

REVIEW ON AIRLESS TYRE

AKSHAY KUMAR A KALAHASTIMATH

STUDENT, DEPARTMENT OF MECHANICAL ENGINEERING, DSCE, BANGLORE, KARNATAKA, INDIA

Abstract - Airless Tyres because the name counsel may be a form of Tyre that doesn't use air to support the load. Albeit Tyres created out of solid rubber exists, they don't have enough compliance and cannot offer a supple ride if employed in traditional vehicles. The NPT mentioned here consists of principally 3 components. A right hub, deformable spokes that support vertical load, bolstered shear band and tread created out of rubber that comes into contact with the surface. The properties of NPT like contact pressure, rolling resistance and cargo carrying capability may be varied by sterilization the size of fabric wont to manufacture NPT another to the standard tire. In this paper there are different approaches made by different companies across the world. Future forecast of the airless tyres are also mentioned.

Key Words: Pneumatic tyre, Flexibility, safety, Environmental concerns, Future.

1. INTRODUCTION

For over one hundred years, vehicles are rolling on cushions of air sheathed in rubber. Sometimes, we have a tendency to get thus accustomed a precise product that no true changes are ever very created for years, decades even. Thus begins a commentary discussing the event of stuffy tyres, one thing that has become additional prevailing within the past few years. Many tyres corporations have started experimenting with styles for non-pneumatic tyres as well as Michelin and Bridgestone; however neither style has created it to production.

Creating a replacement non-pneumatic style for tyres has additional positive implications than one would possibly assume. For one factor, there square measure Brobdingnagian safety edges. Having an unventilated tyre suggests that there's no chance of a blowout, which, in turn, suggests that the quantity of route accidents can however cut considerably. Even for things like Humvees within the military, utilizing non-pneumatic tyres encompasses a nice positive impact on safety. Tyres square measure the liability in military vehicles and square measure usually targeted with explosives. If these vehicles used unventilated tyres, this might now not be a priority.

There is additionally an environmental profit to victimization this sort of tyre. Since they never go flat and may be retreaded, unventilated tyres won't ought to be thrown away and replaced nearly as usually as gas tyres. This can weigh down lowland mass considerably.

Because of the advantages, i feel that it's extraordinarily necessary that analysis and production of unventilated tyres is sustained and raised. This sort of innovation works well in conjunction with many engineering codes of ethics, and therefore ought to be embraced by engineers all over. Cars square measure things that individuals use on a daily basis, thus any enhancements over existing styles would have an effect on the lives of the bulk of individuals.

Learning regarding such a subject, therefore, i feel holds extreme value- particularly for U.S.A. freshmen engineering students. In doing analysis into these types of topics that hold important which means, we are able to see that what we are going to do can create a distinction.

LITERATURE REVIEW

R. Sanjeev kumar, et al in 2020 studied about "**Design optimization of Airless Tyre**" and concluded, that analysis over four design models of the unaired tyre named Spokes, Triangular, Circular, and polygon styles. The circular will be given minimum deflection, wherever applying the load. Therefore they advise the tyre with a Circular structure will be best from their analysis.

T.Prabhuram, et al in 2017 studied regarding "**Static analysis of various spoke structure of airless and standard tyre**" and ended, that Use of air-less tyre eliminates disadvantages longfaced by gas tyres. Air-less tyre provides uniform adhesion and uniform wear whereas absence of air. The unaired tyres needn't to get replaced fairly often and if it wears out and required to get replaced the outer band of the unaired tyre is replaced that saves material in producing purpose of read. The dimensional model of unaired tyre with completely different spoke structures ar generated and finite part analysis is distributed. From the FEA results of various structures, the unaired tyre with diamond structure proves to be additional sturdy than different structures and therefore the standard tyre.

Mohammad Abdullah Mir in year 2020 studied about "**Non-pneumatic Tyres or airless Tyres**" and concluded that, NPT with honeycomb spoke with larger cell angle showed minimum stress concentration This is important for fatigue resistant designs. And also NPT with honeycomb spoke with larger cell angle showed minimum stress concentration This is important for fatigue resistant designs.

Nibin Jacob Mathew et al in year 2017 studied about "**Design and static analysis of airlesstyre to reduce deformation**"

From the design analysis it was concluded that the Diamond tyre structure was found out to be solid, and also bears more load comparative to the other structures. These types of tyres can be mainly employed for the heavy load vehicles where the load factor is a main concern.

Mohil D. Patel et al in year 2019 studied about “**Integration of geometry and small and large deformation analysis for vehicle modelling: chassis, and airless and pneumatic tyre flexibility**” and effects on chassis on usage of airless tyres. The airless tyre is modelled for the first time using ANCF fully parameterised plate/shell elements, which is one of the main contributions of their investigation.

C. Manibaalan et al studied “**Static analysis of Airless tyres**” and terminated that For the close tyre to perform with low rolling resistance and provides higher fuel potency following conditions square measure determined (i) since polymer composite has the capability of each snap and stiffness at identical time, it becomes ideal to perform higher than pneumatic tire just in case of rolling resistance. (ii) From the structural analysis, it may be terminated that polymer offers a large vary of operation applicable for varied load applications. This can be done by sterilization the pure mathematics of the structure or by sterilization the properties of the polymer composite used. (iii) From the fabric study it may be inferred that the absence of rubber and also the higher domination of polymer for the producing of associate degree close tyre makes it a lot of ecofriendly and will increase the fuel potency in an exceedingly larger extent.

J. Jackowski et al studied “**The Influence of Non-Pneumatic Tyre Structure on its Operational Properties**” and concluded that an increase in the curvature (and length) of the spokes significantly decreased the radial stiffness of the tyre as a result of free (within the constraints of the curvature) elongation of the spokes above the tyre’s axis of rotation. The length of the contact patch was extended when the stiffness of the supporting structure was lower.

Vinay T V et al studied about “**Modeling and Analysis of Non-Pneumatic Tyres with Hexagonal Honeycomb Spokes**” and concluded that The Non pneumatic tyres overcome many disadvantages over conventional tyre like possibility of a catastrophic damage, required maintenance of proper internal air pressure and complex manufacturing procedure. The major conclusion is that the honeycomb spokes with a higher cell angle magnitude show lower local stresses, which is good for a fatigue resistant spoke design.

AIRLESS TYRE

Before the technology of airless tyres is discussed, it is important for the reader to understand how standard pneumatic tyres function, and what advantages and disadvantages there are to using them. A brief overview of the general concepts of airless tyres will then follow.

PNEUMATIC TYRES

The basic style of all gas tyres is incredibly similar, despite the fact that there is a unit many alternative varieties. All of them embrace Associate in nursing inner core that holds pressurized air that is then lined with a layer of rubber that comes in touch with the road, referred to as a tread. The tread helps keep traction with the road and prevents slippery and skidding. The tread has the tendency to agitate over time, thus if the tyre has not gone flat, someone can sometimes replace it at now.

A main reason for mistreatment gas tyres is that the deformation that happens throughout rotation. Because the tyre rolls, the burden of the automobile pushing down on that causes the tyre to flatten slightly. This, in turn, causes the tyre to possess a bigger area to be in touch with the bottom that makes for higher traction. It conjointly provides a small artifact impact, creating running over little rocks or scrap unnoticeable. Or, as author for the way Stuff Works impotency Grabianowski puts it. If you’ve ever taken a ride in Associate in nursing old school carriage with wood wheels, you recognize what a distinction a tyre makes.

Pneumatic tyres have their benefits; however they even have their disadvantages yet. The chance of a blowout or flat (when air is unfettered suddenly from the tyre) may be a major concern as a result of they need the tendency to cause severe accidents. The task of control tyre pressure is additionally a drawback as a result of customer’s area unit sometimes not superb at it. Though it’s going to facilitate with traction to possess the tyres a bit flat, it comes at the worth of handling. Once there’s not enough gas pressure within the tyre, the sidewalls flex inflicting the tyre to roughly follow the required line of steering. It’s attributable to these disadvantages that tyre corporations have taken Associate in Nursing interest in coming up with airless tyres.

WHAT IS AIRLESS TYRE (TWEEL)?

Airless tyres or Non-pneumatic tyres (NPT) are the tyres that don’t seem to be supported by atmospheric pressure. These tyres are referred to as Tweel that may be a merger of the words tyre and wheel. This can be as a result of the Tweel doesn’t use a standard wheel hub assembly. The Tweel conception was initial declared by Michelin back in 2005. It’s structure may be a solid inner hub mounted onto the vehicles shaft, that’s encircled by polymer spokes. This forms a pattern of wedges that facilitate to soak up the impacts of the road. These spokes look almost like those found on bicycles and plays the shock-absorbing role of the compressed gas as during an ancient tyre. A sheer band is then stretched across the spokes that forms the border of the tyre. It’s the stress of the band and also the strength of the spokes that replaces the atmospheric pressure used on ancient tyres. Once a vehicle drives over associate obstacle, a sleeping police officer for instance, the tread and shear

bands sink because the spokes bend, before they quickly regain into form.

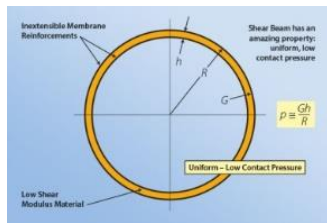


Fig 1

HOW IT WORKS

The Airless tyre (Tweel) doesn't use a conventional wheel hub assembly. A solid inner hub mounts to the shaft and is enclosed by polyurethane spokes clothed in an exceedingly pattern of wedges. A shear band is stretched across the spokes, forming the outer reaches of the tyre. On that sits the tread, the half that comes to bear with the surface of the road. The cushion shaped by the air cornered within a standard tyre is replaced by the strength of the spokes that receive the strain of the shear band. Placed on the shear band is that the tread, the half that creates contact with the surface of the road. Once the Tweel is running on the road, the spokes absorb road defects a similar method atmospheric pressure will within the case of gas tyres. The versatile tread and shear bands deform briefly because the spokes bend, then quickly return to the initial form. Totally different spoke tensions are used, PRN by the handling characteristics and lateral stiffness can even vary. However, once created the Tweel's spoke tensions and lateral stiffness can't be adjusted.

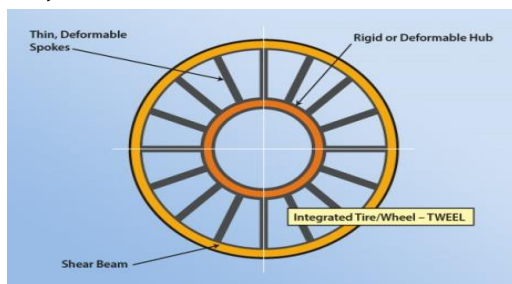


Fig 2 (without surface contact)

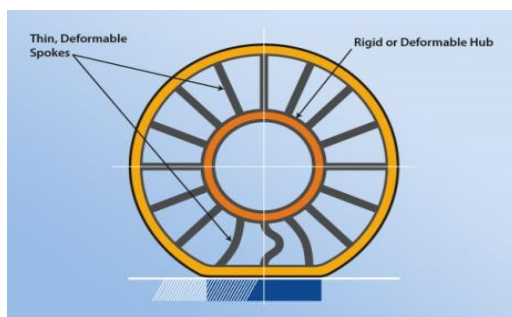


Fig 3 (with surface contact)



Fig 4 (actual image)

DIFFERENT DESIGN APPROACHES

There are many different approaches to the design of the supports. This accounts for the main differences between the overall designs of each company's version of the airless tyre.

The following are approaches to making an airless tyre by different companies. Some solve more problems than others, but it should be noted that all show an extreme amount of ingenuity that may cross over into different types of engineering.

1. NASA and the Apollo Lunar Rover

The first major attempt at creating an airless tyre was in 1970 for NASA's Apollo Lunar Roving Vehicle. The tyres were made of steel strands woven together to form the shape, and then were coated with zinc. In order to gain traction, titanium chevrons were added to the outer surface.

This design worked well on the moon, where comfort of the drivers was not an issue (i.e. cushioning effect of pneumatic tyres), but it would not have been practical on earth. The design would also be very expensive for a regular automobile, which is not attractive to the average consumer.



Fig 5

2. Michelin

The next main try at making Associate in Nursing Airless tyre was known as the Tweel (combination of tyre and wheel) by the tyre company, Michelin. Their style consisted

of a skinny rubber tread with formed spokes made from polyurethane.

There were very high hopes for this model once it came out. editorialist Don Sherman of automotive and Driver writes, introductory claims versus standard gas radials were 2 to a few times the tread life and 5 times higher lateral stiffness with solely a small increase in rolling resistance. This development has terribly positive implications as a result of it means the tyre would last regarding twice longer than a customary tyre before it might need to be retreaded. The sole major drawback with this model is at route speeds, the spokes tend to vibrate, inflicting excessive noise.

When asked regarding recent developments for the Tweel, Michelin refused comment, either as a result of they born the project, area unit operating with the military, or don't wish to give away findings to their competitors.



Fig 6

2. Bridgestone

Another model for the non-pneumatic tyre came from the well-known tyre company, Bridgestone. Though terribly similar in construct to Michelin's Tweel, there square measure some key variations.

The core is formed of rigid atomic number 13 and has thermoplastic spokes divergent outward at an angle in opposite directions on either side. This creates additional stability and fewer lateral movements within the tyre. Bridgestone conjointly fastened the vibration and noise downside during this manner moreover. The most issue with their style was that rubbish had the tendency to induce caught within the gaps between spokes. Additionally, the materials utilized in the tyres square measure utile, tributary to the economical use of resources. Further, by following extraordinarily low rolling resistance and tributary to reductions in greenhouse gas emissions through use of proprietary technologies, Bridgestone believes it's attainable to realize even higher levels of environmental friendliness and safety. Bridgestone is following this technological development with the aim of achieving a "cradle to cradle" method that proactively maximizes the cyclic use of resources from worn tyres into new tyres and therefore the use of utile resources.

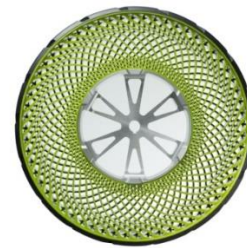


Fig 7

3. Resilient Technologies, LLC

As declared before, the assembly of unaired tyres would be extraordinarily useful to the military. The cluster Resilient Technologies, LLC is functioning with the military to develop such a tyre for Humvees. To satisfy the necessities of serious hundreds and rough tract, these tyres area unit quite industrial-looking. They encompass a thick outer tread with a honeycomb-like structure within. This permits for the load to be equally distributed round the tyre.

The honeycomb style can be adjusted for any application wherever loss of atmospheric pressure causes issues, wherever tyres face varied hazards on an everyday basis or wherever business need to cut back time period for tyre problems and maintenance, like agricultural and construction instrumentality.

This style causes the tyre to be terribly loud, creating in unsuitable for normal vehicles. For military functions but, it's helpful. It will stand up to an outsized quantity of abuse, as well as blasts once vulnerable.

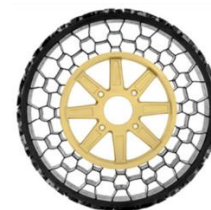


Fig 8

4. SciTech

The most convenient style for everyday vehicles comes from a corporation referred to as SciTech. Their tyre fits on commonplace rims, in contrast to all antecedently mentioned models (which square measure extremely a mixture of a wheel and a tyre), and has the design of a daily tyre type the skin. Rather than supports diverging from the middle, their supports square measure spring-like. There square measure 100 supports in each tyre and 9 square measure in touch with the road at anybody time. There's additionally a secondary web so as to distribute load to all or any of the supports that have 550 pounds of strength every

and square measure made from a thermoplastic optical fiber material.

Because SciTech's tyre has closed sidewalls and no spokes, there's no noise or warming issue yet as no issues with dust. The corporate says the tyre achieved a cool and uniform 10-hour run at main road speed at car load. Mounted on a regular rim with a traditional tyre mounting machine, the stuffy tyre is independent, with internal optical fiber composite ribs supporting the load. Built and cured in a conventional steam-bladder mold at a commercial tyre factory, the composite rib and tyre construction are covered by worldwide patents.

Advantages of airless tyres

1. Eliminates air leaks or tyre blow outs.
2. With no gas pressure you're left with consistent economy and handling.
3. Its flexibility provides a rise in extent of contact.
4. No maintenance required.
5. More elongate tread life.
6. Facilitate utilization.
7. Makes Vehicle a lot of economical have high lateral strength for higher handling while not a loss In comfort.
8. Vehicle remains in restraint even in parking brake.
9. Remains mobile even with a number of the spokes broken or missing.
10. Sturdiness & Long Life.
11. Will take shooting or explosion.
12. Less environmental impact.

Disadvantages of airless tyres

1. Lack of adjustability

One of the most important disadvantages of the Tweel is that when it's been factory-made, it can't be adjusted. During this case if the automobile required a distinct quite setting, an entire new set of Tweels are needed.

2. Not as economic as gas tyres

Michelin are presently functioning on facultative the tweels to be as fuel economical as gas tyres. Currently they're inside five-hitter of the rolling resistance and mass levels.

3. Vibration

This could be one in every of the Tweels biggest downsides. Vibrations become kind once a vehicle is driving on top of fifty mph, whereas inflicting a great deal of noise. Conjointly troubling is that the quantity of warmth the Tweels generate. Long distance journey with tweels would be terribly unpleasant unless these areas are improved upon.

4. Totally different producing method

Another downside is that making unventilated tyres needs a very totally different producing method. At now of your time, the tyre business revolves round the manufacture of ancient gas tyres. To change factories and repair instrumentality would be a significant change, and therefore the facilities simply don't exist however.

APPLICATIONS OF AIRLESS TYRES

1. They are used in some small vehicles such as riding lawn mowers and motorized golf carts.



Fig 10

2. They are also used on heavy equipment such as backhoes, which are required to operate on sites such as building demolition.



Fig 11

3. 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.
4. The airless tyres are also used in All-terrain vehicle (ATV) made by Polaris. These tyres can suffer 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.

SAFETY AND ENVIRONMENTAL CONCERNS

Safety

As declared before, the most danger of gas tyres is that the likelihood of a flat or blowout that typically happens at main road speeds. A blowout is once a tyre essentially pops and deflates quickly. This causes the driving force to lose management of the automobile and risk the chance of striking another vehicle. With Airless tyres, this can be not a difficulty. There's no likelihood for a blowout, and also the driver doesn't have to fret concerning dynamical a flat (also eliminates the necessity for a spare tyre).

The assurance of never having a flat tyre is additionally helpful in areas like construction, wherever there may be sharp junk, and within the military. it's particularly helpful within the military as a result of the tyres of Humvees area unit usually targeted once under fire, as they're the weakest a part of the vehicle. If the tyres area unit blown, the vehicle cannot go anyplace. Close tyres during this sense will save the lives of troops riding in Humvees as a result of the tyres will take a lot of abuse.

Better handling is additionally a profit once it involves safety. Though it doesn't vary by a lot of, it's necessary to possess that further stability within the tyre to form the automobile go precisely within the direction during which it's steered. This can be particularly useful in turning to avoid associate degree obstacle like associate degree animal or another automobile. Therefore for this reason, improved handling isn't only for a more robust driving expertise.

Environmental issues

Non-pneumatic tyres are expected to possess a positive environmental impact. As of now, tyre firms should address the growing mountain of bald tyres defiling the landscape and notice the way to recycle or notice one thing that lasts longer and may be recycled. Within the case of close tyres, it may be the latter. SciTech's close tyre is claimed to be ready to survive the automobile. This has huge environmental implications as a result of with such a lot of cars on the road, there area unit many elderly tyres that got to be disposed of. As a result of close tyres principally use composite materials, there's solely a little quantity of rubber that truly goes into it. Also, since the tread lifetime of most models is longer than that of gas tyres, the rubber doesn't have to get replaced fairly often. This implies that there'll be less of it to lose later.

AIR LESS TYRES MARKET FORECAST 2026.

Airless Tyres Market size valued at USD 34.2 million in 2019 and is poised to grow at a CAGR of over 5.5% between 2020 and 2026. Ongoing technological advancement for reducing vibration and noise generated by tires will drive the market revenue

The airless tires offer enhanced load bearing capabilities, driving performance, and environment friendly design. Consumers are adopting these tires for eliminating the requirement of spare tires, and superior productivity in applications including manufacturing sector, farming, construction & mining sectors.



Fig 12

Airless tires have the potential to scale back carbon emissions thanks to energy loss elimination from tire rolling resistance. Additionally, usage of reclaimable materials, with economical use of resources can drive the market demand. Moreover, rising would like for maintenance free tires notably for vehicles together with military, terrain, utility, motorcycles, and business vehicles can any influence the close tires market size.

Strong potential of the merchandise for substitution standard gas tires can fuel the trade growth. Fleet applications, with sizable amount of vehicles requiring regular maintenance, can induce important growth potential within the trade landscape. Further, shifting focus towards agricultural sector across the world is escalating the demand of agricultural machinery, eventually supporting the market demand.

THE FUTURE OF AIRLESS TYRES

The first large-scale applications could also be within the military wherever a flat-proof tire would be advantageous. Military testing has indicated that the Tweel deflects mine blasts far from the vehicle higher than normal tires which the Tweel remains mobile even with a number of the spokes area unit broken or missing. NASA has shrunk Michelin to develop a wheel for consecutive generation satellite Rover supported the Tweel. This has resulted within the satellite Rover Initiative AB scarabaeus wheels. The Tweel will have many flaws (aside from the name). The worst is vibration. On top of fifty mph, the Tweel vibrates significantly. That in it would not be a drag, however it causes 2 different things: noise and warmth. A quick moving Tweel is unpleasantly

loud. Long-distance driving at high speeds generates a lot of heat.

Another downside involves the tire trade. Creating Tweel is sort of a special method than creating a tire. The sheer scale of the changes that may have to be compelled to be created to various factories, to not mention tire equalization and mounting instrumentality in thousands of automotive vehicle repair retailers, presents a big (though not insurmountable) obstacle to the broad adoption of stuffy tires.

CONCLUSIONS

Tyres could seem to be a trivial part of associate automobile that can't be improved, however analysis into unaired tyres shows otherwise. This new technology can increase the protection of cars in addition as have a positive impact environmentally. Since these tyres are able to be retreaded, there's the likelihood of a smaller value per tyre that is often embraced by the buyer. This innovative project is additionally backed and target-hunting by engineering codes of ethics which can make sure that the event is conducted in an exceedingly approach that it accountable and truthful.

It is additionally vital to accept the implications of a technology like this. This can be reinventing the wheel in an exceedingly way! If engineers can try this, they're going to accept different things which will be improved. Then we'll not solely have inventors of entirely new technologies, however additionally people that will take one thing already in situ and build it even higher. This sort of innovation can become progressively valuable within the future that is why researching topics like this is often vital for teenagers. It provides them a way of what they can do in the end of their hard-working years of schooling which what they'll do will matter.

ACKNOWLEDGEMENT

I am great indebted to guide, Mr. Manjunath R, Asst.Professor, Department of Mechanical Engineering, Dayananda Sagar College of Engineering, Bangalore, for his inspirational guidance, tireless interest and keenness to help students in research problems which greatly enhanced my appreciation for him. It is indeed a great privilege to work under him who has encouraged and guided in spite of his busy and official work. Working under him is highly rewarding and pleasant experience. And I am very thankful for my uncle Mallayya kalahastimath whose inspiring words made me to reach this stage. And all my family members. Finally, I extend my gratefulness to one and all that helped me directly or indirectly involved in the successful completion of this research work.

REFERENCES

- [1]R. Sanjeev Kumar, K. Vetrivel Kumar and T. Ramakrishna, "Design optimization of Airless Tyre - Numerical Approach", IOP Conference Series: Materials Science and Engineering, vol. 1057, no. 1, p. 012032, 2021.
- [2]T. Prabhuram, S. Sundaram, S. Jegadeeswer and V. Kannan, "Static analysis of different spoke structure of airless and conventional tyre", IOP Conference Series: Materials Science and Engineering, vol. 923, p. 012017, 2020.
- [3]M. Abdullah Mir, "Non Pneumatic tyres", INTERNATIONAL JOURNAL OF RECENT TRENDS IN ENGINEERING & RESEARCH, vol. 6, no. 11, pp. 30-39, 2020.
- [4]"Pneumatic radial tyres for heavy vehicles", Composites, vol. 22, no. 5, p. 411, 1991.
- [5]H. Jo, C. Lee, K. Kim and D. Kim, "Vibration Characteristics of Non-pneumatic Tire with Honeycomb Spokes", Transactions of the Korean Society of Automotive Engineers, vol. 21, no. 4, pp. 174-180, 2013.
- [6]N. Mathew, D. Sahoo and E. Chakravarthy, "Design and Static Analysis of Airless tyre to Reduce Deformation", IOP Conference Series: Materials Science and Engineering, vol. 197, p. 012042, 2017.
- [7]A. Shabana, G. Wang, M. Patel and C. Pappalardo, "Integration of geometry and small and large deformation analysis for vehicle modeling: chassis, and airless and pneumatic tyre flexibility", International Journal of Vehicle Performance, vol. 5, no. 1, p. 90, 2019.
- [8]J. Jefferson and H. Sharma, "Design of 3D printable airless tyres using NTopology", Materials Today: Proceedings, 2021.
- [9]Z. Hryciów, J. Jackowski and M. Żmuda, "The Influence of Non-Pneumatic Tyre Structure on its Operational Properties", International Journal of Automotive and Mechanical Engineering, vol. 17, no. 3, pp. 8168-8178, 2020.
- [10]C. Manibaalan, S. Baalamurgun, Dr. Joshi and C. Haran, "STATIC ANALYSIS OF AIRLESS TYRES", International Journal of Scientific and Research Publications, vol. 3, no. 8, pp. 1-4, 2013.

BIOGRAPHIES



AKSHAY KUMAR A
KALAHASTIMATH
(MECHANICLE ENGINEERING)
DSCE, BANGLORE.