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Study of Tweel Non-Pneumatic Tires

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Abstract: Non-Pneumatic Tyre (NPT) is an airless tire that supports the weight of the car. Although tires manufactured of solid rubber exist, they don't provide a smooth ride even though they have enough compliance if used in conventional vehicles. The NPT discussed here is mainly divided into three parts. Deformable spokes that support the downward weight, a rigid hub, Tread made out of rubber which comes into contact with the road and Reinforced shear band also plays a vital role. The properties of Non-Pneumatic Tyres like contact pressure, rolling resistance, and weight carrying capacity can be varied by differentiating the dimensions or the manufacturing materials used to produce NPT. Many kinds of research are taking place all over the world to make NPT an alternative option to the traditional pneumatic tire over a decade. This paper integrates an overview of the research works that were carried out to develop and improve NPT.
Keywords: Pneumatic, Tweel, Honeycomb structure, Hyperelastic

I. INTRODUCTION

Conventional tires or pneumatic tires are used on all types of moving vehicles. These tires are filled with pressurized air made of an airtight inner core. A tread that is usually reinforced with the steel belting or other similar materials, covers this inner core and acts as a barrier between the tire and road. The atmospheric pressure is lower than the pressure inside the tire of the air inside the tire, so the tire remains jacked up even with the weight of a vehicle resting on it. Resistance is provided by the tires' air pressure against forces that try to deform the tire, but to a certain degree, it gives -a padding effect as the tire hits bumps in the road. These tires have some major disadvantages, mostly in highly dangerous or high-performance applications. The main problem, of course, is that a little hole in a tire results in total failure. This blowout can lead to a dangerous road accident due to overspeeding. Military personnel is worried about tires getting blown out by gunfire. A vehicle crew's worst nightmare is getting enclosed in a fire zone due to their tires being all flat. Now for over a century, our vehicles have been functioning on these pneumatic tires. These pneumatic tires have been very helpful to drivers and passengers on-road as well as off-road, but the new design created by the Michelin Company could change all that – the Tweel airless tire. As no air is present in the tire, it cannot burst out or become flat. The flexible polyurethane spokes are connected to the Tweel's hub which is used to support an outer rim that plays the shock-absorbing role of a traditional tire's pneumatic properties.

II. LITERATURE SURVEY

1) Jae Hyung Ju et al. has accomplished exhaustive investigation on the Elastic cellular solid spokes of a stagnant tire presented with the cellular solid spoke, which recreates the part of air as the pneumatic tire, which serves as the air of the pneumatic tire. Here, various iterations of the honeycomb and other shock-dampening structure methods are examined.
2) Amir Gasmi et al. have designed a two-dimensional instance of a compliant non-pneumatic tire. The examination delivers an analytical prototype for a compliant non-pneumatic tire on frictionless, rugged ground. The standard was validated by comparison with two computational instances using the commercial finite component software ABAQUS and empirical rolling resistance data.
3) Nibin Jacob Mathew et al. have examined the Plan and static calculation of airless tires to facilitate deformation. In this creation, a measure of an airless tire is presented with a reserve of natural rubber materials in the position of synthetic rubber in tread and polyester in the place of nylon in the carcass. A momentary structural investigation has been accomplished on the spokes of the airless tires and examined by ANSYS software. The investigation has been taken out on several configurations like a honeycomb, Spokes, triangular, and diamond.
4) Bert Bras and Austin Cobert have discovered the Life-cycle Environmental consequences of Michelin Tweel Tire for passenger Automobiles. The tweel tire could result in a negligibly comparable if not more environmentally agreeable interpretation than the numerous fuel-efficient tires on the market today.

III. METHODOLOGY

When the Tweel is put to the route, the spokes immerse road affects the identical way air coercion does in pneumatic tires. The track and shear bands are temporarily distorted due to bending of the spokes, then quickly spring brings back into shape again. Tweels can be made with additional spoke tensions, qualifying for other operating features. More pliant spokes result in a better relaxing ride with enhanced handling. The sideways immobility of the Tweel is also flexible. However, you can't modify a Tweel once it has been fabricated. Instead, you'll have to choose a separate Tweel. For testing, Michelin provided an Audi A4 with Tweels created with five times as considerably lateral stiffness as a pneumatic tire, resulting in "extremely responsive handling." Michelin reports that "The Tweel prototype is within 5 percent of the rolling oppose and the mass levels of normal pneumatic tires that decode to mean within 1 percent of the fuel thrift" of the tires on your automobile. Nevertheless, Michelin could enhance those numbers since the Tweel is exceptionally earlier in its expansion.

Fig 1: Tweel

Several vehicles are using non-pneumatic tires. Some of them are detailed below:

1) Earthmovers
2) NASA Lunar rover
3) Military vehicles

A. Earth Movers

The non-pneumatic tires provide increased stability to the earth movers to rise in all terrains. It provides a much smoother passage than a pneumatic tire due to its superior shock absorption. Even if the automobile is heavy, it will not harm the running surface. In expansion, the NPT is exceptionally immune to dents than the standard tires, which last longer.

Fig 2: Earthmover

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B. NASA Lunar Rover

It is a six-legged robot developed by NASA for moon exploration. All the wheels contain NPT. It can roll or walk over an extensive range of terrains and was designed to tackle various techniques. It is impossible to utilize pneumatic tires in the stretch because of vacuum; these airless tires have the upper hand in space exploration.

Fig 3: NASA lunar rover

C. Military Vehicle

American military automobiles such as Hummer, trucks, etc., are non-pneumatic tires. The primary benefit of the military automobiles utilizing this tire is that it needs extremely small or no supervision. It will stay portable even with some spokes impaired or missing. In addition, it passed the ballistic trial, i.e., it will remain portable even if it is pounded by ammunition, which is a benefit on the battleground.

Fig 4: Military vehicle with NPT

IV. DESIGNS

Earlier, honeycomb architects created an adequate in-plane modulus of hexagonal honeycombs utilizing the beam approach, and these products are collectively named cellular textiles view. The advanced honeycomb structures of the non-pneumatic tires are as follows. Six classes of honeycomb spokes are supposed for NPTs, as indicated in. Standard honeycombs and auxetic honeycombs with a negative adequate Poisson ratio are employed for the cellular spoke structure. Types A, B, and C are stable honeycomb structures, and types D, E, and F are auxetic. These six cellulars spoke designs are packed for the importance of vertical displacement of 20mm for each tire classification, and the force-displacement charts are analyzed.

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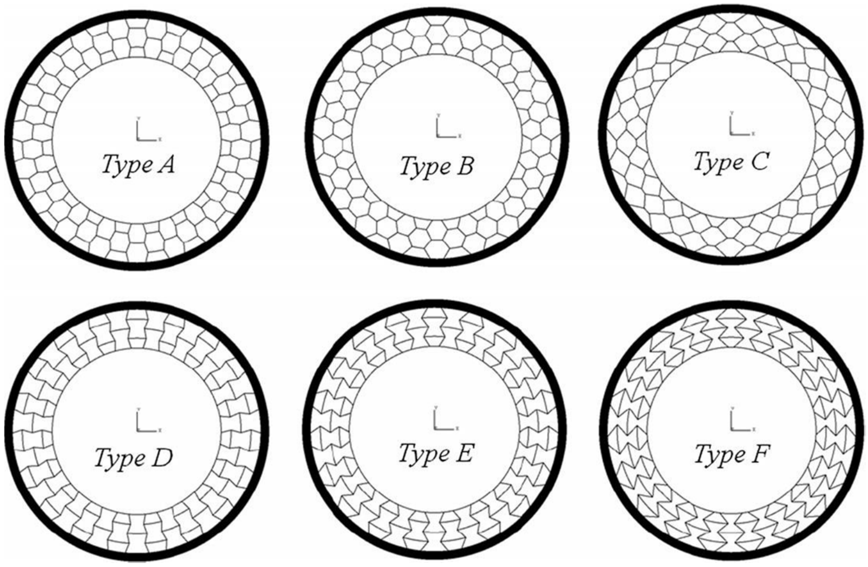
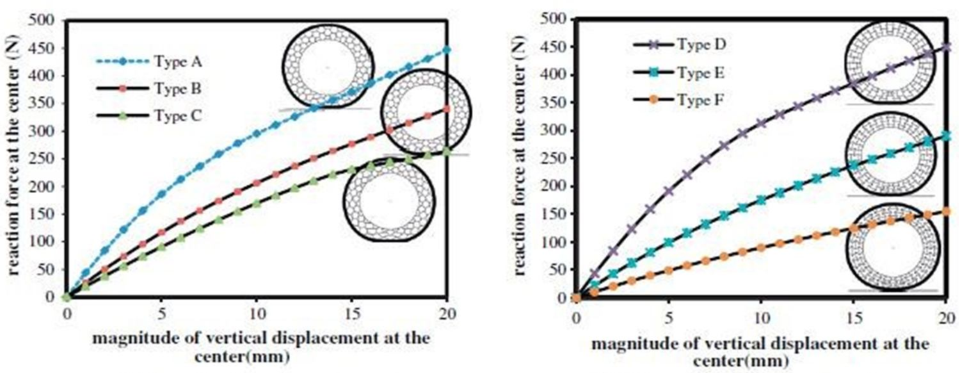


Fig 5: Suggested honeycomb spoke design.

A. Shapes Of Designs

The pressures in the honeycomb spokes are contested when the NPTs have identical load-carrying capabilities. Due to the nonlinear load-carrying conduct as a function of vertical eviction, packing at a particular vertical displacement can be utilized as a connection worth. The practical force-deflection curve primarily indicates the nonlinear conduct associated with combined nonlinear results of materials and geometries.



(a) Regular honeycomb spokes (b)Auxetic honeycomb spokes

Fig 6: force-displacement curves with cell wall thickness are 5mm and tire width of 100mm.

Hyperelastic material behavior and big deflection, buckling of cell walls of honeycomb spokes offer the force-deflection curve of an NPT with the Type D honeycomb spokes whose cell barricade consistency is 4.85 mm associated with the connection load-carrying capacity design. A comparable macroscopic force-deflection conduct as an NPT with the Type A spoke is glimpsed due to the similar effective modulus between the Type A and the Type D spokes in the radial and the circumferential directions. The most elevated local stress classes of the Type D spokes are also nearly identical to those of the Type A spokes. Extensive compartment deformation of the Type D honeycomb spokes is also maintained just as it was in the Type A spokes, which power be generated by the low cell wall viscosity structure-directing to leisurely deformation of cell walls, including buckling.

The Type F spokes have a higher t, advancing mass to meet the consideration load-carrying capacity, a 23.5% mass increase corresponded to the Type A spokes. The international force-deflection curve of an NPT with the Type F spokes having a t of 10.2mm. A nonlinear geometric effect is seldom attended approximated to the one-time honeycomb spokes. This directs the spokes to have more low provincial stress values, suitable for fatigue-resistant honeycomb spokes. The honeycomb spokes of Types C and F are fit for fatigue resistance. Concerning lower mass design, the Type C spokes are exemplary among the honeycomb spokes scrutinized.

V. CONCLUSION

A. This new technology will increase the safety of cars as well as have a positive impact environmentally. Since these tires are also able to have retreated, there is the possibility of a smaller cost per tire- which is always embraced by the consumer.

B. This project is supported and guided by many researchers which will ensure that the development is conducted in a way that is fair and responsible. The outcome of this project will have a huge impact on the upcoming generation because this project saves too much energy and assure safety from tire bursts as that of Pneumatic tires.

C. NPT has many advantages, for instance, vehicle handling, cushioning effect, and a wide range of applications.

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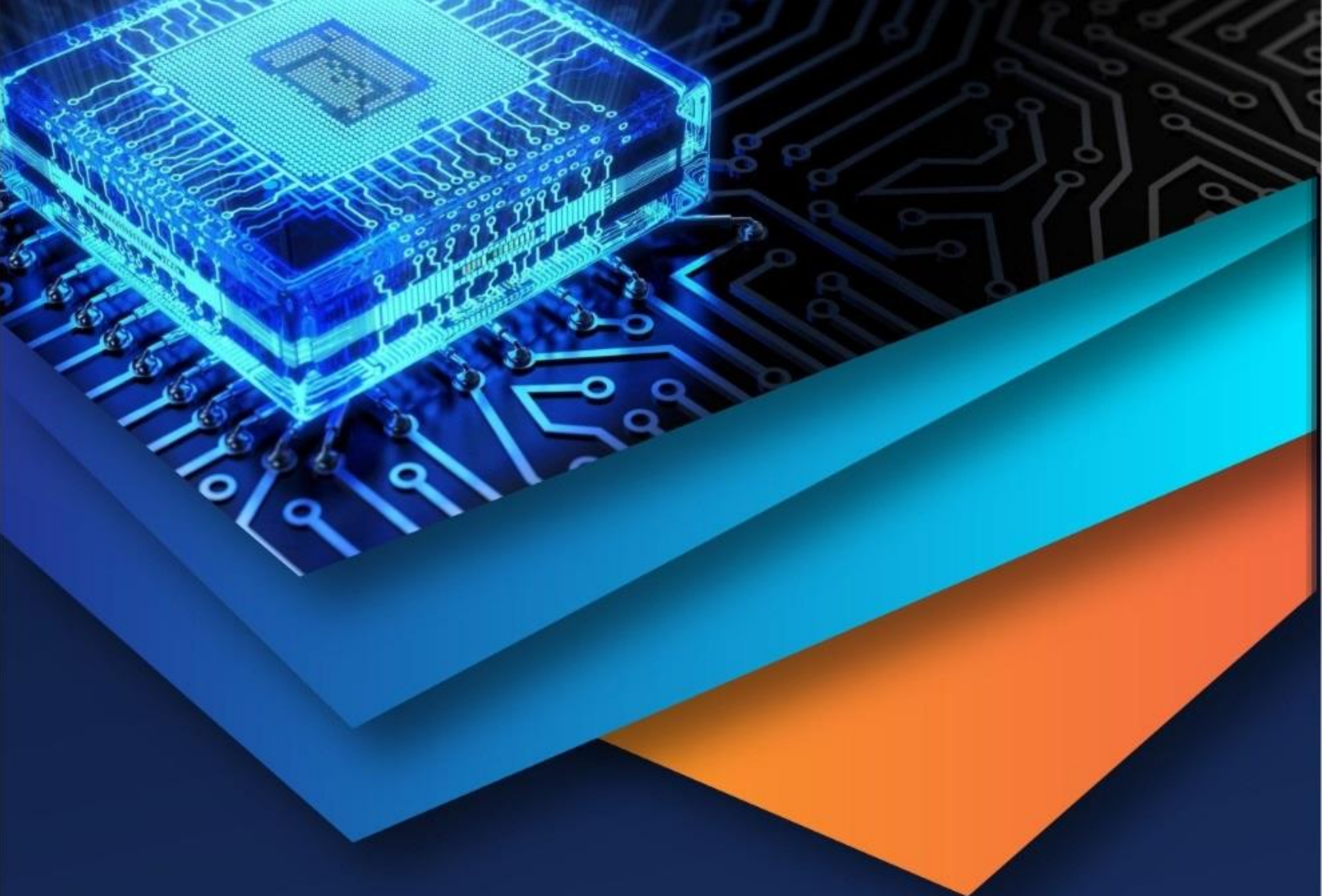

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