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Effect of Tyre Overload and Inflation Pressure on Rolling Loss (resistance) and Fuel Consumption of Automobile Cars

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ABSTRACT:

Rolling loss or rolling resistance is an ever important property for the tyre and automotive industries because of its practical implication. The tyre rolls under a load, it deforms. The load presses down on the tyre and squashes it against the road. As the tyre turns, the squashed part comes off the road and returns to its original shape while another part of the tyre gets squashed. The sidewalls of the tyre flex over and over again, close to 500 times per minute at highway speeds. And, the tread goes from a circular to a flat shape and back to circular again there are some practical things that can reduce deformation and heat. Inflation pressure has an effect. Underinflated tyres deform much more, get much hotter, and cut fuel economy. So properly inflated tyres save fuel by reducing rolling resistance.

Fuel consumption and tyre rolling loss in all types of automobiles have become increasingly important because of adverse environmental effects and economic costs. If rolling resistance is reduced because of better tyre maintenance, consumers may end up spending less on tyres, because properly inflated tyres will have longer wear in addition to providing better fuel economy. In this thesis, the effect of rolling resistance on fuel consumption of radial passenger and truck tyres is discussed. A possible method of optimizing fuel use by adjusting the tyre load/pressure Conditions will be suggested. All these estimates will be obtained for radial tyres. Finite element analysis is done on the tyre by applying tyre load and inflation pressure. The investigations are made on two tyre models of automobile cars Skoda Rapid and Ford Classic. Modeling is done in Pro/Engineer and analysis is done in Ansys.

KEYWORDS: *Ansys, Rolling loss or rolling resistance, Pro/Engineer, Tyre.*

I. INTRODUCTION

The pneumatic tyre plays an increasingly important role in the vehicle performance of road. However, this status is achieved because of more than one hundred years' tyre evolution since the initial invention of the pneumatic tyre by John Boyd Dunlop around 1888. Tyres are required to produce the forces necessary to control the vehicle. As we know that the tyre is the only means of contact between the road and the vehicle but they are at the heart of vehicle handling and performance (Nicholas, 2004). The inflated rubber structure provides comfortable ride for transportation. With the growing demand for the pneumatic tyre, many improvements have been made based on the initial conception, such as the reinforcement cords, the beads, the vulcanization, the materials and the introduction of the tubeless tyre. The relationship between human and tyre and environmental surrounding play an important role for developing of tyre technology. These concerns include traffic accidents caused by tyre failure, the waste of energy due to bad tyre conditions, the pollution through the emission of harmful compounds by tyres, and the degradation of road surfaces related to tyre performance, etc.Tyre as one of the most important components of vehicles requires to fulfill a fundamental set of functions are to provide load-carrying capacity, to provide cushioning and dampening against the road surface, to transmit driving and braking torque, to provide cornering force, to provide dimensional stability, to resist abrasion (Mir Hamid, 2008). Tyres have ability to resist the longitudinal, lateral, and vertical reaction forces from the road surface without severe deformation or failure. Tyre performance is depends on the tyre rolling resistance, cornering properties, tyre traction, tyre wear, tyre temperature, tyre noise, tyre handling and characteristics, etc. There are various losses associated with the vehicle that affect its fuel economy as it is being operated. These losses include engine, driveline, aerodynamic and rolling losses, while the rolling loss is associated with the vehicle tyres.

1.1 . Tyre axis terminology

It is need to understand some of the basic terminology for tyre, especially regarding the systems of coordinates, orientations, velocities, forces, moments. Nomenclature and definitions based on the SAE standard as shown in Figure 1 X-axis is the intersection of the wheel plane and the road plane with positive direction forward. The Z-axis perpendicular to the road plane with positive direction downward. The Y-axis in the road plane, its direction being chosen to make the axis system orthogonal and right hand. There are several forces, moments and angles that prove to be very important in tyre behavior. All these forces can be seen as the forces and moments acting on the tyre from the road. First, there are two main angles to consider, the camber angle and the slip angle. The camber angle is the inclination angle from its vertical position while the slip angle is the difference in wheel heading and direction.

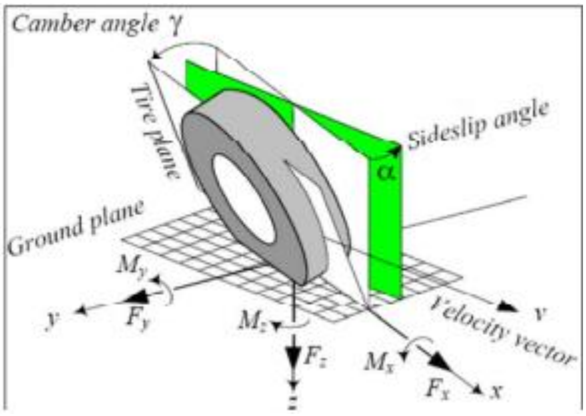

Figure 1.Tyre Axis Terminology

II. INTRODUCTION TO PRO/ENGINEER

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

Customer requirements may change and time pressures may continue to mount, but your product design needs remain the same - regardless of your project's scope, you need the powerful, easy-to-use, affordable solution that Pro/ENGINEER provides.

3. 3D models of tyre and rim assembly

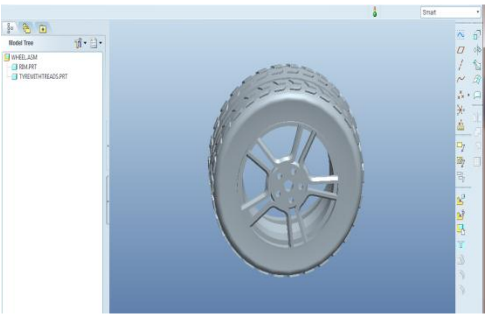

Figure 2.Assembly of Skoda

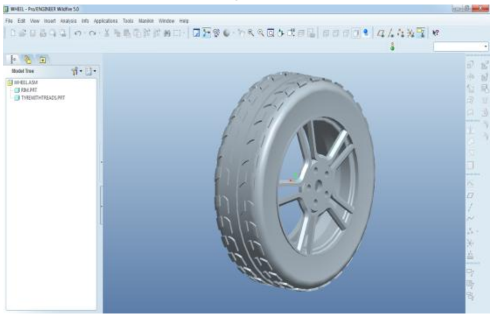

Figure 3.Assembly of Ford

4. Analysis by using ansys

4.1 Structural analysis of Skoda tyre

4.1.1 Car weight + 5 persons weight (at pressure 1.116)

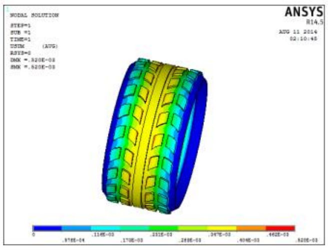

Figure 4. Displacement

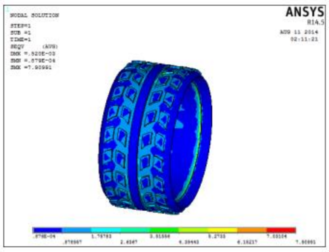

Figure 5. Stress

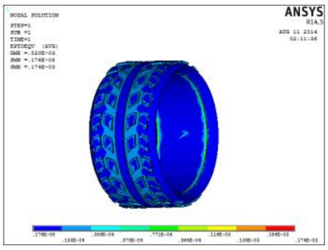

Figure 6.Strain

4.1.2 Car weight + 6 persons weight (pressure - 1.118n/mm^2)

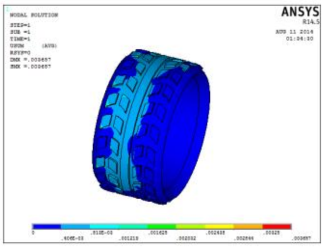

Figure 7. Displacement

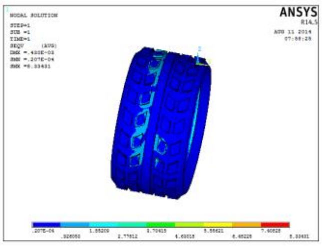

Figure 8. Stress

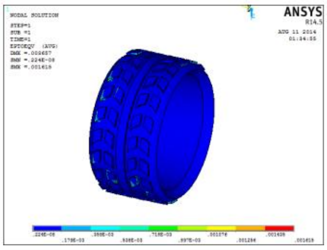

Figure 9. Strain

4.1.3 Car weight + 7 persons weight (at 1.214 pressure)

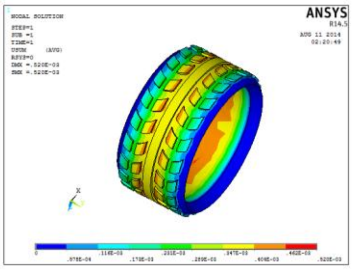

Figure 10. Displacement

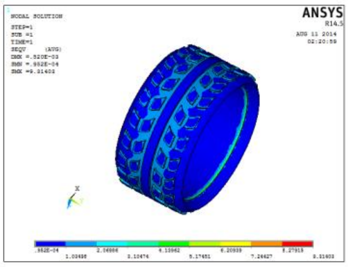

Figure 11. Stress

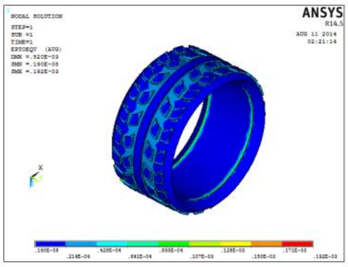

Figure 12. Strain

4.2 Structural analysis of ford tyre

4.2.1 Car weight + 5 persons weight (pressure at 0.6211)

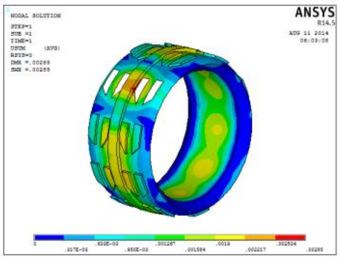

Figure 13. Displacement

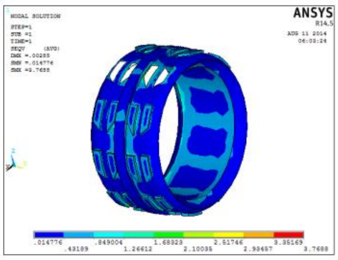

Figure 14. Stress

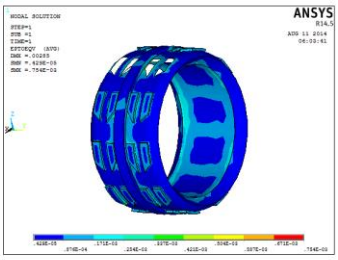

Figure 15. Strain

4.2.2 Car weight + 6 persons weight(at pressure 0.65 n/mm^2)

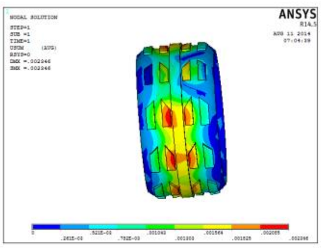

Figure 16. Displacement

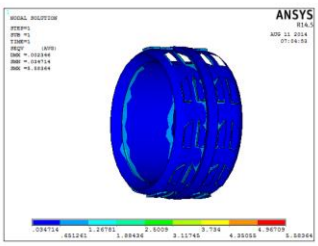

Figure 17. Stress

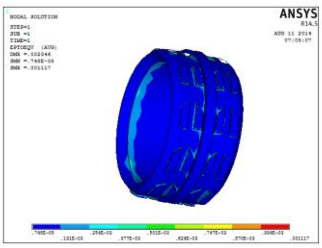

Figure 18. Strain

4.2.3 Car weight + 7 persons weight (at pressure 0.6790 n/mm^2)

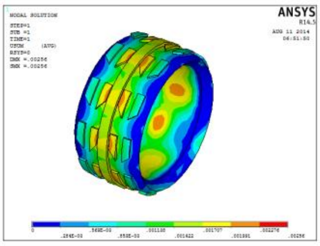

Figure 19. Displacement

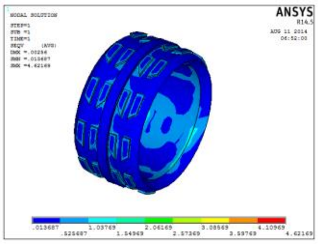

Figure 20. Stress

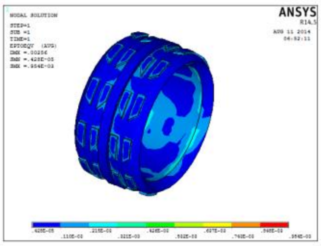

Figure 21. Strain

III. RESULTS TABLE

5.1 Skoda tyre

Pressure (N/mm^2)	**Displacement (mm)**	**Stress(N/mm^2)**	**Strain**
At 1.116	0.520e-03	7.90991	174e-02
At 1.181	0.003657	8.33431	0.001615
At 1.214	0.520e-03	9.31402	0.192e-03
Inflation pressure(0.036)	0.130e-04	0.160046	0.325e-05

Table 1.Results of skoda tyre

5.2 Ford tyre

Pressure (N/mm^2)	**Displacement (mm)**	**Stress(N/mm^2)**	**Strain**
At 0.6211	0.00285	3.7688	0.754e-03
At 0.650	0.002346	5.58364	0.001117
At 0.6790	0.00256	4.62169	0.954e-03
Inflation pressure(0.036)	0.739e-03	0.510433	0.112e-03

Table 2.Results of ford tyre

IV. CONCLUSION

In this thesis, the effect of tyre over load and inflation pressure on the rolling loss and fuel consumption is analyzed. The investigations are made on two models of tyre Skoda Rapid and Ford Classic. The analysis is done by applying the loads of car weight and persons weight. When the car is overloaded, also analysis is done. Analysis is done by applying inflation pressure. The material used for tyre is rubber.
Modeling is done in Pro/Engineer and analysis is done in Ansys.

The analysis is done by applying the car weight + 5 persons weight, overloading the tyre, that is, car weight + 6 persons weight and car weight + 7 persons weight. The analysis is also done by applying the inflation pressure.

By observing the analysis results, the stresses produced are less than the yield strength value of rubber even the tyre is overloaded. The rolling loss will be more for overloading than the specified load and the fuel consumption will also be more. A possible method of optimizing fuel consumption by adjusting tyre operating load/pressure conditions is suggested. Increasing tyre pressure is a convenient and inexpensive method of partially or fully compensating for rolling resistance increase. Some fuel saving might be accomplished by this method.

By comparing the results ford classic tyre is best which is getting less stress values compared to Skoda tyre in the case of overloaded condition and the fuel consumption also more for Skoda compared to ford classic.

6.1 By the results the following Observations are made:
1. The more stress is developed when the vehicle is over loaded.
2. The rolling loss also increased by over loading.
3. The stresses are produced more than the material yield strength in the case of over loaded condition.
4. If the rolling loss increased the stress on the tyre also increased simultaneously the load on the engine will be more with this effect the fuel consumption will be more.
5. From the above observations we are concluding that by the over load of the tyre the fuel consumption is more and inflation of rolling loss also increases.
6. In the case of overloading condition also ford stress values are less compared to Skoda so we are concluding that ford tyres are better than Skoda in the fuel consumption of over loading condition.

6.2 Suggestions:
1. To optimize the fuel consumption the over loading must be decreased.
2. And the pressure of air in tyres must be monitored and by increasing the pressure we may optimize the fuel consumption.
3. By the above two conditions the fuel consumption in automobiles are optimized.
4. By reducing the weight of the car also the consumption may optimized.
5. Usage of composite material parts, which will reduces the weight of the cars and the fuel consumption reduced accordingly.

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