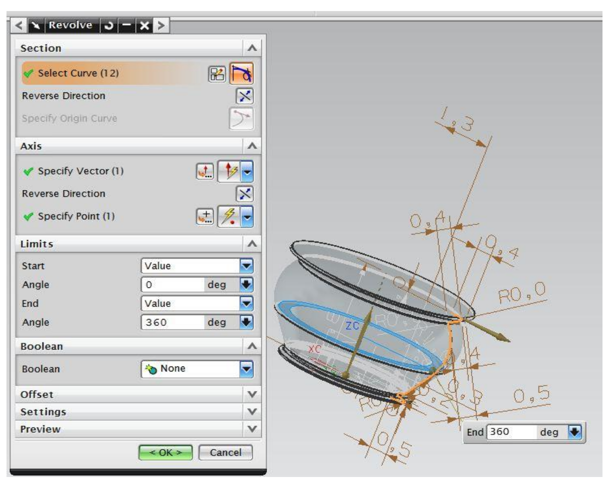


Fig 2.3: end model of rubber boot steering end tie rod

In modified rubber boot the thickness of rubber boot had increased by 0.02 mm so that we can attain best temperature levels for the modified one and also to increase the height of air vent.

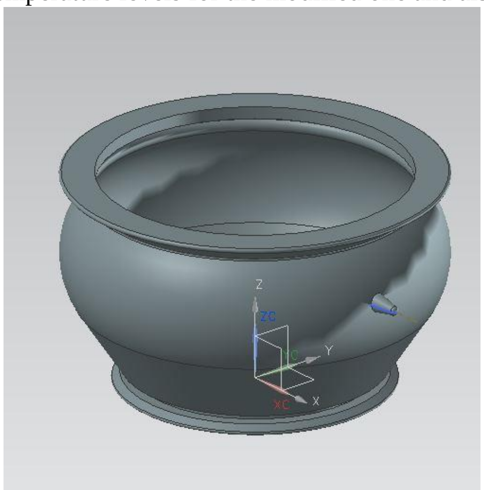


Fig 2.4: Isometric view of Rubber Boot

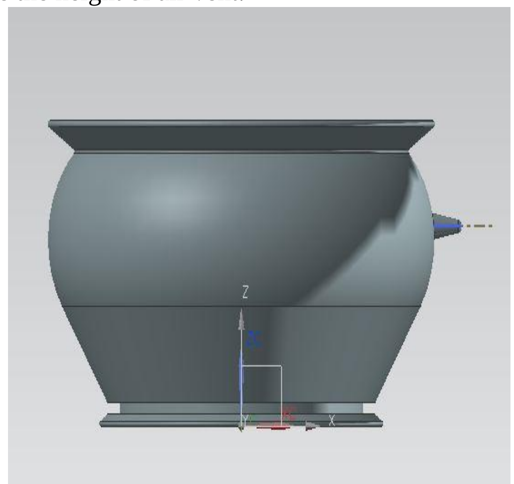


Fig 2.5:Side view of Rubber Boot

III. THERMAL ANALYSYS OF RUBBER BOOT

Finite element analysis has been carried out on the modified RUBBER BOOT with thickness of 0.05mm and 0.07mm is carried out to record the stresses and deflections. Initially thermal analysis is carried out to find the temperature distribution. The 3D model and the FE model of the RUBBER BOOT used for analysis is shown in the below figures.

A thermal analysis calculates the temperature distribution and related thermal quantities in a system or component. Typical thermal quantities of interest are:

The temperature distributions

The amount of heat lost or gained

Thermal gradients

Thermal fluxes.

Thermal simulations play an important role in the design of many engineering applications, including internal combustion engines, turbines, heat exchangers, piping systems, and electronic components. In many cases, engineers follow a thermal analysis with a stress analysis to calculate thermal stresses

Thermal analysis is done to plot the temperature distribution of the body with given conditions.

Thermal properties of the **Poly urethane material** used for the rubber boot are:

Thermal conductivity: 0.19 w/m-k, Specific heat: 1760 j/kg-k

The element type used in the thermal analysis of the rubber boot is **PLANE77**

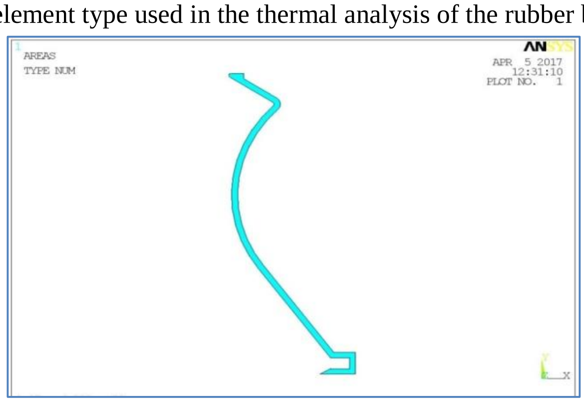


Fig 3.1: Model in ANSYS

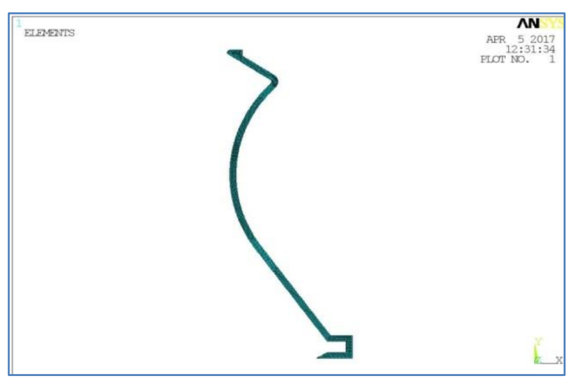


Fig 3.2: Finite Element Model

A. THERMAL ANALYSIS OF THE RUBBER BOOT WITH A THICKNESS OF 0.05MM FOR NATURAL CONVECTION:

In natural convection, the convective film coefficient of air is taken as 10 w/m^2 k.
The boundary conditions applied on the rubber boot are:
The inner surface temperature is given as 453k
Outer surface is given for natural convection of air

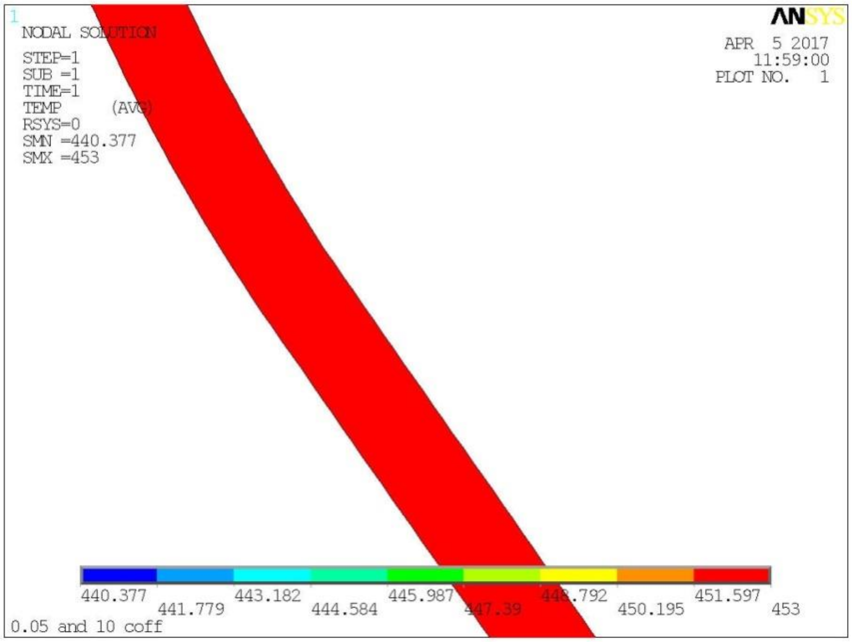
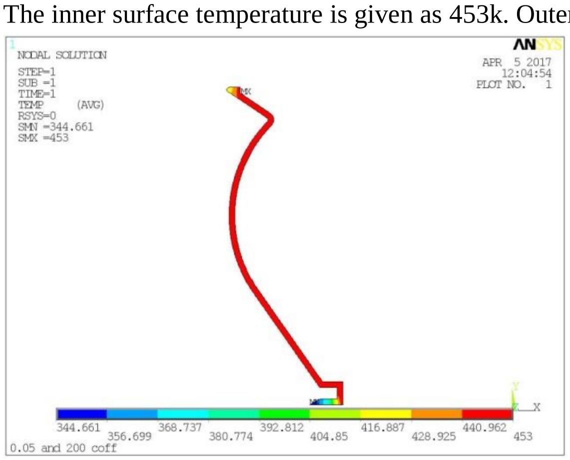


Fig 3.3: Temperature Distribution for Natural Convection in closed view

B. THERMAL ANALYSIS OF THE RUBBER BOOT WITH A THICKNESS OF 0.05MM FOR FORCED CONVECTION:

In forced convection, the convective film coefficient of air is taken as 200 w/m^{2}k.
The boundary conditions applied on the rubber boot are:
The inner surface temperature is given as 453k. Outer surface is given for natural convection of air



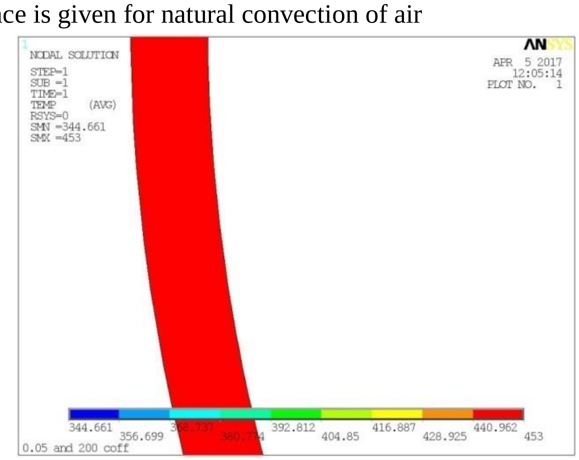


Fig 3.4: Temperature Distribution for Forced Convection

Fig 3.5: Temperature Distribution for Forced Convection in closed view

IV. RESULTS & CONCLUSIONS

RESULTS

In the thermal analysis of the poly urethane with the two different thicknesses and for two different types of convection following can be observed.

For natural convection of rubber boot with thickness 0.05mm the outer temperature is same as the inside temperature at every corner.

For forced convection of rubber boot with thickness 0.05mm the outer surface exhibited a temperature nearer to inside temperature. i.e. 453k

For forced convection of the rubber boot with thickness 0.07mm, the outer surface exhibited a temperature of 433.063k

CONCLUSIONS

From the above results it is under stood that, the rubber boot with thickness of 0.07mm has dissipated the more heat than that of the rubber boot with 0.05mm thick for forced convection.

The number of failures would be considerably reduced by increasing thickness by 0.02 mm.

The resistivity of heat is improved in the latter one.

Thus it is suggested to replace the rubber boot of 0.05mm with 0.07mm and to provide a forced convection.

REFERENCES

1. A.H. Falah *, M.A. Alfares, A.H. Elkholy, "Failure investigation of a tie rod end of an automobile steering system", Mechanical Engineering Department, Kuwait University, P.O. Box 5969, Safat 13060, Kuwait 19 November 2006.ISSN #1593
2. Wei Duan a, Suraj Joshi, "Failure analysis of threaded connections in large-scale steel tie rods", Department of Mechanical and Industrial Engineering, Concordia University, Sir George Williams Campus, 1515 St. Catherine Street West. ISSN #5460
3. Sergio Lagomarsino,ChiaraCalderini, "The dynamical identification of the tensile force in ancient tie-rods", Department of Structural and Geotechnical Engineering, University of Genoa, Via Montallegro 1, 16145 Genova, Italy,17 January 2005. ISSN #4201
4. George Campbell and Wen Ting, "Buckling and geometric nonlinear analysis of a tie rod in NASTRAN VERSION68", Light Truck Divison, Ford Motor Company,14 November 2006, ISSN #5065
5. Michael Adam Kaiser, "Advancements in the Split Hopkinson Bar", Test Faculty of the Virginia Polytechnic Institute, Blacksburg, Virginia May 1, 1998. ISSN 8850-9856
6. Manik A. Patil "FEA of Tie Rod of Steering System of Car", Rajarambapu Institute of Technology, Sakharale. Islampur, India., ISSN 2319 – 4847
7. PradeepMahadevappa Chavan1 and M MPatnaik (2014) "Performance evaluation of passenger car tie rod using numerical and theoretical approach with different materials" IJRET: International Journal of Research in Engineering and Technology, Volume: 03 Issue: 08 eISSN: 2319-1163 pISSN: 2321-7308.
8. Raghavendra K and Ravi K (2014) "Buckling analysis of tractor tie rod subjected to compressive load" International Journal of Mechanical and Industrial Technology, Vol. 2, Issue 1,pp: (125-129).
9. Manik A. Patil1 et al (2013) "FEA of Tie rod of steering system of car" International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 2, Issue 5, May 2013 ISSN 2319 – 4847.

10. George Campbell, Wen Ting from Ford Motor and PeymanAghssa and Claus C. Hoff from MSC Software (1994) “Buckling and Geometric Nonlinear Analysis of a Tie Rod in MSC/NASTRAN Version 68” World Users' Conference (pp.1-15). Lake Buena Vista, FL: MSC Software Corporation, (Acrobat 630KB) #1594
11. Ir. J.J. Wijker, Ir. F.M. Maitimo and Ing. C.J. de Haan of Fokker Space B.V. Dep. Engineering Mechanical Engineering, P.O. Box 32070, NL-2030 DB Leiden, The Netherlands. (1999) “Modal Analysis - An Elegant Solution” 1999 MSC Aerospace Users' Conference, #5299, 19 pgs
12. Claus C. Hoff, MacNeal-Schwendler Corporation, 815 Colorado Blvd, Los Angeles, CA (1996) “Improvements in linear buckling and geometric nonlinear analysis” MSC Software world’s user conference
13. David F Bella, Senior Development Engineer, The MacNeal-Schwendler Corporation (1995) “DMAP Alters to add differential stiffness and follower force matrices to MSC/Nastran linear solutions” MSC 1995 World Users' Conference (Acrobat 341KB) #3395
14. M.H.Schneider, Jr. and R.J. Feldes from McDonnell Douglas Aerospace, Huntington Beach, California J.R. Halcomb and C.C.Hoff, from MSC Software (1995) “Stability analysis of perfect and imperfect cylinders using MSC Nastran Linear and nonlinear buckling” MSC 1995 World Users' Conference #2795
15. Dr. V.S. Joshi, Dr. G.S. Lathkar, DSKB sir (2011) “Wear and frictional characteristic of some polymeric material for gears used in machine tool” institute of engineers vol. 92, production jour.