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OPTIMIZATION OF CELL ANGLE OF HONEYCOMB SPOKES FOR NON-PNEUMATIC TYRE

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Abstract - *A conventional tyre is made up of air enclosed rubber packed by means of compressed air. Conventional tyres over period have been dominating the world marketplace because it exhibits ride excellence and robustness. But it has a disadvantage such as burst out while driving, compound manufacturing method, the necessity to keep interior pressure. An innovative technology is under advancement to exploit only one of its kind blends of materials and geometry that does not need compressed air to hold up the load. Hence Non-pneumatic tyres were introduced. The designing was carried out in CATIA and the static analysis was conducted in Ansys Workbench. A brief structural study has been done on spokes of airless tyre and analyzed by ANSYS software.*

Key Words: **Honeycomb structure, Spokes, Deformation, Rolling Resistance, NPT, CATIA, ANSYS.**

1. INTRODUCTION

Since the earlier invention of a NPT in 1920's, the NPT is getting more attention due to its advantages over the pneumatic counterpart. Many design studies are still needed from the viewpoint of material, pattern, and structures. However, no systematic research for such important design issues has been reported in the literature up to now. The first npt (airless tire) was first developed in 2005 by michelin and it was named as Tweel. The tweel name is a combination of the words tire and wheel. Tweel's hub connects the flexible polyurethane spokes which are used to support an outer rim. If we use Non-Pneumatic tyre for a vehicle it absorbs the impact more efficiently than a regular tyre. The components of NPT in which shear band is the most important factor to absorb impact as it deforms and comes forth to it's original position. This is how the shear band helps by distributing the impact uniformly by deforming temporarily.

2. Literature Survey

Non-pneumatic tyres (NPT) are introduced with a compliant cellular solid spoke component which functions as air of a pneumatic tire. This project investigates hexagonal honeycomb spokes for NPT tire under macroscopic uni-axial loading. The spokes of an NPT undergoes tension-compression cycle while the tyre rolls. The spokes of an NPT is required to have both stiffness and resilience, which are conflicting requirements. Three types of honeycomb spokes are designed in AUTOCAD, namely A, B and C. Three dimensional models are created in CATIA. The mass of the designed tyres are found out. ANSYS finite element analysis is used to study about the deformation and stresses developed in different type of honeycomb spokes. Type C honeycomb spokes are found to be better considering both fatigue resistance and lower mass design

Table -1:

TABLE 1			
PART	HUB	Spokes	Outer ring
Material	AL7075-T66	Composite Polyurethane	AISI 4340
Density P,Kg/m3	2900	1350	7900
Youngs Modulus E	7300	35	22000

Chart -1: Hexagonal Honeycomb Spokes

3. METHADOLOGY

We designed a 3D model of a Non-pneumatic tyre using CATIA software and then that model was analysed using ANSYS software. The material and the mechanical properties were added in the ANSYS data accordingly. In ANSYS software we carried out a mesh analysis on a 3D model. After meshing we analysed the structure and the solution was obtained for total deformation, stress, strain and modal analysis. While designing of various protypes on CATIA we followed the standard process of designing like we started with 2D sketch by giving required dimensions. We then converted the 2D sketch into 3D by using padding command. After designing various parts of the wheel we then assembled all the parts of the wheel. By using various command like alignment, mate and contact constraint etc. and finally converted the saved file into a standard extension of ANSYS.

4. PROBLEM STATEMENT

Airless tyres usually have high rolling resistance compared to regular /conventional tyres. Also, NPT tends to dissipate less heat. It is a major problems which is stopping it from mass produced. In airless tyre the spokes and the shear band undergoes deformation simultaneously a load therefore it is mandatory to minimize the stresses and strain in the shear band and spokes. The shear band of NPT must have high fatigue resistance. Here after investigating and conducting several researches we found out that honeycomb spokes gives the best result among all the other spokes.

This is because of the light weight structure of the honeycomb spokes. If we speak about the honeycomb structure, it is made up of hollow cell and consisting of thin walls.

As NPT has high rolling resistance, this problem can be reduced by altering the cell angle. Honeycomb structure gets better with the increase in cell angle. Under cyclic load condition the spokes of airless tyre must have the properties of stiffness and resilience.

The material of the spokes have high modulus of rigidity then it will show less elastic strain. Our goal is to use the material which contains the properties high modulus of rigidity and low elastic strain limit.

5. PROTOTYPE

6. Geometric Dimensions

- The wheel size is 24.9" ×6.9" ×9.98"
- The hub or rim diameter is = 270mm.
- Inner hub diameter =210mm
- Hub thickness is = 27 mm.
- The outer ring diameter is = 610mm.
- The outer diameter of the wheel is =630 mm.
- The width of the wheel is = 165.5 mm.

7. ADVANTAGES

- The main advantage of airless tires is that they do not go flat.
- Other advantages are that airless tires need to be replaced less, resulting in savings.
- Heavy equipment outfitted with airless tires will be able to carry more weight and engage in more rugged activities.
- No maintenance required.
- Facilitate recycling
- Durability and long life.

8. DIS-ADVANTAGES

- Lack of adjustability
- Vibration
- Complex manufacturing process
- Not as economic as pneumatic tire

9. CONCLUSIONS

In this project, the spokes of airless tyres is examined with regular honeycomb spokes. NPT's do not have air like the regular tyres even though they can overcome many disadvantages and drawbacks offered by a regular NPT like high sustainability.

In NPT it is required to maintain proper air pressure. The manufacturing process of NPT is rather complex. The constituent materials of a hexagonal honeycomb spokes were studied. Various prototypes of spokes are modelled and their static structural analysis was conducted. The total mass of the designed models were found out from CATIA. We observed that there is an increase in the mass due to increase in cell wall thickness. We conclude that the honeycomb spokes with a greater cell angle magnitude show lower stresses and better ride quality, which is good for a fatigue resistant spoke design. In NPT the maximum stress is found to be at the edges of the spokes which is at the contact between spokes and the outer ring. The NPT based on hexagonal honeycomb spokes can be used to replace a conventional pneumatic tyre. Hence a NPT with Hexagonal honeycomb spokes is a favourable replacement for a conventional pneumatic tyre.

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