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

Kaneriya Deep[1], Patil Prafful[2], Sonwane Dhaval[3], Patel Yash[4], Mr. Mitesh patel[5]
*Guide, Department of mechanical Engineering, Bhagwan Mahavir college of engineering and technology, Surat, Gujarat, India*
*Department of mechanical Engineering, Bhagwan Mahavir college of engineering and technology, Surat, Gujarat, India*

***Abstract*- The effect of rolling resistance R on fuel consumption of radial passenger and Car Tyres is discussed in this project work. The model equation for the rolling loss R was directly proportional to Tyre load W (R α W) and inversely proportional to inflation pressure p (R α 1/px). These relationships were experimentally quantified. Using manufacturer's recommended values for load W and pressure p as reference points the R values for different overload conditions (from +10 to +100%) at constant p were estimated. Similarly, the required pressure values to support 10 to 50% additional load to maintain original R were also estimated. Then the estimated R values for different overload/inflation pressure conditions were combined with the fuel saving factor F (obtained from researched literature results). Then the relative change in fuel consumption of Car/truck Tyres for different load/pressure combinations vis-a-vis the fuel use for the manufacturer's recommended W and p values was evaluated. The present analysis showed that for the same amount of fuel use a truck carrying a 100% overload and making one round trip would correspond to slightly more than two round trips by a Car of same size carrying the recommended load. finally, a possible method of optimizing fuel use by adjusting the Tyre load/pressure conditions was suggested. all these estimates were obtained for radial Tyres. modelling from the design of tyre is done cad software and analysis is done in Ansys software. different loading conditions are applied and conclusion is made from it by comparison on analyzed results.**

## I. INTRODUCTION

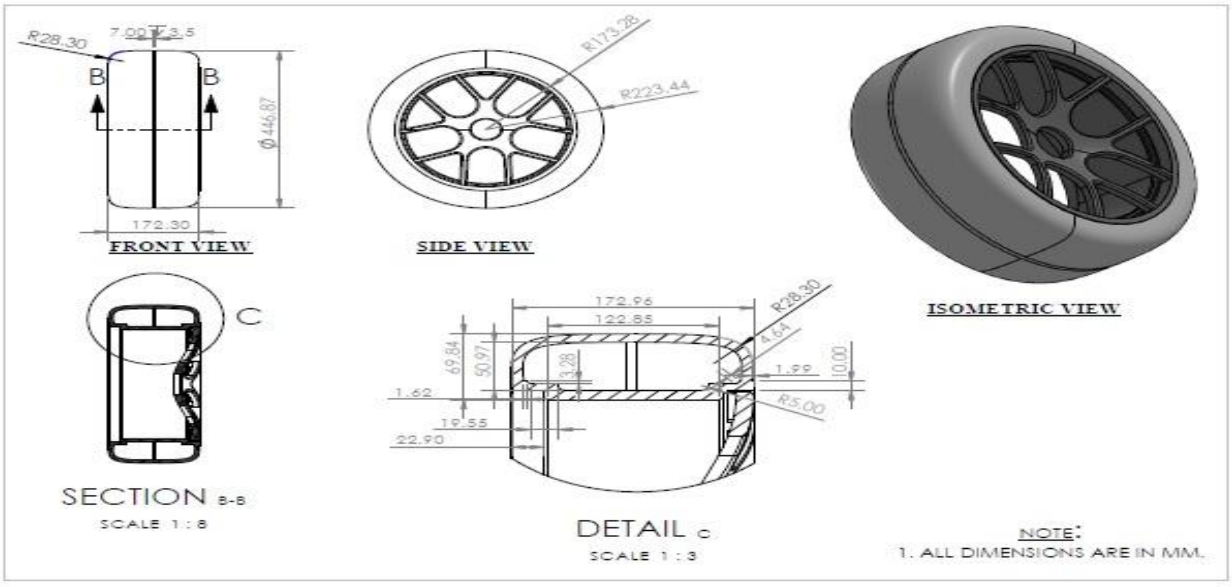
The pneumatic tyre plays an increasingly important role in the vehicle performance of road. However, this status is achieved because of more than one hundred years' tyre evolution since the initial invention of the pneumatic tyre by John Boyd Dunlop around 1888. Tyres are required to produce the forces 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.
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 fulfil 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 depending 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. This paper tells about the theoretical study about the tyre background, tyre axis terminology, tyre performance parameters, experimental setup available for this parameter, and survey on tyre testing setups available for tyre testing. 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 behaviour. 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.

Tyre Pressure Inflation System

As such it has also prompted the use of tyres, which according to studies carried out are the second highest operating cost the vehicle after fuel. It has also been adverted by the Technology and Maintenance Council (TMC) of America that 53.5 percent of road-side breakdowns were caused by tyre problems and also that tyres were the second leading causes of inspection citation after brakes (TMC S.2 Tyre and Wheel., 2010). Furthermore the cost of fuel and tyres has significantly increased in the past years, yet the general majority of drivers doesn't know that proper and timely pressure inflation or pressure management systems can lead to great cuts on maintenance and fuel costs as shown by the research done by the North American Council for Freight Efficiency (NACFE, 2013), that improperly inflated tyres can lead to the vehicle taking more than necessary fuel when in operation due to promoted retardation since underinflated tyres increase the drag force on a vehicle. Improper tyre inflation also leads and promotes treads which simply ensues from increased rolling resistance as referred to by the Goodyear article on Tyre Pressure Monitoring Systems (Dr.Benedict, 2012), it has been stated in researches by the TPMS (TMC S.2 Tyre and Wheel., 2010) that under inflation of tyres by 20 percent increases treading by 25 percent and reduce the tyre life by 30 percent, 10 percent over inflation reduces treading by 5 percent due to the uneven abrasion of the tyres against the road. A proper and automated pressure inflation system would eliminate both the problem of cost and improper inflation since it is censored with the adequately necessary pressure levels depending on tyre condition. This would in turn preserve the tyres as well as the fuel.

Designing & Modelling: -




(Figure. Drafting of tyre)

Pressure Influence On: Vehicle Performance; Tyre Life; Fuel

The detail from the analysis discussed above is used in the dimensioning and structural outlay of the tyre, i.e. resilient material selection, size ratio with the vehicle, as well as optimum operating pressure levels. Effects of incorrect operating tyre pressure levels are shown by the picture below


(Figure; - Pressure Influence On: Vehicle Performance; Tyre Life; Fuel)

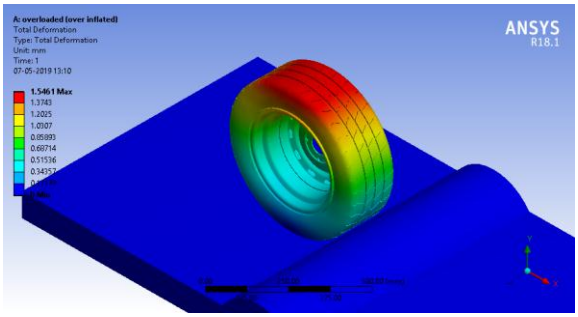
FEA Simulation of Tyre

The main characteristics of passenger vehicles are: mobility, safety and availability. 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 behavior of the tire when passing obstacles, the tire-ground contact pressure, tirebehavior when crossing a trench and so on. Most tire simulations with FEM were static analysis, because tire is one of most complex structures. A non-linear static and transient FEA analysis of a tire model was performed , 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 , as well. Using the implicit formulation, a steady-state cornering simulation was performed, requiring a fine mesh only in the contact region because of the formulation by moving reference frame technique. The present research is focused on modeling and simulation of a special type of tire, used for passenger.

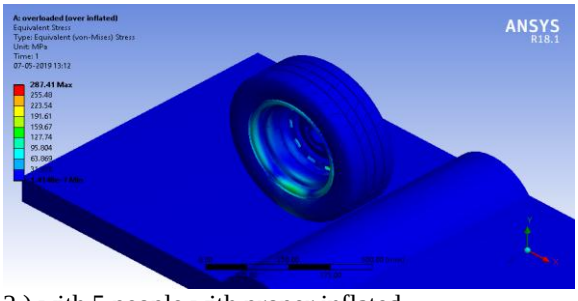
An existing wheel configuration is analyzed in order to find improved design solutions. The wheel is designed not only to assure the mobility of the vehicle, but also to withstand to high stress levels during the vehicle's movement. A solution for replacing the old tyres is to reconfigure the existing rims, so that a run flat technology can be used. The aim is to increase the mobility and the safety of the vehicles. This process involves preliminary simulation attempts, experiments and testing procedures for homologation.

1.) Overload with Over-inflated

a.) Total deformation

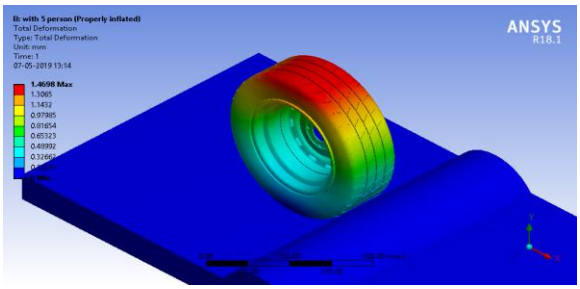



b.) Stress

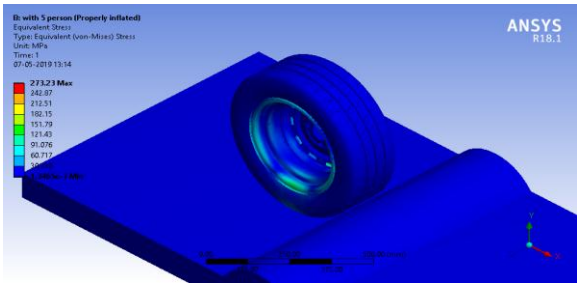



2.) with 5 people with proper inflated

a.) Total deformation

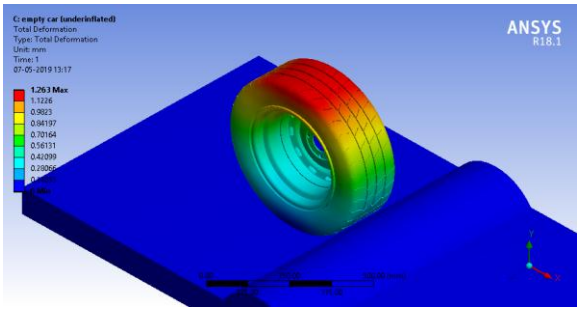



b.) Stress

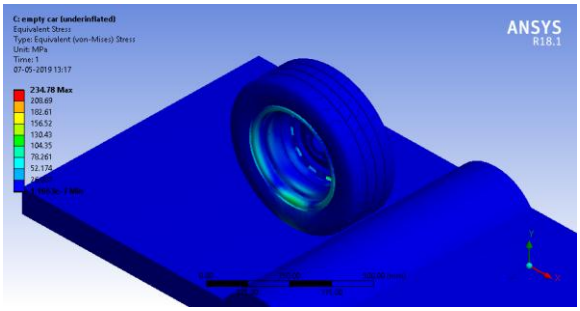



3.) Empty car with under-inflated

a.) Total deformation




b.) Stress




- Results from FWEA simulation

4) When tyre is not carrying any load, only pressure effects are considered

| Pressure (N/mm2) | Total Deformation (mm) | Stress(N/mm2) |
|---|---|---|
| At 0.77 (over-inflated) | 1.5461 | 287.41 |
| At 0.732 (proper inflated) | 1.4698 | 273.23 |
| At 0.629 (under-inflated) | 1.263 | 234.78 |

## CONCLUSION

In this project, the effect of tyre over load and inflation pressure on the rolling loss and fuel consumption is analyzed. The investigations are made on one models of tyre Skoda superb. The analysis is done by applying the loads of car weight and persons weight. The material used for tyre is rubber. The analysis is done by applying the car weight + 5 persons weight, overloading the tyre, 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 Under-inflated than the specified inflation and the fuel consumption will also be more and also surface contact increases which reduces tyre life or efficiency. Increasing tire 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.

Empty car condition generally the normal inflation or standard inflation pressure which is almost required to the air pressure on tyre for its good usage & service & long activity is analysed carefully so that the amount of fuel consumption can reduced to some extant as well as the rolling resistance can be reduced as compared to overload and loading condition. In this condition car remaining is idle condition (remain stationary) & tyre remains in road surface contact.

Overloading condition includes the 6 passenger weight, tyre self-weight, Car kerb weight, luggage, etc.. due to all this, the effect of inflation pressure rolling resistance and fuel consumption may be increased which is unnecessary & needs to be in controlled, otherwise efficiency decreased which is undesired.

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