© 2016 IJSRSET | Volume 2 | Issue 3 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Analysis of a Tyre on Different Treads at Same Pressure and Load under Static Conditions

Ankur Singhal, M. S. Khidiya, Divya Gautam, Sukhdeep Meena, Kapil Gahlot

Department of Mechanical Engineering, College of Technology and Engineering, Udaipur, Rajasthan, India

ABSTRACT

The Tyre tread pattern can be described as the systematic mesh of blocks, grooves and spaces, moles and channels drawn into the tread to improve its grip on the road. Tread is the topmost layer of any tyre which contacts on the road and it has its contribution towards mileage, traction, low noise and heat built up properties. It would be meaningful to conduct a stretched analysis on the tyre tread blocks for to evaluate its working in static condition to predict its performance and wear of tread block in on-road condition. The Finite Element software Ansys is used for the analysis of the tread block and its behaviour was studied on road as contact surfaces. The tread block is modelled in two different shapes and analysed. The deformation stress strain characteristic of tyre is studied which will be useful in deciding the contact behaviour, stresses and strains on tyre and its corresponding parts. The regular and the mixed type geometry show a distinguished variation in the analysis. The static stiffness and deformed shape was analysed in this study and it has its own effect in tyre design. The analysis of tyre geometric shape would be vital in tread pattern optimization as well as to know various stresses and failure in a tyre. In this analysis strain calculated on different tread patterns in static condition.
Keywords: Tread Pattern, Static, Geometric Shape

I. INTRODUCTION

Tyre is an important part of today automobile industry and various experiments to increase its capacity. Many road accidents are result of bursting of tyre or failure. This document involves a thorough study of a tyre under static conditions i.e. the study of axial load, horizontal load, elastic strain, and displacement etc, a tyre may get under due to car load, and air pressure. The tire is the very important component of vehicles.

The tire wear can be reduced as well as the operating life of a tire, for which it is necessary for vehicle manufacturers to research and develop a tyre having better operating characteristics. The tyre also contributes in generating noises like squeak etc.. Tire noise is a major source of noise in vehicles. These noise forms a major part of noises generated moving at higher speed. During acceleration this becomes a significant contributor to the overall noise generated. Reducing the tire wear is effective for reducing the noise of vehicle. The process of wear is very complex. Tire wear can be caused by a number of factors. Some of these include invariable inflation (low tire pressure equals outer edge wear e), improper alignment, and over-loading and worn out shockers can be reasons of wear. Tyre wear is estimated by experiments in the conventional researches or it can be predicted by the tire vibration and modal analysis. Recently, with the progress in the field of computers. Calculating the tyre wear becomes easy and sophisticated. However, tire tread pattern largely influences simulation results.

II. METHODS AND MATERIAL

A. Literature Review on various axial load:

There are numerous forces acting on a tyre vertical load due to car weight and passenger weight or the goods if it's a goods carriage. These forces play even more important on a slope. Simulation procedures combined with experiments on contact tire-surface interaction enable the designer to improve both the construction of the tire and the control system, taking into account the wheel dynamics.

Important problems to which structural analysis can give solutions are: tire inflation, the behaviour of the tire when passing obstacles, the tire-ground contact pressure, and tire behaviour when crossing a trench and so on. As Tire is one of the most complex structures hence its dynamic analysis becomes very difficult therefore we mostly employ static analysis. A non-linear static and transient FEA analysis of a tire model was performed [1], simulating the radial and lateral static stiffness test conditions, dynamic free-drop test conditions and the rolling cornering stiffness, but the analysis didn't focused on the bed-rim interaction. Characteristics of the tire analysis by means of FEM codes were described in [2], In this paper, a simulation procedure for sliding tread blocks under consideration of thermal effects and abrasion is introduced. It is intended as a powerful tool in tire design and development complementary to experimental investigations. A contact model especially suited for the contact pairing rubber and rough road is developed. Subsequent changes of the model geometry in the course of the simulation allow for the reproduction of abrasion effects described in [3]. In this paper a steady state analysis was carried on the implicit formulation, simulation was performed, because of the formulation requiring a fine mesh in the contact region by moving reference frame technique. The present research is focused on modelling and simulation of a special type of tire, used for cars. An existing wheel configuration is analysed in order to find improved design solutions. The wheel is designed not only to assure the mobility of the vehicle, but also to withstand to high stress levels during the vehicle's movement.

B. Methodology:

1. 3D Model of Tyre

A pneumatic tire is a stretchy structure of the shape of a toroid, filled with compressed air. The most important structural element of the tire is the casing. It is made up of flexible cord layers withhigh modulus of elasticity, sheathed in a matrix of low modulus rubber compounds. The cords aregenerally made of fabrics of natural, synthetic, and nylon rubber, and are anchored around beads made of high tensile strength steel wires. The beads serveas a support for the housing and provide suitable seating of the tire on the rim (Fig. 1). The components of the rubber compounds are selected to provide the tire specific properties.

Dimension of Tyre

S.NO.	width	Aspect ratio(width/height)	Tyre type	diameter
1.	145	70	RADIAL	12

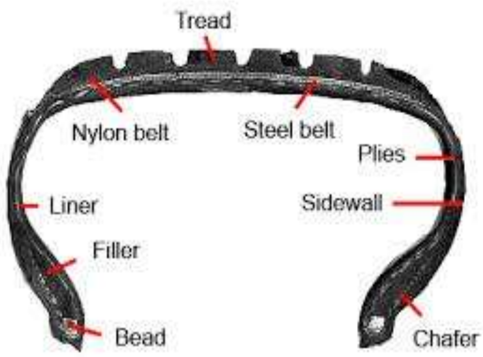

Figure1. Tyre 3d model (source: https://en.wikipedia.org/wiki/Tire)

2. Tread Pattern: In this analysis, three tyre tread pattern is used

(a)

(b)

(c)

Figure 2 : (a) Tread 1 (b) Tread 2 (c) Tread 3 (Source: CAD lab CTAE)

3. Static analysis using ANSYS:

The geometry and structure of a tyre is complex, the first step is to build a simple model, without any tread, beads etc. to import the model in the solver and to adjust the computational parameters with the materials in the simulation environment .A primary static analysis was performed, considering only the inflation pressure, the loads both vertical and horizontal forces applied on the tyre and its tread. The road surface represents a fixed support for the tire surface bonded to the rim. As the analysis is nonlinear, only a small sector of the tire was initially used. The analysis took advantage of the two perpendicular planes of the wheel, saving calculation time. In order to determine the optimum computational parameters, initially we employ a simple homogenous model of the tyre, without any steel insertion and with a smooth tread surface, without tread. Two rubber-type materials, available in ANSYS material library were used for the tyre and Structural Steel for the road surface.

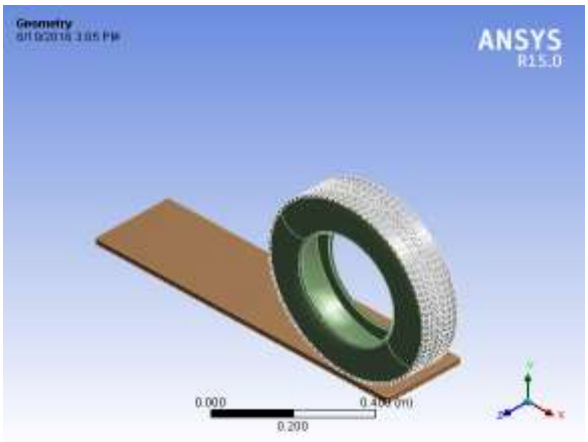

Figure 3. Analysis of tyre in Ansys (Source: CAD lab CTAE)

4. Meshing

The process of generating a mesh that approximates a geometric region is known as Mesh Generation. It is also termed as grid generation. Typical uses are for physical simulation such as finite element analysis or computational fluid dynamics. The input model varies greatly but common sources are CAD, NURBS, B-rep, STL or a point cloud. The field is highly anticipated with influences found in mathematics, computer science, and engineering.

Three-dimensional meshes in finite element analysis need to consist of tetrahedral, pyramids, prisms or hexahedra. Those used for the finite volume method one consists of arbitrary polyhedral. Those used for finite difference methods usually need to consists of piecewise structural arrays of hexahedral structured meshes. A mesh can be termed as a discretization of a domain existing in various dimensions.

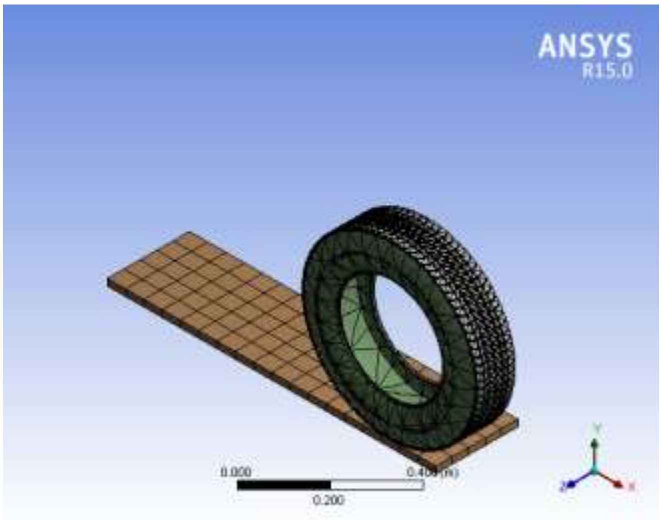

Figure 4. Meshing of Tyre (Source CTAE CAD Lab) 3.5

5. Pressure and load on tyre:

The tyre is subjected to varying pressure and vertical and horizontal loads.

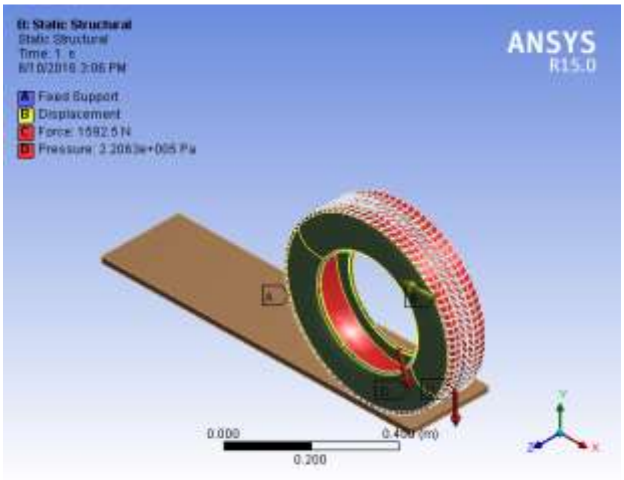

Figure 5. Pressure and Force diagram of tyre (Source: CAD lab CTAE)

6. Simulation:

Configuration of tyre of vehicles is very complex. The complexity is required by the specific purpose of vehicles and the intense stress subjected to the tire during its life on different types of road. The meshed model used for this simulation was as shown in fig 4

III. RESULTS AND DISCUSSION

This study is an initial simulation attempt for an improved design for the better suspension and movement of vehicles, in order to increase their mobility. More experimental for more realistic results and improved design solution one has to resort to better meshing and analysis. Figure 11 and fig 12 is represented Equivalent Elastic Strain in different treads Equivalent Elastic strain varies between0.026124m/m to0.0025293 m/m in tread 1, varies between in 0.021443 m/m to .00014329 m/m in tread 2, and varies between in 0.25715 m/m to 0.00011827m/m in tread 3.

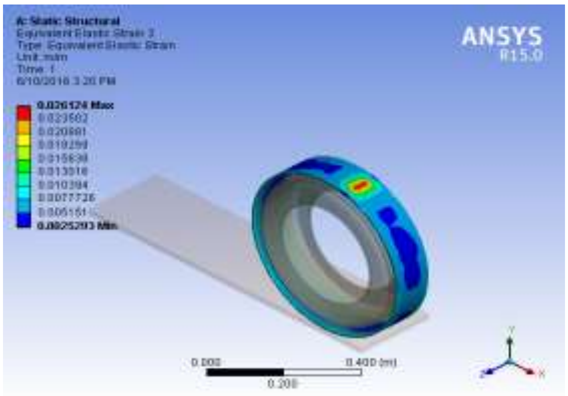

Figure 6. Equivalent Elastic Strain (m/m) in tread 1 (source CTAE CAD LAB)

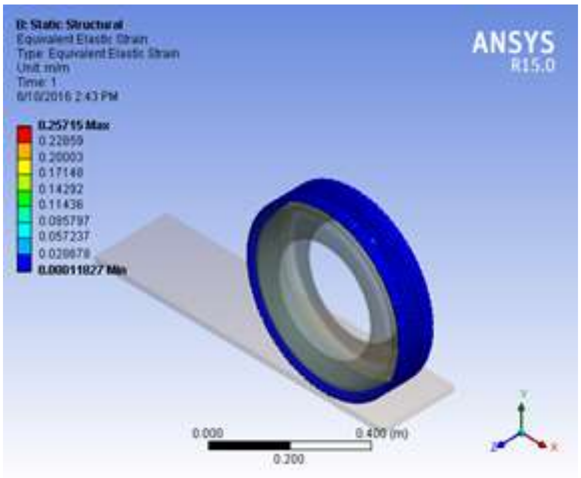

Figure 7. Equivalent Elastic Strain (m/m) in tread 2 (source CTAE CAD LAB)

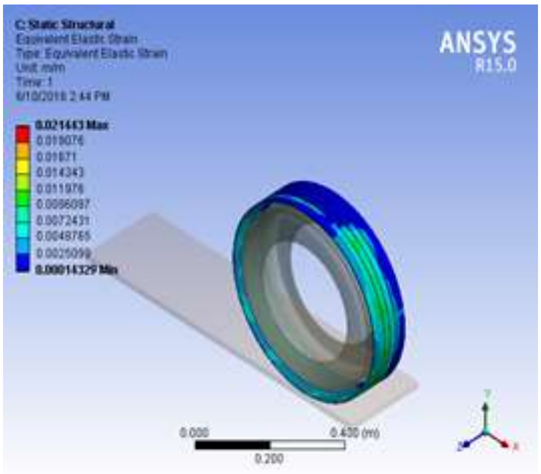

Figure 8. Equivalent Elastic Strain (m/m) in tread 3 (source CTAE CAD LAB)

Time [s]	Minimum [m/m]	Maximum [m/m]
0.2	3.7656e-004	4.7568e-003
0.4	8.0937e-004	9.5268e-003
0.7	1.7954e-003	1.8246e-002
1.	2.5293e-003	2.6124e-002

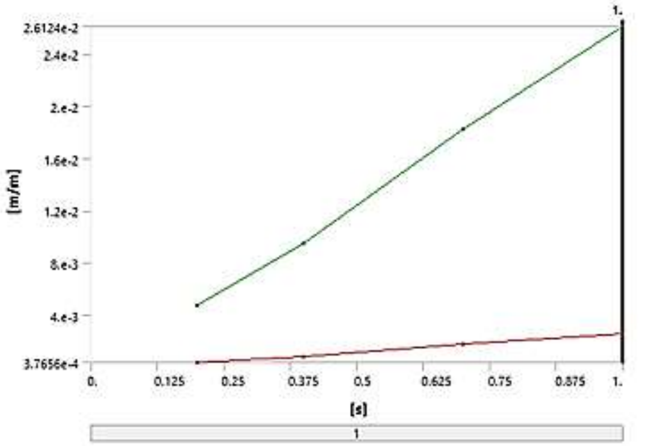

Figure 9. Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Elastic Strain 3

Time [s]	Minimum [m/m]	Maximum [m/m]
0.2	2.3396e-005	5.0529e-002
0.4	5.05e-005	0.10104
0.6	7.5054e-005	0.15154
0.8	9.9478e-005	0.20365
1.	1.1827e-004	0.25715

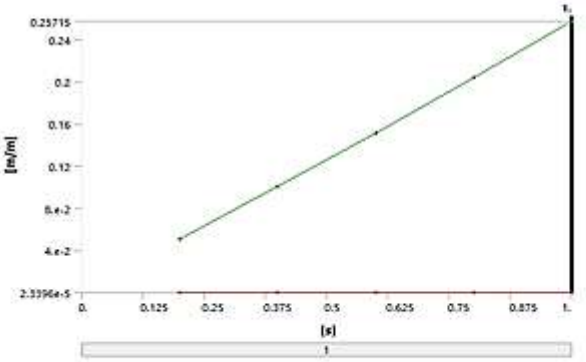

Figure 10. Model (B4) > Static Structural (B5) > Solution (B6) > Equivalent Elastic Strain

Time [s]	Minimum [m/m]	Maximum [m/m]
0.2	2.551e-005	4.0682e-003
0.4	5.3726e-005	8.4165e-003
0.7	9.7261e-005	1.4938e-002
1.	1.4329e-004	2.1443e-002

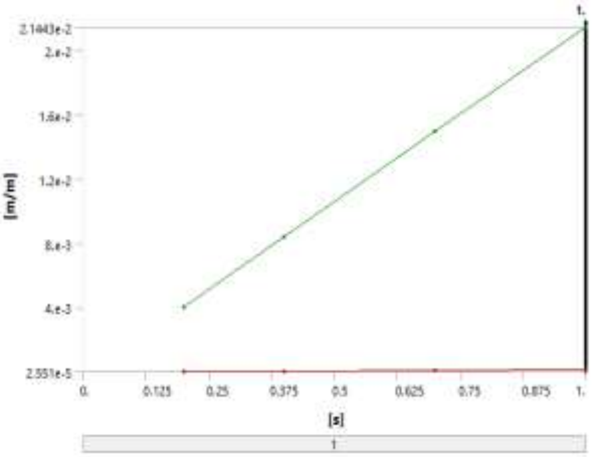

Figure 11. Model (C4) > Static Structural (C5) > Solution (C6) > Equivalent Elastic Strain

IV. CONCLUSION

The quality of the static analysis results were shown in Figure. Figure shows the Equivalent Stress (Pa) and Equivalent Elastic Strain in tire and treads evaluated using ANSYS and A good fit can be observed. We observed maximum equivalent elastic strain in tread 1 as a compared to other and minimum strain in tread 3. Wear and tear is minimum in tread 3 and maximum in tread 1.FIGURE shows Equivalent Elastic Strain in tread 1, tread 2 and tread 3.

V. REFERENCES

[1] Lee, C., Kim, J., Hallquist, J., Zhang, Y. et al. "Validation of a FEA Tire Model for Vehicle Dynamic Analysis and Full Vehicle Real Time Proving Ground Simulations," SAE Technical Paper 971100, 1997

[2] Kazuyuki Kabe, K., Koishi, M. "Tire cornering Simulation using finite element analysis", John Wiley & Sons, Inc. J ApplPolymSci 78: p.1566-1572, September 2000

[3] K. Hofstetter *, Ch. Grohs, J. Eberhardsteiner, H.A. Mang, "sliding behavior of simplified tyre tread pattern investigated by means of FEM" Paper from science direct

[4] Giurgiu, T. "Modélisation et simulation du comportement des pneus a l'aide du logiciel ANSYS", Project. Master Conception Integree des SystemesTechnologiques, "Politehnica" University of Bucharest, July 2012

[5] Giurgiu, T., Ciortan, F., Pup ă z a , C., "Tire Modeling using ANSYS",Engineering Numerical Modeling & Simulation, PRINTECH Publishing House, 2012

[6] Ogden, R.W, Saccomandi, G., Sgura, I - Fitting hyperelastic models to experimental data.

[7] Maia N.M.M., Silva J.M.M.Editors.Theoretical and Experimental Modal Analysis.

[8] Taunton Research Studies Press, 1997

[9] Iliescu M, Nut u E, Georgescu L. "Finite Element Method Simulation and Rapid Prototyping", 8th WSEAS International Conference POWER '08,p. 257-262, ISSN 1790-5117, Venice, Italy, November 21-23, 2008

[10] Marinescu D., Nicolescu A. "Gantry Robot Volumetric Error Evaluation using Analytical and FEM Modelling", "Annals of DAAAM International Symposium", Zadar, Croatia, 2010, ISSN 1726-9687, ISBN 978-3-901509-73-5, p. 1059-1060

[11] TIBERIU GIURGIU, FLORINA CIORTAN1, CRISTINA PUPAZA2, Machines and Manufacturing Systems Department,University POLITEHNICA of Bucharest.