Design And Analysis Of New Generation Non Pneumatic Tyre Concept

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Abstract- *This work is to provide advanced level solution for 4 wheeler wheels to provide puncture proof, stable and self shock absorber wheels with longer life to provide safe and comfortable rides.as new type of alloy wheels are not permitting heavy loads and also getting yield during bumps and pits in long run. Hence in this project geometric and material optimization is analysed using different types of lattice (spokes) structure and composite materials using finite element analysis on the basis of loading/impacts. After achieving the best structure and material using finite element analysis regarding load/stress conditions the same is suggested in place of pneumatic tyres with alloy wheels to over come the drawbacks of pneumatic tyres.*

Keywords- Tweel , Structural Analysis , Materials , Optimisation , New Composites.

I. INTRODUCTION

For more than 100 years, vehicles have been rolling along on cushions of air encased in rubber. Sometimes, we get so used to a certain product that no true changes are ever really made for years, decades even. So begins an article discussing the development of airless tires, something that has become more prevalent in the past few years. A few tire companies have started experimenting with designs for non-pneumatic tires including Michelin and Bridgestone, but neither design has made it to mass production.

Creating a new non-pneumatic design for tires has more positive implications than one might think. For one thing, there are huge safety benefits. Having an airless tire means there is no possibility of a blowout, which, in turn, means the number of highway accidents will but cut significantly. Even for situations such as Humvees in the military, utilizing non-pneumatic tyres has a great positive impact on safety. Tyres are the weak point in military vehicles and are often targeted with explosives. If these vehicles used airless tyres, this would no longer be a concern.

There is also an environmental benefit to using this type of tyre. Since they never go flat and can be retreaded, airless tyres will not have to be thrown away and replaced nearly as often as pneumatic tyres. This will cut down landfill mass significantly.

Because of the benefits, I believe that it is extremely important that research and production of airless tyres is continued and increased. This type of innovation works well in conjunction with several engineering codes of ethics, and thus should be embraced by engineers everywhere. Cars are things that people use every day, so any improvements over existing designs would affect the lives of the majority of people. Learning about such a topic, therefore, I believe holds extreme value- especially for us freshmen engineering students. In doing research into these kinds of topics that hold significant meaning, we can see that what we will do can make a difference.Going back in history, initially a craftsman known as wheelwright forged bands of iron & steel, tying the wheel segments together as the metal contracted around the wheel. Hence the name, tyre, as it tied the wheel together. This was then placed on wooden wheels of carts and wagons.

Explorers had seen Indians using sheets of rubber for waterproofing and in the 1800's, Charles Mcintosh was experimenting with this latex – sap from a tree in the Amazon. It had its problems as the cold weather caused it to be brittle whilst in hot weather they became sticky. However, in 1839, Charles Goodyear discovered that by adding sulphur to the melted latex it gave elasticity and strength. This vulcanized rubber was used to as cushion tyres for cycles.

John Dunlop, trying to make his son's bicycle more comfortable to ride on, managed to invent the pneumatic tyre. Another person, Robert Thomson, had already patented the idea of a pneumatic rubber tyre so the Dunlop Rubber Company was established and won a legal battle with Thomson. In 1891, the detachable pneumatic tyre was invented by two brothers, Micheline, consisting of a tube bolted on to the rim.

In 1948, Michelin revealed the first radial tyre was developed and this was a revolutionary achievement as it used steel-belted radial tyres. The advantages meant longer life and

increased mileage for the vehicle. However, it required a different suspension system and so was slowly adopted. This was the tyre along with Dunlop's invention, which gives us the tyre we have today.

We have seen heavy tyre development, especially in motorsport, however we are yet to see anything as revolutionary as previous key points in history. There have been concepts, with a major one being the Michelin Tweel announced in 2005.

II. PROBLEM DESCRIPTION

In this project geometric and material optimization is analyzed using different types of lattice structure and with composite materials using Finite element analysis on the basis of loading conditions.

New model tweel/Airless tyre is introduced in this project which is not having tube instead of a rubber layer and self-shock absorbing system with best structure for stability and best material for durability is analyzed and suggested in place of pneumatic tires with alloy wheel to overcome the above drawbacks.

III. LITERATURE REVIEW

1. Sadok Sassi, Mohamed Ebrahemi, Musab Al Mozien and Yousef El Hadary [1], modern pneumatic tires (PT) are the results of enormous progress in science, technology, and manufacturing process. However, they are still subjected to adverse problems that could compromise the road safety and lead to accidents of different severities.
2. Vinay T V, Kuriakose J Marattukalam, Sachu Zachariah Varghese, Shibin Samuel, Sooraj Sreekumar [2], a pneumatic tyre is made of an airtight inner core filled with pressurized air. Pneumatic tyres have been dominant in the world market due to many advantages like low mass design, low vertical stiffness and low contact pressure.
3. RutikaGotad, Sukanya Yadav , Aarti Dung [3], the paper introduces the new advanced developing tire technology which is used mainly in automobile industry. As we come across different types of accidents in our day to day life so in order to avoid such accidents, we had developed new technology as tweel tyre.
4. Raymond R. Ma, Joseph T. Belter, Aaron M. Dollar [4], this paper describes a novel fabrication technique called hybrid deposition manufacturing (HDM), which combines additive manufacturing (AM) processes such as fused deposition manufacturing (FDM) with material deposition and embedded components to produce multi material parts and systems for robotics, mechatronics, and articulated mechanism applications.
5. Rathindra Nath Biswas, Mohit Ojha and Arijeet Bhadra [5], a lot of new challenges are being posed in front of the automobile industry by the growing customer demands. Tire puncture is a common problem in Automotive Vehicles. We are thinking of a tire
6. M .Aboul Yazid et al(2013) examined three dissimilar structures of the Tweel, and conducted the quasi static, 2D analysis on contact pressure, vertical tire stiffness and stress which are effected by spoke structures and shear band by creating two NPTs, a tire with composite ring and another without composite ring. The result showed that shape and size of spokes has effect on tire behaviour and the shear layer reduces the impact of the deformed spokes.
7. Anuj suhag and Rahul Dayal has done static analysis on polyurethane spokes of airless tires their study involves fabrication of an airless tire prototype for domestic cars. this will be followed by a stress analysis study of prototype .the study has been done in solid works

IV. DESIGN FEATURES CONSIDERED

i. TREAD

The tread of a tire or track refers to the rubber on its circumference that makes contact with the road or the ground. As tires are used, the tread is worn off, limiting its effectiveness in providing traction. A worn tire can often be retreaded.

The grooves in the tire are correctly called the tread pattern, or simply the pattern, but the word tread is often used casually to refer to the pattern of grooves molded into the rubber. The grooves are not the tread, as they do not make contact with the ground. This distinction becomes significant in the case of racing slicks: which certainly have a tread but do not have grooves, and so they neither have a pattern.

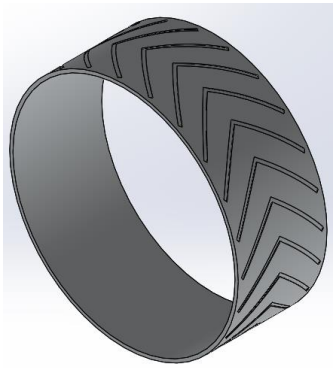


Fig 1 Tread of our Designed Tweel

ii. Deformable Spokes

A spoke is one of some number of rods radiating from the center of a wheel (the hub where the axle connects), connecting the hub with the round traction surface.

The term originally referred to portions of a log that had been split lengthwise into four or six sections. The radial members of a wagon wheel were made by carving a spoke (from a log) into their finished shape. A spokeshave is a tool originally developed for this purpose. Eventually, the term spoke was more commonly applied to the finished product of the wheelwright's work, than to the materials he used.

Our design of Deformable Spokes

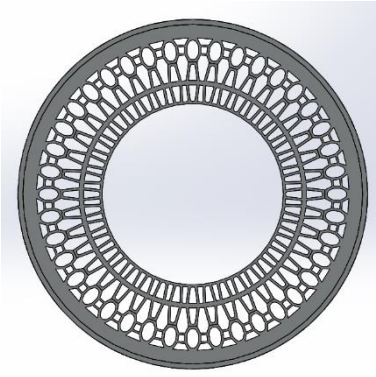


Fig 2 Tweel Design 1

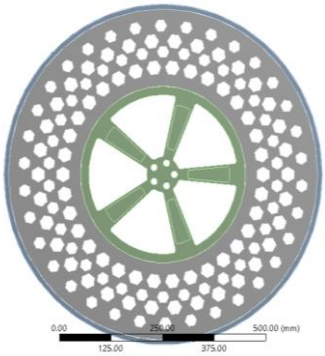


Fig 3 Tweel Design 2

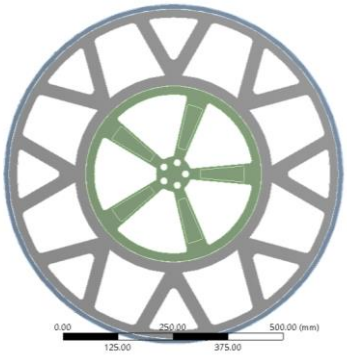


Fig 4 Tweel Design 3

V. FEA SIMULATION

The FEM is a numerical technique used to resolve problems which describe by differential equation or can be resolve as a functional minimization. In finite elements approximating functions or determined with the help of nodal values of continuum which is sought. The physical problem is converted into a discretized small finite element problem with unknown nodal values. FEM is a computer program utilize to analyse a material and to find how stresses will effect the design or material for the applied load

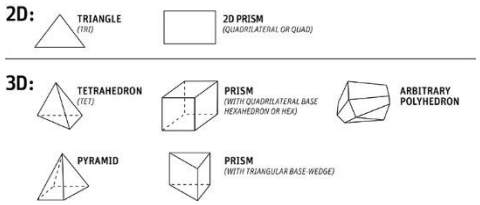
1. Developing a 3d individual part models
2. Assembling them together using solidworks assembly
3. Modelling and changing lattice structures in assembly
4. Converting them into STEP file
5. Importing the STEP FILE INTO ANSYS WORKBENCH design modeller
6. Meshing using mesh modeller.
7. Assigning appropriate materials.
8. Assigning boundary conditions.
9. Selecting the loading conditions and fixed conditions.
10. Considering static loading conditions.
11. Obtaining and investigating results

Points 1 to 5 are discussed in the Above Chapter including detailed structure dimensions and Overview

VI. MESHING

Meshing is an integral part of the engineering simulation process where complex geometries are divided into simple elements that can be used as discrete local approximations of the larger domain. The mesh influences the accuracy, convergence and speed of the simulation. Furthermore, since meshing typically consumes a significant portion of the time it takes to get simulation results, the better

and more automated the meshing tools, the faster and more accurate the solution.



Triangle: This cell shape consists of 3 sides and is one of the simplest types of mesh. A triangular surface mesh is always quick and easy to create. It is most common in unstructured grids.

2D Prism: This cell shape is a basic 4 sided one as shown in the figure. It is most common in structured grids.

Tetrahedron: A tetrahedron has 4 vertices, 6 edges, and is bounded by 4 triangular faces. In most cases a tetrahedral volume mesh can be generated automatically.

Prism: A prism has 6 vertices, 9 edges, bounded by 2 triangular and 3 quadrilateral faces. The advantage with this type of layer is that it resolves boundary layer efficiently.

Pyramid: A quadrilaterally-based pyramid has 5 vertices, 8 edges, bounded by 4 triangular and 1 quadrilateral face. These are effectively used as transition elements between square and triangular faced elements and other in hybrid meshes and grids.

Polyhedron: A polyhedron (dual) element has any number of vertices, edges and faces. It usually requires more computing operations per cell due to the number of neighbours (typically 10).[2] Though this is made up for in the accuracy of the calculation.

Fig 6Meshing of the Geometry consider

The Above fig Represents the Tweel geometry designed for simulation the designed model is then imported to the ansys module there on it is meshed using tetrahedron elements as we can see the tweel model is discretized with the tetrahedron elements this meshing configuration gives the accurate results.

Material Selection:

The Configuration of materials considered to simulate the Tweel model Hub is considered to be aluminum at all times the Tire material is considered to be tread and the spokes are considered to be Epoxy carbon UD and Epoxy E glass. respectively.

Assigning Boundary Conditions:

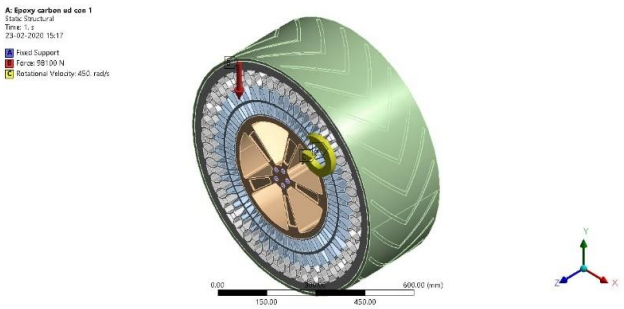


Fig 7 Loading Conditions for Simulation

The above fig represents the loading conditions of the geometry considered the mounting holes in the hub is considered as fixed and the constant load of 98100 N are applied in the downward direction with a wheel rotation velocity of 450 rad/s considered for all 3 configuration same loads are considered to perform the simulation for all the 3 designs.

VII. RESULTS SUMMARY

Epoxy carbon UD	Design	Deformation (mm)	Shear(Mpa)	Von mises (Mpa)	Mass(kg)
	Hybrid ribs	1.153	102.5	269.79	28.31
	Pentagonal	1.038	90.562	219.22	61.34
	Triangle	4.16	813.93	1190.4	38.72
Epoxy E glass				Epoxy E glass	
	Design	Deformation (mm)	Shear	Von mises	
	Hybrid ribs	1.2781	133.53	333.27	25.45
	Pentagonal	1.103	119.44	280.74	56.01
	Triangle	5.9055	1052.4	1489.1	35.54

VIII. CONCLUSION

- Design and development of air-less tire eliminates air in the tire. Air-less tire can provide uniform traction and uniform wear while absence of air.
- The 3 Configuration designs satisfies the main functions of the tire.

- Air-less tire has two components that are outer band and flexible inner band. In the air-less tire design manufacturing point of view ,material saving is obtained by replacing outer band only after tread wear.
- The flexible inner band repeated use obtained green engineering and also reduce the environmental pollution. The driver mind-stress may reduce by using air-less tire in automobile by avoiding air related problems in the tire.
- In this thesis Epoxy Carbon UD and Epoxy E Glass materials are used, among these two materials Epoxy Carbon UD is preferable.
- From static structural, I concluded that, the material Epoxy Carbon UD is preferable one, Pentagon inner Band because the material Epoxy Carbon UD is got less deformation as 1.030 mm and stress 90.562 MPa from static structural analysis.

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