FINITE ELEMENT ANALYSIS OF SYNTHETIC RUBBER AND POLICHLOROPRENE RUBBER AT DIFFERENT MESH SIZE ON TYRE TO INCREASE SKID RESISTANCE

Naveen Kumar Kori [1], Dr. Shiv Kumar [2], Prof. Ranjeet Kumar[3]

ME Scholar[1], Director [2], HOD[3]
Department of Mechanical Engineering[1,2]
Vaishnavi Institute of Thnology and Science Bhopal, India

Abstract

The effective uses of a modified asphalt tyres are limited at its maximum operational junction ability. The study was conducted by using the Finite element method. The different material tyres are used. The major study was done on tyres by using different mesh sizes with different materials (Synthetic rubber and polychloroprene rubber). An area mean pressure was analyzed is performed for validation.

In our analysis, ANSYS was used and the model was developed on unigraphics 8.0. In order to verify the present base paper model, the contact stresses with five types of mesh size are compared with the available experimental results present in the base paper and the design of Synthetic rubber and polychloroprene rubber tyres with different materials. In this study, the simulations of different profile Synthetic rubber and polychloroprene rubber tyres and five types of mesh size were analyzed for contact stresses and the configurations of Synthetic rubber and polychloroprene rubber tyre design are proposed.

The results show that polychloroprene rubber material tyre the increased in a contact stresses and area mean pressure in different mesh sizes. The shear and normal stresses are decreased as compare to Synthetic rubber tyre.

Keywords— *Tyre, Skid Resistance, Synthetic Rubber*

I. INTRODUCTION

In this newsletter, we are concerned with car dynamics that is the examine of car movement. Necessarily, the motion of a car outcomes from the forces that act on it. The widespread majority of the forces that act on a vehicle originate from the tyres. The few that don't are the gravitational load, aerodynamic downforce and drag. So, it's miles that maximum of the forces acting on a car come from the tyres and if we are to get the excellent out of the car meaning getting the most out of the tyres. A correct way to think of a tyre is to consider it to be a six-degree-of-freedom element that acts among the road surface and the stub axle to which the wheel is set up. Since tyres are elastic factors, the forces they broaden depend on the deflections they preserve in every of those six ranges of freedom. It is simple to look that a tyre acts like a spring element within the vertical course, a load on the tyre reasons it to deform, and because the deformation proceeds, there develops a pressure to face up to it. The circular nature of the tyre means that as the deformation proceeds the contact patch grows in size and the vertical load increases lots more than linearly with deformation. Similar results practice in plunge while the stub axle is deflected linearly alongside its axis and additionally forward and aft beneath the motion of tractive and braking effort. On top of these three linear deflections, there are three rotational ones. Imagine a tyre with a tractive effort being supplied; in reality, the tyre will deflect rotationally beneath this torque. Further to this, a tyre may be turned around about a vertical axis, as for guidance. When this takes place, the tyre contact patch will deform and, as we will see, will produce a torque to oppose this inspired movement. Lastly, in the the front view, a tyre may rotate about the contact patch and lean in or outwards. Again, there may be elastic deformations in the touch patch, and those will serve to resist the overturning. Taken collectively, the tyre consequently gives compliance in all six stages of freedom.

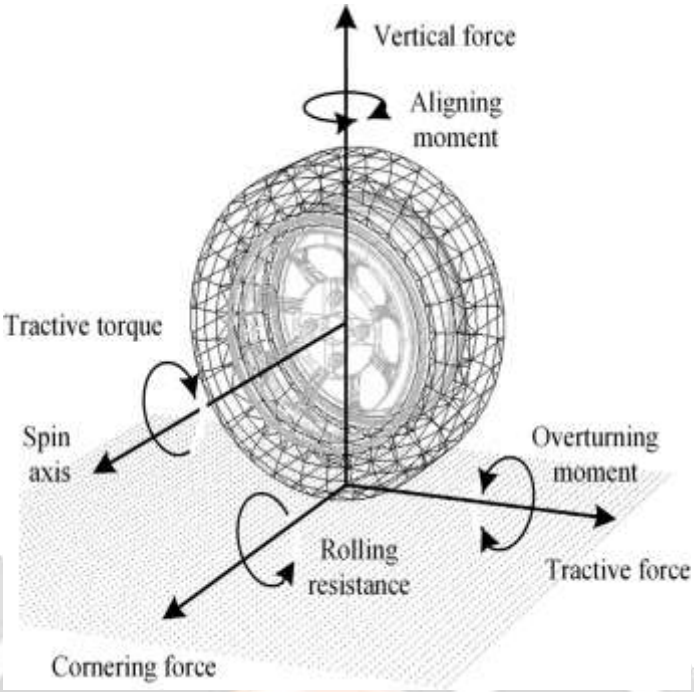

Figure 1-1 Force and moments acting on a tyre.

II .Basic Components /Tyre Construction

Tread- The tread is the outermost covering of the tyre, and is the handiest element that typically comes in contact with the road floor. It, therefore, need to be designed to guard the frame of the tyre from cuts and put on. Depending at the intended use of the tyre, the rubber compound applied to the tread can be changed to customize reduce tread pattern additionally has a huge effect on the performance of the tyre. A variety of tread styles are available for one of a kind kinds of operations. These styles characteristic incredible reduce resistance, traction and longer serviceability. These elements are taken into consideration when recommending a tyre exceptional acceptable for the operation.

Sidewall- The aspect partitions are composed of bendy, crack resistant rubber, and defend the carcass from harm. For jobs wherein chuck holes, large rocks, and so on. Are a hassle, tyres with high reduce resistant sidewalls can be used. The sidewalls are designed to cushion the body plies from surprise and reducing, even as being capable of flex and bend without cracking. The sidewall should additionally be able to face up to the ravages of the weather with out deterioration.

Plies- A tyre is composed of some of layers or plies. These plies are high tensile nylon cords which might be loosely woven together and lined on both facets with a rubber compound. These layers of plies assist include the inflation pressure of the tyre in supporting the load. The high-tensile nylon cords have a more resistance to shock, cutting and warmth. This improves the sturdiness of the tyre.

Carcass or Cord Body- The compressed air in a tyre helps the load positioned on the tyre. The carcass forms a semi-inflexible body for the compressed air, however it's miles flexible sufficient to take in a few shocks and jolts. The carcass of the Bias tyre includes a number of rubber lined layers of cloth referred to as ―piles‖. The carcass determines the electricity of the tyre and the ability to flex.

Bead- The beads repair the tyre to the rim to help the load.

Belts- In radial tyres stabilizer bias ply belts under the bottom rubber supply introduced safety to the radial plies below and decide the shape of the footprint.

Liner- In tubeless tyres, that is composed of or greater layers of rubber, designed to hold air or liquid below strain. The inner partitions of tubeless tyres are covered. The liner is made of an air-impermeable rubber compound and is

corresponding to tubes used in tube type tyres. Tubeless tyre normally weight less than comparable tube kind tyres and are less difficult to hold tube and flap are removed..

III. A subset of tyre production: tyre treads

A right tread layout improves traction, improves managing and will increase Durability. It also has a right away impact on trip consolation, noise level and gas efficiency. Each part of the tread of your tyre has a extraordinary call, and a one-of-a-kind function and impact on the overall tyre. Your tyres may not have these types of functions, however here is a rundown of what they appear like, what they may be called and why the tyre producers spend millions every yr playing with all these things.

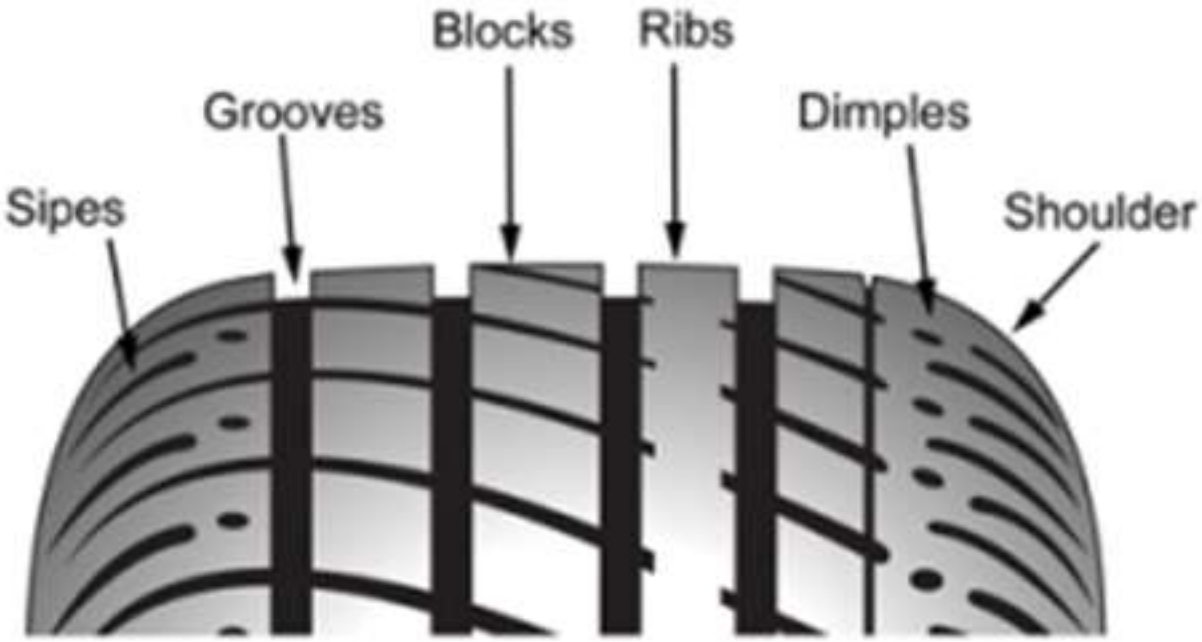

Fig 1.3 A subset of tyre construction

Sipes are the small, slit-like grooves within the tread blocks that allow the blocks to flex. This brought flexibility will increase traction by way of developing an extra biting aspect. Sipes are particularly helpful on ice, light snow and free dirt.

Grooves create voids for better water channeling on moist street surfaces. Grooves are the maximum efficient manner of channeling water from in the front of the tyres to at the back of it. By designing grooves circumferentially, water has much less distance to be channeled.

Blocks are the segments that make up the general public of a tyre's tread. Their number one function is to provide traction.

Ribs are the directly-coated row of blocks that create a circumferential contact "band."

Dimples are the indentations inside the tread, commonly in the direction of the outer fringe of the tyre. They improve cooling.

Shoulders offer continuous touch with the street even as maneuvering. The shoulders wrap barely over the internal and outer sidewall of a tyre.

The Void Ratio is the amount of open area within the tread. A low void ratio method a tyre has more rubber is in contact with the road. A excessive void ratio will increase the ability to drain water. Sports, dry-weather and high overall performance tyres have a low void ratio for grip and traction. Wet-climate and snow tyres have excessive void ratios.

Tread patterns- There are loads if no longer heaps of tyre tread styles to be had. The real pattern itself is a mixture of capability and aesthetics. In amongst all this, there are three simple sorts of tread pattern that the producers can select to go along with:

- **Symmetrical:** consistent across the tyre's face. Both halves of the treadface are the same design.
- **Asymmetrical:** the tread pattern changes across the face of the tyre. These designs normally incorporates larger tread blocks on the outer portion for increased stability during cornering. The smaller inner blocks and greater use of grooves help to disperse water and heat. Asymmetrical tyres tend to also be unidirectional tyres.

Unidirectional: designed to rotate in only one direction, these tyres enhance straight-line acceleration by reducing rolling resistance. They also provide shorter stopping distance. Unidirectional tyres must be dedicated to a specific side of the vehicle, so the information on the sidewall will always include a rotational direction arrow. Make sure the tyres rotate in this direction or you'll get into all sorts of trouble.

IV. Tyre Use Classifications

Tyres are labeled into several preferred sorts based totally at the sort of car they serve. Since the manufacturing procedure, raw materials, and device vary in step with the tyre kind it is commonplace for tyre factories to specialize in one or greater tyre types. In maximum markets factories that manufacture passenger and mild truck radial tyres are separate and wonderful from those that make plane or OTR tyres.
Passenger and Light Truck- High Performance tyres, Mud and Snow tyres, all-season tyres, all-terrain tyres are normal passenger & light truck tyres.
Run-Flat Tyre- Several progressive designs had been introduced that permit tyres to run accurately with out a air for a restricted range at a limited pace. These tyres function nonetheless load helping sidewalls and frequently plastic load-bearing inserts.
Heavy duty truck tyres- Heavy obligation tyres are also called Truck/Bus tyres. These are the tyre sizes used on cars which includes business freight trucks, dump vans, and passenger busses.
Off-the-Road (OTR)- The OTR tyre type consists of tyres for production motors such as backhoes, graders, trenchers, etc; in addition to big mining vans. These tyres are constructed with a huge quantity of reinforcing plies to resist intense provider conditions and high loads. OTR tyres are utilized in as an alternative low speed conditions.
Agricultural- The agricultural tyre category consists of tyres used on farm cars, typically tractors and strong point vehicles like harvesters. High floatation tyres are used in swampy environments and characteristic massive footprints at low inflation pressures.
Racing- Racing tyres are relatively specialised in line with vehicle and race song conditions. Tyres are especially engineered for specific race tracks in keeping with floor conditions, cornering hundreds, and tune temperature.
Industrial- The Industrial tyre type consists of pneumatic and nonpneumatic tyres for uniqueness industrial motors such as skid loaders and fork carry trucks.
Bicycle- This type consists of all forms of bicycle tyres, together with racing tyres, mountain-bike tyres, and snow tyres

Objective of the Work

The main objective of the current work is

1.Validation of the ANSYS models by comparing the present simulated results with Bo Chen et.al (Author of Base Paper).
2.To predict shear stresses of tyre.
3.Parameter sensitivity of tyre with different mesh size.
4.To define normal stress and area mean pressure for the different mesh size.

Problem Formulation

The study of various literatures we find the area mean pressure is lower as compared to present study. The purpose of this study is to predict contact stresses and area mean pressure with different mesh sizes in the tyre with different mesh size for analysis..

V. LITERATURE REVIEW

Bo Chen et al. [1] - the experimental research at the actual touch area and pressure distribution between tyre and asphalt tyre, a stress-touchy film changed into carried out and followed for measuring radial tyre touch pressure. In this study, the fractal size of the fracture floor changed into envisioned to describe the floor roughness of 4 kinds of track forums in phrases of making use of the progressed projective overlaying technique. The outcomes confirmed that Weibull distributions had been applicable to describing the contact stress distribution between tyre and tyre, and the Weibull expectation could efficaciously signify the strain degree. In addition, it turned into observed that extra stress expectations indicated more sizable strain attention effects on the tyre surface. The strain distribution multiplied with an increase of tyre texture depth or tyre load or a lower of the tyre inflation pressure. The have an impact on of tyre roughness and tyre load become greater giant than tyre inflation strain on the strain attention. Compared to the overall tyre texture intensity (sand patch technique), the floor fractal measurement adequately defined the surface roughness such as macro-texture and micro-texture, and it turned into directly suffering from the proportion of coarse aggregate. The tyre skid-resistance overall performance became especially prompted via its excessive pressure regions (>1.8 MPa) at the top of asperities. The skid-resistance performance of asphalt tyre become proved to be higher with a excessive-level average powerful strain.

J. Marais and G. Venter [2]-this research in numerical modelling of the internal warmth technology in passenger automobile tyres using finite detail evaluation is a well-known numerical method. However, this application is instead unusual for earthmover tyres. This paper describes the development of a finite detail version of a 23.5R25 earthmover tyre for the numerical modelling of the tempera- ture distribution inside the tyre pass-phase at consistent-nation heat transfer situations using an uncoupled analysis technique. Considering the non-linear behaviour of the rubber com- kilos used for the producing of these tyres, in addition to the complexity associated with the composite structural elements of the tyre, the cloth homes used for the seasoned- posed numerical model were hooked up experimentally. In the analyses completed, the tyre behaviour was studied through simulations at various inflation pressures, hundreds and rolling velocities. The numerical tyre defection was within an 8% deviation from the real tyre behaviour. Thermal simulation outcomes had been used to derive an equation that may be used to expect the maximum temperature that would arise inside the tyre's move-phase as a function of its vertical deflection, its ahead rolling pace and the ambient temperature of the environment. The numerical fashions and simulations offered on this paper had been completed using MSC.Marc/Mentat.

Theodoros Grigoratos et al. [3] - the research Treadwear Rating (TWR) supplied at the sidewall of the tyre is a marking supposed to inform the patron about the expected durability of the tyre. The cutting-edge examine explores whether there's a correlation between the TWR and tyres' tread mass loss. Furthermore, it explores the viable correlation among the TWR and tyre wear dust emitted inside the shape of PM10 and PM2.Five. For that cause, two tyres of the same brand (B) however with exclusive TWR and three tyres of various manufacturers (C and D with the same TWR as one of the B tyres and A with a decrease TWR) have been tested at a steady speed of 70 km/h by way of the Swedish National Road and Transport Research Institute (VTI) street simulator. Tyres of the same TWR but of various manufacturers confirmed exceptional behavior in phrases of material loss, PM, and PN emissions beneath the chosen testing conditions. This manner that it is not possible to categorize tyres of different manufacturers in terms in their emissions primarily based on their TWR. The check accomplished on the 2 tyres of the identical brand however with extraordinary TWR showed instead a sizable (not statistically massive) distinction in both overall wear and PM10 emissions. The tyre with the better TWR (B2) confirmed less put on and PM10 emissions in comparison to the B1 tyre having a decrease TWR. Since most effective tyres of the identical brand and with unique TWR had been examined, this result can't be generalized and extra assessments are vital to verify the relation inside the same brand. In general, the tyre tread mass loss showed no apparent statistical relation to PM10, PM2.Five or PN awareness. In all instances about 50% (with the aid of mass) of emitted PM10 fall in the size variety of excellent debris, whilst PN size distribution is ruled by means of nanoparticles most customarily peaking at 20–30 nm.

Jing Zhang et al. [4] - the research Benzothiazole (BT) and its derivates are generally used as vulcanization accelerators in rubber production. Information on the incidence of BTs in road dust (RD) and on human expoure to those compounds may be very limited. BT and its six derivates in tyre put on debris (TWPs) and RD had been decided on this have a look at. Samples had been extracted the use of solid-liquid extraction, purified by means of a HLB SPE column, and decided through ultra-high performance liquid chromatography-tandem mass spectrometry (UPLC-MS/MS). All seven BTs have been located in 17 TWPs samples from special tyre manufacturers. The mass fractions of all seven BTs (ΣBTs) in TWPs ranged from 46.93 to 215 μg/g with an average awareness of ninety nine.32 μg/g. Benzothiazole and 2-hydroxybenzothiazole (2-OH-BT) have been the 2 most important compounds, accounting for 56%–89% of the total. The seven BTs have been additionally observed in all 36 sets of RD samples (each set blanketed one sample of TSP (debris < 75 μm in diameter), PM10 (debris < 10 μm in diameter) and PM2.5 (debris < 2.Five μm in diameter) fractions of RD. The median ΣBTs concentration become maximum in PM2.5

(26.62 µg/g), observed by means of PM10 (22.03 µg/g), and TSP(zero.68 µg/g). Of the seven BTs, BT, 2-aminobenzothiazole (2-NH2-BT), 2-mercaptobenzothiazole (MBT), and a couple of-(methylthio)benzothiazole (MTBT) were disbursed in PM2.5 and a pair of-OH-BT changed into dispensed in PM2.Five-10 of RD. Based at the mass fractions of BTs inside the TSP, PM10, and PM2.Five fractions of RD, human publicity through ingestion, inhalation and dermal absorption had been evaluated. Ingestion was discovered to be the main publicity pathway in people, and each day intake of BTs in PM2.Five changed into highest, accompanied by means of M10 and TSP, respectively. Children may also go through greater health risks than adults whilst uncovered to RD.

Ding Han et al. [5] - this research In order to research tyre footprints in specific situations and calculate dynamic responses of asphalt tyre with vehicle braking, a tyre-tyre coupling simulation device, which could use a viscoelastic constitutive version of asphalt concrete considering temperature dependence, is hooked up. The person subroutine of the cloth version turned into programmed via the FORTRAN language, and viscoelastic parameters of the cloth model were diagnosed primarily based on dynamic pressure records of dynamic impact exams, whose validity changed into tested by means of using test information within the literature. The tyre-tyre coupling simulation system was installed to analyze tyre footprints in static and dynamic situations at unique temperatures of asphalt concrete layer, whose calculation accuracy of the numerical simulation turned into tested. Based on measured temperature statistics at unique depths of an real tyre structure and the corresponding simulation model, thermal parameters of every layer within the tyre shape were recognized. Field distributions of the viscoelastic parameters in the asphalt concrete layer of the coupling simulation device had been received through the use of the warmth switch analysis and the person subroutine. Average braking decelerations of vehicles at a chosen intersection were calculated in step with the research data. Based on the tyre-tyre coupling simulation gadget, height values of dynamic shear stress in the asphalt concrete layer at the intersection had been calculated, which taken into consideration the coupling impact among axle loads and temperature fields.

VI MODELING AND ANALYSIS

The procedure for solving the problem is

- Modeling of the geometry.
- Meshing of the domain.
- Defining the input parameters.
- Simulation of domain**.**

Finite Element - Analysis of modified asphalt tyre
Analysis Type – Static structural analysis

4.1 Preprocessing

Preprocessing include UG 8.0 model, meshing and defining boundary conditions.

4.1.1 Model

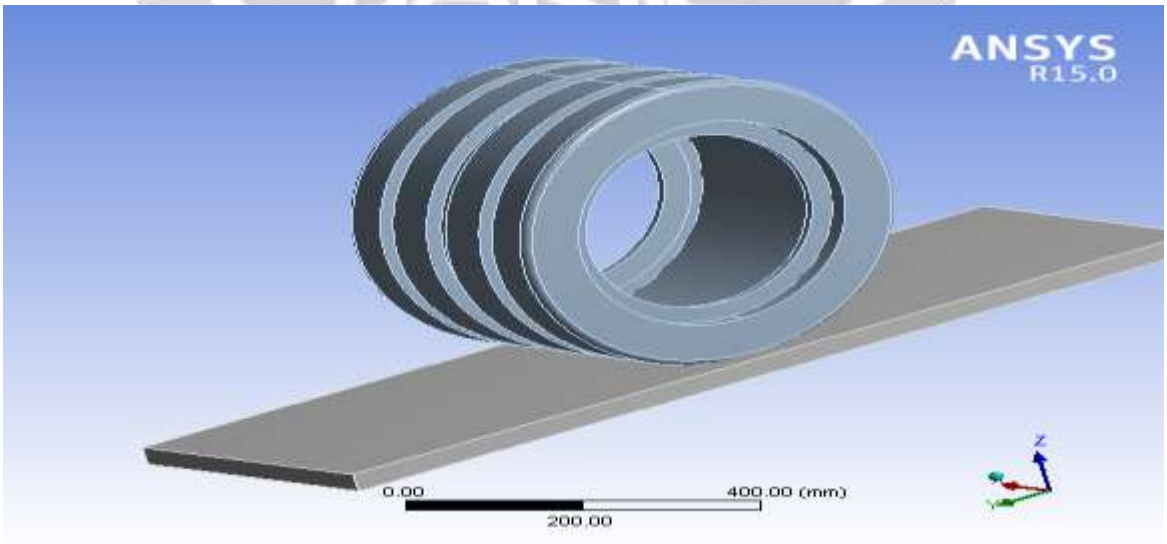

Figure No.: 4.1 CAD Model of tyre.

4.1.2 Meshing

The group of nodes and elements is known as meshing this process is done to determine convergence of solution the phenomenon convergence of solution is a relation between accuracy, degree of freedom and no. of nodes and elements as the quantity of nodes and elements are increased at variable iteration a convergence of solution is obtained. Meshing are of different types i.e. Tetrahedral, Quadrahedral, Hexahedral, Square mesh and triangular mesh, tetrahedral mesh gives better convergence during finite element simulation a stiffness matrix, damping matrix, stress matrix is solved on ANSYS at each and every node and element by iteration methods like runge-kutta etc. to determine convergence of solution.

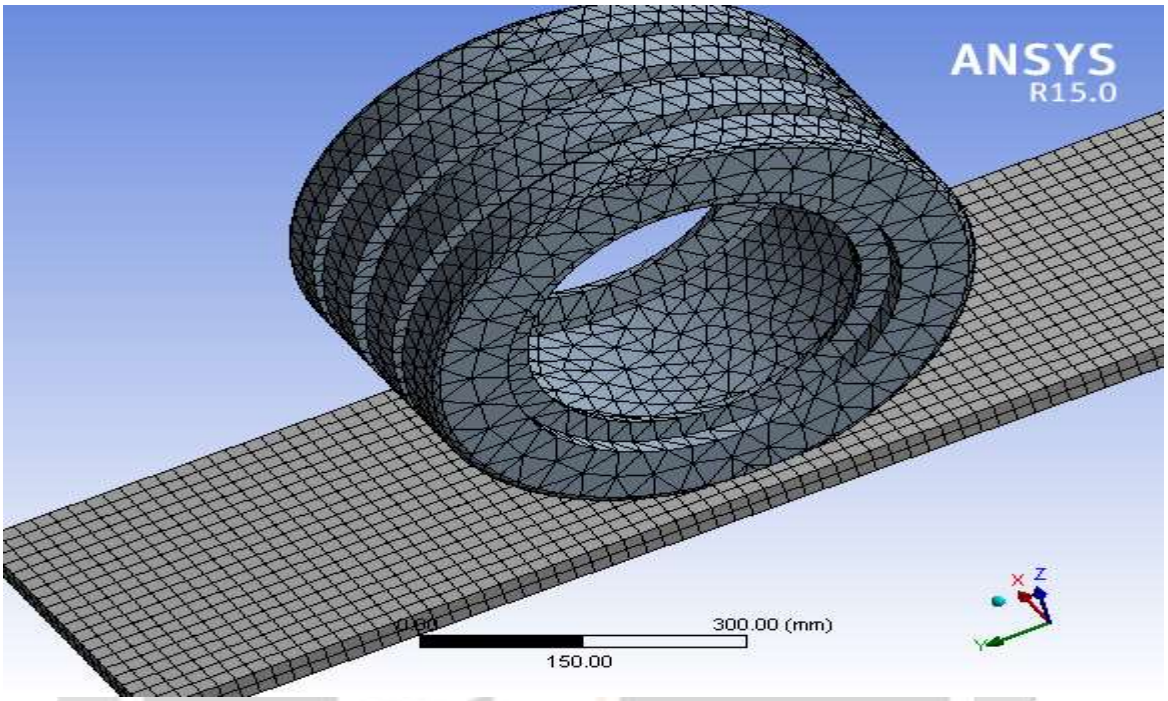

Figure No.: 4.2 Mesh domain of tyre of mesh size18.5

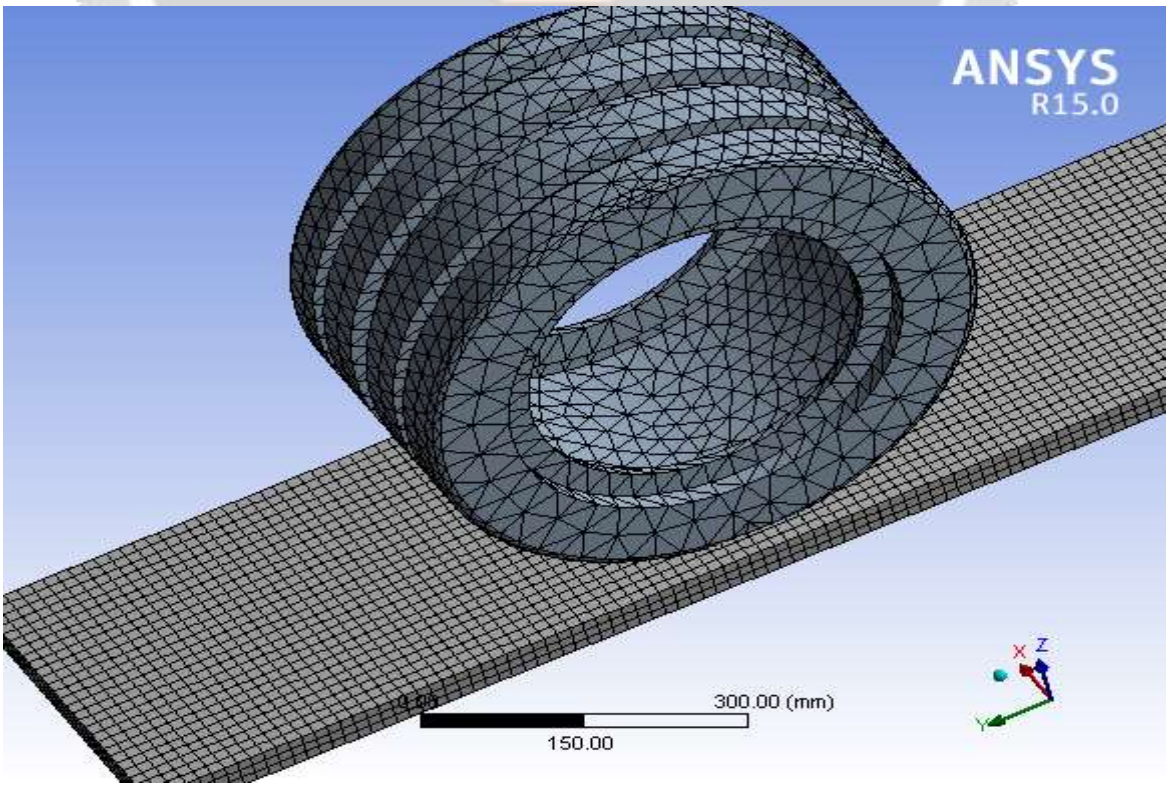

Figure No.: 4.3Mesh domain of tyre of mesh size13.4

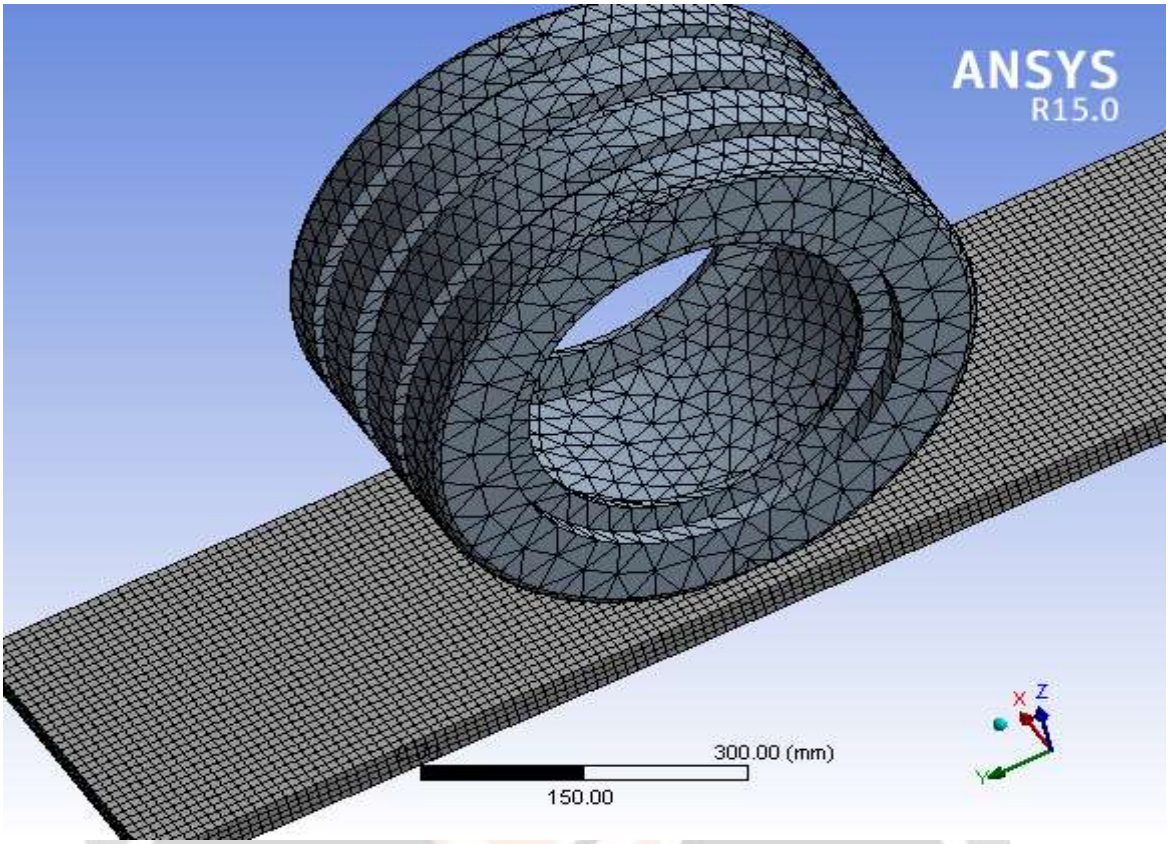

Figure No.: 4.4 Mesh domain of tyre of mesh size10.3

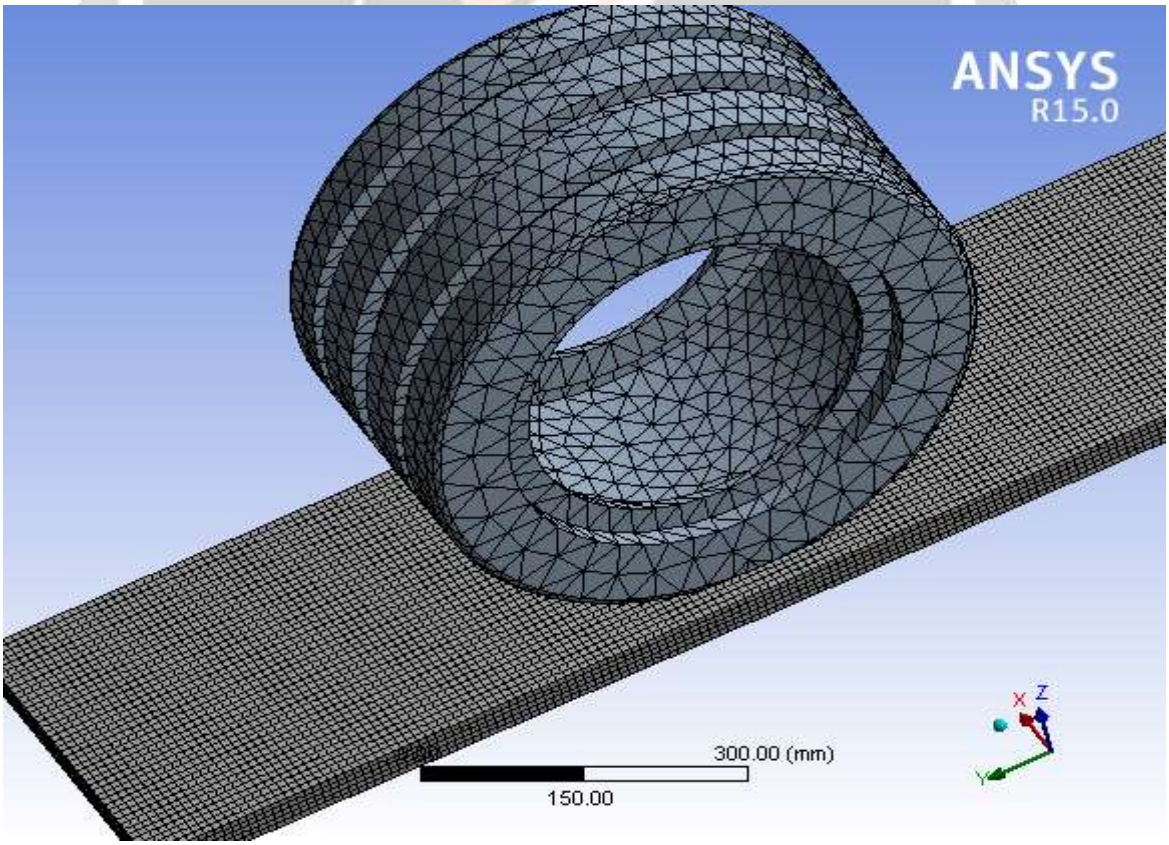

Figure No.: 4.5 Mesh domain of tyre of mesh size8.5

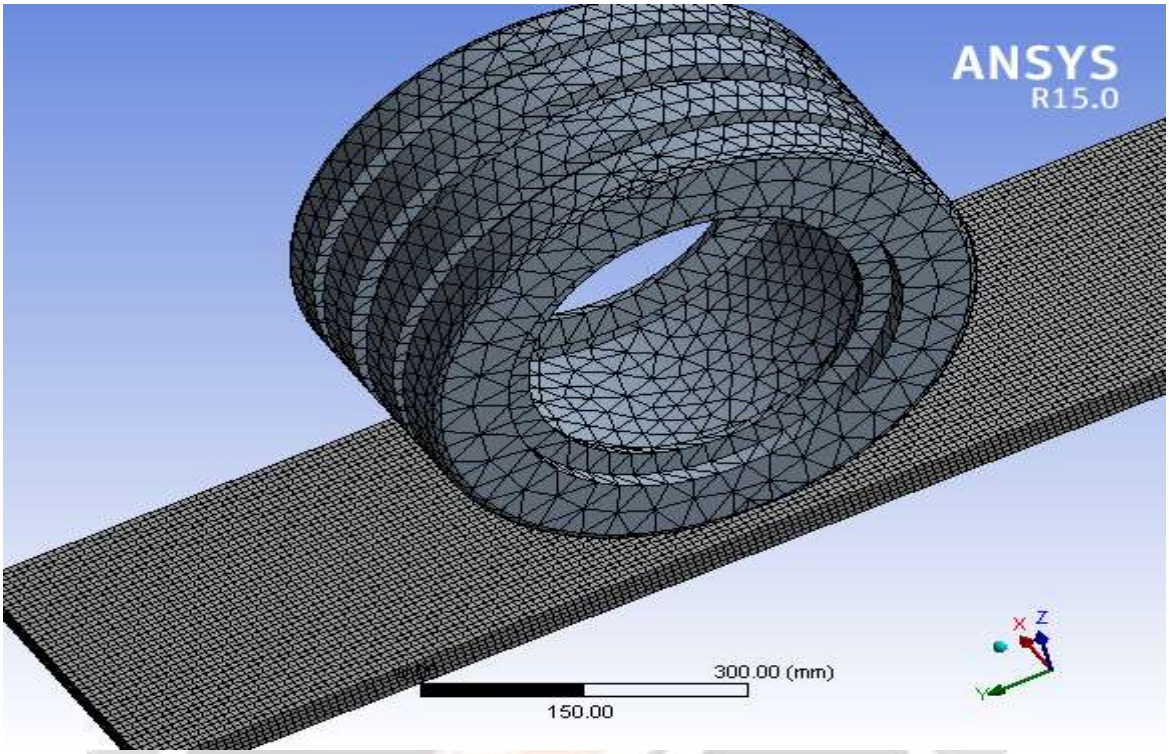

Figure No.: 4.6 Mesh domain of tyre of mesh size7.75

VII RESULT AND DISCUSSION

5.2.4 Synthetic rubber tyre with mesh size 8.5

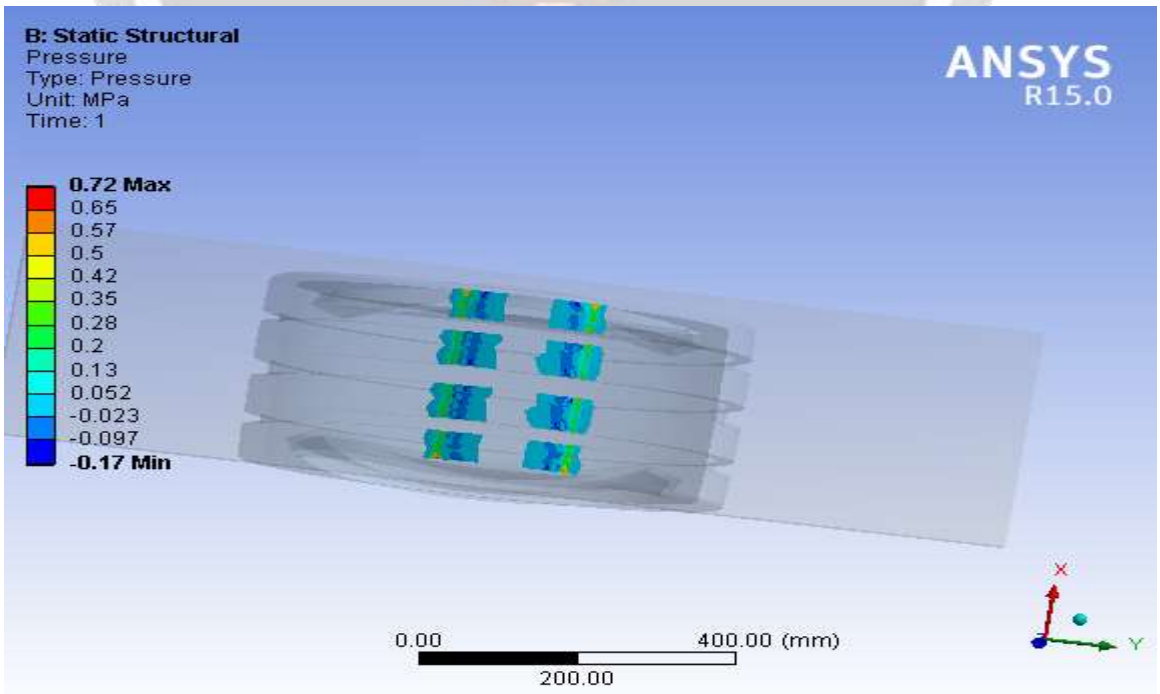

Figure No.: 5.10 Contour plot of contact pressure between tyre of mesh size 8.5.

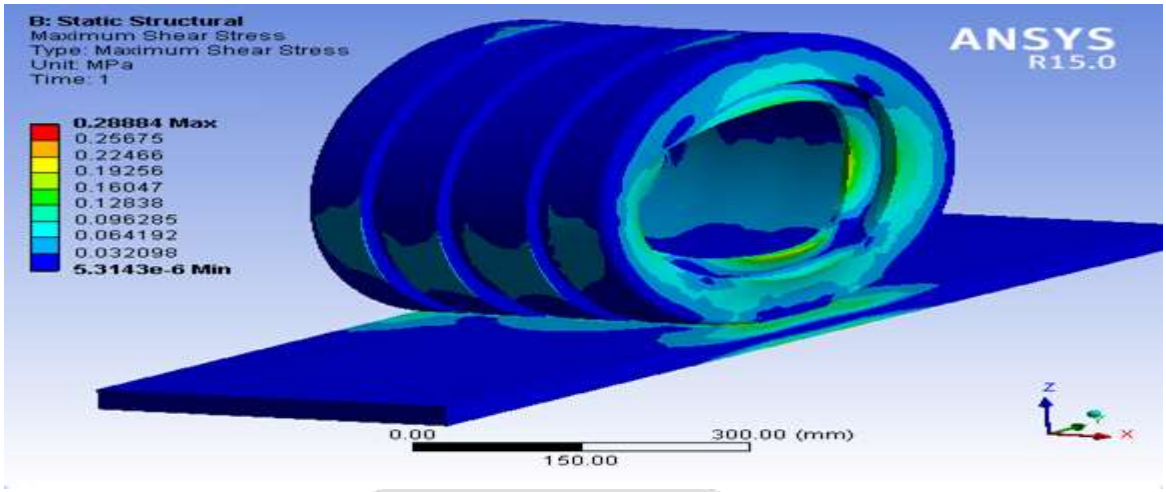

Figure No.: 5.11 Contour plot of shear stress on tyre of mesh size 8.5.

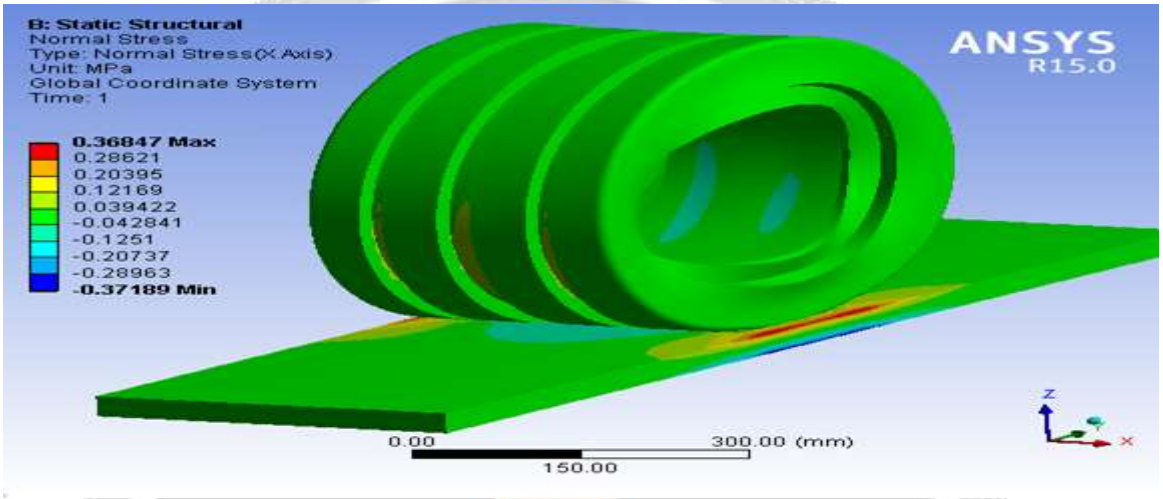

Figure No.:5.12 Contour plot of normal stress of tyre of mesh size 8.5.

5.2.5 Synthetic rubber tyre with mesh size 7.75

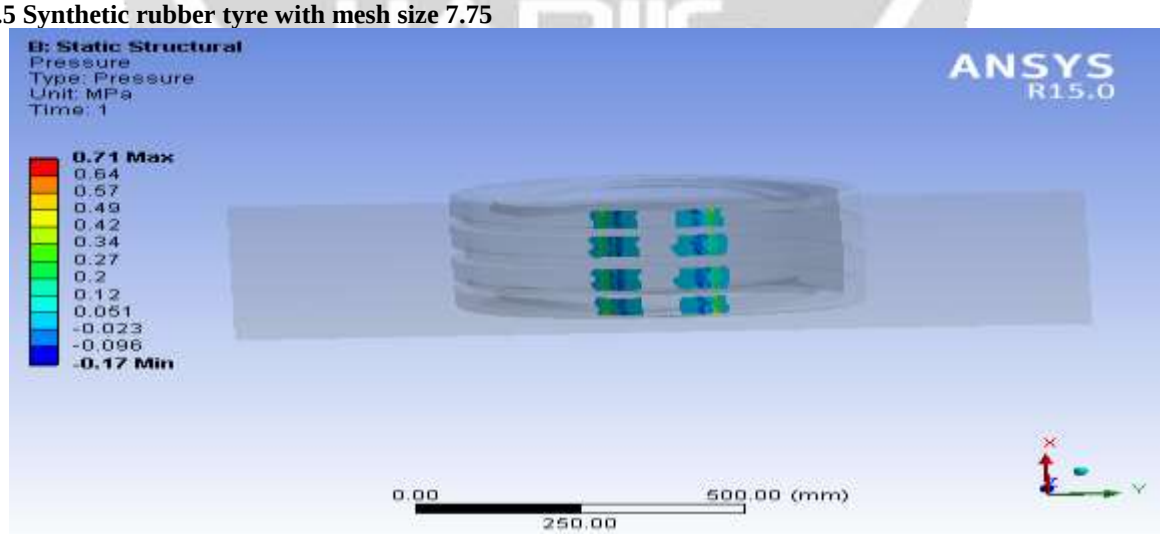

Figure No.: 5.13 Contour plot of contact pressure between tyre of mesh size 7.75 .

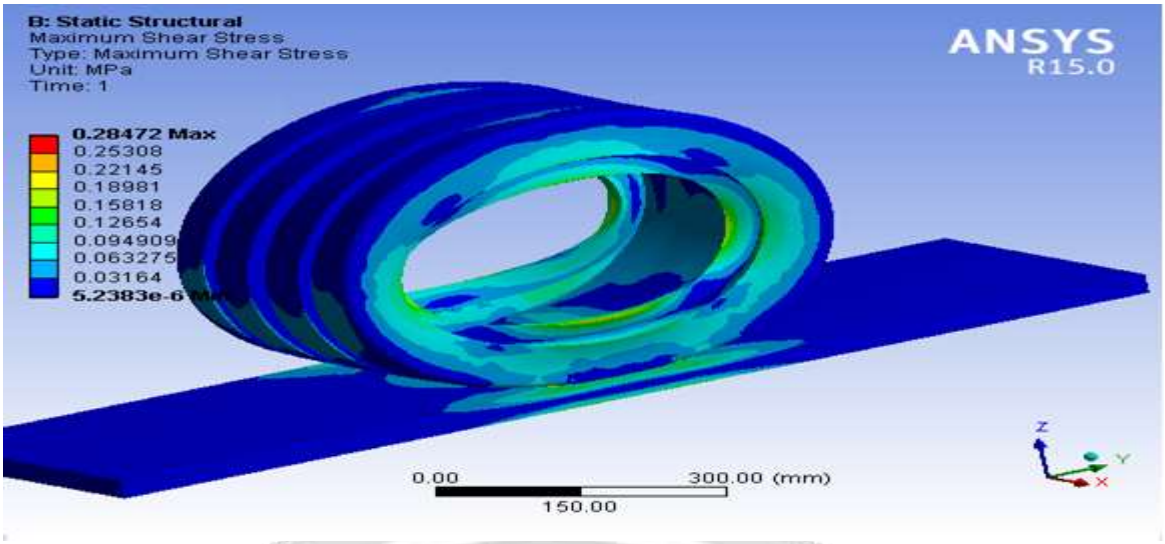

Figure No.: 5.14 Contour plot of shear stress on tyre of mesh size 7.75 .

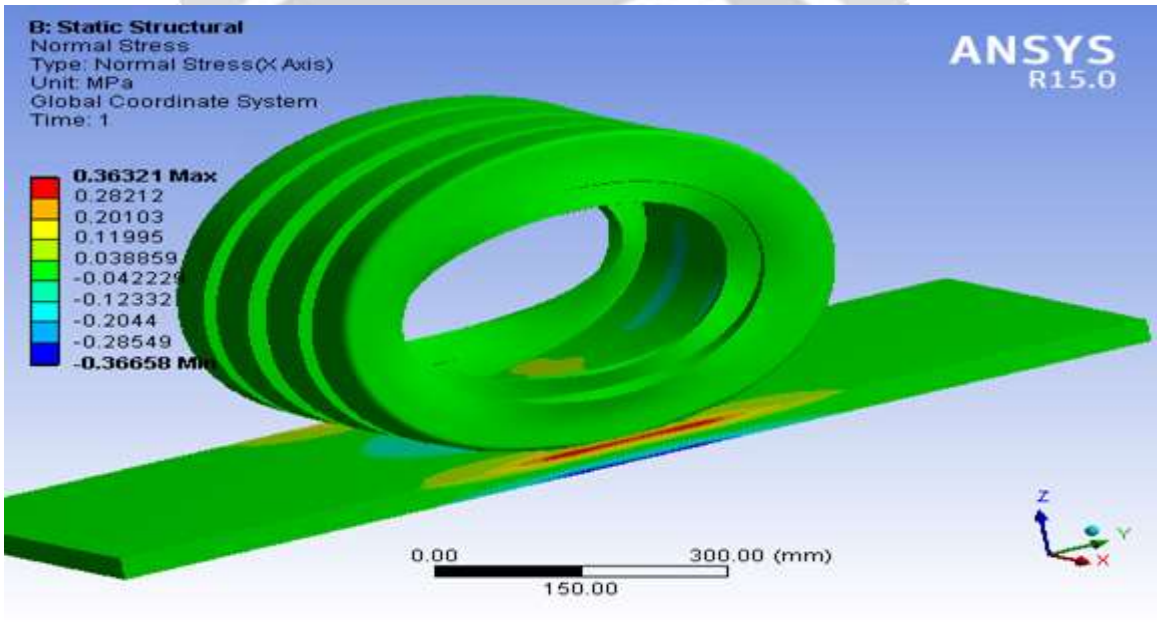

Figure No.:5.15 Contour plot of normal stress of tyre of mesh size 7.75 .

Table No.: 5.2 Contact stresses with different mesh size.

Mesh size	Contact stresses
18.5	0.89709
13.4	0.89707
10.3	0.89706
8.5	0.89706
7.75	0.89706

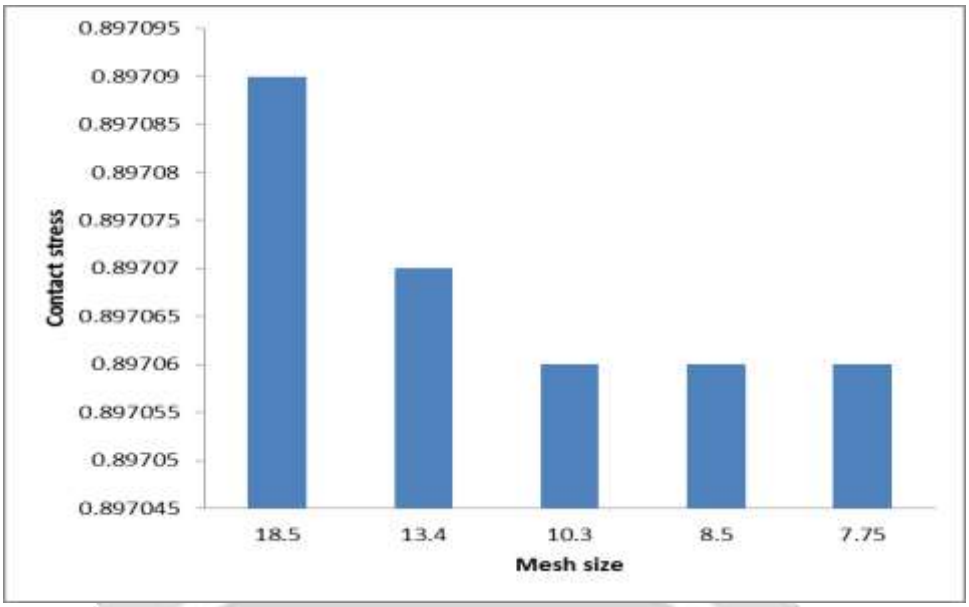

Figure No.:5.17 Graph shows Contact stresses with different mesh size.

5.3 Optimization results of Polychloroprene rubber tyre with variable mesh size.

5.3.1 Polychloroprene rubber tyre with mesh size 18.5

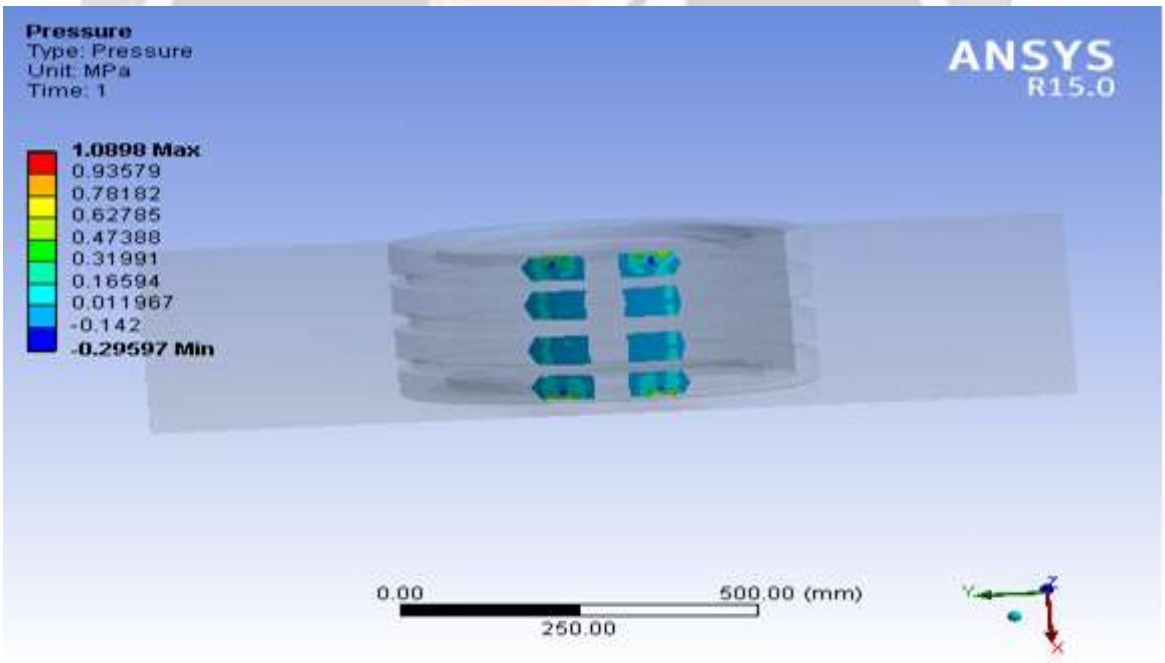

Figure No.: 5.18 Contour plot of contact pressure between tyre of mesh size 18.5.

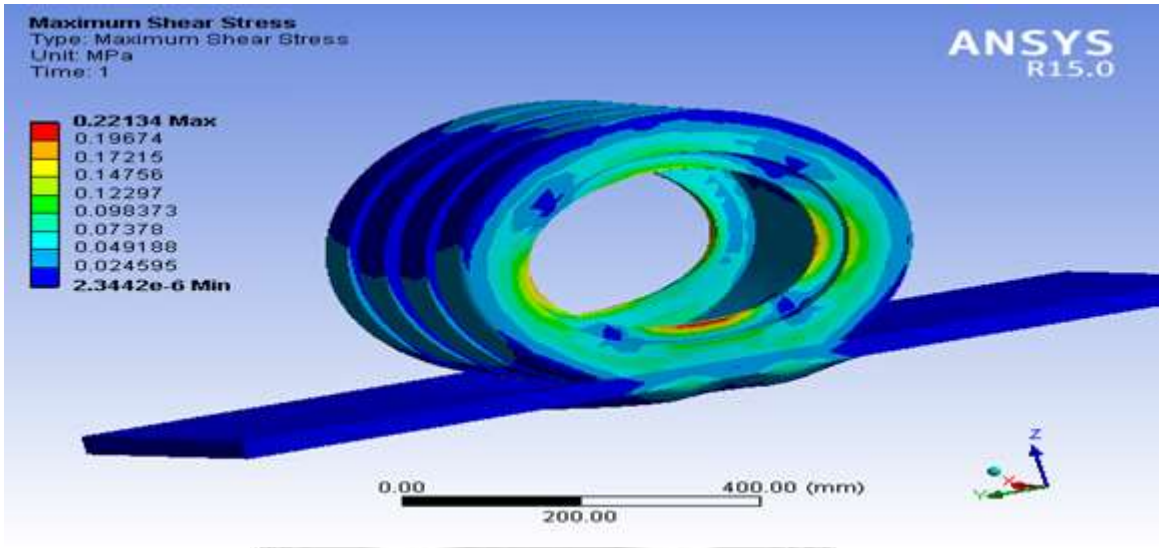

Figure No.: 5.19 Contour plot of shear stress on tyre of mesh size 18.5.

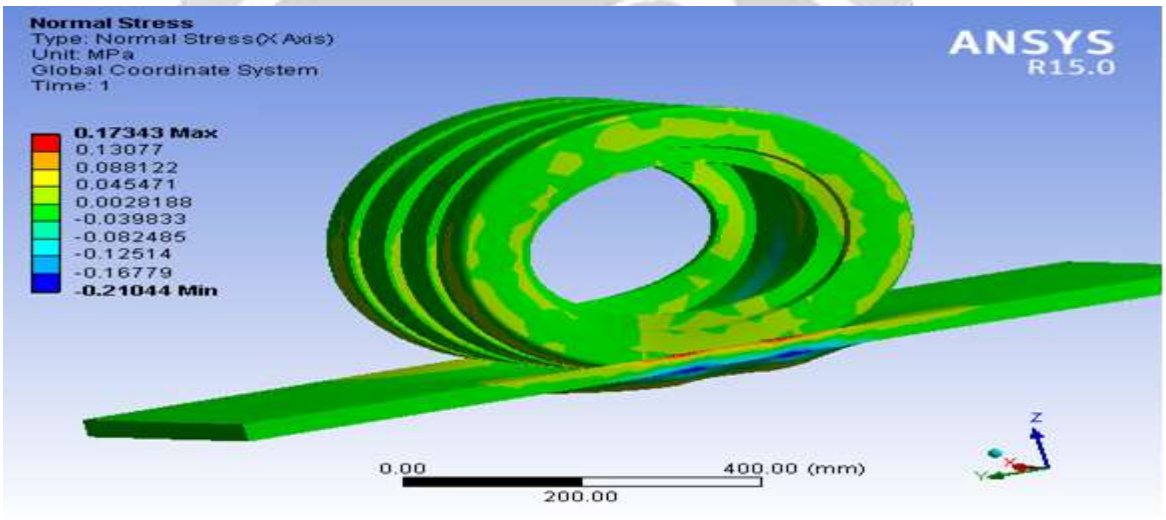

Figure No.:5.20 Contour plot of normal stress of tyre of mesh size 18.5.

Table No.: 5.3 Comparison of area means pressure with base paper.

Area mean pressure (MPa)		
Mesh size	Base paper	Polychloroprene rubber tyre
18.5	0.465	0.62785
13.4	0.550	0.71145
10.3	0.583	0.75346
8.5	0.602	0.72487
7.75	0.632	0.82154

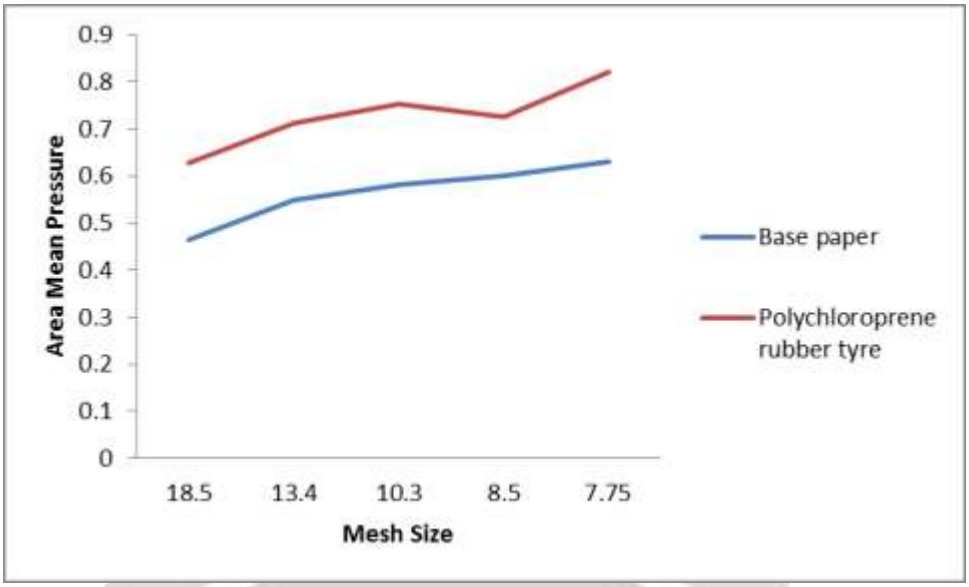

Figure No.:5.33 Graph shows Comparison of area mean pressure with base paper and polychloroprene rubber .

The above table & graph shows the comparison of area mean pressure of base paper and polychloroprene rubber with respect to different mesh size. We found the polychloroprene rubbervalues are increases as compared from base paper value.

VIII. CONCLUSION

6.1 Influence of different modified asphalt mesh size profiles

- The contact stress along the tyre profiles is found to be maximum for the polychloroprene rubber material profile with mesh size of 13.4mm varies along the contact area of the tyre. The pressure distribution along the area of contact between tyre is maximum for polychloroprene rubber and mesh size for 13.4 shows maximum convergence.
- The shear stresses is minimum in case of polychloroprene rubber material profile with different mesh sizes i.e. 7.75 to 18.5mm. The nature of the shear stresses is maximum near the mesh size 8.5mm.
- The nature of the normal stresses is minimum in case of polychloroprene rubber material profile with different mesh sizes i.e. 7.75 to 18.5mm. The nature of normal stresses is maximum near the mesh size of 7.75mm and minimum near the mesh size of 13.4mm.
- In a comparison Synthetic rubber and polychloroprene rubber material w.r.t different mesh sizes. We found the results in contact stresses and area mean pressure is higher of polychloroprene rubber as compare to Synthetic rubber. So polychloroprene rubber is better as compare to Synthetic rubber.

Future Scope

- Different dmaterial could be used to analyze contact stresses.
- Different mesh sizes can be used for analyzing area mean pressure for different types of tyre materials.
- Different load could be also analyzed for different mesh size to predict area mean pressure and contact stresses for tyre.
- Stiffness is also analyzed in different mesh size of tyre

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