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Optimization of 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. Non-Pneumatic tyres give more safety advantages and having very less environmental impact. In this paper different parameters affecting vehicle performance, efficiency, tyre life such as drawbar pull, soil content, spokes structure, inflation pressure, slip, tire aspect ratio etc are studied. Different types of tyres such as Resilient, Tweel, and Honeycomb are studied. Design and Modification is done in different parts of tyres. Modeling and analysis is carried out of non-pneumatic tyre by using Solidworks and ANSYS.

KEYWORDS: Airless tyre, Non-pneumatic tyre(NPT) , spokes , tyre.

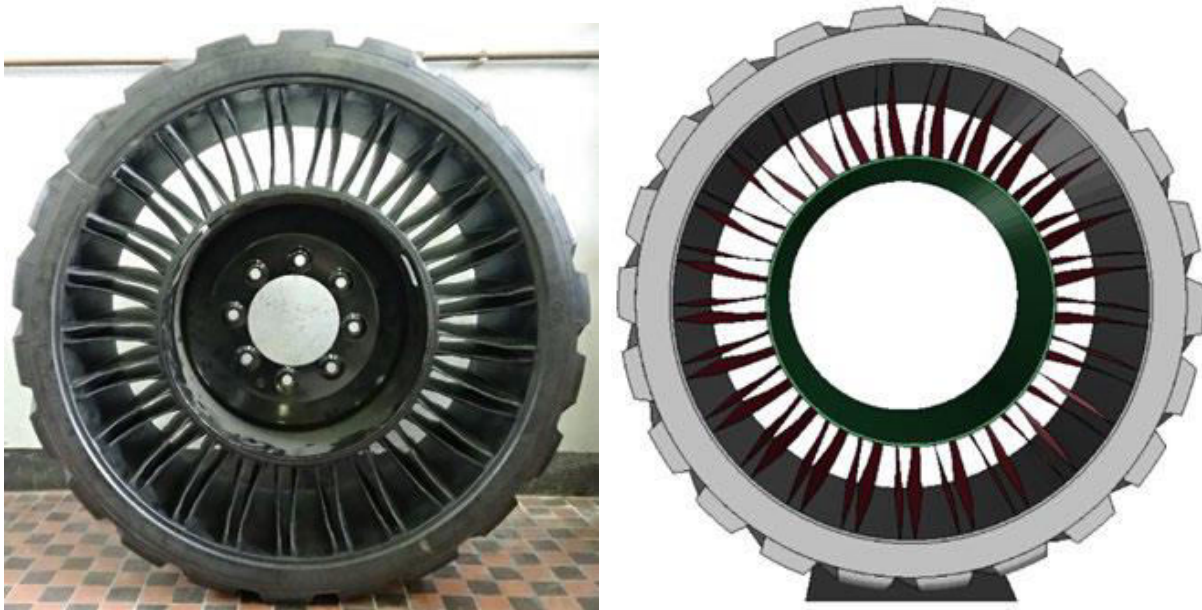
I. INTRODUCTION

More than a century vehicles are running on tyres made up of rubbers and pneumatically inflated with air. A tyre is one of the most important parts of any automobile. Tyre provides sufficient traction on road surface for accelerating, driving and breaking. Also carries the weight of the vehicle and provides cushion over road irregularities and eliminate noise. Tyre made up of rubber is mounted on wheel's rim, there is tube present inside the tyre and in case of tubeless tyres; tube is absent in it. One of their advantage is they are comparatively low value of unsprung mass and easily changing of tyre stiffness by changing the pressure of air inside the tyres. An important disadvantage of pneumatic tyres is the danger of blowing off or unsealing the tyre during running vehicle causes vehicle immobilization. This drawback is more important when vehicle is using in off-road condition (exp. raw roads, construction sites etc.) or where it is exposed to enemy fire.

Airless tires generally have higher rolling resistance and provide somewhat less suspension than similarly shaped and sized pneumatic tires. Other problems for airless heavy equipment tires include dissipating the heat buildup that occurs when they are driven. Airless tires are often filled with compressed polymers (plastic), rather than air or can be a solid molded product.

Installation of airless tires depends on the use. Heavy equipment will need special equipment to mount, but an airless bicycle tire can be mounted with little or no effort. Solid airless lawn mower tires come pre-installed on the wheel, allowing quick installation.

The NPT consists of three basic parts including a circular deformable beam, thin elastic collapsible spokes and a rigid hub. The NPT tyre aims at performance levels beyond those possible with conventional pneumatic technology because of its spokes design, added suspension, and decreased rolling resistance. It delivers pneumatic-like load-carrying capacity, ride comfort, and as it has no pressurized air cavity, it cannot fail by loss of air pressure. Eventually it may be able to outperform conventional tires since it can be designed to have high lateral stiffness for better handling without a loss in comfort. Currently there are environmental issues all throughout a tire's lifespan.



The non-pneumatic (a) tyre and its (b) model[19], pg-4

The traditional tire is replaced with the NPT which has reduced weight compared to conventional tyres so this will reduce the weight of vehicle and helps by improving efficiency of the engine. Non-pneumatic tyres are also expected to have a positive environmental impact. In the design process, the aim of changing the spoke structure is to determine the values of design variables in order to optimize the performance of the NPT with given constraints. In this study of Spokes, design Optimization of spokes will be upgraded intended to increase load carrying capacity, rolling resistance; contact pressure etc. problem would be resolved in final process at certain degrees the fuel consumption can be reduced which losses during skidding & weight etc by optimizing design of lug's tread & Spokes.

II. RELATED WORK

More than a century vehicles are running on tyres made up of rubbers and pneumatically inflated with air. A tyre is one of the most important parts of any automobile. Tyre provides sufficient traction on road surface for accelerating, driving and breaking. Also carries the weight of the vehicle and provides cushion over road irregularities and eliminate noise. From the early 1920s, efforts were made to develop a resilient wheel by adding wire spokes in order to deliver a quality pneumatic tire while guaranteeing safety. The first attempt to study three areas where tractor performance and fuel efficiency can often be improved was carried out by Mike Staton et al in 1914^[1]. They studied three areas such as optimum performance, Tire inflation, focus on operation rather than setup. After 79 years S.A Al-hamed et al continued study of the tractor tire performance parameters for radial tire. It includes parameters such as wheel slip, drawbar pull and tractive efficiency^[2]. They reported that radial tires produced higher tractor drawbar power on various soil surfaces compared to bias-ply tires. The study on parameters continued in 2008. M. Schreiber and H.D. Kutzbach studied three tire parameters radius, width, inflation pressure and five soil parameters such as soil cover, upper soil strength, lower soil strength, clay content, moisture content etc^[3].

In Feb 2009 Tyler Olmstead and Erika Fischer study the effectiveness of pressure pads originally designed for ergonomics in displaying real data for vertical pressure distribution when buried in soil. Smooth the test section as much as possible to reduce bouncing of vehicles. This allows for better prediction of vertical force exerted on the test section above the area of interest^[4]. In same year Thomas R. Way et al studied Effects of two radial-ply drive tires, each with a different aspect ratio, on soil bulk density and cone index, Effects of dynamic load and inflation pressure of the tires on soil bulk density and cone index^[5]. They also compared the tire tread centerline and edge locations of soil bulk density and cone index. The bulk density and cone index in soil just above a hardpan were not affected by the aspect ratio and differences in dimensions of two radial-ply tractor drive tires. At constant inflation pressure, the bulk density and cone index increased with increasing dynamic load. Soil beneath the edge of a tractor drive tire is likely to be compacted less, and to provide a better crop root environment than soil beneath the centerline of the tire. One year later Hisanorishinone et al carried out experimental analysis of tread pattern effects on tire tractive performance on sand

using an indoor traction measurement system with forced-slip mechanism. To verify the capability of updated traction measurement system, and secondly to clarify the effects of four tread patterns—smooth, lug, rib and block—on tractive performance of tires running on sand using this updated system. Among the four tread patterns of tires tested, the tire with lug pattern or block pattern generally showed higher drawbar pull than the tire with other tread patterns for slip greater than 17.8%^[6].

In 2011 J.R cho et al did Optimum design of run-flat tire insert rubber by genetic algorithm (GA) to present a generalized multi objective optimization method making use of GA in order to simultaneously enhance the passenger comfort and the durability of a side-wall reinforced run flat tyre by optimally tailoring the side-wall insert rubber^[7]. One year later Jaehyung Ju et al studied Flexible cellular solid spokes of a non-pneumatic tire. The two cases of hexagonal honeycombs are designed the same cell wall thickness and the same load carrying capacity^[8]. In same year N. Nankali et al developed a 2D multi-laminated model of a tractor tire on soil and compared Analysis with 3D model. The model provides a reliable pattern of soil-tire interface stress distribution and compared to the 3-D analysis, more accuracy is observed in the present 2-D model, due to using fine meshing soil particle^[9].

Next year in 2013 V.T. Atkari, P.B. Arote and S.B. Patil studied Effect of different tire inflation pressures on drawbar performance of tractor in different gear setting to evaluate the height for maximum pull and power for wheel slip in recommended range and to evaluate maximum drawbar pull, drawbar power, wheel slip and fuel consumption at various tire inflation pressures in different gears for the best suitable hitch height. Optimum tractive performance of a driving tire can be obtained by adjusting the inflation pressure of the tire according to the soil conditions over which it moves. The benefits of lower inflation pressure include decreased soil-tire interface pressures, increased tire performance, decreased soil compaction, and a smoother ride. Include decreased soil-tire interface pressures, increased tire performance, decreased soil compaction, and a smoother ride^[10]. One year later Mallikarjun Veeramurthy did Optimization of geometry and material properties of a non-pneumatic tyre for reducing rolling resistance. Geometric optimisation of the shear band thickness and spoke thickness of the NPT. Material property optimisation of a non-linear hyperelastic elastomer with finite element based numerical experiments. Shear modulus of PU (Polyurethane) is the most important design parameter to decide rolling resistance, vertical stiffness, and contact pressure. Increase in shear modulus of PU and shear band thickness makes an NPT have a low rolling resistance owing to the lower deformation of shear band. NPT has low rolling resistance when shear modulus of PU and the shear band thickness increase associated with a lower shear deformation while rolling^[11].

One year later in 2014 A.M. Aboul-Yazid et al studied Effect of spokes structures on characteristics Performance of non-pneumatic tires in this Two cases of NPTs are investigated a tire with a composite ring and a tire without a composite ring. The spoke pairs model have the best shape due to its lower rolling resistance, low contact pressure, and least Von Mises stresses on its spokes. Honeycomb spoke have the best shape due to having the least rolling resistance, low mass value, lower and more uniform contact pressure distribution, and accepting Von Mises stresses on its spokes^[12]. In same year Cristobal Gonzalez Diaz et al studied Dynamic behavior of a rolling tyre Experimental and numerical analysis. They studied the effect of rotation on the tyre. To improve the ability to control and optimize the noise and vibrations that result from the interaction between the road surface and the rolling tyre^[13].

Next year in 2016 Umesh G C et al did Design and Analysis of Non-Pneumatic Tyre (NPT) With Honeycomb Spokes Structure to study the honeycomb structure of NPT tyres and structural analysis of NPT tyres by using Ansys. The equivalent stress value obtained in static analysis for honeycomb tyre is 76.344 MPa which is under permissible limits of material properties. So the structure is safe. Honeycomb tyres are most convenient to replace the conventional tyre since they provide uniform traction and wear as that of conventional tyre^[14]. One year later Nandikanti Supriya Reddy & Mr. G. Vinodreddy did Modeling And Analysis Of NPT By Using Ansys to model, simulate and perform static analysis of a NPT used in a four wheeler under working conditions and NPT is modeled in CATIA^[15].

Further study and investigation continued for better methods. Vladimir Mazur 2018 carried out Experimental research in automobile NPT force heterogeneity to study Coefficient of force heterogeneity and Amplitude of radial force

buckling. Radial force heterogeneity is not connected with modulus peculiarities of new type wheeled movers but depends on the terms of their manufacturing. Intensive buckling leads to the enhancement of vibration load level for a driver, passengers and cargo transported by a motor vehicle, as well as to the decrease of hauling and speed properties, fuel saving, stability and motor vehicle controllability^[16]. A year later K. Tarakaram et al did Modeling and analysis of NPT with different design structures using fem method. To Study different types of NPT's structures that are: honeycomb, plate, triangle and curved shape. Triangular, Plate, and Curved shapes. To design and analyses different types of spokes by using Ansys^[17]. In same year LibinRajan et al did Design and Comparative Analysis of Non-Pneumatic Tires for a Tractor to Study, design and static analysis of three types or tires i.e Michelin Tweel, Honeycomb structure by Resilient Technology and Airless Tire concept introduced by Bridgestone^[18]. In September 2020 Z. Hryciów et al studied the Influence of Non-Pneumatic Tyre Structure on its operational Properties to study the structure of NPT tyres, to solve highly non-Linear statics on dynamics problems and to study characteristics of NPT tyres^[19].

In the 2021 five researches are carried out:

- first in Jan KshitijNimkar et al did optimization of cell angle of honeycomb spokes for non-pneumatic tyre to design 3D model of a Non-pneumatic tyre using CATIA software and then that model was analysed using ANSYS software. Three types of honeycomb spokes are designed in AUTOCAD, Ansys finite element analysis is used to study about the deformation and stresses developed in different type of honeycomb spokes^[20].
- In April Akshay Kumar A Kalahastimath did review airless tyre to study of different types of NPT tyres and got that Military Usage Tweel deflects 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. SciTech's tyre has closed sidewalls and no spokes, there's no noise or warming issue yet as no issues with dust. In Resilient Technologies, LLC load is equally distributed round the tyre^[21].
- In May Dots. MakhmudjonMelibaev et al determined the Parameters Affecting The Performance Of Tractor Tires to determine the value of the half-transverse deviation from the specified trajectory, slipping, the amount of fuel consumption, the average resource of the operating time and wear of the tire tread, the number of steering influences during the period of correcting the trajectory of the tractor^[22].
- In May Liz Hutton & John O'Connor study Tractor tyre selection to study the methods for selecting tyres, types of tyres and factors affecting it. There are two distinct types of tyre construction: bias ply and radial ply. For most farming applications, radial tyres are preferred as their construction improves stiffness along the tread and results in greater traction^[23].
- In July KunalDangane et al studied Non-pneumatic tyres of different designs NASA And The Apollo Lunar Rover, Michelin Tweel and Bridgestone NPT and found the use of a flexible structure on six beehive aircraft was proposed– the honeycomb spokes of an NPT to replace the air of a pneumatic tyre. NPT are more profitable in future than pneumatic tyre.^[24]

III. CONCLUSION

There are two distinct types of tyre construction: bias ply and radial ply. For most farming applications, radial tyres are preferred as their construction improves stiffness along the tread and results in greater traction. There are five main types of tyre tread designs: R1, R1W, R2, R3 and R4. R1W tyres have deeper skids that provide increased traction in wet, sticky soil conditions. R2 tyres are used for field work in wet conditions and for high-value vegetable crops such as rice and sugarcane. Heat, air currents, oils, fuels and solvents, sunlight, water, dust and dirt etc are the factors affecting tyres. 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. 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. Non-Pneumatic tyres gives more safety advantages and having very less environmental impact. Due to the smaller tires of the wheels, the experimental tractor consumes less fuel by 7.1% than the serial one. It is possible to state the specificity of the driving mode of the tractor with the developed tread in a given technological operation. Military Usage Tweel deflects 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.

There is more research is going on spokes of tyres that's why we have selected "Optimization of Non-pneumatic tractor tyre" For Project.

REFERENCES

- [1] Mike Staton, Tim Harrigan and Reed Turner, "Improving Tractor Performance and Fuel Efficiency" 1914.
- [2] S.A Al-hamed, R.D Grisso, F.M Von Bargen, "Tractor performance spreadsheet for radial tires", 1993, NE 65853-0726, USA.
- [3] M. Schreiber, H.D. Kutzbach, "Influence of soil and tire parameters on traction", 2008, Germany.
- [4] Tyler Olmstead and Erika Fischer, "Estimating Vertical Stress on Soil Subjected to Vehicular Loading", 2009, US Army Research.
- [5] Thomas R.Way, Tadashi Kishimoto, H. Allen Torbert, Eddie C. Burta, Alvin C. Bailey, "Tractor tire aspect ratio effects on soil bulk density and cone index", March 2009, Japan.
- [6] Hisanori Shinone, Hiroshi Nakashima, Yuzuru Takatsu, Takahiro Kasetani, Hisao Matsukawa, Hiroshi Shimizu, Juro Miyasaka, Katsuaki Ohdoi, "Experimental Analysis of Tread Pattern Effects on Tire Tractive Performance on Sand using an Indoor Traction Measurement System with Forced-slip Mechanism", 2010.
- [7] J.R cho, J.H Lee, K.M Jeong, K.W kim, "Optimum design of run-flat tire insert rubber by genetic algorithm", 2011, Republic of Korea.
- [8] Jaehyung Ju, Doo-Man Kim, Kwangwon Kim, "Flexible cellular solid spokes of a non-pneumatic tire", 2012, Republic of Korea.
- [9] N. Nankali, M. Namjoo and M. R. Maleki, "Stress Analysis of Tractor Tire Interacting with Soil using 2D Finite Element Method", April 2012, vol-5.
- [10] V.T. Atkari, P.B. Arote and S.B. Patil, "Effect of different tire inflation pressures on drawbar performance of tractor in different gear setting", 2013, India.
- [11] Mallikarjun Veeramurthy, Jaehyung Ju, Lonny L. Thompson and Joshua D. Summers, Mallikarjun Veeramurthy, Jaehyung Ju, Lonny L. Thompson and Joshua D., "Optimisation of geometry and material properties of a nonpneumatic tyre for reducing rolling resistance", 2014, vol-66, USA.
- [12] 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 tires", 2015, vol-11, Egypt.
- [13] Cristobal Gonzalez Diaz, Peter Kindt, Jason Middelberg, Stijn Vercammen, Christophe Thiry, Roland Close, Jan Leyssens, "Dynamic behavior of a rolling tyre: Experimental and numerical analyses, 2015", Luxembourg.
- [14] Umesh G C, Amith Kumar S N PG student, Assistant Professor, "Design and Analysis of Non-Pneumatic Tyre (NPT) With Honeycomb Spokes Structure", 2016, Vol-6, India.
- [15] Nandikanti Supriya Reddy & Mr. G. Vinodreddy, "Modeling And Analysis Of Non-Pneumatic Tyre By Using Ansys", 2017, vol-4.
- [16] Vladimir Mazur, "Experimental research in automobile non-pneumatic tire force heterogeneity", 2018, Russia.
- [17] Tarakaram, 2Dr. K. Rambabu, 3D. PHanindra Varma, "Modeling and analysis of non-pneumatic tyres with different design structures using fem method", 2019, Vol-4.
- [18] Libin Rajan, Shobith Nambiar, C. Ayyanar, Akash Verma, S. Subhash Raj, "Design and Comparative Analysis of Non-Pneumatic Tires for a Tractor", May 2019, vol-8.
- [19] Z. Hryciów, J. Jackowski and M. Żmuda, "The Influence of Non-Pneumatic Tyre Structure on its Operational Properties", 2020, Vol-17, Poland.
- [20] Kshitij Nimkar, Krishna Tiwari, Ayush Chordia, "optimization of cell angle of honeycomb spokes for non-pneumatic tyre", Jan 2021, vol-8.
- [21] Akshay Kumar A Kalahastimath, "Review on airless tyre", April 2021, vol-8.
- [22] Dots. Makhamudjon Melibaev, student Jaloliddin Yigitaliyev Adkhamjonugli, "Determination Of Parameters Affecting The Performance Of Tractor Tires", May 2021, vol-5.
- [23] Liz Hutton and John O'Connor, "Tractor tyre selection", May 2021.
- [24] Kunal Dangane, Rutwesh Hinge, Siddhey Auti, Pratiksha Kakade, "Non-pneumatic tyres", July 2021, vol-8.



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