

Bumping and Vibration Analysis of Airless Tyres

Submitted in partial fulfilment of the requirements for the award of

BACHELOR OF ENGINEERING

In

AUTOMOBILE ENGINEERING

by

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SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with "A" grade by NAAC | 12B status by UGC |

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APRIL – 2021



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BONAFIDE CERTIFICATE

This is to certify that this project report is the bonafide work of **JANESWARAN G** (Reg. No. **37860013**) and **NAVEEN PRASAD K** (Reg. No. **37860020**) who carried out the project entitled “**BUMPING AND VIBRATION ANALYSIS OF AIRLESSTYRES**” under my supervision from **2020** to **2021**.

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DECLARATION

We **JANESWARAN G** (Reg.no **37860013**) and **NAVEEN PRASAD K** (Reg.no. **37860020**) hereby declare that the Project Report entitled “**Bumping and Vibration Analysis of airlessTyres**” done by us under the guidance of **MR. DILIP KUMAR SAHOO, M.E.,(Ph.D),Department of Automobile Engineering** at SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering in AUTOMOBILE.

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ABSTRACT

Once the conventional tyres are worn out the material of the tyre becomes wastage and over years so much of wastage may produce due to the automobile tyres. In order to overcome these, non-pneumatic (airless) tyres are introduced in which the design is simple and durable. No air inside the tyres which makes it to stick to the surface for a little and gives more grip for the vehicle.

The main thing in the airless tyres is the rubber or the material. The profile adds the stiffness to the tyres.

In this study, a tyre model is taken and it will be designed with three different profiles and the design is validated under suitable load conditions to check whether the tyre meets the guidelines of the design requirements such as,

- The airless tyres should have lateral stiffness 5 times greater than the conventional pneumatic tyres.
- The material of the tyre should withstand the weight of the car distributed over one tyre.
- Vibration should be less because the more vibration will affect the riding quality of the vehicle

By means of the static analysis, the dead load analysis and bump load analysis are done using for the boundary condition to find the total deformation and equivalent stress at the force and pressure for the three different profiles of airless tyres (or) NPT.

Modal analysis are used to find the natural frequency for the different types of airless types profiles.

As the result, using those analysis values and result that one type of profile to be selected for improvement in the performance.

TABLE OF CONTENTS

CHAPTER NO	TITLE	PAGE NO
	ABSTRACT	V
	LIST OF TABLES	IX
	LIST OF FIGURES	X
	LIST OF GRAPH	XIII
	LIST OF SYMBOLS AND ABBREVIATIONS	XIV
1	INTRODUCTION	
	1.1 AIRLESS TYRE	1
	1.2 PNEUMATIC TYRES	2
	1.3 AIRLESS TYRE (TWEEL)?	2
	1.4 ADVANTAGES AND DISADVANTAGES OF AIRLESS TYRES	3
	1.5 APPLICATIONS OF AIRLESS TYRES	5
	1.6 THE FUTURE	6
2	LITERATURE REVIEW	7
3	AIM & OBJECTIVES	
	3.1 AIM	19
	3.2 OBJECTIVES	19
	3.3 METHODOLOGY	20
4	MATERIALS AND EXPERIMENTAL PROCESS	21

4.1	MODELING	22
4.1.1	INTRODUCTION TO MODELING	22
4.1.2	COMPUTER AIDED DESIGN	23
4.1.3	RATIONALE FOR CAD/CAM	23
4.2	AIRLESS TYRE MODELS	24
4.3	DESIGNS DONE IN SOLIDWORKS	27
4.4	FINITE ELEMENT ANALYSIS	28
4.4.1	STRUCTURAL ANALYSIS	29
4.4.2	MESH GENERATION	29
4.4.3	MESH THE MODEL	30
4.4.4	INTRODUCTION TO ANSYS	30
4.4.5	PROCEDURES TO PERFORM FEA BY ANSY	31
4.4.6	TYPES OF ELEMENT	32
4.5	MESHING	33
4.6	BOUNDARY CONDITIONS	35
5	RESULT AND DISCUSSION, PERFORMANCE ANALYSIS	
5.1	DEAD LOAD ANALYSIS	36
5.2	BUMP LOAD ANALYSIS	41

	5.3 MODAL ANALYSIS	46
	5.3.1 INTRODUCTION TO MODAL ANALYSIS	46
	5.4 RESULT	57
	5.4.1 <i>DEAD AND BUMP LOAD ANALYSIS</i>	57
	5.4.2 DEAD LOAD ANALYSIS GRAPH	58
	5.4.3 BUMP LOAD ANALYSIS GRAPH	59
	5.5 MODAL ANALYSIS	60
	5.5.1 MODAL ANALYSIS GRAPH	61
6	CONCLUSION	
	6.1 CONCLUSION	62
	REFERENCES	63

LIST OF TABLES

TABLE NO	TITLE	PAGE NO
2.1	COMMON PROBLEM IDENTIFIED IN NON-PNEUMATIC TYRE	17
4.1	MATERIAL PROPERTIES	21
4.2	POLYETHYLENE PROPERTIES	22
5.1	OUTPUT FOR DEAD LOAD	41
5.2	OUTPUT FOR BUMPLOAD	46
5.3	MODAL TYRE 1 OUTPUT	50
5.4	MODAL TYRE 2 OUTPUT	53
5.5	MODAL TYRE 3 OUTPUT	56
5.6	RESULT FOR DEAD AND BUMP	57
5.7	RESULT FOR MODAL ANALYSIS	60

LIST OF FIGURES

FIGURE NO	TITLE	PAGE NO
1.1	PNEUMATIC TYRE	2
1.2	UNIFORM LOW CONTACT PRESSURE	3
1.3	AIRLESS TYRE LAWN CARTS	5
1.4	AIRLESS TYRE USED IN EARTH MOVERS	5
1.5	TWEEL USED IN ARMY	6
1.6	ALL TERRAIN VEHICLES	6
4.1	MATERIAL PROPERTIES	22
4.2	TYRE 1 DESIGN(DETAIL VIEW)	24
4.3	TYRE 1 ISOMETRIC VIEW	24
4.4	TYRE 2 DESIGN(DETAIL VIEW)	25
4.5	TYRE 2 ISOMETRIC VIEW	25
4.6	TYRE 3 DESIGN(DETAIL VIEW)	26
4.7	TYRE 3 ISOMETRIC VIEW	26
4.8	TYRE 1(FRONT VIEW)	27
4.9	TYRE 2(FRONT VIEW)	27
4.10	TYRE 3(FRONT VIEW)	27
4.11	TETRA HEDRON ELEMENT	33
4.12	MESHED MODEL	34
5.1	CONTACT BETWEEN ROAD AND TYRE	36
5.2	FIXED SUPPORT	36

5.3	VERTICAL (DEAD) FORCE	37
5.4	TYRE 1 DEFORMATION	38
5.5	TYRE 1 VONMISES STRESS	38
5.6	TYRE 2 DEFORMATION	39
5.7	TYRE 2 VONMISES STRESS	39
5.8	TYRE 3 DEFORMATION	40
5.9	TYRE 3 VONMISES STRESS	40
5.10	FIXED BOUNDARY CONDITION	42
5.11	PRESSURE ACTING UPWARDS	42
5.12	TYRE 1 DEFORMATION	43
5.13	TYRE 1 VONMISES STRESS	43
5.14	TYRE 2 DEFORMATION	44
5.15	TYRE 2 VONMISES STRESS	44
5.16	TYRE 3 DEFORMATION	45
5.17	TYRE 3 VONMISES STRESS	45
5.18	DISPLACEMENT	47
5.19	TYRE 1 MODE SHAPE 1	47
5.20	TYRE 1 MODE SHAPE 2	48
5.21	TYRE 1 MODE SHAPE 3	48
5.22	TYRE 1 MODE SHAPE 4	49
5.23	TYRE 1 MODE SHAPE 5	49
5.24	TYRE 1 MODE SHAPE 6	50
5.25	TYRE 2 MODE SHAPE 1	50
5.26	TYRE 2 MODE SHAPE 2	50
5.27	TYRE 2 MODE SHAPE 3	51

5.28	TYRE 2 MODE SHAPE 4	51
5.29	TYRE 2 MODE SHAPE 5	52
5.30	TYRE 2 MODE SHAPE 6	52
5.31	TYRE 3 MODE SHAPE 1	53
5.32	TYRE 3 MODE SHAPE 2	53
5.33	TYRE 3 MODE SHAPE 3	54
5.34	TYRE 3 MODE SHAPE 4	54
5.35	TYRE 3 MODE SHAPE 5	55
5.36	TYRE 3 MODE SHAPE 6	55

LIST OF GRAPH

GRAPH NO	TITLE	PAGE NO
5.1	TOTAL DEFORMATION FOR DEAD LOAD	58
5.2	EQUIVALENT STRESS FOR DEAD LOAD	58
5.3	TOTAL DEFORMATION FOR BUMP LOAD	59
5.4	EQUIVALENT STRESS FOR BUMP LOAD	59
5.5	MODAL BAR GRAPH	61

LIST OF SYMBOLS AND ABBREVIATIONS

CAD	- Computer Aided Design
CAM	- Computer Aided Manufacturing
FE	- Finite Element
FEM	- Finite Element Method
F	- Force
N	- Newton
P	- Pressure
Mpa	- Mega Pascal
Mm	- Millimeter
F	- Frequency
(Hz)	(Hz)
NPT	Non-Pneumatic tyres

CHAPTER 1

INTRODUCTION

For more than 100 years, cars have been rolling along on cushions of air encased in rubber. From time to time, we get used to certain products and we may not be able to make changes for years or years. This is where the story of progress begins. Several tire companies began trying to manufacture non-pneumatic tyres such as Michelin and Bridgestone, but none of the designs led to the production of consumer goods. The tire pressure system has better results than one might think. First, there are important security benefits. The use of airless tyres eliminates the possibility of tyres falling and can reduce road hazards. Even in conditions like the military, the use of non-pneumatic tyres has a significant impact on safety. tyres are military vehicles and are often explosive. If this vehicle uses airless tyres, this is not the case.

The use of this type of tire also has environmental benefits. Ventilated tyres do not need to be discarded and replaced in the same way as flat tyres, as they are not damaged and legible. This will reduce the size of the trash. I think it's very important to keep researching more and developing windless tyres. This type of innovation works very well with various engineering principles and requires engineers everywhere to adopt it. Cars are things. People use it every day, so improving its quality will affect the lives of many people. Therefore, I think studying a subject like this is very valuable, especially for those of us who are new to engineering. For topics that make sense, we can see that what we do is different.

1.1 AIRLESS TYRE

Before discussing the tyre less technology of tyres, it is important that readers understand the characteristics of hot air tyres and their advantages and disadvantages. The following is an overview of Airless tyres.

1.2 PNEUMATIC TYRES

The basic design of all tyres is very similar, although there are different types. They all have an internal center that keeps the compressed air closed with a rubber plug that is in contact with the road, which is called a filter. The feet maintain traction on the road and prevent slipping. These tyres wear out over time, so if the tyres don't fit they are usually replaced by someone right now. The main reason for using tyres is the inability that occurs during rotation, and when the tire rolls, the weight of the vehicle pushing it causes the tire to bend slightly, leaving more room for contact with the tyres. . Improvises promotes the crisis. It also has a calming effect that causes a flow on rocks and debris that cannot be ignored. Or, Ed Grabianowski, as the author of How Stuff Works. The wheelchair wheel is made to measure by wood, you will know how the tyres make a difference.



Fig:1.1 Pneumatic Tyre.

Weak and strong tyres. the chance of accidental tire thieving or accidental tire theft could be a major concern, because it will cause serious accidents. Adjusting the tire pressure is additionally useless as most users notice it uncomfortable. Removing some tyres can increase their durability, however at a lower price. If the tyres don't have enough air, the sidewalls will bend and the tyres won't follow the specified line at all. As a results of this failure, tire corporations took an interest within the industry. rotary engine

1.3 AIRLESS TYRE (TWEEL)

Air less tyres or Non-pneumatic tyres (NPT), are the tyres that aren't supported by air pressure. These tyres also are known as as tweel that could be a merger of the words Tyre and wheel. This is often as a result of the tweel doesn't use a

standard wheel hub assembly. The Tweel conception was 1st declared by Michelin back in 2005. It's structure is a solid inner hub mounted onto the vehicles axle, that's encircled by polymer spokes. This forms a pattern of wedges, which facilitate to soak up the impacts of the road. These spokes look just like those found on bicycles and plays the shock-absorbing role of the compressed gas as Associate in Nursing exceedingly in a very} ancient Tyre. A sheer band is then stretched across the spokes, that forms the environs of the Tyre. It's the stress of the band and therefore the strength of the spokes that replaces the gas pressure used on traditional tyres. Once a vehicle drives over an obstacle, a sleeping police officer for example, the tread and sheer bands slip because the spokes bend, before they quickly convalesce into shape.

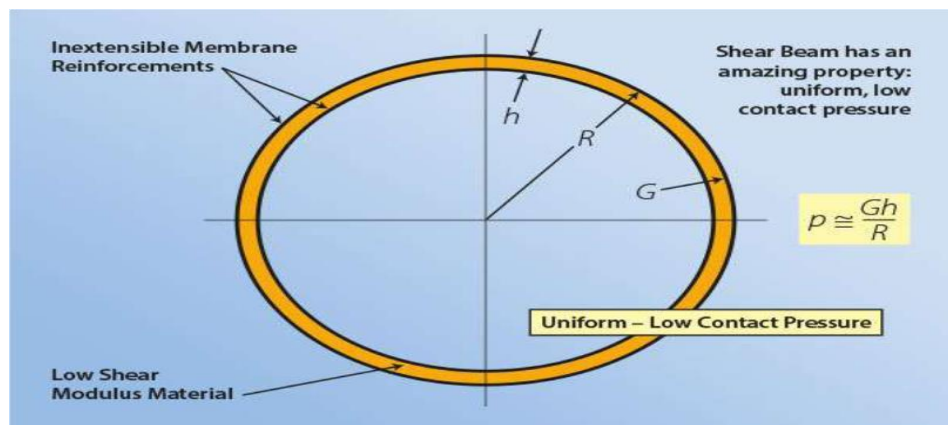


Fig:1.2 Uniform Low Contact pressure

1.4 ADVANTAGES AND DISADVANTAGES OF AIRLESS TYRES

Advantages of Airless Tyres :

- Eliminates air leaks or Tyre blow outs.
- With no air pressure you are left with consistent economy and handling.
- Its flexibility provides an increase in surface area of contact.
- No maintenance needed.
- To lengthen tread life.
- Facilitate recycling.
- Makes Vehicle more Efficient have high lateral strength for better handling without a loss in comfort.

- Vehicle remains under control even in emergency brake.
- Remains mobile even with some of the spokes damaged or missing.
- Durability & Long Life.
- Can take gunfire or explosion.
- Less environmental impact.

Disadvantages Of Airless tyres:

- Lack of adjustability

One of the largest disadvantages of the Tweel is that after it's been manufactured, it can't be adjusted. During this case if the automobile required a special quite setting, a full new set of tweel are going to be required. On the and facet tweel are created with 5 times the lateral stiffness compared to gas tyres, sanctionative terribly responsive handling.

- Not as economic as pneumatic tyres

Michelin are presently acting on enabling the Tweel to be as fuel economical as pneumatic tyres. Presently they're among 5% of the rolling resistance and mass levels.

- Vibration

This might be one amongst the Tweels biggest downsides. Vibrations become tactful once a vehicle is driving higher than fifty mph, whereas inflicting a great deal of noise. Conjointly worrisome is that the quantity of warmth the Tweels generate. Long distance journey with tweels would be terribly unpleasant unless these areas are improved upon.

- Different Manufacturing process

Another problem is that producing a airless tyres requires a totally different manufacturing process. At the same time, the Tyre industry revolves around the manufacture of traditional pneumatic tyres. To change of factories and service equipment would be a major change, and the facilities just don't exist still now.

1.5 APPLICATIONS OF AIRLESSTYRES

They are used on some tiny vehicles such as riding lawn carts and motorized golf carts.



Fig:1.3 Airless Tyre Lawn Carts

They are also used on weight equipment such as backhoes, which are needed to operate on sites such as building ,demolition.



Fig:1.4 Airless Tyre Used In Earth Movers

Army Usage Tweel explores mine blasts away from the vehicle better than standard tyres and that the Tweel remains mobile even with some of the spokes damaged or missing.



Fig:1.5 Tweel used in Army

The airless tyres are also used in All-terrain vehicle (ATV) made by 24efence. These tyres can have a shot from a .50-caliber rifle and still travel 350 miles, and also drive 1,000 miles after running over a railroad spike. It will start at \$14,999.



Fig:1.6 All Terrain Vehicles

1.6 THE FUTURE

Bridgestone is advancing development of the air-free conception Tyre are a a lot of environmentally friendly product than existing tyres and aims to cause industrial use in a very big selection of vehicles as shortly as possible.

Bridgestone believes that through effective resource usage and economical operations aboard carbon dioxide emissions from improved fuel efficiency, as a part of its aim to attain a balance between its business and therefore the environment, it will still provide engaging product to its shoppers so much into the future. Bridgestone can continue to implement multiple technological innovations to assist cause a a lot of property society.

CHAPTER 2

LITERATURE REVIEW

2.1 DR. R. RAMACHANDRA (2017) : DESIGN AND ANALYSIS OF AIR LESSTYRES

This paper is based on airless tires is a separate unit that replaces tires in its components, replacing every part of conventional slender tires, and is composed of a central point that does not bend and is customizable through a method The customizable tires attached to the cutting belt are deformable polyurethane spokes. As a protector, everyone can become one. However, through horizontal confirmation, the tire is a variant of an airless tire, showing its non-specific use in the plaintiff's particles for military and ground use. This installation can be made redundant with putty pneumatic tires. Our project includes a research project on airless tires for the manufacture of chewing machines; next is the consideration of fear. The model is implemented in Pro E, and the research is carried out in Ansys. The test results can be replaced by pneumatic tires instead of airless tires. The rim provides good grip and cushioning effect. The four-sided honeycomb structure fulfills the main functions of the tire. An airless tire consists of two parts: an outer belt and a flexible inner belt. From the point of view of producing airless tire construction, material savings are achieved by replacing the tread only after the tread. Flexible use of internal protection devices multiple uses can ensure environmental protection technology and reduce environmental pollution. For airless tires on cars, in order to avoid minor tire problems, it was finally found that nylon 4-6 material

2.2 MIHIR MANGESH PEWEKAR, SAMBHAJI D. GAIKWAD(2018):STRENGTH VALIDATION OF HEXAGONAL CELLULAR SPOKED NON-PNEUMATICITYRES FOR AUTOMOBILES THROUGH FINITE ELEMENT ANALYSIS

This paper is based on composite materials and structures and can be said to be the main example of the modern scientific revolution. The widespread adoption of this paradigm led to the invention of non-pneumatic tires, also known as "airless tires." Attempt to study the deformation mechanism of alveolar cell structure. With

NPT, since the rigidity of the NPT spokes is reduced under the same load capacity, the contact pressure is lower than that of the tire. The deformation mechanism is verified by the finite element prediction in the mechanical solver APDL ANSYS. This document focuses on the situation where NVV is only applicable to vehicles. The study of this adaptability must consider four load conditions: compression, side cutting, torsion, and circumferential torsion: if the resistance to this load is not confirmed, it cannot be put into use. Don't limit your analysis to analyzing each load in the FEA environment independently. These loads are discussed and quantified to confirm the resistance of this type of tire. The main research content includes the stress concentration of 28 obstacles 28, the deformation mode and maximum deflection of the element radius, and the contact stress of the tire-road interface. This document contains two sets of results: quantitative and qualitative. These result sets are generated. They came to the following conclusions:

- The combination of hexagonal grid structure and super-elastic material may be suitable for non-pneumatic tires.
- The structure can bear compression, torsion, transverse shear and transverse torsional loads.
- Due to the presence of the inner and outer rings, the tire fails due to fatigue. However, in general, the structural integrity of the tire will not be compromised because the hexagonal grid and shear bars will not be damaged. The results show that there is a linear relationship between the observed results, so it can be said that the function of the tire is at the elastic limit, that is, it is an elastic structure.
- The tire has extremely high torsional rigidity, but low lateral rigidity. Therefore, we can conclude that more research is needed to increase the stiffness

2.3 A.M. ABOUL-YAZID¹, M.A.A. EMAM¹, S. SHAABAN¹ AND M.A. EL-NASHAR¹ EFFECT OF SPOKES STRUCTURES ON CHARACTERISTICS PERFORMANCE OF NON-PNEUMATIC TYRES

This article investigates three different configurations of Michelin Tweel™, elastic technology and Bridgestone Non-Pneumatic Tire (NPT) by searching for compatible spoke designs. The stiffness and tension of the tire are affected by the

spoke structure and the shear layer. Two TPN cases were examined: (i) tires with composite beads and (ii) tires without composite beads. By comparing with four computer-aided finite element models, the results of the model are verified. The results show that the shape of the spokes in the second case has a great influence on the performance of the tire, while the shear layer in the first case has a great influence on the performance of the tire. Reduce the impact of changing the shape of the spokes, especially under contact pressure. Four different spoke structures (a pair of spokes, curved spokes, new curved spokes and honeycomb spokes) were analyzed in two dimensions on non-pneumatic tires to improve the influence of the spoke structure and the shear layer on the tire contact pressure. , Vertical stiffness, tension, mass and rolling resistance. Four full shear bars with non-stretchable outer membranes and a non-shear NPT model were used for the study. It can be concluded from the first case that the spokes seem to have the best shape to the model due to lower rolling resistance, lower contact pressure and lower von Mises stress on the spokes. The conclusion is that the honeycomb spoke model seems to have the best shape because it has the lowest rolling resistance, lowest quality, lower and more uniform contact pressure distribution, and it has accepted Von Mises in its radio. Stress.

2.4 SONDRE LUDVIGSEN (JUNE 2017) : FINITE ELEMENT ANALYSIS ON PRESSURE PROFILE OF AIRLESS TYRES COMPARED TO CONVENTIONAL TYRE

The harsh Arctic climate has always been one of the most difficult areas to navigate, and the severe loss of traction caused by snow and ice on the roads increases the risk of collisions. Since its launch in 1930, three revolutionary changes have taken place over the years. The introduction of bolts, the change of tread pattern and the optimization of rubber performance. Avoid installing pins at this time. This is because people are paying more and more attention to air pollution and environmental hazards caused by the wear of road eyelets. It is believed that the tread design and rubber performance are close to their limits and cannot improve traction, so the industry must look for new directions. The purpose of this master's thesis is to replace traditional pneumatic tires with airless tires to improve traction in Arctic conditions. Tire grip is determined by the weight

of the vehicle and the friction between the tire and the road. The coefficient of friction used to determine friction is a function of contact pressure. This work aims to obtain the concentrated pressure of airless tires in the pressure curve compared with traditional tires. The finite element analysis was performed on two different models using ANSYS Workbench 18.0. Different configuration files are analyzed. The model is used to discuss whether airless tires have the potential for better grip under the same load conditions as traditional tires. After completing this study, they came to the following conclusions:

- The pressure curve changed from pneumatic to non- pneumatic. The pressure curve of the non-aerodynamic model shows the concentrated pressure in the center of the pillow. The pressure is more evenly distributed across the width of the tire, and the average and maximum pressure is higher. It is believed that since the coefficient of friction is a function of pressure, this concentration of pressure increases the grip of the tire.

- Finite element analysis seems to be an effective way to analyze the pressure distribution between two static objects.

- Improved grip of non-pneumatic tires is just one of the advantages. There are other advantages. O Reduced road wear due to reduced demand for studded tires. This reduces the cost of road maintenance.

O consumers will not be affected by any failures and failure risks. o Depending on the spring material, the performance of the tire will not be as strongly affected by temperature fluctuations as the pressure in the tire.

- Only study linear materials. Factors to be considered when considering the equivalent values of stress and pressure in the model. Especially the aerodynamic model, because its material has more nonlinear behavior.

- Although more research is needed, non-pneumatic tires may mark the next revolutionary milestone in the history of winter tires.

Further work:

- Non-linear materials can be used for finite element analysis to ensure correct behavior, especially the behavior of aerodynamic models.

- Compare the results with conventional tires and, if possible, laboratory tests on another tire. The concept of non-pneumatic equipment manufacturers

- Attempt to build prototypes of non-pneumatic wheels specifically designed for Arctic conditions.

2.5 UMESH G C, AMITH KUMAR S N (2016 IJESC) DESIGN AND ANALYSIS OF NON-PNEUMATIC TYRE (NPT) WITH HONEYCOMB SPOKES STRUCTURE

This conventional tire file consists of air-wrapped rubber filled with compressed air. Conventional tires have occupied the global market for some time due to their excellent drivability and reliability. However, they have disadvantages such as explosion during operation. Driving, coordination method, necessity. Maintain internal pressure. Innovative technology development uses only materials and unique blends of materials No compressed air is required to support the geometry of the load. This is how non-pneumatic tires appeared. Non-pneumatic tires are flexible honeycomb-shaped members with a deflection radius, which act like air in conventional tires. In this project, we replaced the traditional light alloy wheels with a flexible spoke design. We checked the hexagonal honeycomb non-pneumatic tires along the spokes by applying a uniaxial load. Rolling compression. Therefore, the spokes must be rigid. Non-pneumatic tire developed in ANSYS Workbench, (1) Honeycomb. ANSYS finite element analysis is used to determine deformation and stress. Fatigue resistance and durability. A static analysis of the alveolar splint was performed. The equivalent tension value of the alveolar splint obtained by static analysis is 76.344 MPa, which is lower than the allowable limit of material performance. Therefore, the design is safe.

- The deformation of the alveolar splint is 9839 mm, and the deformation of the body splint is 1.4847 mm, which contradicts the result.
- Honeycomb tyres are Conventional tires, because they provide uniform traction and wear compared to conventional tires.

2.6 ARAVIND MOHAN, C AJITH JOHNY, A TAMILARASU, J PRADEEP BHASKER AND K RAVI (ICSET-2017) DESIGN AND ANALYSIS OF NON-PNEUMATIC TYRE

The focus of this paper is non-pneumatic tires (NPT) because, as the name suggests, it is a tire that does not use air to support the load. Although solid rubber

tires do exist, they lack elasticity and will have elasticity. When used in conventional vehicles, it does not provide flexibility. The NVV discussed here mainly includes three parts: a rigid hub, a deformable spoke that bears vertical loads, an enhanced shear band, and the contact of the rubber profile with the surface. The characteristics of NPT, such as down force, rolling resistance, and load capacity, can be changed by changing the size or material of the NPT manufactured. Various researches are underway around the world to make NPT replace traditional tires.

Summarizes the research overview of the development and improvement of TPN. The structural analysis of TPN is performed with a radius made of a hexagonal alveolar structure with the same cell wall thickness. ONPT with a honeycomb radius with a large hole angle exhibits the lowest stress concentration important for the fatigue structure. The relationship between the inclination angle of the hole and the height of the hole is an important factor in determining the flexibility of the honeycomb structure under axial load. A larger ratio provides greater design flexibility. O Since the vertical rigidity is reduced under load, the contact pressure of the NPT with a hexagonal radius is small. O-type A design has the largest unit cell angle among the three designs, has smaller tension, largest deflection and smallest contact pressure, and has better static performance. The rolling resistance provided by this structure must be checked for further optimization.

2.7 T.PRABHURAM, S. C. MEENAKSHI SUNDARAM, S.JEGADEESWER, V.SATHISH KANNAN (ICTAMDMES'20) STATIC ANALYSIS OF DIFFERENT SPOKE STRUCTURE OF AIRLESS AND CONVENTIONAL TYRE

AirlessTyres are also called non-pneumaticTyres that are not exposed to air pressure. The main problems associated with tires are tire flatness and flatness due to wear, which led to the development of airlessTyres. -Considering different materials for 3D printing with different structures, start the static analysis of airlessTyres. Consider the radial structure of honeycomb, triangular and diamond printing materials, as well as acrylonitrile butadiene sTyrene + polycarbonate (ABS + PC), polyethylene terephthalate (PET) and impact-resistant polysTyrene (HIPS) and other 3D printing materials airless tire modeling. For ordinary tires, it is considered to be neoprene. Use ANSYS 19.2

workstation to perform static analysis, and compare and evaluate the total elongation, equivalent elastic elongation, equivalent von Mises stress and energy elongation of conventional tires and airless tires. The use of airless tires eliminates the drawbacks faced by tires.

Even if air is not used, traction and wear are even. Airless tyres do not need to be replaced frequently. When they wear out and need to be replaced, the shape of the airless tyres is replaced, thereby saving manufacturing materials. The possibility of a puncture in a pneumatic Tyre is high, which may cause more accidents. For safety, the use of airless tyres is essential. When you drive a vehicle with airless tyres, there is no need to worry about safety. Another advantage is that they can be reused, old tires will flatten and must be thrown away, which is why airless tires must be used. Driving these cars can reduce mental stress. In this paper, dimensional models of airless tyres with different spoke structures are established and finite element analysis is carried out. According to the results of finite element analysis of various structures, airless tyres with rhombic structure are stronger than other structures and conventional tyres. In the future, the same model will be dynamically analyzed. Using these material properties, composite materials for 3D printing can be developed, and static and dynamic printed models can be checked. Loading conditions.

2.8 K. TARAKARAM, DR. K. RAMBABU, D. PHANINDRA VARMA (JANUARY 2019 IJSDR) MODELING AND ANALYSIS OF NON-PNEUMATIC Tyres WITH DIFFERENT DESIGN STRUCTURES USING FEM METHOD

Ordinary tyres are made of rubber wrapped with compressed air. Conventional tyres have always dominated the global market due to their superior operability and reliability. But it has disadvantages such as exploding while driving and driving style. Manufacturing of composite materials. , Need to maintain internal pressure. The innovative technology aims to use only a unique combination of materials and geometries, without the need for compressed air to support the load. Therefore, non-pneumatic tyres were introduced. It is a malleable component with a bendable honeycomb radius, and its function is similar to the air in a conventional Tyre. In this project, we replaced the traditional aluminum rim with a flexible spoke structure. We have studied various knitting needle designs, namely: the

honeycomb structure of knitting needles, the structure of triangular knitting needles, and the flat knitting needles. The curved spoke structure and design of non-pneumatic tires with uniaxial load and speed. When they roll, I like to squeeze. The non-pneumatic Tyre was designed on the CATIA desktop, and analyzed on the ANSYS desktop, and finally the equivalent stress, strain, deformation and shear stress were carried out. It also analyzes the model and then determines the appropriate non-pneumatic Tyre design. Based on the analysis of the design, it was concluded that the honeycomb spoke design proved to be robust and can also withstand higher loads than other designs. The structure is because the honeycomb structure provides more space for the same material, while the closed cell (hexagonal) structure can withstand greater force, so it has higher compressive strength and shear strength. The honeycomb spoke has local stress and small deformation, which is very suitable for the anti-fatigue spoke structure. Therefore, the proposed structure can withstand greater force while showing compensation. Like conventional tyres, it provides uniform traction and wear, as well as good strength, service life (endurance limit) and reliability, and reduces total weight and total cost.

2.9 PROBLEM IDENTIFICATION

2.9.1 The Common Problem Identified In Pneumatic Tyre:

Since the car is the only point of contact on the road, the main cause of the problems encountered is probably related to the tyres. It is important to know the signs of Tyre problems so that you can fix or fix it. Replace the vehicle immediately after discovering the problem to ensure that your vehicle is always safe to drive.

Our Munster Tyre team has compiled guidelines for the most common Tyre problems that drivers may encounter.

Over Inflation:

Over-inflated tyres cannot work safely because the more tyres are inflated, the more difficult it is for them to maintain contact with the road surface and impart

traction to the tread. The more load the Tyre is filled, the greater the load on the tyre structure, which in turn will shorten the life of the Tyre.

Under Inflation:

Studies have shown that about 60% of family cars on European roads have Tyre pressures below the recommended value. If the Tyres are under-inflated, it may cause some or all of the following problems:

- The risk of understeer increases, which may cause a collision.
- Poor handling, difficult to manipulate accurately.
- More susceptible to general wear and tear.
- Increased risk of failure.

If you are concerned about under-inflated tyres, you can independently monitor the air pressure in the tyres and inflate or deflate accordingly..

Cracking and Bulging:

Cracks and bulges may cause cracks and bumps in the Tyre, which may cause the Tyre sidewall to crack. If the Tyre is over-inflated or over-inflated, this problem is more likely to occur and can only be solved. Replace the rubber completely. However, this is not necessarily a bad thing, because cracks may indicate that the Tyre has aged and still needs to be replaced.

Driving At High Speed:

If you drive at high speed on a regular basis (for example, when driving on the motorway), your tyres are at greater risk of damaging them than at lower speeds. Speeds can cause higher levels of damage, while overheating caused by higher driving speeds can damage the tyres and lose control while driving. If you notice damage to your Tyre after continuously driving at high speeds, you should replace your Tyres immediately to ensure your safety when on the road.

Misalignment:

When your Tyre is worn out more on one side than the other, known as camber wear, it can become misaligned. Whether your vehicle hits a curb, adjusts the

height of your vehicle, or if you suffer from general wear and tear, this is what you should be aware of. A misaligned tire should be overhauled or replaced depending on the severity of the wear, as it can reduce the traction and road grip of the tire if not properly installed.

Cuts And Puncture:

Puncture damage often occurs due to a specific road hazard, such as: B. Broken glass on the street. Consequently, this type of damage is rarely the fault of the driver. However, you can strengthen your puncture defenses by making sure your tires are properly inflated.

Emergency Braking Damage:

The problem with emergency braking is that it can brake almost instantly. Tyre wear in a very specific area. Ultimately, this can cause them to go flat and make the vehicle difficult to drive if left standing for too long. If you recently performed an emergency stop, check your tires for localized wear.

Wear And Tear:

General wear and tear occurs with all tyres as they will be used over time. However, it is important to monitor the tread depth of yourTyres to ensure that it is within legal limits. If the tread depth is less than 1.6mm, you cannot legally drive on the road and will need to replace your tyres. It should be noted, however, that this wear and tear is the bare minimum. If you swap out your tires before they reach this level, you can be sure that your tires will be safe to drive on the road without sacrificing performance and grip.

2.9.2 The Common Problem Identified In Non-Pneumatic Tyre:

Table: 2.1 Common Problem Identified In Non-Pneumatic Tyre

s.no	Reference	work done	problem identified
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1	Design and Analysis of Air less tyres	Structural Analysis Modal Analysis Thermal Analysis	This work does not involve Dead & Bumping load analysis
2	Strength Validation of Hexagonal Cellular Spoked Non-Pneumatic tyres for Automobiles through Finite Element Analysis	Compressive, lateral Shear, Lateral Torsion, Circumferential torsion	Aluminium alloy is used as material which is costlier.
3	Effect of Spokes Structures on Characteristics Performance of Non-PNEUMATIC tyres	contact pressure, vertical tire stiffness and stresses.	The quasi-static, two-dimensional analysis focused on this paper. There is no 3D Analysis.
4	Finite Element Analysis on Pressure profile of Airless Tyres Compared to Conventional Tyre	Analysis of pressure profiles	purpose replacing the conventional air-filled Tyres with a non-air filled Tyres to improve the grip in arctic heconditions
5	Design and Analysis of Non-Pneumatic Tyre (NPT) With Honeycomb Spokes Structure	Liner static analysis Model analysis	Honeycomb structure is not compared with other otr structures.

CHAPTER 3

AIM & OBJECTIVES

3.1 AIM

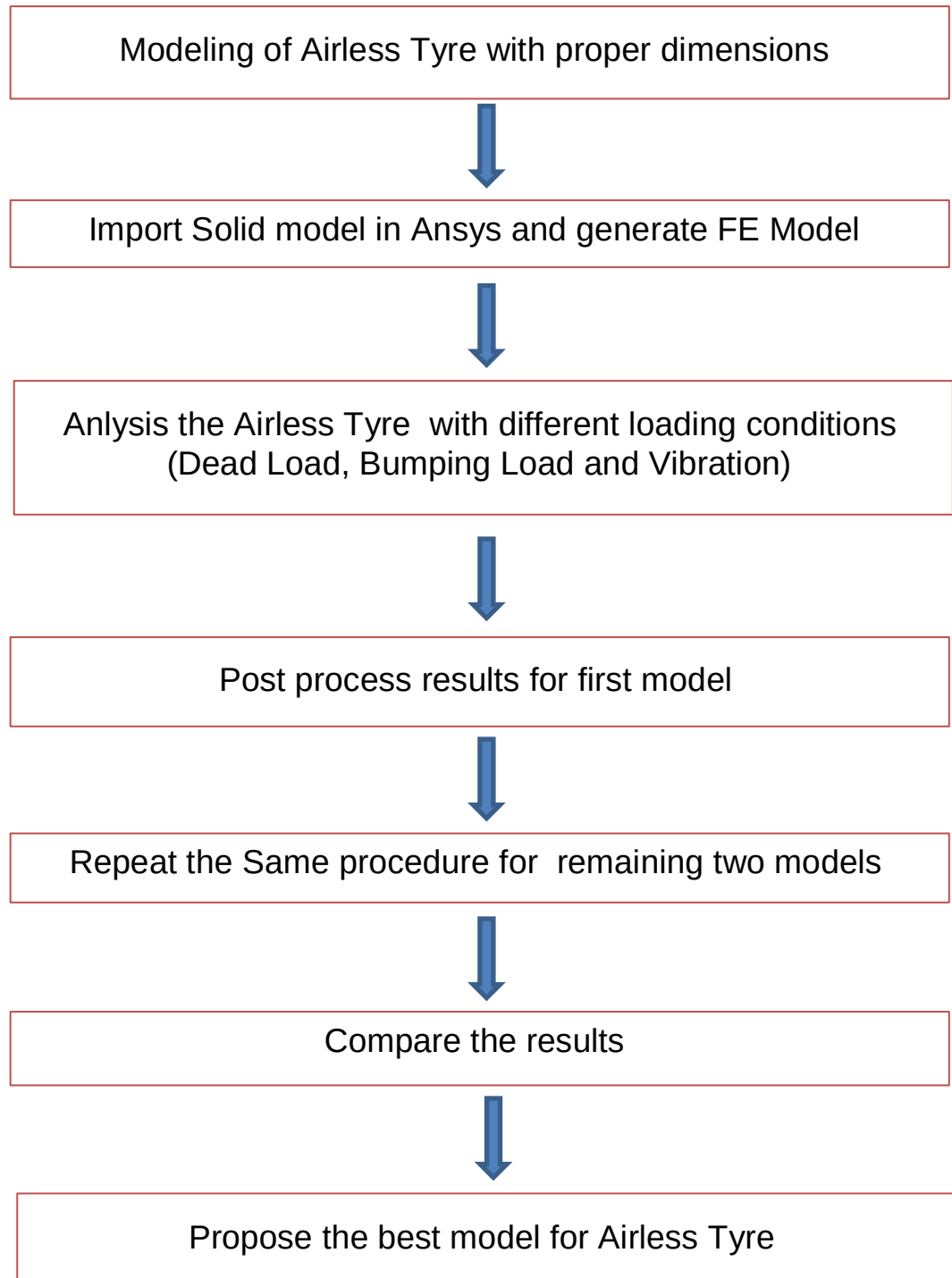
The project aim is to find the Bumping and Vibrational Analysis Of Non-pneumatic Tyre (NPT) by Using the polyethylene rubber material. We are creating three different types of airless tyre or Non-pneumatic tyres(NPT) and this design as been designed and analysed through Solid work's and Ansys Workbench(Static structural & modal).As a result one tyre model must be an improvement in performance.

3.2 OBJECTIVES

- Study the Stiffness of the airless tyres.
- Modelling three different type of airless Tyre structures by using solid works.
- Select the proper material airless Tyre structures.
- Analyze the airless Tyre with different boundary condition.
- The dead and Bump load has been used to analyse the deformation and stress in the tyre.
- Modal analysis is done to find the frequency acting in the tyre.
- Finally compare the results among three structures and select the

best profile.

3.3 METHODOLOGY



CHAPTER 4

MATERIALS AND EXPERIMENTAL PROCESS

Polyethylene is a lightweight and durable thermoplastic with a variable crystal structure. It is one of the most widely used plastics in the world (tens of millions of tons are produced worldwide each year).

Polyethylene is used to manufacture films, pipes, plastic parts, laminates, etc. in various markets (packaging, automotive, electrical, etc.). Polyethylene is made by polymerizing ethylene (or ethane) monomer polyethylene chemical formula $(C_2H_4)_n$. Polyethylene is a thermoplastic resin, which means that products made from this material can be recycled, melted and reshaped.

Table: 4.1 Material Properties

MECHANICAL PROPERTY	METRIC	UNITS
Yield Strength	2.62e7 – 3.1e7	Pa
Tensile Strength	2.21e7 - 3.1e7	Pa
Elongation	11.2 - 12.9	% strain
Hardness (Vickers)	7.75e7 - 9.71e7	Pa
Impact Strength (unnotched)	1.9e5 - 2e5	J/m ²
Fracture Toughness	1.52e6 - 1.82e6	Pa/m ^{0.5}
Young's Modulus	1.07e9 - 1.09e9	Pa

- The material of non-pneumatic tyres plays an important role. Due to the lack of air, the tires can also play a reinforcing role.
- The material must be flexible and have the characteristics of a rubber-like material.
- Good flexibility, but not interrupted, must be able to withstand wear and friction.

Table:4.2 Polyethylene Properties

MATERIAL	Young's Modulus	Poisson's Ratio (Gpa)	Density (kg/m^3)
Polyethylene	0.8	0.42	950

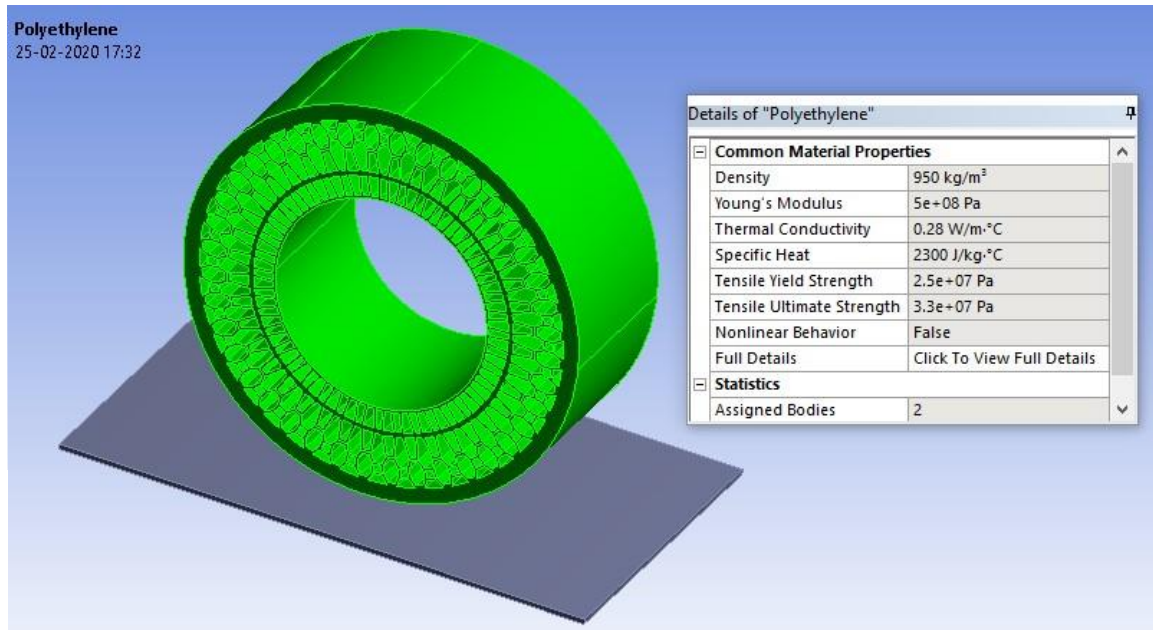


Fig:4.1 Material Properties

4.1 MODELING

4.1.1 Introduction To Modeling

Throughout the history of our industrial society, many inventions have been patented and whole new technologies have evolved. Perhaps the single development that has impacted manufacturing more quickly and significantly than any previous technology is the digital computer. Computers are being used increasingly for both design and detailing of engineering components in the drawing office.

4.1.2 Computer Aided Design

Computer-aided design (CAD) is defined as the application of computers and graphics software to aid or enhance the product design from conceptualization to documentation. CAD is most commonly associated with the use of an interactive computer graphics system, referred to as a CAD system. Computer-aided design systems are powerful tools and in the mechanical design and geometric modelling of products and components.

There are several good reasons for using a CAD system to support the engineering design function:

- To increase the productivity
- To improve the quality of the design
- To uniform design standards
- To create a manufacturing data base.
- To eliminate inaccuracies caused by hand-copying of drawings and inconsistency between drawings.

4.1.3 Rationale For CAD/CAM

The CAD/CAM **logic** is similar to **the logic** used to **ensure** the improvement of **manufacturing technology**. **This is due to the** need to continuously improve productivity, quality and competitiveness. **other** reasons why **companies** can **move** from manual processes to CAD/CAM **are**:

- **Higher** productivity
- Better quality
- Better communication
- Common **production** database
- **Fewer** mold prototypes
- Faster customer **response**

4.2 AIRLESS TYRE MODELS

Airless Tyre Model 1:

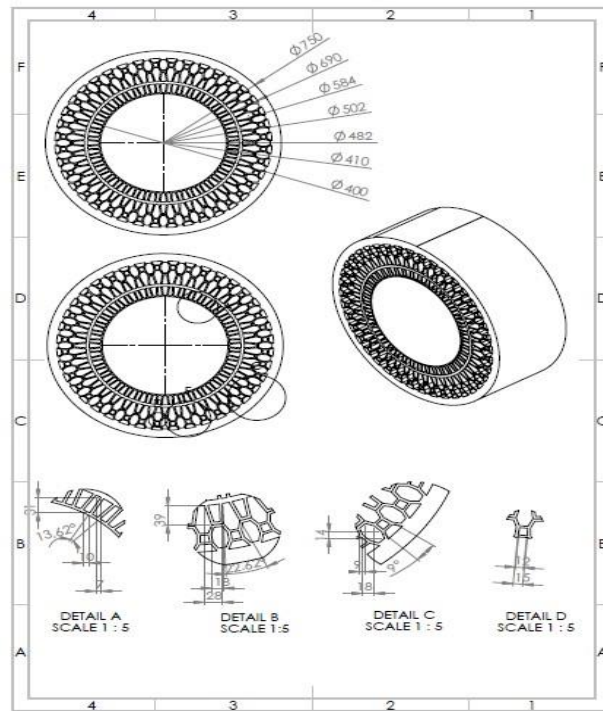


Fig:4.2 Tyre 1 Design(Detail view)

Honey comb shaped structure as a spokes in the outer layer of the Tyre

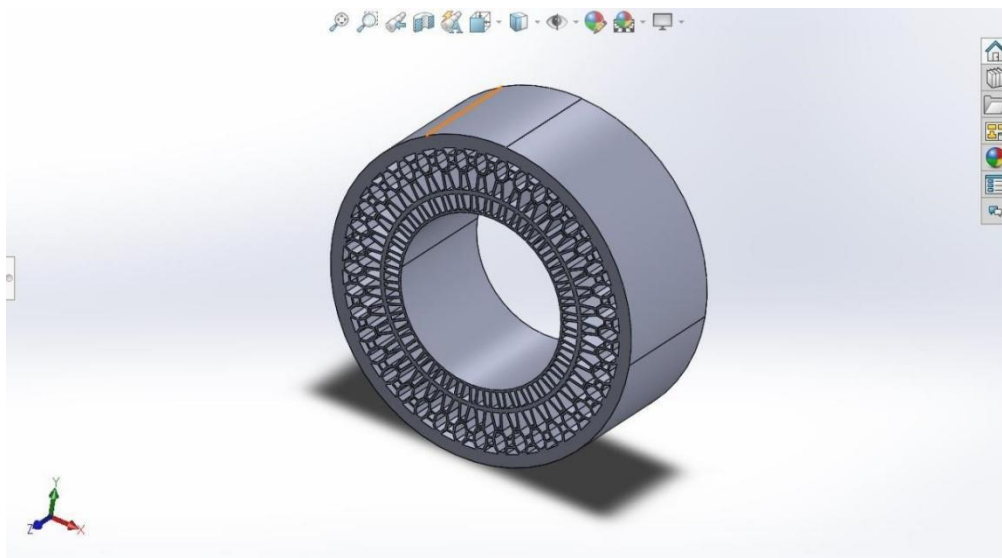


Fig:4.3 (Isometric View)

Airless Tyre Model 2:

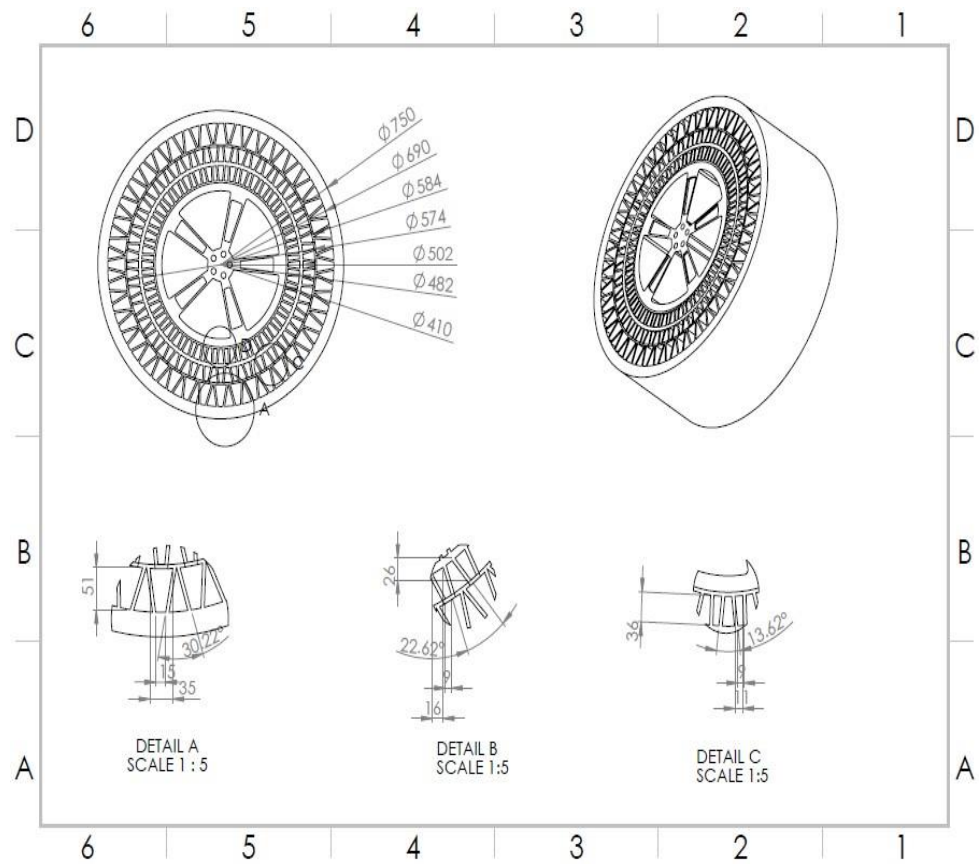


Fig:4.4 Tyre 2 Design(Detail view)

Honey comb shaped structure in the spokes is replaced with the alternative design

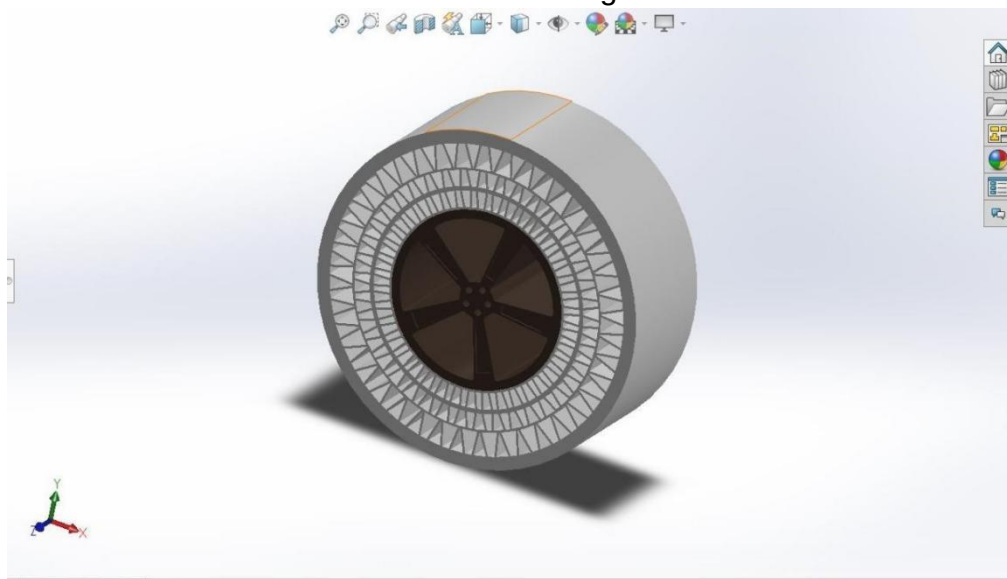


Fig:4.5 (Isometric View)

Airless Tyre Model 3:

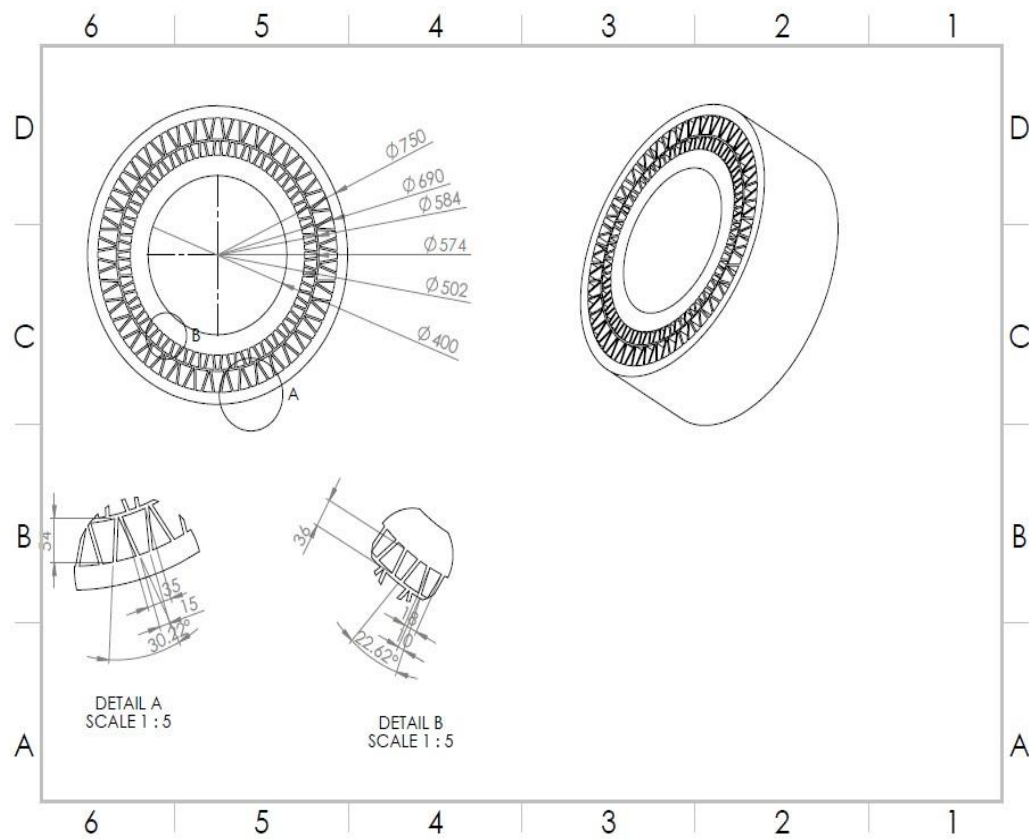


Fig:4.6 Tyre 3 Design(Detail view)

Spokes replaced with the fill of materials

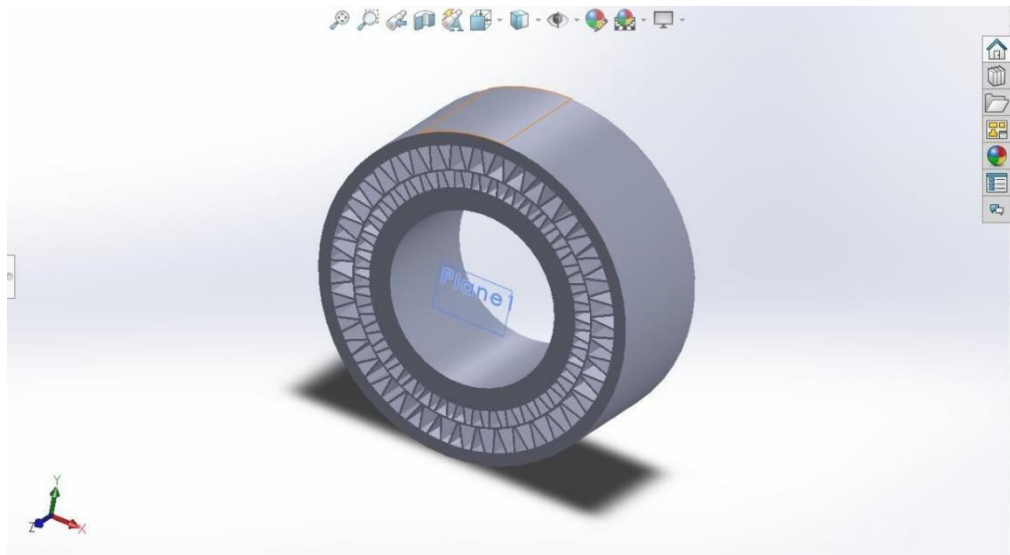


Fig:4.7 (Isometric View)

4.3 DESIGNS DONE IN SOLIDWORKS

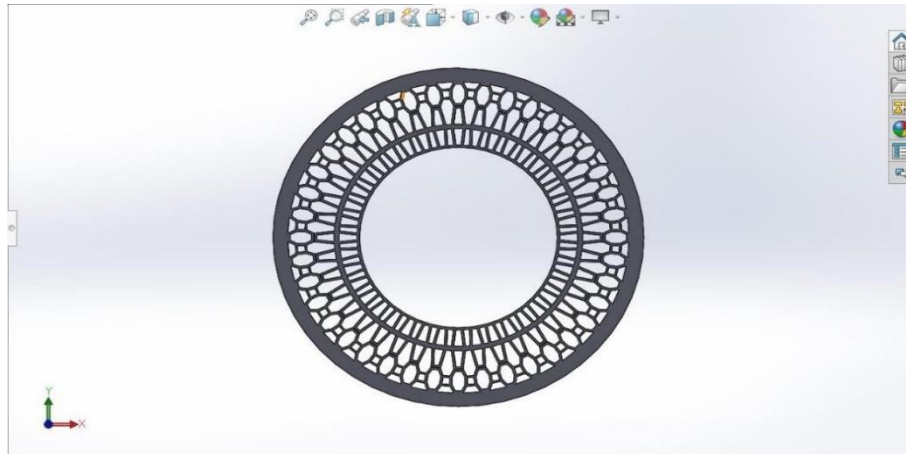


Fig:4.8 Tyre 1(Front View)

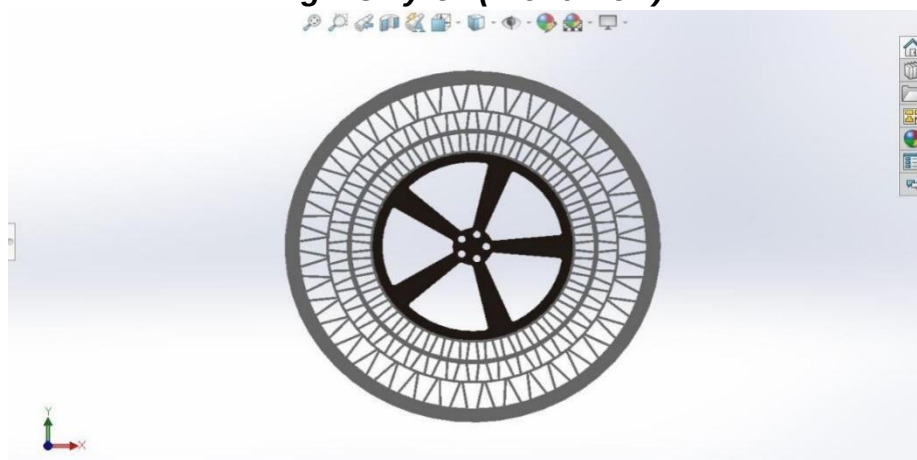


Fig:4.9 Tyre 2(Front View)

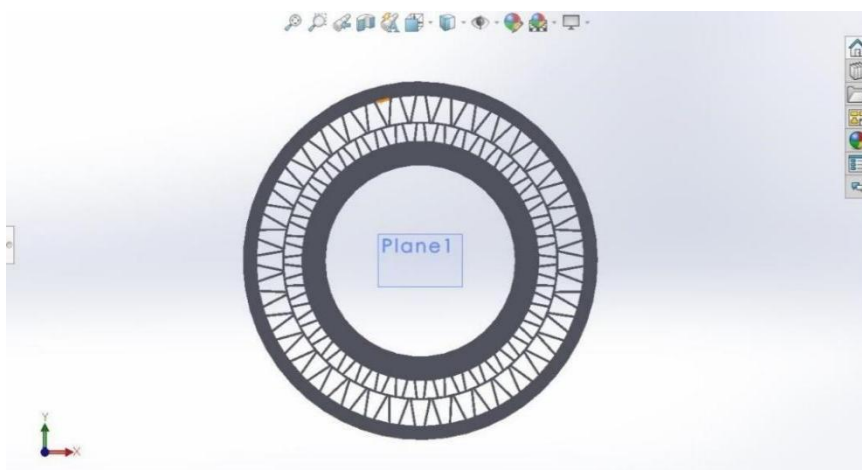


Fig:4.10 Tyre 3(Front View)

4.4 FINITE ELEMENT ANALYSIS

The finite element method is a numerical method that can solve continuous mechanical problems with acceptable accuracy to engineers. The finite element method is a mathematical modeling tool that can discretize continuous regions using structural blocks called finite elements. At the same time transfer other nodes. This process includes finite element modeling and finite element analysis. In displacement-based FEM, the stiffness of the entire structure (part or assembly) is determined by the stiffness of each element. Apply loads and constraints to nodes, and use matrix methods and numerical methods to solve simultaneous equations. Therefore, the finite element method is a numerical method for solving ordinary differential equilibrium equations. Starting from simple linear static stress and heat transfer analysis, various popular software (including Cosmos, NASTRAN, ANSYS and NISA) can be used to successfully analyze complex models of nonlinear fluid flow and dynamic events on a personal computer. Three steps in finite element calculation.

- Modeling
- Mesh the model
- Analysis

4.4.1 Structural analysis

Structural analysis is probably the most common application of FEM. The term "structure" includes not only technical structures such as bridges and buildings, but also aircraft and mechanical maritime structures and mechanical structures such as ships, zeros, airplanes, and fuselages. Parts such as pistons, machine parts and tools. The following are the seven types of structural analysis available in the ANSYS product line:

- Static analysis
- Modal analysis
- Harmonic analysis
- Transient dynamics analysis
- Spectrum analysis
- Buckling analysis

- Explicit Dynamics analysis

4.4.2 Mesh generation

Discretize the geometry to form a network of elements and nodes. This means that the structure is divided into small subdomains in which numerical simulations of constitutive equations can be created. The grid design depends on the following.

- The geometry of the structure.
- Analysis type, ie static, dynamic, thermal or nonlinear
- Boundary conditions
- Loads
- Required results

4.4.3 Mesh the model

Meshing involves three main steps:

1. Set the element attributes and material properties
2. Set mesh controls
3. Generate the mesh

Elements attributes

Before meshing the model, elements attributes should be specified based on the material, analysis and also on the required results. The elements used in this analysis are explained in the following sub-topics.

Minimal assumptions are used in arriving at the slope of nonlinear force-displacement relationship, i.e., element target stiffness hence; they are also called consistent formulations.

4.4.4 INTRODUCTION TO ANSYS

ANSYS is the only engineering simulation technology provider with the depth and breadth of tools to enable real-world multiphysics. The ANSYS Workbench™ platform provides the foundation for delivering integrated multiphysics simulation

with a high degree of automation and a user-friendly interface all in a unified environment. ANSYS Workbench allows users to create parametric models across physics and geometry and to perform sensitivity studies and design optimization with coupled-physics solutions. This, in turn, provides the highest level of fidelity in virtual modeling, when physical testing is either too costly, impractical or even impossible.

4.4.5 PROCEDURES TO PERFORM FEA BY ANSYS

ANSYS has five typical steps to perform finite element analysis. The first step is to **collect** data **about** the problem. The second step is to **create** a finite element model for the applied problem.

This step includes actions such as defining elements, selecting element types, defining material properties, and creating finite element models. Regarding the definition o

f the element system, it should be noted that ANSYS does not assume the element system. Therefore, the user is responsible for maintaining the consistency of the unit system for all entries in ANSYS. Regarding the selection of the element type, the decision is based on the attributes of the element type in order to better model/adjust the application geometrically and physically. Depending on the element type, the material properties can be linear or non-linear. Isotropic, orthotropic or anisotropic; constant temperature, independent of or dependent on temperature. ANSYS provides two methods for creating finite element models: automatic meshing (also called solid modeling in ANSYS terminology) and manual meshing (also called direct meshing in ANSYS terminology). Users must have a solid model before they can create a finite element model. If there is such a solid model, the user can instruct ANSYS to automatically design the finite element model (nodes and elements). Automatic meshing frees users from the tedious work of creating complex finite element models. However, this method requires a lot of CPU time and sometimes cannot maintain communication between nodes and elements.

4.4.6 Types of element:

Different types of elements may be used in Engine casing models to obtain characteristic responses of a structure system. Elements can be categorized based on their principal structural actions.

- a) Truss Element
- b) Beam Element
- c) Frame Element
- d) Shell Element
- e) Plate Element

f) Tetrahedron elements (Element used):

The shape function is the function which interpolates the solution between the discrete values obtained at the mesh nodes. Therefore, appropriate functions have to be used and, as already mentioned, low order polynomials are typically chosen as shape functions. In this work linear shape functions are used.

For three-dimensional finite element simulations it is convenient to discretize the simulation domain using tetrahedrons, as depicted. Thus, linear shape functions must be defined for each tetrahedron of the mesh, in order to apply the Galerkin method.

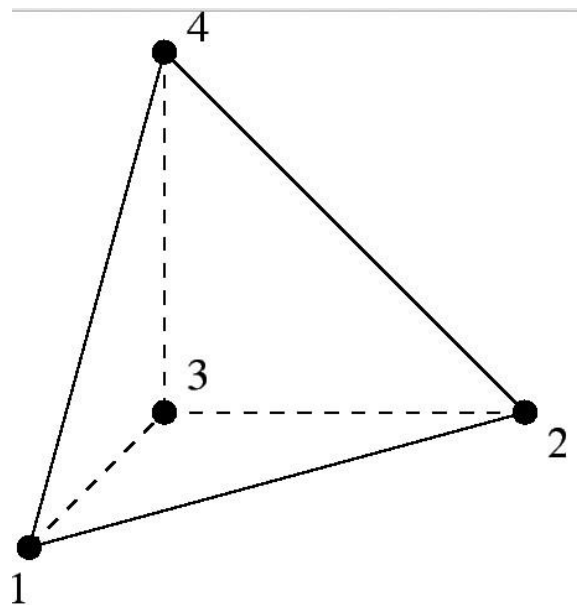


Fig:4.11 Tetrahedron element

4.5 MESHING

As usual, when working with FEM in this thesis project, it was necessary to determine the mesh size that gives the best balance between computation time and precision in order to ensure that the results provided by the program are similar to reality. Quality offers a more accurate solution. For example, you can refine the mesh in certain areas of the geometry where the gradients are high, which increases the fidelity of the solutions in the region. This also means that if a mesh is not refined enough, the precision of the solution is more limited, so the quality of the mesh is determined by the precision

FE modelling is done with Tetrahedron elements for more accuracy

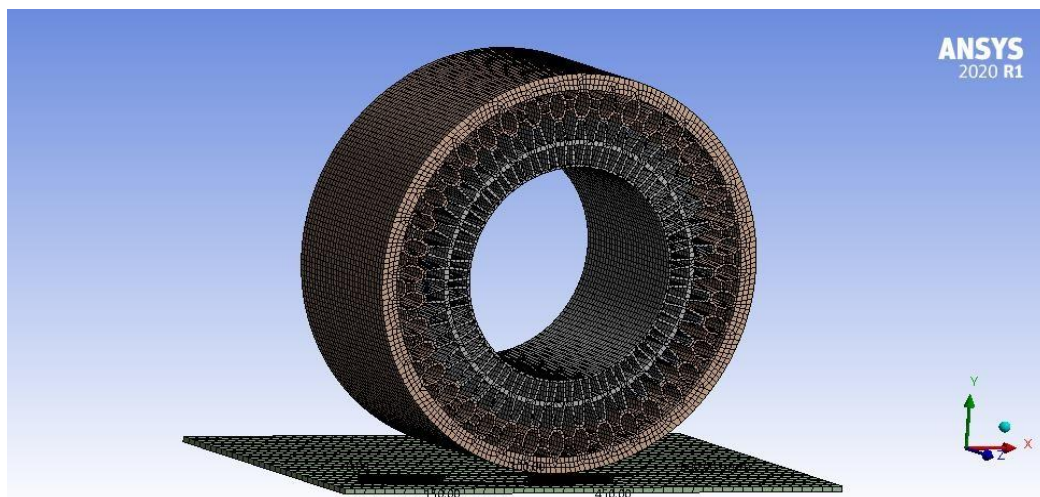


Fig:4.12 Meshed Model

QUALITY TEST OF FE MODEL

SUMMARIZE SHAPE TESTING FOR ALL SELECTED ELEMENTS

SHAPE TESTING SUMMARY FOR ALL SELECTED ELEMENTS				
Element count	1890	SURF154		
	102630	SOLID186		
Total	104520			
Test	Number tested	Warning count	Error count	Warn+Err %
Aspect Ratio	104520	0	0	0.00 %
Parallel Deviation	104520	0	0	0.00 %
Maximum Angle	104520	780	0	0.75 %
Jacobian Ratio	102630	0	0	0.00 %
Warping Factor	102630	0	0	0.00 %
Any	104520	780	0	0.75 %

Number of Elements=104520

Number of Nodes =496259

Shape checking was done in ANSYS in order to ensure that the model has minimum error percentage than the threshold limit of 5% (**NAFEMS**).our model has the error percentage of 0.75% only which is in the limit.

4.6 BOUNDARY CONDITIONS

BOUNDARY CONDITION

Each Tyre model is tested with three different load cases, Out of which the optimistic design has to be identified. The load cases are

- Dead Load :

This is a condition at which the vehicle is in immobilized condition. All the self weight of the vehicle and the Weight of the average sized four passengers will get distributed on the four wheels of the vehicle.

The tyres have to withstand the loading condition with the minimal deflection due to the dead load of the vehicle without any failure.

- Bump Load :

When the vehicle is in motion some of the other dynamic forces will get added to the wheels If the vehicle approaches a sudden bump in the road then most of the vehicles load will be transferred to the wheel which hits the bump and the wheel experiences a sudden shock load due to that bump.

TheTyres should bear the sudden shock loads and have the capacity of absorbing the shock.

- Modal (Natural Frequency) :

In order ensure the rider Quality the Tyre should have the tendency to absorb the shocks and vibrations from the contact surface such as road, bump.

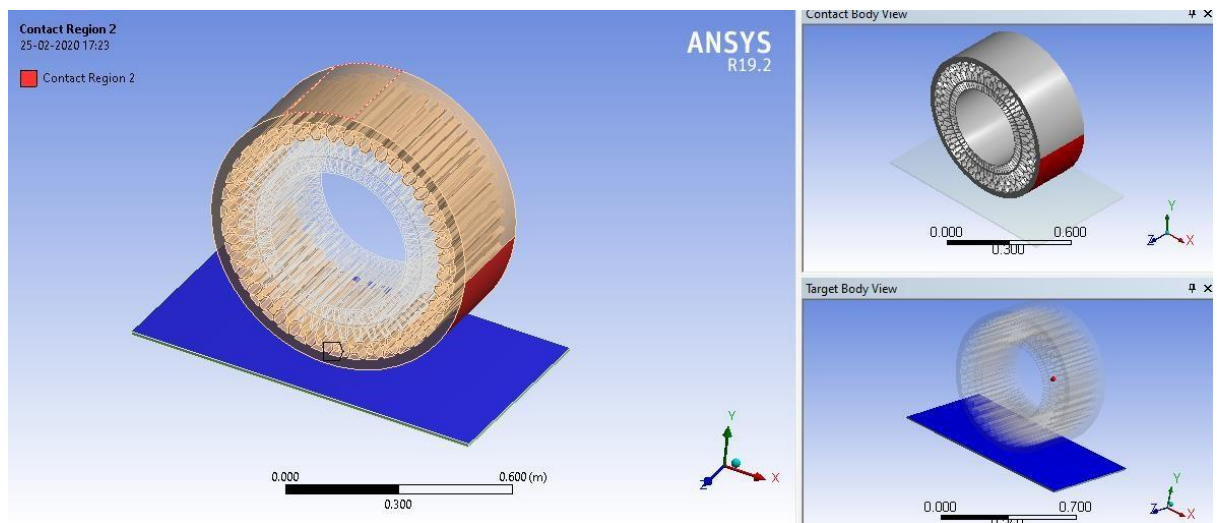
The modal analysis is to determine how the Tyre is vibrating at the fixed conditions.

CHAPTER 5

RESULT AND DISCUSSION, PERFORMANCE ANALYSIS

5.1 DEAD LOAD ANALYSIS

A surface is considered to simulate the exact of the road like conditions. The spoke and the axial will transfer the dead weight of the vehicle to the Tyre. Here a vehicle of 1300 Kg with average of 4 persons with 80kg weight is taken into account for the force.



Fig;5.1 Contact between road and Tyre

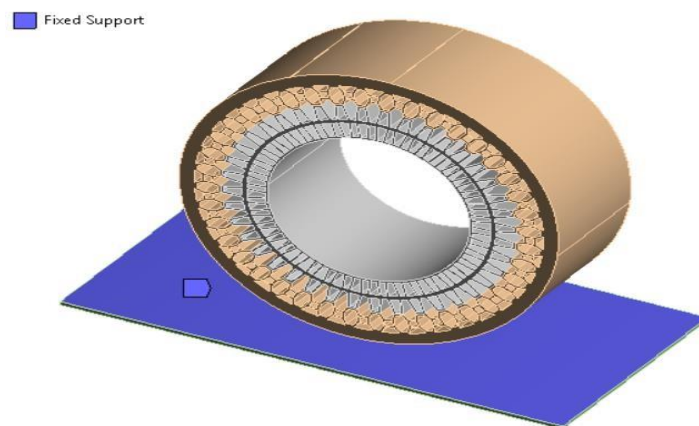


Fig:5.2 Fixed support

Load Calculation:

For the simulations the mass of the small sized car(Nissan micra)=1300 kg. with 4passenger weight= 4(average weight of single person 80) kg.

$$= 4(80) \text{ kg}$$

$$W_{\text{passengers}} = 320 \text{ kg}$$

Which is around the average weight of the car. The calculation below shows this weight was used to get the correct force applied to the models.

Force from the car (F_{car}) calculated by multiplying the weight of the car + passenger weight by gravity (g)

$$F_{\text{car}} = W_{\text{car}} + W_{\text{passengers}} * g$$

$$F_{\text{car}} [\text{N}] = 1300[\text{kg}] + 320 * 9.81[\text{m/s}^2]$$

$$F_{\text{car}} = 16200 \text{ N}$$

Force from the car divided between the four wheels

$$F_{\text{wheel}} = 16200 / 4$$

$$= 4050 \text{ N}$$

Force: 4050. N
Components: 0, -4050, 0. N

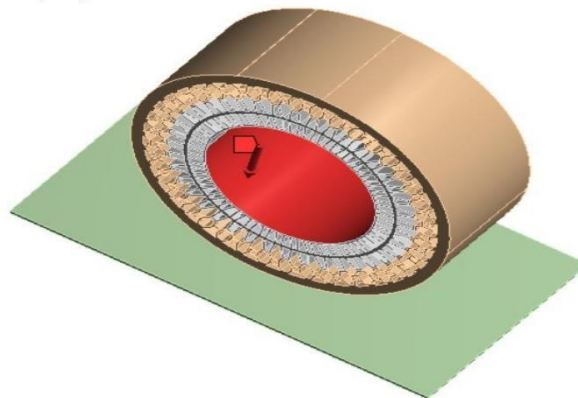


Fig: 5.3 Vertical (Dead) Force

Dead Load Analysis -Tyre Model 1:

Input: Force=4050N

Total Deformation (mm)

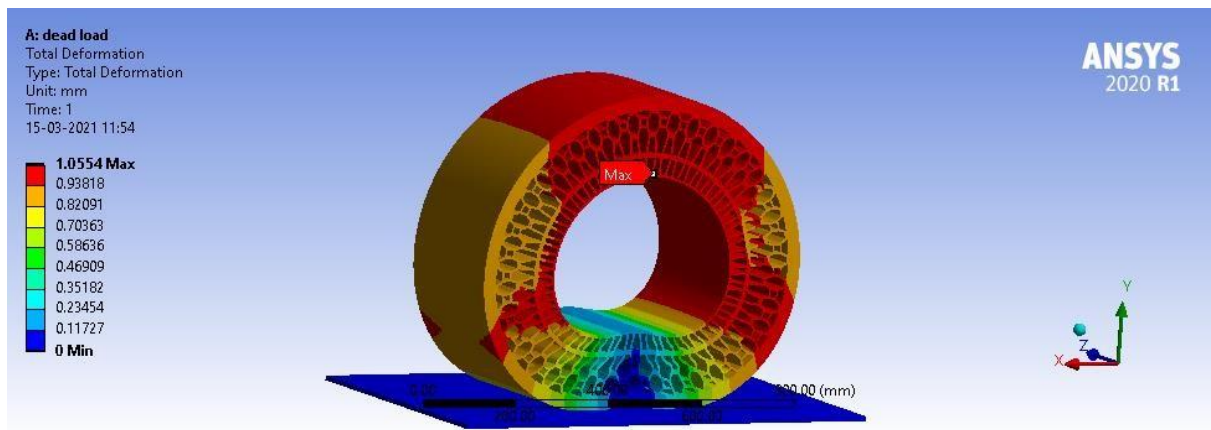


Fig:5.4 Tyre 1 Deformation

This figure shows the deformation for airless Tyre . Model 1 maximum deformation value is 1.0554mm and minimum deformation value is 0.11727mm in the above figure the red colour indicates maximum deformation and blue colour indicates minimum deformation.

Equivalent stress (Mpa)

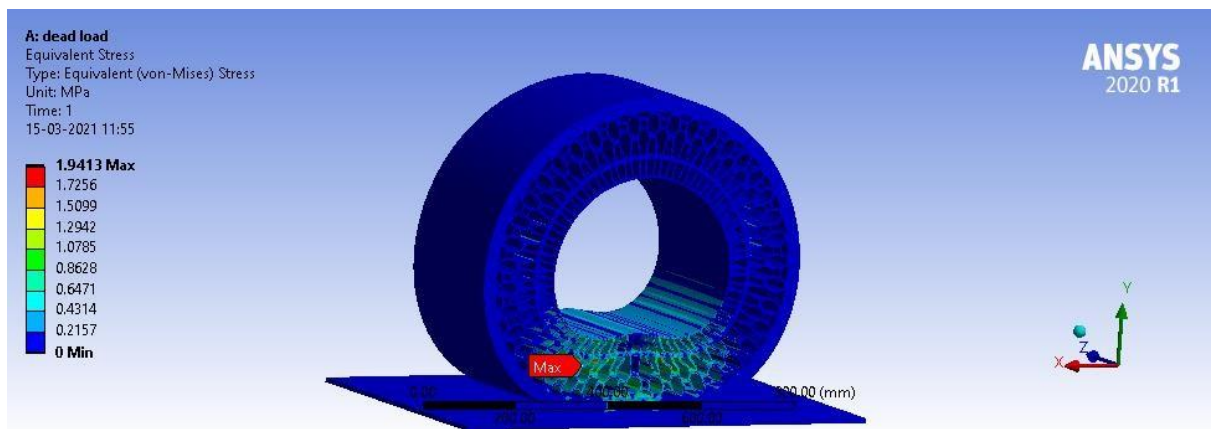


Fig:5.5 Tyre 1 Von-mises Stress

This figure shows the equivalent stress for for airless Tyre . Model 1 maximum equivalent stress value is 1.9413mm and minimum equivalent stress value is 0.2157mm in the above figure the red colour indicates maximum equivalent stress and blue colour indicates minimum equivalent stress.

Dead Load Analysis -Tyre Model 2

Total Deformation (mm)

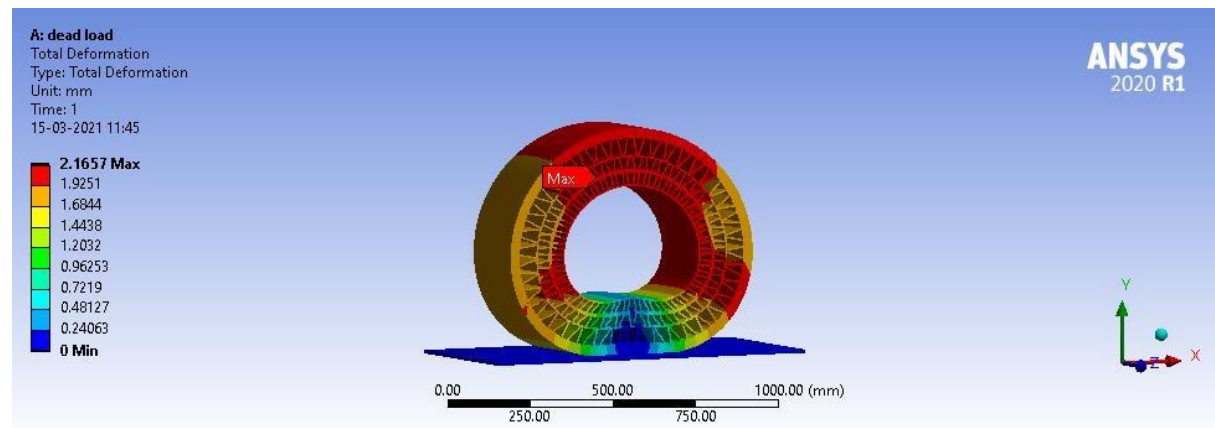


Fig5.6 Tyre 2 Deformation

This figure shows the deformation for airless Tyre . Model 2 maximum deformation value is 2.1657mm and minimum deformation value is 0.24063mm in the above figure the red colour indicates maximum deformation and blue colour indicates minimum deformation.

Equivalent stress (Mpa)

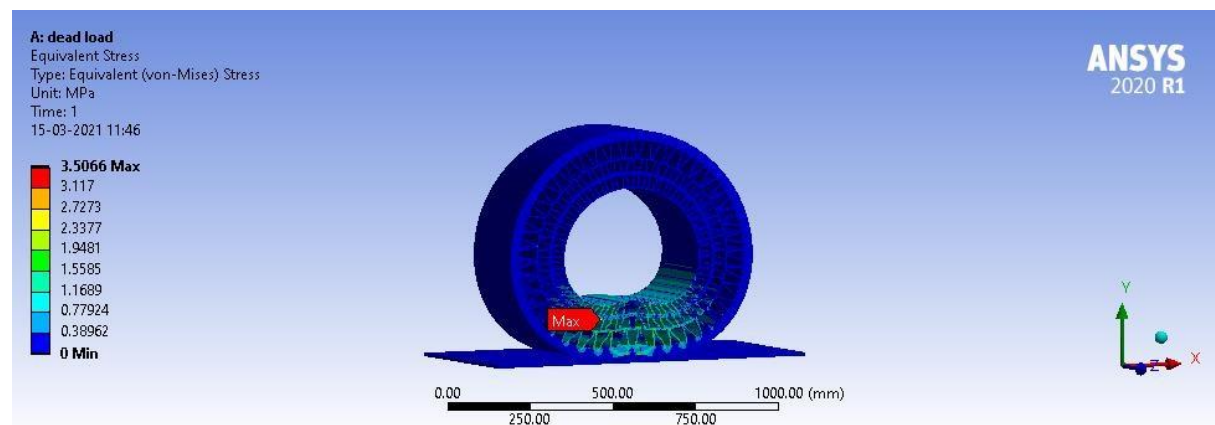


Fig5.7 Tyre 2 Vonmises Stress

This figure shows the equivalent stress for for airless Tyre . Model 2 maximum equivalent stress value is 3.5066mm and minimum equivalent stress value is 0.38962mm in the above figure the red colour indicates maximum equivalent stress and blue colour indicates minimum equivalent stress.

Dead Load Analysis -Tyre Model 3

Total Deformation (mm)

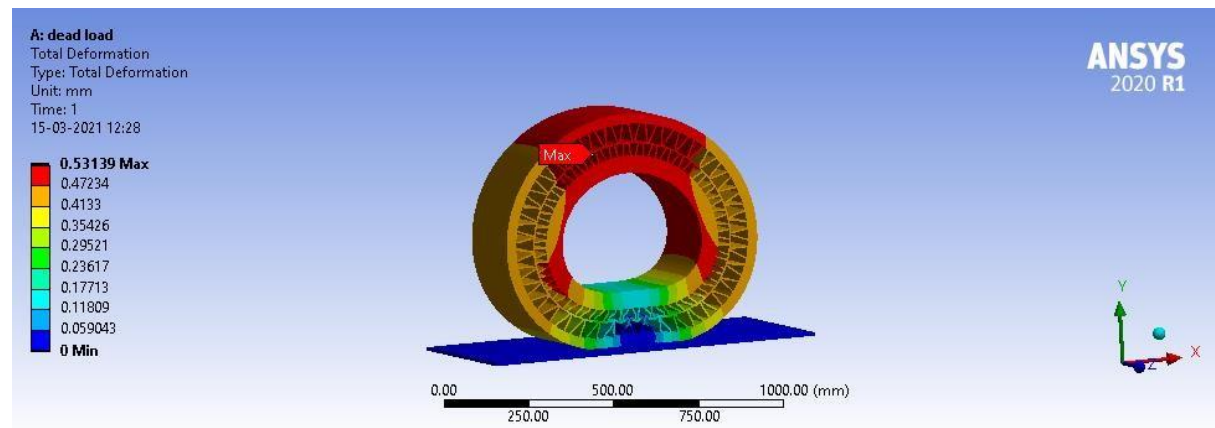


Fig:5.8 Tyre 3 Deformation

This figure shows the deformation for airless Tyre . Model 3 maximum deformation value is 0.53139mm and minimum deformation value is 0.059043mm in the above figure the red colour indicates maximum deformation and blue colour indicates minimum deformation.

Equivalent stress (Mpa)

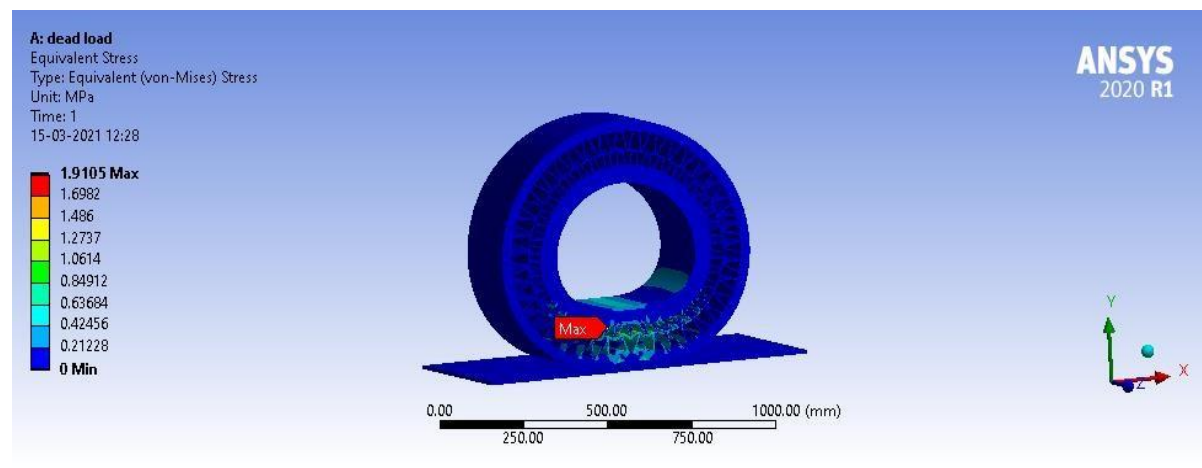


Fig:5.9 Tyre 3 Vonmises Stress

This figure shows the equivalent stress for for airless Tyre . Model 3 maximum equivalent stress value is 1.9105mm and minimum equivalent stress value is 0.21228mm in the above figure the red colour indicates maximum equivalent stress and blue colour indicates minimum equivalent stress.

Output For Dead Load :

Table:5.1 Output For Dead Load

OUTPUT	TYRE 1		TYRE 2		TYRE 3		UNIT
	RANGE MAX	RANGE MIN	RANGE MAX	RANGE MIN	RANGE MAX	RANGE MIN	
DEFORMATION	1.0554	0	2.1657	0	0.53139	0	Mm
EQUIVALENT STRESS	1.9413	0	3.5066	0	1.9105	0	Mpa

5.2 BUMP LOAD ANALYSIS

When the vehicle is in motion some of the other dynamic forces will get added to the wheels. If the vehicle approaches a sudden bump in the road then most of the vehicle's load will be transferred to the wheel which hits the bump and the wheel experiences a sudden shock load due to that bump.

The Tyres should bear the sudden shock loads and have the capacity of absorbing the shock.

For the simulation the mass of the car weight is 1300 kg. Which is around average weight of record and also take road surface area at contact region 60689mm^2 . The calculation below shows how this pressure to be applied in the airless Tyres.

PRESSURE

It is the force per unit perpendicular area over which the force is applied.

$$P = F/A$$

Force from the car has already calculated in the dead load analysis that is 4050N.

Road surface area value taken from the journals that is 60689mm^2 .

Force can be multiplied by times. Why because due to suddenly applied load.

Generally load will more 2 to 3 times when happened short period of time.

$$F = 4050 \times 3$$

$$= 12150\text{N}$$

$$P = 12150/60689$$

=0.2Mpa

The pressure value of 0.2Mpa to be applied for all the Tyre models.

Displacement
Components: 0,0,0. mm

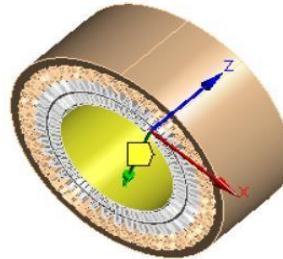


Fig:5.10 Fixed Boundary condition

Pressure: 0.2 MPa

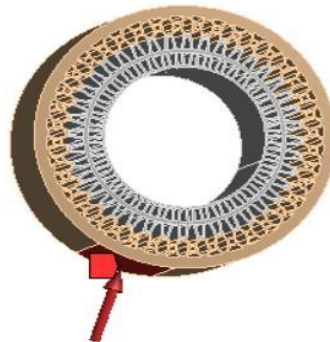


Fig:5.11 Pressure Acting upwards

Bump Load Analysis -Tyre Model 1

Input: Pressure=0.2Mpa

Total Deformation (mm)

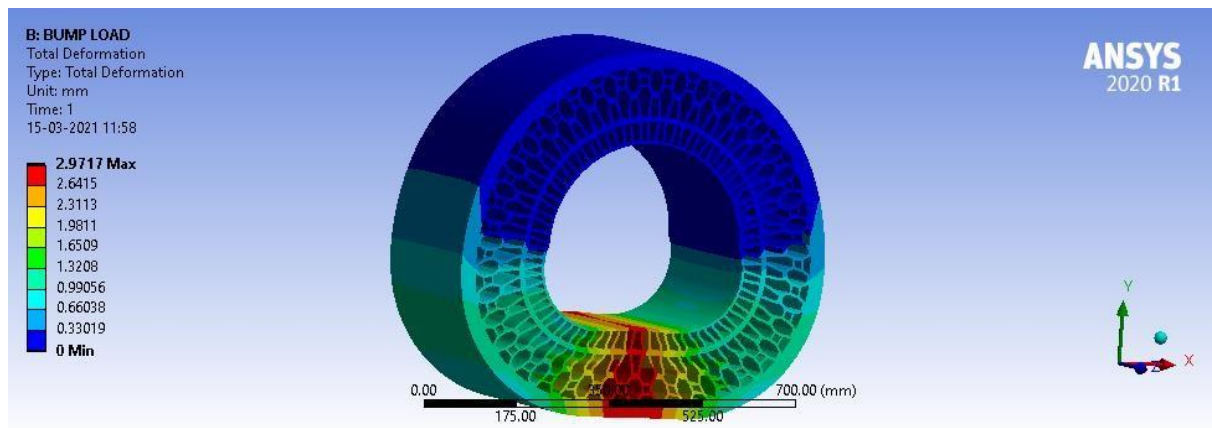


Fig:5.12 Tyre 1 Deformation

This figure shows the deformation for airless Tyre . Model 1 maximum deformation value is 2.9717mm and minimum deformation value is 0mm in the above figure the red colour indicates maximum deformation and blue colour indicates minimum deformation.

Equivalent stress (Mpa)

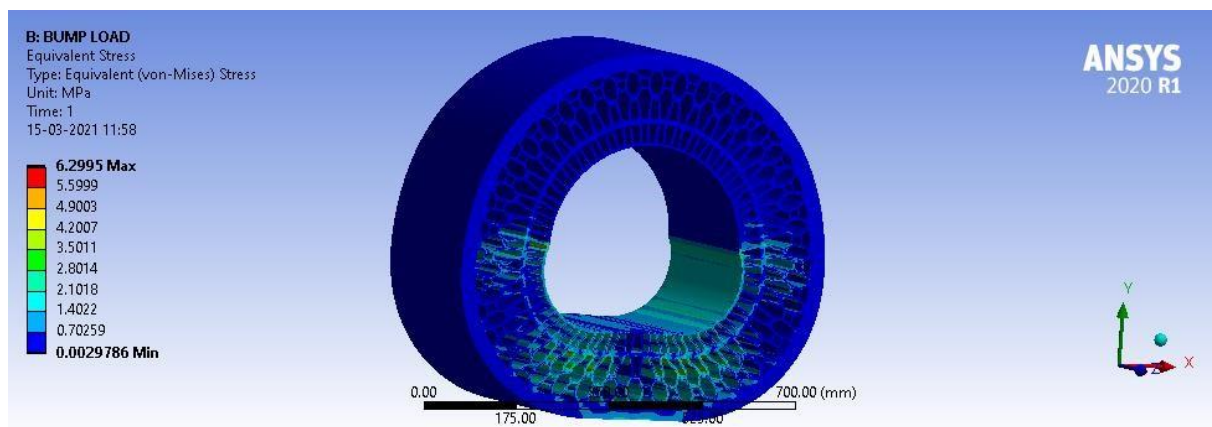


Fig:5.13 Tyre 1 Vonmises Stress

This figure shows the equivalent stress for for airless Tyre . Model 1 maximum equivalent stress value is 6.2995mm and minimum equivalent stress value is 0.0029786mm in the above figure the red colour indicates maximum equivalent stress and blue colour indicates minimum equivalent stress.

Bump Load Analysis -Tyre Model 2

Total Deformation (mm)

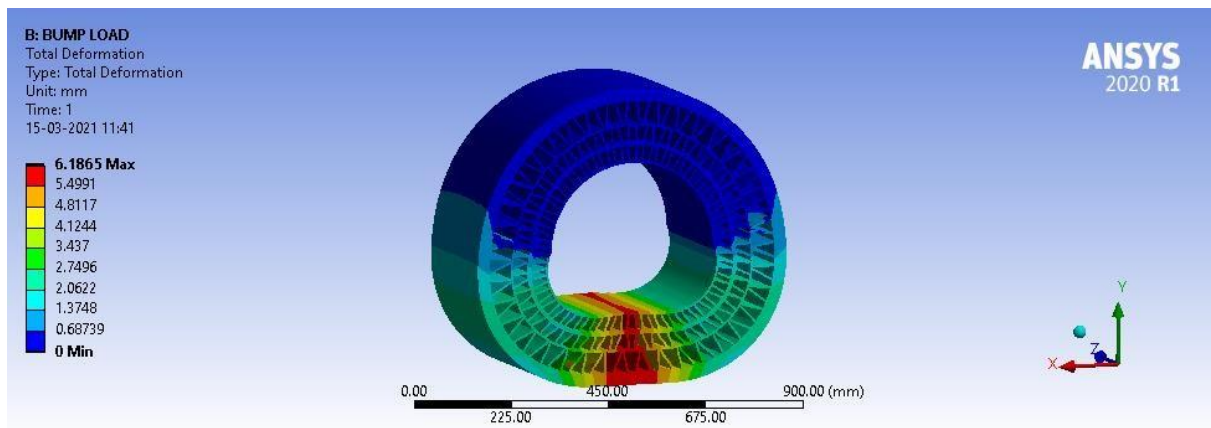


Fig:5.14 Tyre 2 Deformation

This figure shows the deformation for airless Tyre . Model 2 maximum deformation value is 6.1865mm and minimum deformation value is 0mm in the above figure the red colour indicates maximum deformation and blue colour indicates minimum deformation.

Equivalent stress (Mpa)

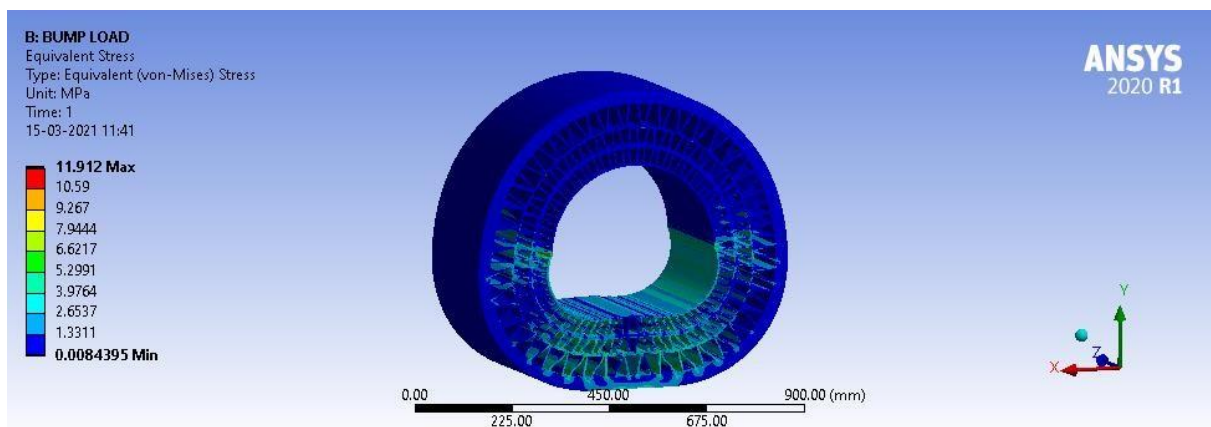


Fig:5.15 Tyre 2 Vonmises Stress

This figure shows the equivalent stress for for airless Tyre . Model 2 maximum equivalent stress value is 1.9105mm and minimum equivalent stress value is 0.0084395mm in the above figure the red colour indicates maximum equivalent stress and blue colour indicates minimum equivalent stress.

Bump Load Analysis -Tyre Model 3

Total Deformation (mm)

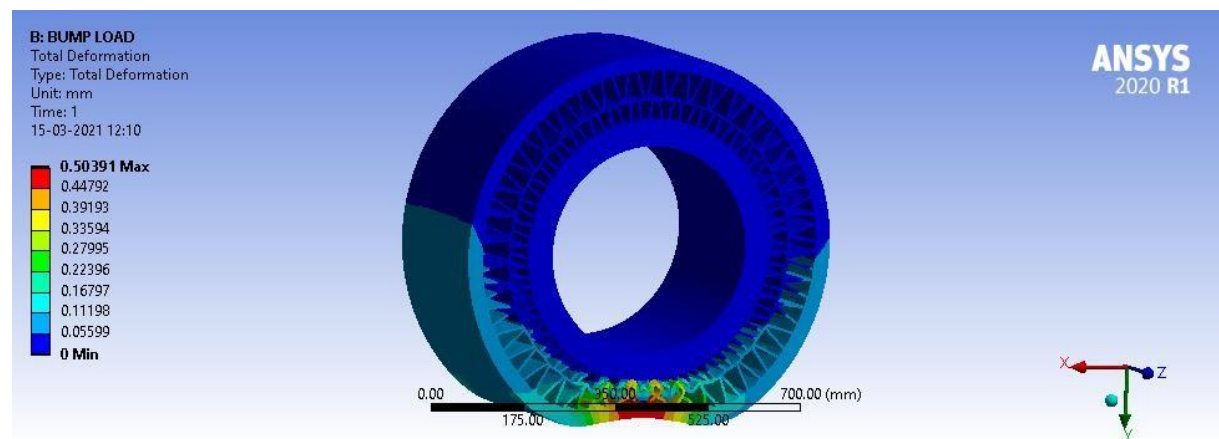


Fig:5.16 Tyre 3 Deformation

This figure shows the deformation for airless Tyre . Model 3 maximum deformation value is 0.50391mm and minimum deformation value is 0mm in the above figure the red colour indicates maximum deformation and blue colour indicates minimum deformation.

Equivalent stress (Mpa)

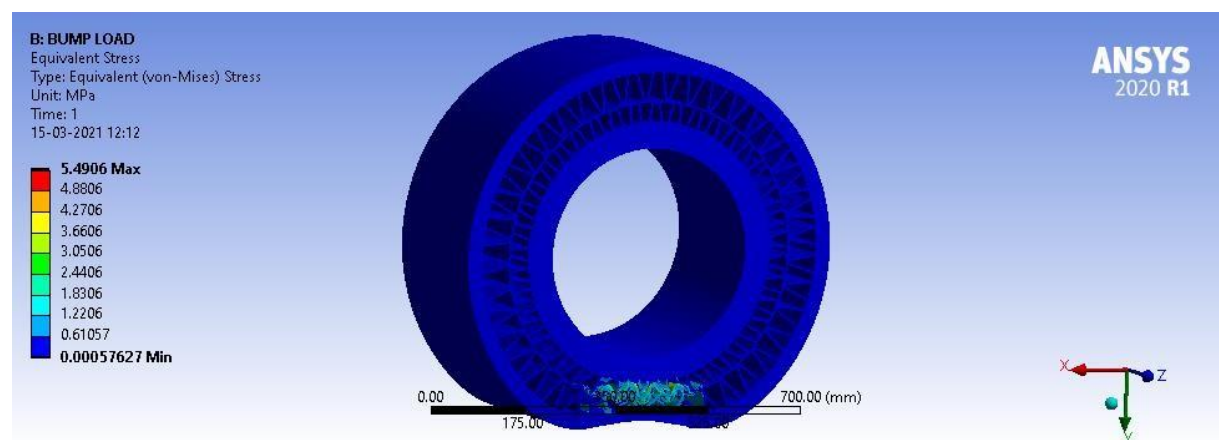


Fig:5.17 Tyre 3 Vonmises Stress

This figure shows the equivalent stress for for airless Tyre . Model 3 maximum equivalent stress value is 5.4906mm and minimum equivalent stress value is 0.00057627mm in the above figure the red colour indicates maximum equivalent stress and blue colour indicates minimum equivalent stress.

Output For Bumpload:

Table:5.2 Output For Bumpload

OUTPUT	TYRE 1		TYRE 2		TYRE 3		UNIT
	RANGE MAX	RANGE MIN	RANGE MAX	RANGE MIN	RANGE MAX	RANGE MIN	
DEFORMATION	2.9717	0	6.1865	0	0.50391	0	mm
EQUIVALENT STRESS	6.2995	0.00297	11.912	0.00843	5.4906	0.00057 6	Mpa

5.3 MODAL ANALYSIS

Modal Analysis is mostly dispensed to seek out natural frequency of the system and completely different mode shapes at different Eigen values. In this work, totally different modes and Eigen values square measure calculates and premeditated between mode shapes versus natural frequencies. This shows the stiffness and rigidity of the material toward totally different modes.

5.3.1 Introduction To Modal Analysis

The goal of modal analysis in structural mechanics is to determine the natural mode shapes and frequencies of an object or structure during free vibration. It is common to use the finite element method (FEM) to perform this analysis because, like other calculations using the FEM, the object being analyzed can have arbitrary shape and the results of the calculations are acceptable. The types of equations which arise from modal analysis are those seen in Eigen systems. The physical interpretation of the eigen values and eigenvectors which come from solving the system are that they represent the frequencies and corresponding mode shapes. Sometimes, the only desired modes are the lowest frequencies because they can be the most prominent modes at which the object will vibrate, dominating all the higher frequency modes.

Boundary Conditions :

The rim surface has been arrested in all three directions.

The boundary conditions are same for all the three Tyres. The results of the Tyres are compared with each other for the identification of optimistic design.

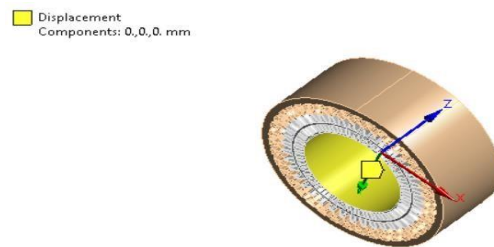


Fig:5.18 Displacement

Modal Analysis -Tyre Model 1

Total Deformation (mm) Mode shape 1:

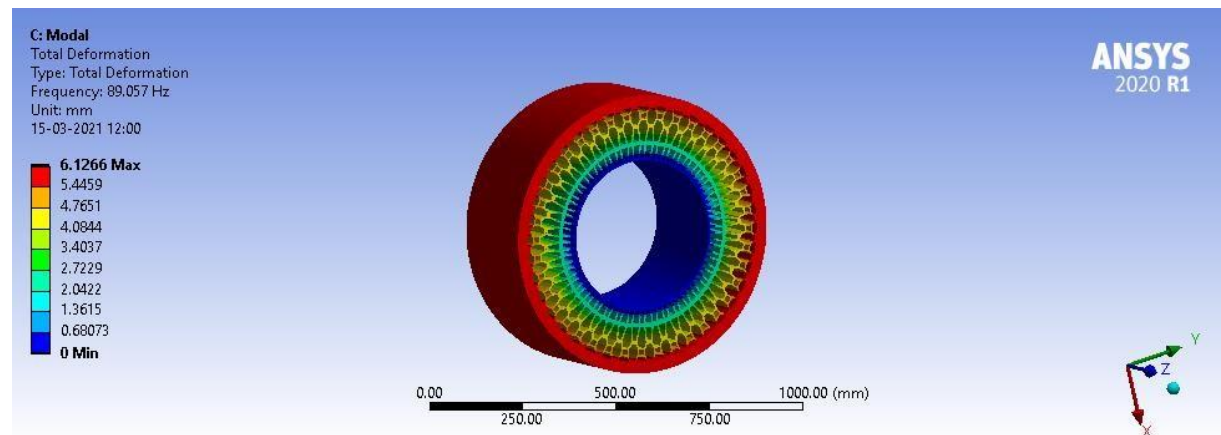


Fig:5.19 Tyre 1 Mode Shape 1

The figure shows that Frequency response analysis done on the Tyre at Frequency (F)=89.057 Hz and the total deformation value for the model 1 is 6.1266mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 2:

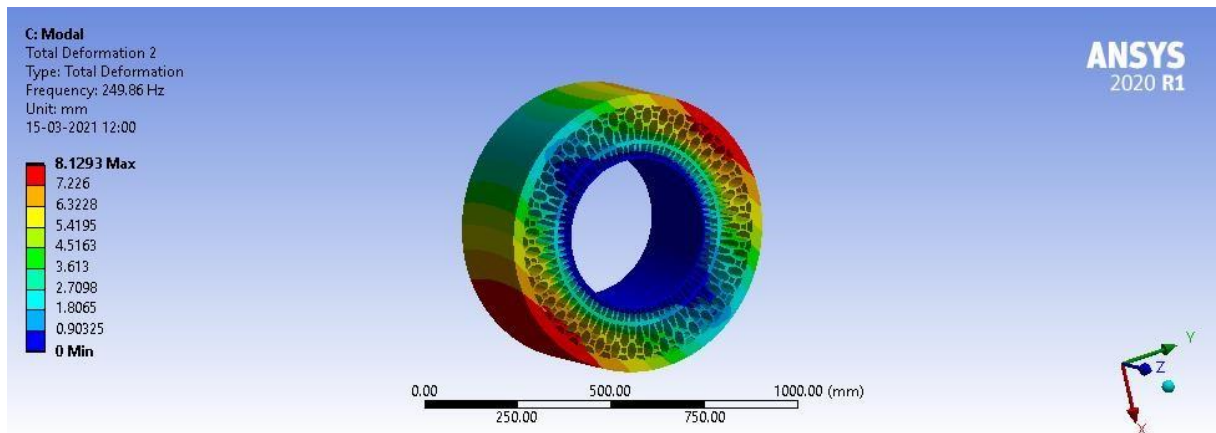


Fig:5.20 Tyre 1 Mode Shape 2

The figure shows that Frequency response analysis done on the Tyre at Frequency

(F)=249.86 Hz and the total deformation value for the model 1 is 8.1293mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 3:

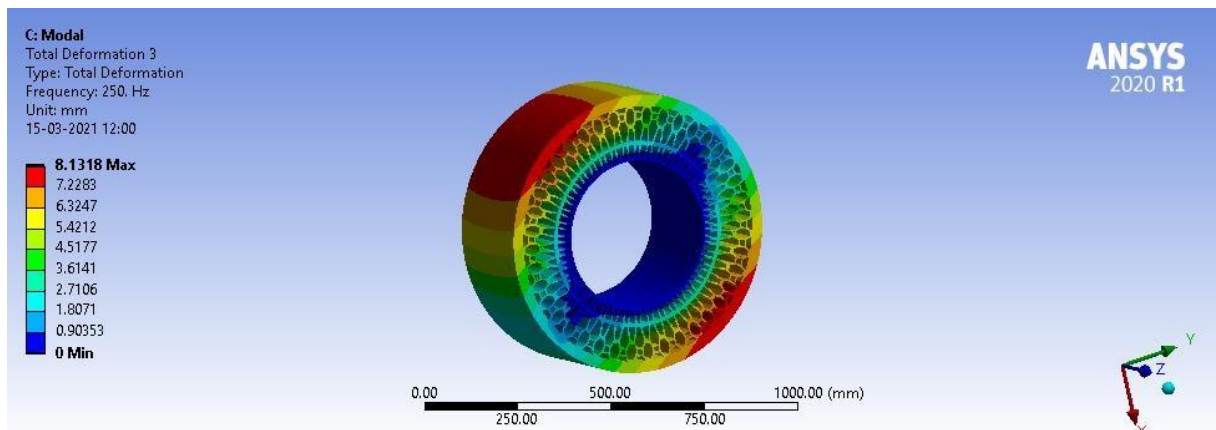


Fig:5.21 Tyre 1 Mode Shape 3

The figure shows that Frequency response analysis done on the Tyre at frequency (F)=250 Hz and the total deformation value for the model 1 is 8.1318mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 4:

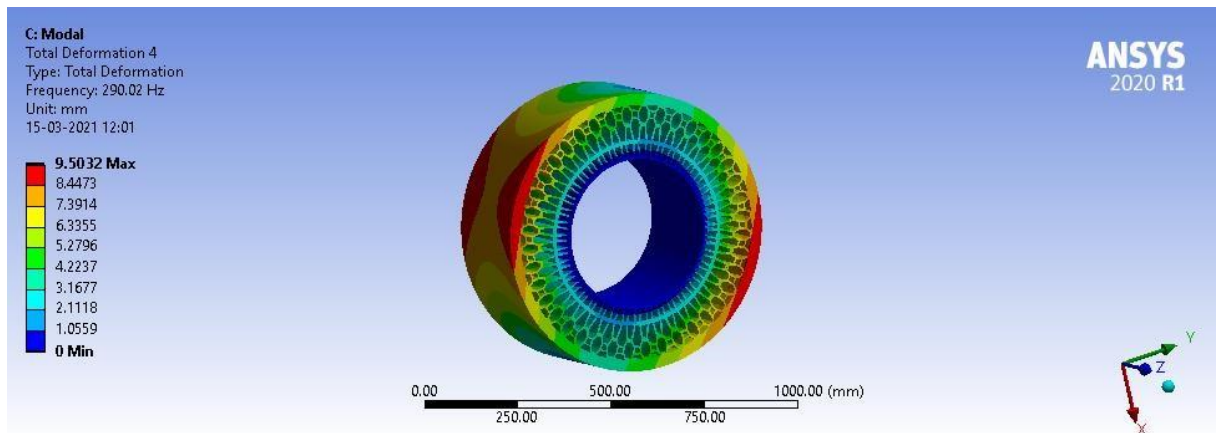


Fig:5.22 Tyre 1 Mode Shape 4

The figure shows that Frequency response analysis done on the Tyre at frequency (F)=290.02 Hz and the total deformation value for the fourth model 1 is 9.5032mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 5:

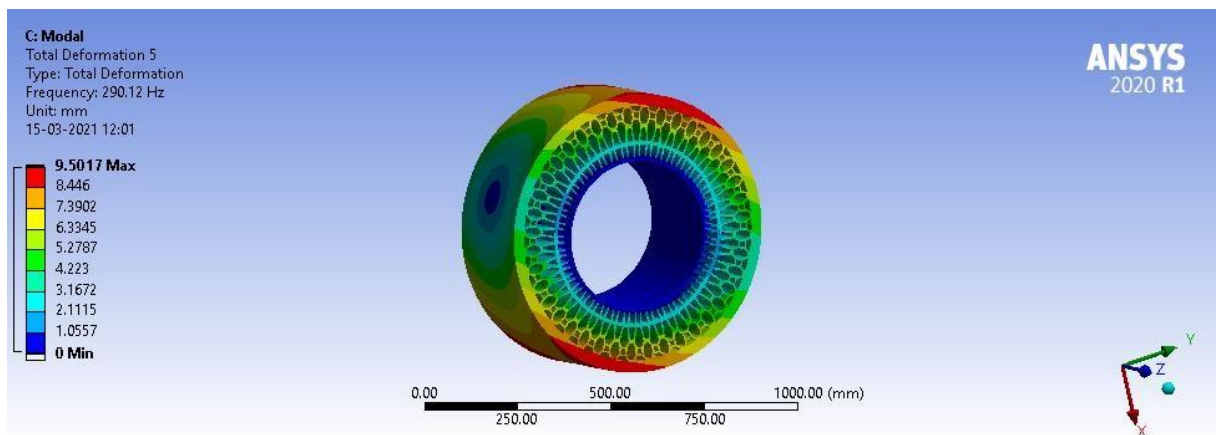


Fig:5.23 Tyre 1 Mode Shape 5

The figure shows that Frequency response analysis done on the Tyre at frequency (F)=290.12 Hz and the total deformation value for the model 1 is 9.5017mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 6:

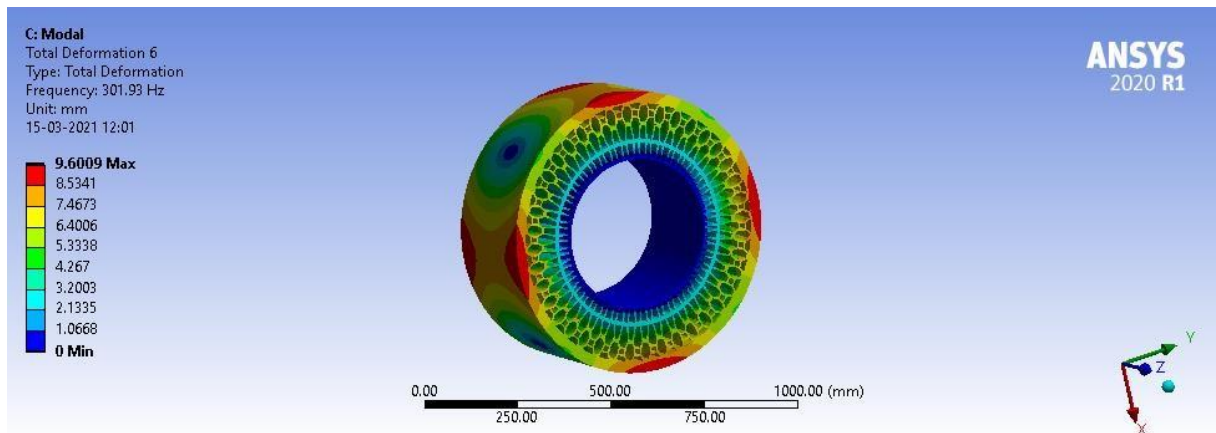


Fig:5.24 Tyre 1 Mode Shape 6

The figure shows that Frequency response analysis done on the Tyre at frequency (F)=301.93 Hz and the total deformation value for the model 1 is 9.6009mm. The red colour indicates the total deformation.

Tyre Model 1 Output:

Table:5.3 Modal Tyre 1 Output

MODE	1	2	3	4	5	6
FREQUENCY (Hz)	89.057	249.86	250	290.02	290.12	301.93

Modal Analysis -Tyre Model 2

Total Deformation (mm) Mode shape 1:

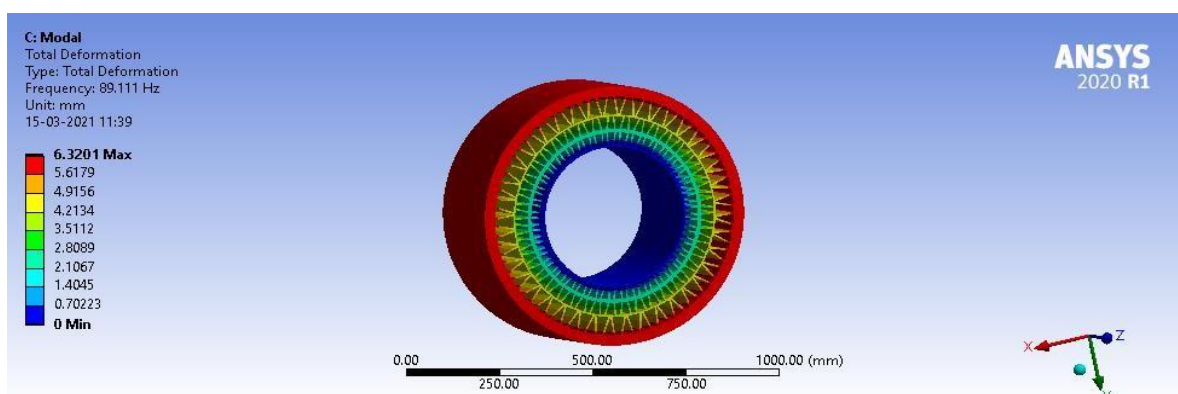


Fig:5.25 Tyre 2 Mode Shape 1

The figure shows that Frequency response analysis done on the Tyre at Frequency (F)=89.111 Hz and the total deformation value for the second model is 6.3201mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 2:

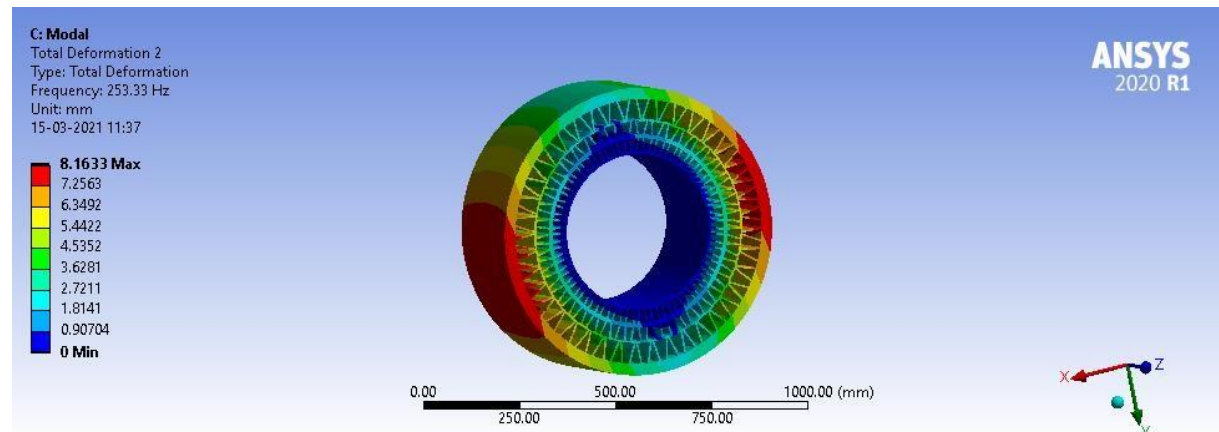


Fig:5.26 Tyre 2 Mode Shape 2

This figure shows that Frequency response analysis done on the Tyre at Frequency (F)=253.33Hz and the total deformation value for the second model is 8.1633mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 3:

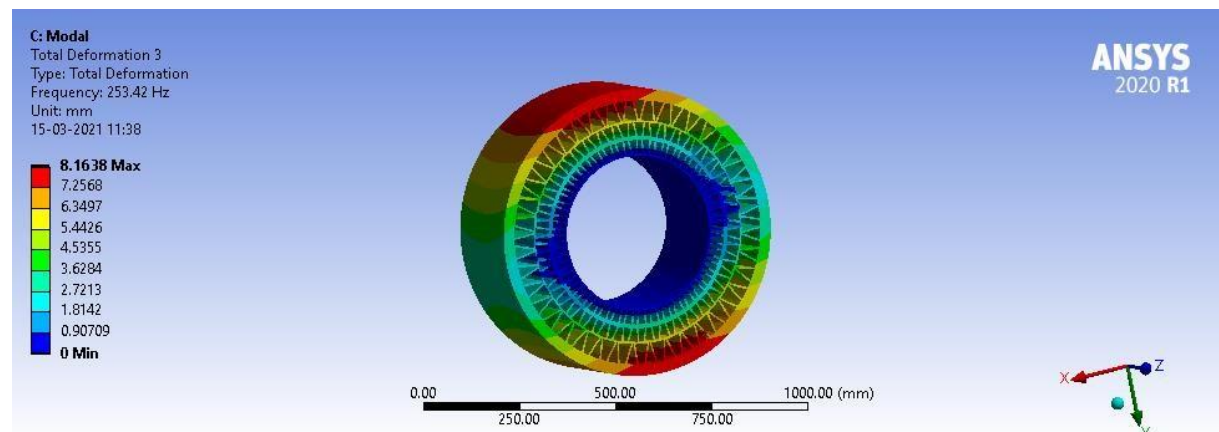


Fig:5.27 Tyre 2 Mode Shape 3

This figure shows that Frequency response analysis done on the Tyre at frequency (F)=253.42 Hz. The total deformation value for the second model is 8.1683mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 4:

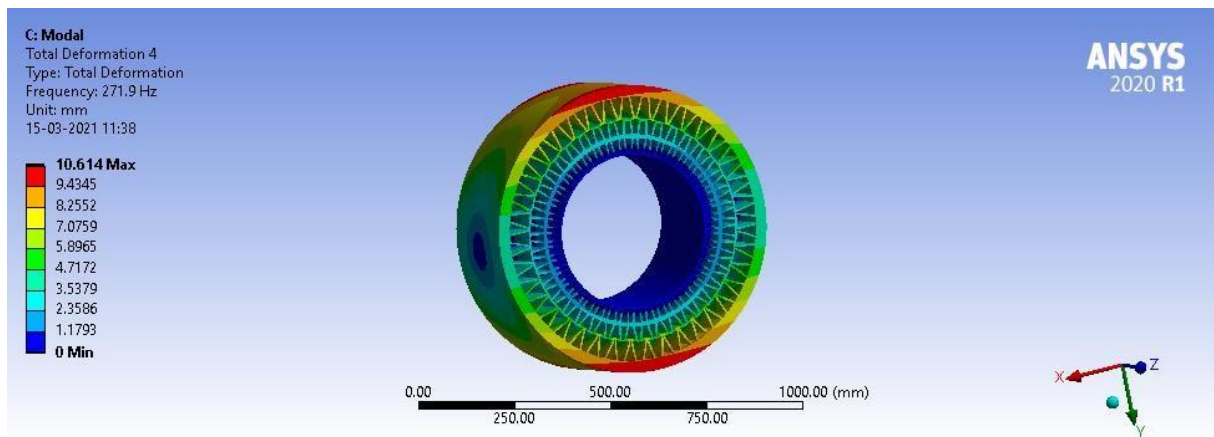


Fig:5.28 Tyre 2 Mode Shape 4

This figure shows that Frequency response analysis done on the Tyre at frequency (F)=271.9 Hz. The total deformation value for the second model is 10.614mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 5:

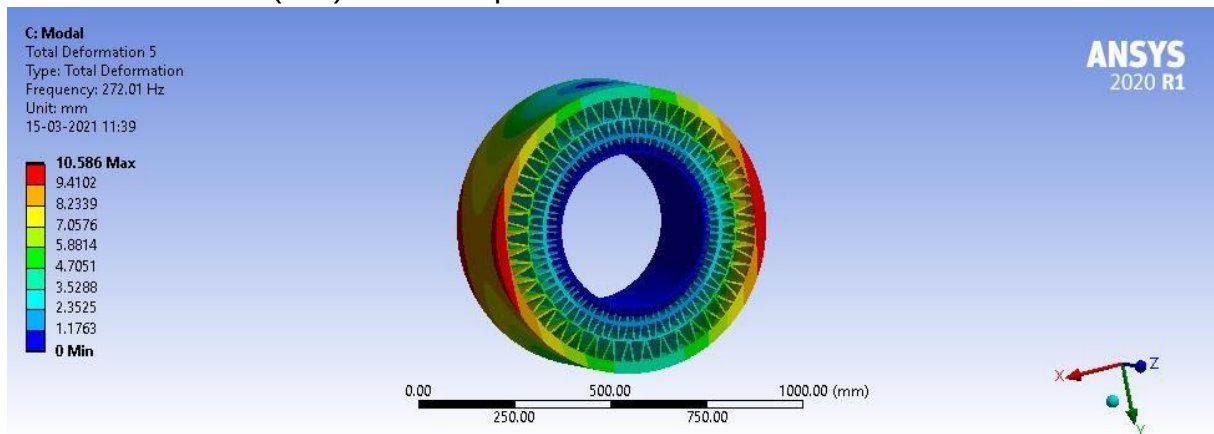


Fig:5.29 Tyre 2 Mode Shape 5

This figure shows that Frequency response analysis done on the Tyre at frequency (F)=272.01 Hz. The total deformation value for the second model is 10.586mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 6:

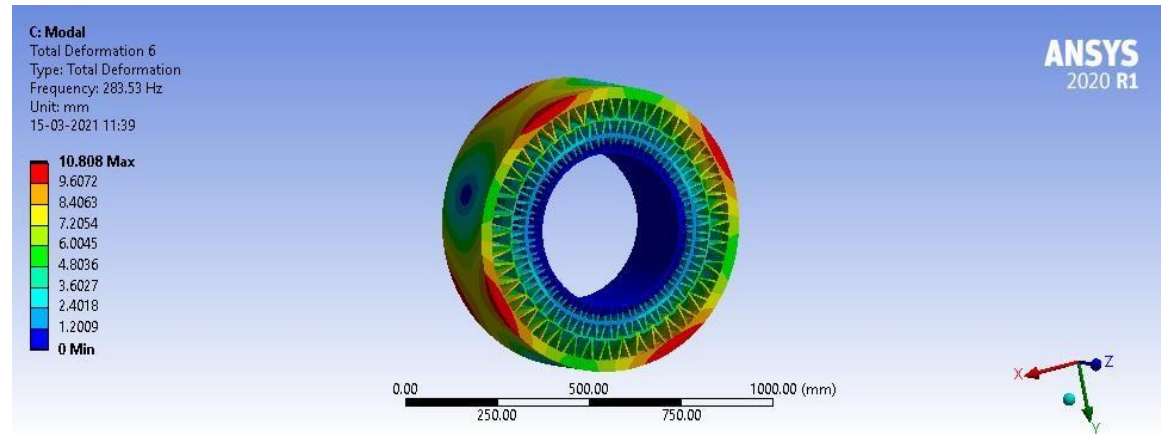


Fig:5.30 Tyre 2 Mode Shape 6

This figure shows that Frequency response analysis done on the Tyre at frequency (F)=283.53 Hz. The total deformation value for the second model is 10.808mm. The red colour indicates the total deformation.

Tyre Model 2 Output:

Table:5.4 Modal Tyre 2 output

MODE	1	2	3	4	5	6
FREQUENCY (Hz)	89.111	253.33	253.42	271.9	272.01	283.53

Modal Analysis -Tyre Model 3

Total Deformation (mm) Mode shape 1:

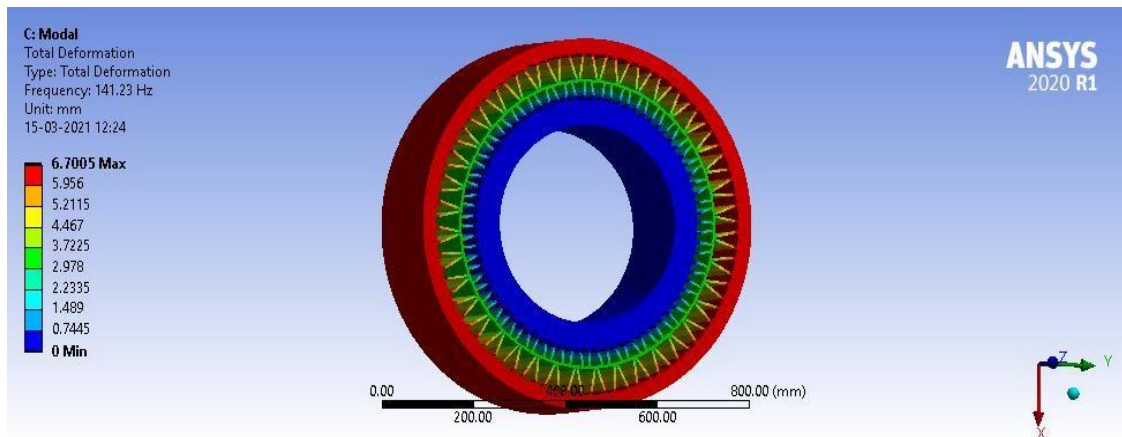


Fig:5.31 Tyre 3 Mode Shape 1

This figure shows that Frequency response analysis done on the Tyre at Frequency (F)=141.23 Hz. The total deformation value for the third model is 6.7005mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 2:

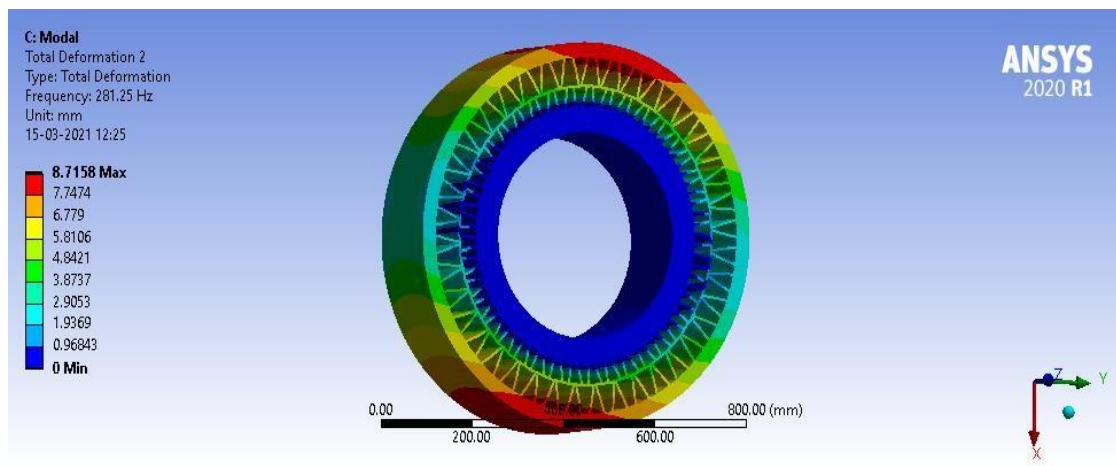


Fig:5.32 Tyre 3 Mode Shape 2

This figure shows that Frequency response analysis done on the Tyre at frequency (F)=281.25 Hz. The total deformation value for the third model is 8.7158mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 3:

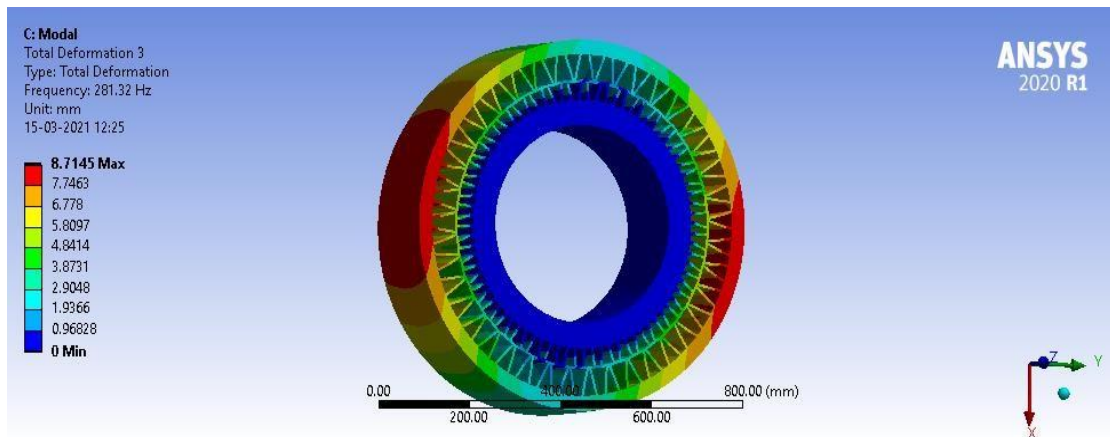


Fig:5.33 Tyre 3 Mode Shape 3

This figure shows that Frequency response analysis done on the Tyre at frequency(F)=281.25 Hz. The total deformation value for the third model is 8.7145mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 4:

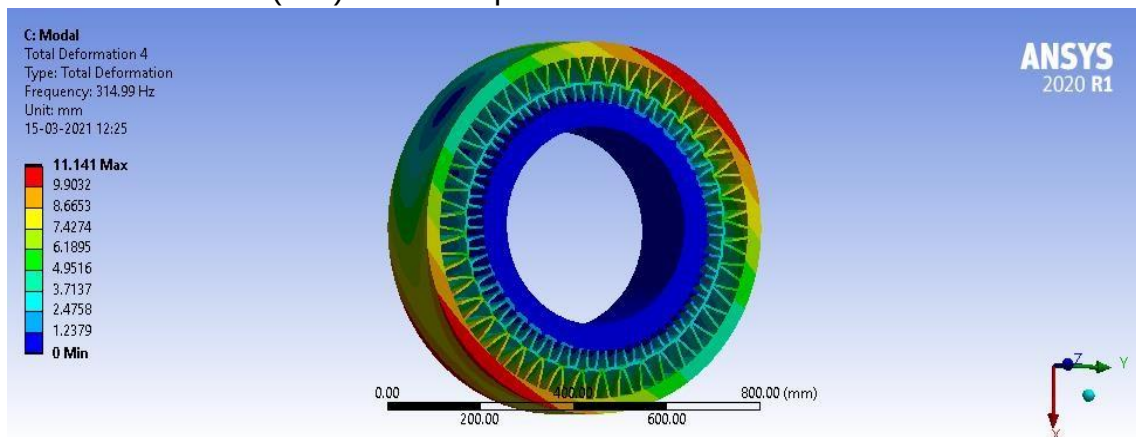


Fig:5.34 Tyre 3 Mode Shape 4

This figure shows that Frequency response analysis done on the Tyre at frequency (F)=314.99 Hz. The total deformation value for the third model is 11.141mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 5:

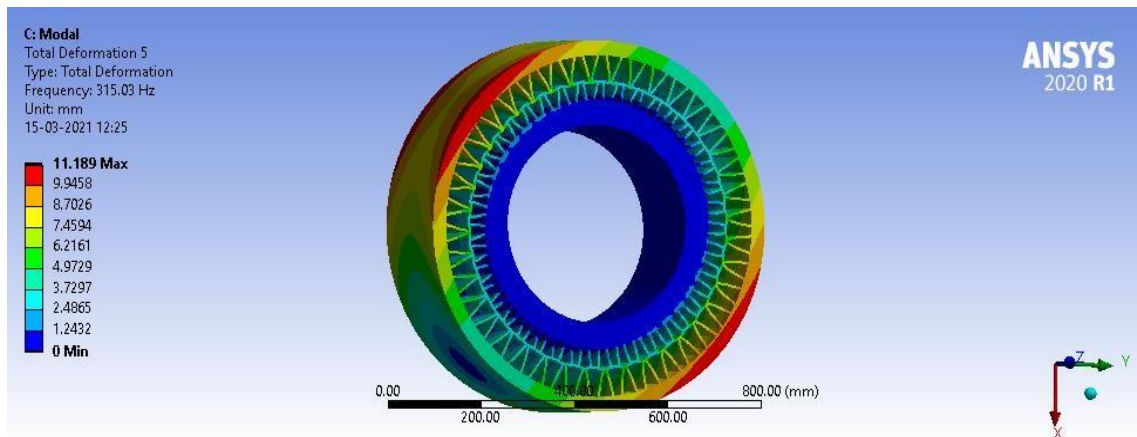


Fig:5.35 Tyre 3 Mode Shape 5

This figure shows that Frequency response analysis done on the Tyre at frequency (F)=315.03 Hz. The total deformation value for the third model is 11.189mm. The red colour indicates the total deformation.

Total Deformation (mm) Mode shape 6:

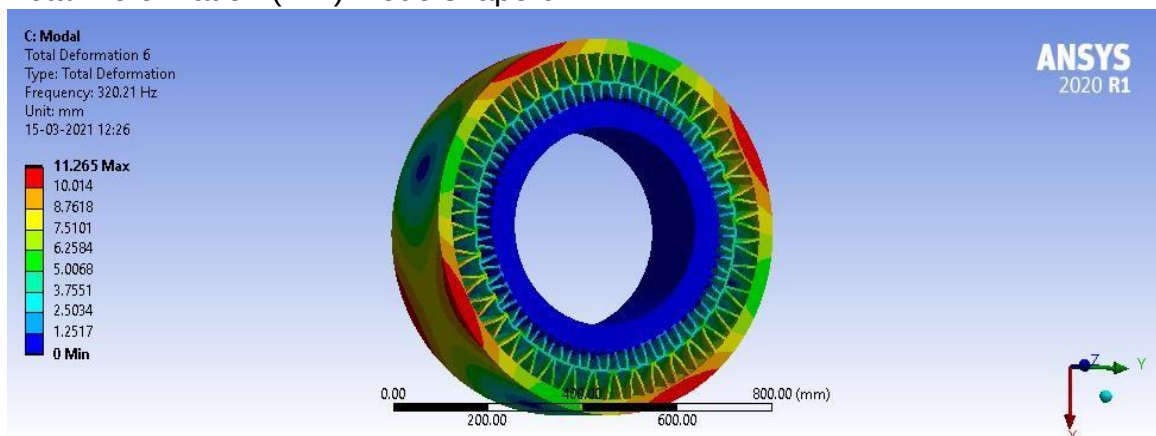


Fig:5.36 Tyre 3 Mode Shape 6

This figure shows that Frequency response analysis done on the Tyre at frequency (F)=320.21 Hz. The total deformation value for the third model is 11.265mm. The red colour indicates the total deformation.

Tyre Model 3 Output:

Table:5.5 Modal Tyre 3 Output.

MODE	1	2	3	4	5	6
FREQUENCY (Hz)	141.23	281.25	281.25	314.99	315.03	320.21

5.4 RESULT:

Dead Load Analysis :

This is a condition at which the vehicle is in immobilized condition. All the self weight of the vehicle and the Weight of the average sized four passengers will get distributed on the four wheels of the vehicle.

The Tyres have to withstand the loading condition with the minimal deflection due to the dead load of the vehicle without any failure.

Bump Load Analysis:

When the vehicle is in motion some of the other dynamic forces will get added to the wheels . If the vehicle approaches a sudden bump in the road then most of the vehicles load will be transferred to the wheel which hits the bump and the wheel experiences a sudden shock load due to that bump.

The tyres should bear the sudden shock loads and have the capacity of absorbing the shock.

5.4.1 Dead And Bump Load Analysis:

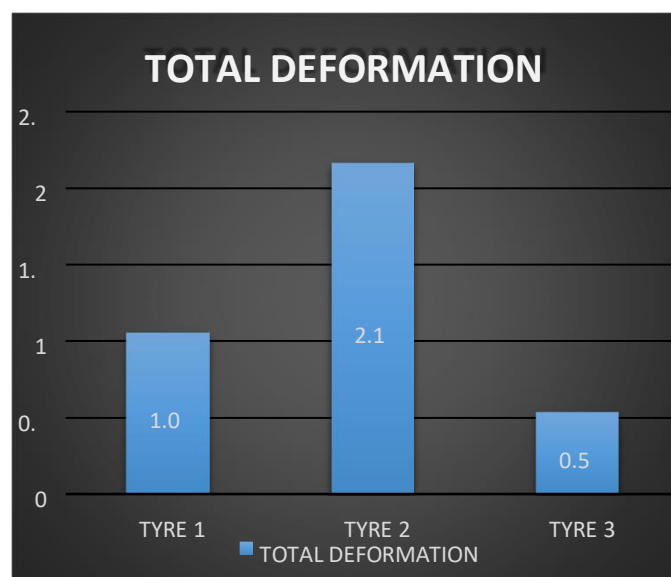
The following table represents the result of Dead Load Analysis and Bump Load Analysis.

From the result table we can identified the total deformation and equivalent stress values for the three diffirent airless Tyre models . In the result comparison for all the three the model 3 has Less deformation and equivalent stress when compared with other two models.

TABLE;5.6 Result For Dead And Bump

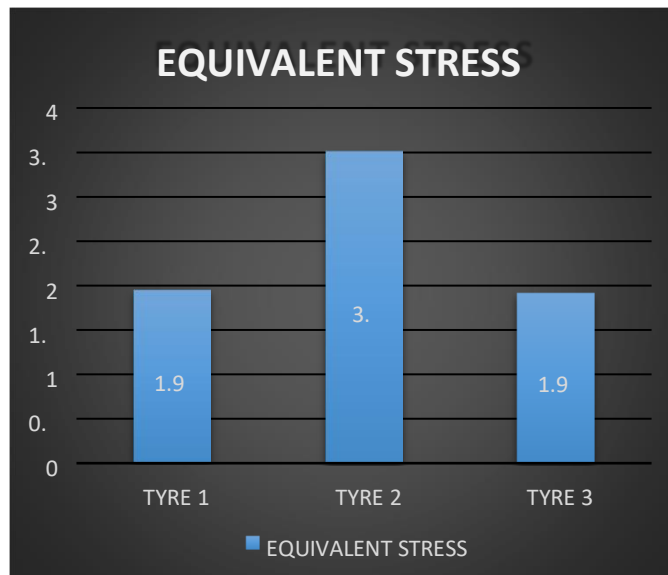
TYRE MODEL	Dead Load analysis		Bump load analysis	
	Total Deformation	Equi.stress (Mpa)	Total Deformation	Equi.stress (Mpa)
MODEL 1	1.05	1.94	2.97	6.29
MODEL 2	2.16	3.50	6.185	11.912
MODEL 3	0.53	1.910	0.50	5.490

5.4.2 Dead Load Analysis graph



Graph:5.1 Total deformation For Dead load

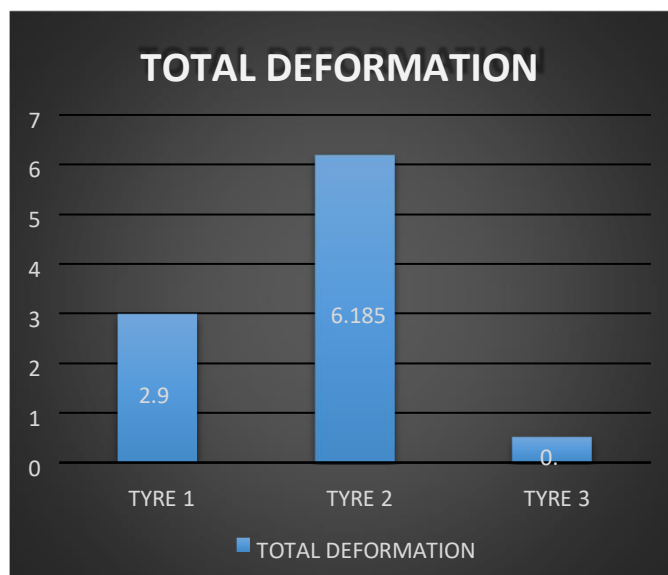
This graph represents the total deformation of three Tyres from Dead load analysis. In this Tyre 3 has less deformation when comparing with all the three Tyres.



Graph:5.2 Equivalent Stress For Dead Load.

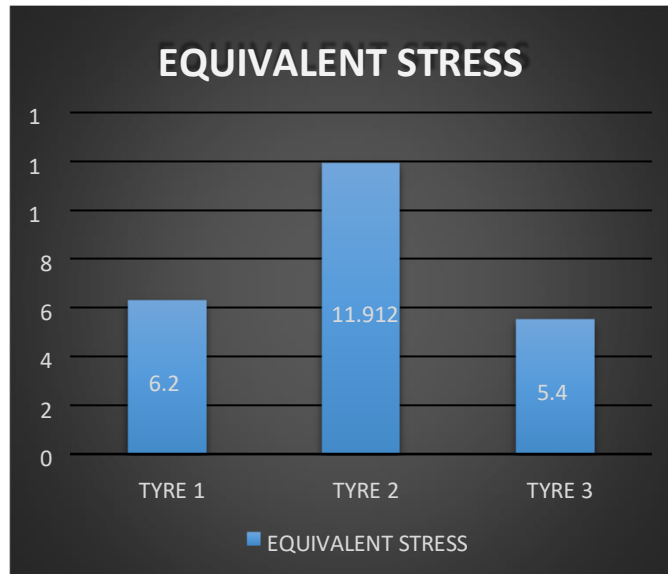
This graph represents the equivalent stress of three Tyres from Dead load analysis. In this Tyre 3 has less stress when comparing with all the three Tyres.

5.4.3 Bump Load Analysis graph



Graph:5.3 Total Deformation For Bump Load.

This graph represents the total deformation of three Tyres from Bump load analysis. In this Tyre 3 has less deformation when comparing with all the three Tyres.



Graph: 5.4 Equivalent Stress For Bump load.

This graph represents the equivalent stress of three tyres from Bump load analysis. In this Tyre 3 has less stress when comparing with all the three tyres.

5.5 MODAL ANALYSIS

In order ensure the rider Quality the tyre should have the tendency to absorb the shocks and vibrations from the contact surface such as road, bump.

The modal analysis is to determine how the tyre is vibrating at the fixed conditions.

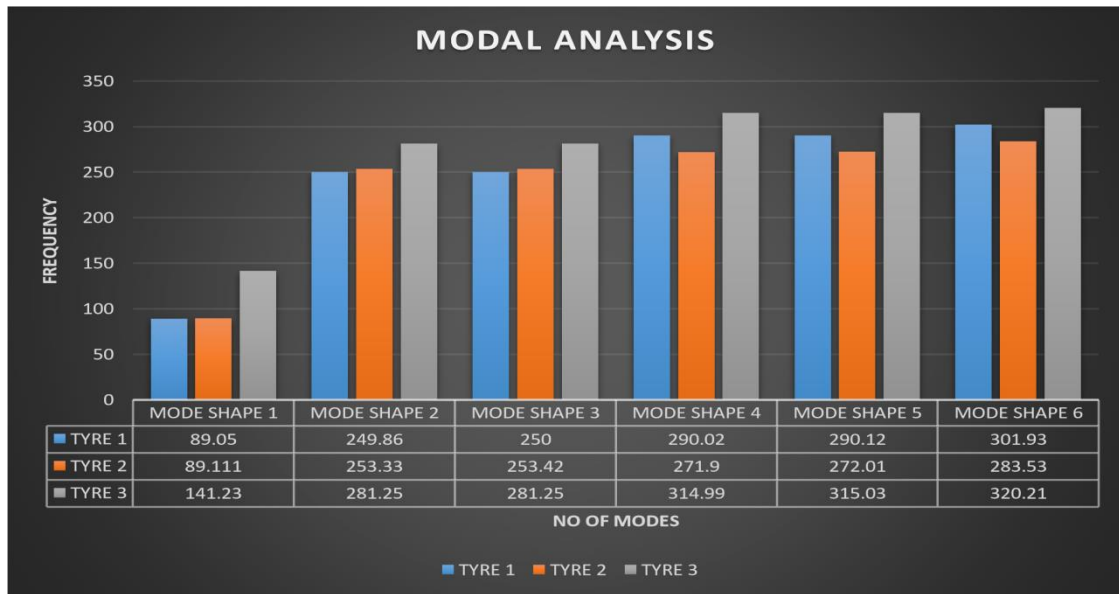
The following table represents the result of Modal Analysis.

In the below table we identified Tyre 3 has less vibration when compared with other two tyres.

Table:5.7 Result For Modal Analysis.

TYRE MODEL	Modal analysis					
	1	2	3	4	5	6
TYRE MODEL 1	6.1266 (89.057 Hz)	8.1293 (249.86 Hz)	8.1318 (250 Hz)	9.5032 (290.02 Hz)	9.5017 (290.12 Hz)	9.6009 (301.93 Hz)
TYRE MODEL 2	6.3201 (89.111 Hz)	8.1633 (253.33 Hz)	8.1638 (253.42 Hz)	10.614 (271.9 Hz)	10.586 (272.01 Hz)	10.808 (283.53 Hz)
TYRE MODEL 3	6.7005 (141.23 Hz)	8.7158 (281.25 Hz)	8.7145 (281.25 Hz)	11.141 (314.99 Hz)	11.189 (315.03 Hz)	11.265 (320.21 Hz)

5.5.1 Modal Analysis graph



Graph:5.5 Bar Graph.

The following graph represents the natural frequency of the three different non pneumatic Tyres. In this blue colour represents Tyre 1, orange colour represents Tyre 2 and Grey colour represents Tyre 3.

CHAPTER 6

CONCLUSION

6.1 CONCLUSION

- The Tyre design which has minimum deflection, possesses the maximum stiffness .
- Based on the results, The model 2 has more deflection probably it possesses minimum stiffness.
- In comparison with model 1 and model 3 , model 3 has less deflection and it possesses maximum stiffness.
- Replacing the honey comb design with the suitable alternate and adding material to the inner band of the non pneumatic Tyre will lead to greater improvements in the stiffness.

Use of air-less tyre eliminates disadvantages faced by pneumatic tyres. Air-less tyre provides uniform adhesion and uniform wear while absence of air. The airless tyres need not to be replaced very often and if it wears out and needed to be replaced the outer band of the airless tyre is replaced which saves material in manufacturing point of view. In pneumatic tyres, there was a high possibility of the flatten which can cause more number of accidents. Using airless tyres it's an outsized impact on safety. If the vehicles with airless tyres are used then one needn't worry about safety. Another benefit is that they're going to be reused and earlier tyres go flat and wish to be thrown away so there was the need for the event of airless tyres. Driving these vehicles reduces mind-stress. In this work there dimensional model of airless tyre with different spoke structures are generated and finite element analysis is carried out. From the FEA results of different structures, the airless tyre with honeycomb structure is replaced with fill of material structure proves to be more durable than other structures and the conventional tyre.

The NPT based on honeycomb structure is replaced with fill of material spokes can be used to replace a conventional pneumatic tyre since they provide uniform traction and wear as that of conventional tyre and also it offers good strength, fatigue life (endurance limit), reliability and reduces the overall weight and cost than the conventional pneumatic tyre

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