AISSMS
COLLEGE OF ENGINEERING
ज्ञानम् सकलजनहिताय
Accredited by NAAC with "A+" Grade

Department of Production Engineering (Sandwich)

A

TPP REPORT

ON

AIRLESS TYRES

SUBMITTED BY

URVESH PATIL (SEAT NO. B150217553)

UNDER THE GUIDANCE OF

Prof. Y R CHANDWADE

(YEAR 2020-21)

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CERTIFICATE

This is to certify that the TPP Report entitled

AIRLESS TYRES

Submitted by

MR. URVESH PATIL SEAT NO. B150217553

Is a Bonafide work carried out under the supervision and guidance of Prof. Y R Chandwade and it is approved for the partial fulfillment of the requirements of Savitribai Phule Pune University for the award of the Degree of Bachelor of Engineering (Production Sandwich). The Technical Paper Presentation report has not been earlier submitted to any other Institute or University for the award of any Degree or Diploma.

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Abstract

Airless tyres or non-pneumatic tyres is introduced with a replacement of poly- composite materials in place of air in a definite structure.

The construction and material study of these tyres is done by comparing it with pneumatic tyres. A brief structural study on spokes of airless tyres is done and is related with rolling resistance and fuel efficiency.

Airless tyres or flat-proof tyres (also known as tweel) is designed to have Poly composite compound treaded around a hub of flexible spokes.

The aim of this research paper is to highlight the importance of the Finite Element Method (FEM) is used to model and simulate the dynamic interaction between non-pneumatic.

Airless Tyres

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 tyres, something that has become more prevalent in the past few years, A few tyre companies have started experimenting with designs for non-pneumatic tyres including Michelin and Bridgestone, but neither design has made it to mass production.

Creating a new non-pneumatic design for tyres has more positive implications than one might think. For one thing, there are huge safety benefits. Having an airless tyre means there is no possibility of a blowout which, in tum, 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.

HISTORY

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.

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 design of all pneumatic tyres is very similar, even though there are many different types. They all include an inner core that holds pressurized air which is then covered with a layer of rubber that comes in contact with the road, called a tread. The tread helps keep traction with the road and prevents slipping and skidding. The tread has the tendency to wear down over time, so if the tyre has

not gone flat, a person will usually replace it at this point.

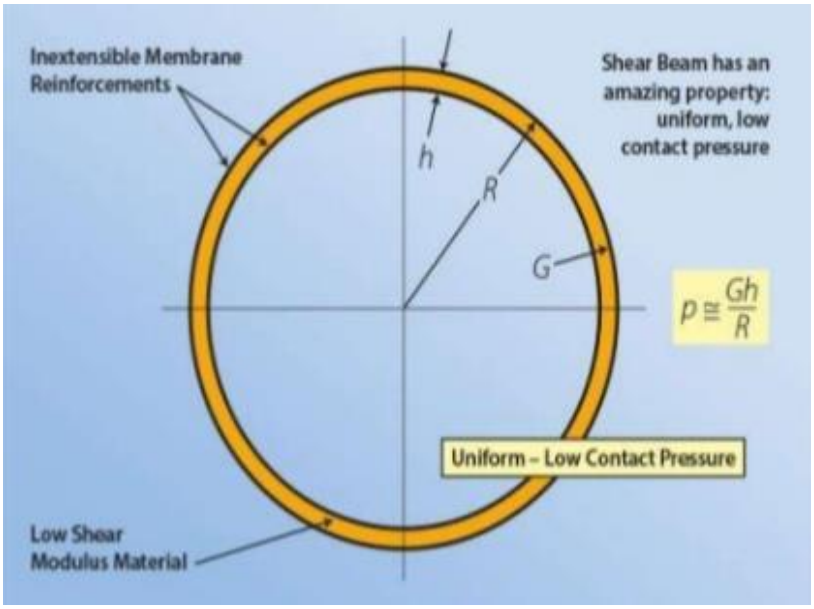
A main reason for using pneumatic tyres is the deformation that occurs during rotation. As the tyre rolls, the weight of the car pushing down on it causes the tyre to flatten slightly. This, in turn, causes the tyre to have a larger surface area to be in contact with the ground, which makes for better traction. It also gives a slight cushioning effect, making running over small rocks or debris unnoticeable. Or, as writer for How Stuff Works Ed Grabianowski puts it. If you've ever taken a ride in an old-fashioned carriage with wooden wheels, you know what a difference a pneumatic tyre makes.

Pneumatic tyres have their advantages, but they also have their disadvantages as well. The possibility of a blowout or flat (when air is let out suddenly from the tyre) is a major concern because they have the tendency to cause severe accidents. The task of regulating tyre pressure is also a disadvantage because consumers are usually not very good at it. Although it may help with traction to have the tyres a little flat, it comes at the price of handling. When there is not enough air pressure in the tyre, the side walls flex causing the tyre to not quite follow the desired line of steering. It is because of these disadvantages that tyre companies have taken an interest in designing airless tyres.

WHAT IS AIRLESS TYRE (TWEEL)?

Airless tyres or non-pneumatic tyres (NPT), are the tyres that are not supported by air pressure. These tyres are also called as Tweel which is a merger of the words tyre and wheel. This is because the Tweel does not use a traditional wheel hub assembly. The Tweel concept was first announced by Michelin back in 2005. Its structure is a solid inner hub mounted onto the vehicle’s axle, that is surrounded by polyurethane spokes. This forms a pattern of wedges, which help to absorb the impacts of the road. These spokes look similar to the ones found on bicycles and plays the shock-absorbing role of the compressed air as in a traditional tyre.

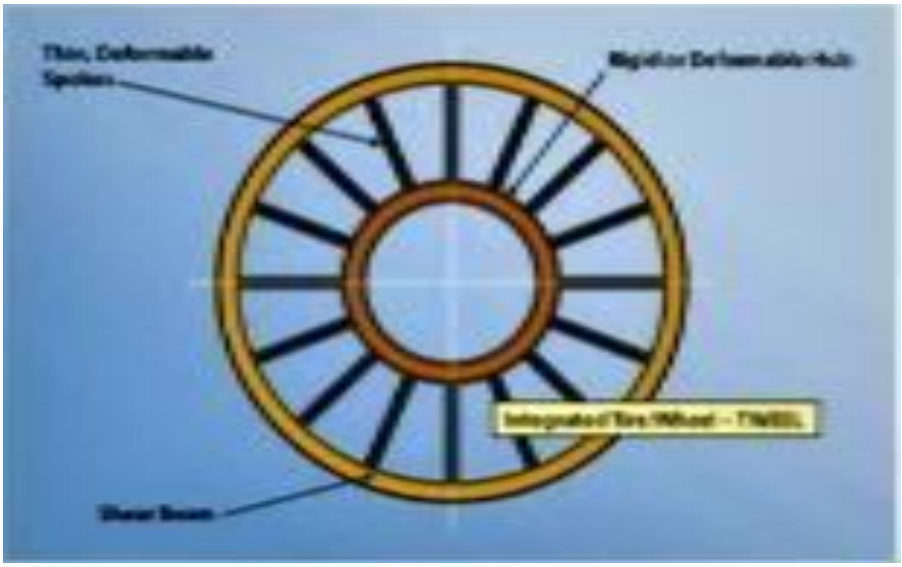
A sheer band is then stretched across the spokes, which forms the outer edge of the tyre. It is the tension of the band and the strength of the spokes that replaces the air pressure used on traditional tyres. When a vehicle drives over an obstacle, a sleeping policeman for example, the tread and shear bands give way as the spokes bend, before they quickly bounce back into shape.



1.1 Tweel Tyres structure

HOW IT WORKS

The Airless tyre (Tweel) doesn't use a traditional wheel hub assembly. A solid inner hub mounts to the axle and is surrounded by polyurethane spokes arrayed in a pattern of wedges. A shear band is stretched across the spokes, forming the outer edge of the tyre. On it sits the tread, the part that comes in contact with the surface of the road. The cushion formed by the air trapped inside a conventional tyre is replaced by the strength of the spokes, which receive the tension of the shear band. Placed on the shear band is the tread, the part that makes contact with the surface of the road. When the Tweel is running on the road, the spokes absorb road defects the same way air pressure does in the case of pneumatic tyres. The flexible tread and shear bands deform temporarily as the spokes bend, then quickly go back to the initial shape. Different spoke tensions can be used as required by the handling characteristics and lateral stiffness can also vary. However, once produced the Tweel's spoke tensions and lateral stiffness cannot be adjusted.



1.2 Tweel Tyres structure

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.

NASA and the Apollo Lunar Rover:

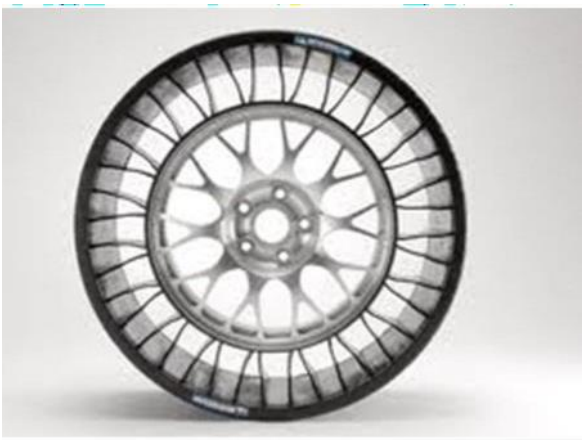
The first major attempt at creating an airless tyre was in 1970 for NASA's Apollo Lunar Roving Vehicle. The tyres were made of steel strands woven together to form the shape, and then were coated with zinc. In order to gain traction, titanium chevrons were added to the outer surface. This design worked well on the moon, where comfort of the drivers was not an issue (ie. 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.

Michelin:

The next main attempt at creating an airless tyre was called the Tweel (combination of tyre and wheel) by the tyre company, Michelin. Their design consisted of a thin rubber tread with V-shaped spokes made of polyurethane.

There were extremely high hopes for this model when it came out. Columnist Don Sherman of Car and Driver writes, introductory claims versus conventional pneumatic radials were two to three times the tread life and five times higher lateral stiffness with only a slight increase in rolling resistance. This development has very positive implications because it means that the tyre would last about two times longer than a standard pneumatic tyre before it would have to be retreaded. The only major problem with this model is at highway speeds, the spokes tend to vibrate, causing excessive noise.

When asked about recent developments for the Tweel, Michelin refused comment, either because they dropped the project, are working with the military, or do not want to divulge findings to their competitors.

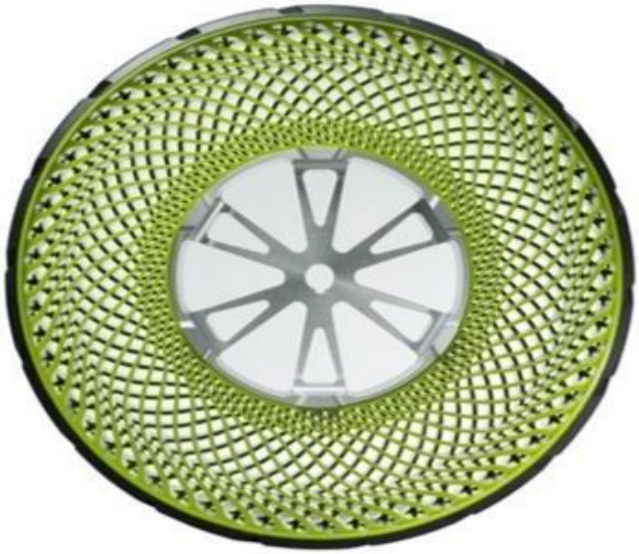


1.4 Michelin

Bridgestone:

Another model for the non-pneumatic tyre came from the well-known tyre company, Bridgestone. Although very similar in concept to Michelin s Tweel, there are some key differences.

The core is male of rigid aluminum and has thermoplastic spokes radiating outward at an angle in opposite directions on each side. This creates more stability and less lateral movement in the tyre. Bridgestone also fixed the vibration and noise problem in this way as well. The main issue with their design was that debris had the tendency to get caught in the gaps between spokes. In addition, the materials used in the tyres are recyclable, contributing to the efficient use of resources. Further, by pursuing extremely low rolling resistance and contributing to reductions in CO2 emissions through use of proprietary technologies, Bridgestone believes it is possible to achieve even higher levels of environmental friendliness and safety. Bridgestone is pursuing this technological development with the aim of achieving a "cradle to cradle" process that proactively maximizes the cyclical use of resources from worn tyres into new tyres and the use of recyclable resources.



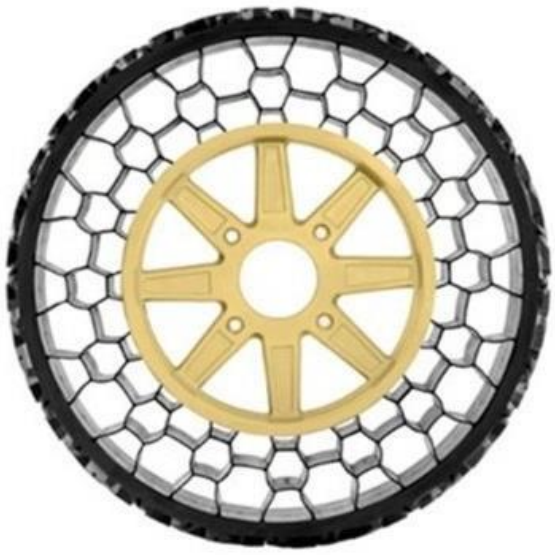
1.5 Bridgestone

Resilient Technologies, LLC:

As stated before, the production of airless tyres would be extremely beneficial to the military. The group Resilient Technologies, LLC is working with the military to develop such a tyre for Humvees. To meet the requirements of heavy loads and rough terrain, these tyres are quite industrial-looking. They consist of a thick outer tread with a honeycomb-like structure inside. This allows for the load to be evenly distributed around the tyre.

The honeycomb design could be adjusted for any application where loss of air pressure causes problems, where tyres face numerous hazards on a regular basis or where business want to reduce downtime for tyre issues and maintenance, such as agricultural and construction equipment

This design causes the tyre to be very loud, making in unsuitable for regular automobiles. For military purposes however, it is useful. It can withstand a large amount of abuse, including blasts when under attack.



1.6 Resilient Technologies

SciTech:

The most convenient design for everyday vehicles comes from a company called SciTech. Their tyre fits on standard rims, unlike all previously mentioned models (which are really a combination of a wheel and a Tyre), and has the look of a regular pneumatic tyre form the outside. Instead of supports radiating from the center, their supports are spring-like.

There area hundred supports in every tyre and nine are in contact with the road at any one time. Thereis also a secondary support system in order to distribute load to all of the supports which have550 pounds of strength each and are made of a thermoplastic glass fiber composite material. Because SciTech's tyre has closed sidewalls and no spokes, there is no noise or overheatingissue as well as no problems with debris.

A division of SciTech industries, has announced asuccessful test of the company's non-pneumatic airless tyre at an industry laboratory in Ohio. The company says the tyre achieved a cool and uniform 10-hour run at highway speed atpassenger car load. Mounted on a standard rim with a conventional tyre mounting machinesthe airless tyre is self-supporting, with internal glass fiber composite ribs supporting the load.Built and cured in a conventional steam-bladder mold at a commercial tyre factory, thecomposite rib and tyre construction are covered by worldwide patents.

Hankook i-Flex:

A futuristic design concept, the Hankook i-Flex is an airless wheel and tyre, all in one. Aiming to keep losses to a minimum when converting energy, Hankook Tyres engineers have reconceptualized the automobile tyre. With the Hankook Tyres i-Flex, the company presents the prototype of a non-pneumatic tyre that will help increase the overall efficiency of vehicles thereby improving their energy balance.

With 95 percent of its construction being recyclable, the Hankook i-Flex is made from polyurethane synthetics, with the tyre manufactured in conjunction with its rim as one unit. It is considerably lighter than conventional wheel-tyre combinations and does not require air like conventional pneumatic tyres, able to offer shock absorbency through the unique design. Fuel consumption and noise emissions are thus optimized while simultaneously increasing vehicle safety.

Displayed at the Frankfurt show on an ABT-tuned Volkswagen Up. the Hankook i-Flex tyre specification is 155/590 14 (155mm wide. 590mm diameter. 14-inch simulated wheel size). Through Hankook Tyres hands-on display and video guides, visitors to the Frankfurt show can alter the colors of the Hankook i-Flex.

At the 65th IAA (International Automobil-Ausstellung). September 12-22, in Frankfurt, premium tyre manufacturer Hankook Tyre will present its latest innovations, production-ready prototypes and trend-setting tyre concepts designed to meet the demands of future mobility, in Hall 8. Stand 24.

1.7 Hankook i-Flex

Advantages of airless Tyres:

1. Eliminates air leaks or Tyre blow outs.
2. With no air pressure you are left with consistent economy and handling.
3. Its flexibility provides an increase in surface area of contact.
4. No maintenance needed.
5. To lengthen tread life.
6. Facilitate recycling.
7. Makes Vehicle more Efficient have high lateral strength for better handling without a loss in comfort.
8. Vehicle remains under control even in emergency brake
9. Remains mobile even with some of the spokes damaged or missing.
10. Durability & Long Life.
11. Can take gunfire or explosion.
12. Less environmental impact.

Disadvantages of airless tyres:

1. Lack of adjustability: -

One of the biggest disadvantages of the Tweel is that once it has been manufactured, it cannot be adjusted. In this case if the car needed a different kind of setting, a whole new set of Tweels will be required. On the plus side Tweels are made with five times the lateral stiffness compared to pneumatic tyres, enabling very responsive handling.

2. Not economic as pneumatic tyres: -

Michelin are currently working on enabling the Tweels to be as fuel efficient as pneumatic tyres. Currently they are within 5% of the rolling resistance and mass levels.

3. Vibration: -

This could be one of the Tweels biggest downsides. Vibrations become considerate once a vehicle is driving above 50 mph, while causing a lot of noise. Also disturbing is the amount of heat the Tweels generate long distance journey with tweels would be very unpleasant unless these areas are improved upon.

4. Different Manufacturing process: -

Another problem is that creating airless tyres requires a totally different manufacturing process. At this point of time, the tyre industry revolves around the manufacture of traditional pneumatic tyres. To modify factories and service equipment would be a major change, and the facilities just don't exist yet.

APPLICATIONS OF AIRLESS TYRES:

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

1.8 Golf cars

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

1.9 Heavy Equipment

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

1.10Military Tweel

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.

1.11 Terrain vehicle

Safety:

As stated before, the main danger of pneumatic tyres is the chance of a flat or blowout that usually occurs at highway speeds. A blowout is when a tyre basically pops and deflates rapidly. This causes the driver to lose control of the car and risk the possibility of hitting another vehicle. With airless tyres, this is no longer an issue.

There is no chance for a blowout, and the driver does not have to be concerned about changing a flat (also eliminates the need for a spare tyre).

The assurance of never having a flat tyre is also beneficial in areas such as construction, where there can be sharp debris, and in the military

It is especially useful in the military because the tyres of Humvees are often targeted when under attack, as they are the weakest part of the vehicle. If the tyres are blown, the vehicle cannot go anywhere. Airless tyres in this sense can save the lives of troops riding in Humvees because the tyres can take more abuse.

Better handling is also a benefit when it comes to safety. Although it does not vary by much, it is important to have that extra stability in the tyre to make the car go exactly in the direction in which it is steered. This is especially helpful in swerving to avoid an obstacle such as an animal or another car. So for this reason, improved handling is not just for a better driving experience

Environmental Concerns:

Non-pneumatic tyres are also expected to have a positive environmental impact. As of now, tyre companies must address the growing mountain of bald tyres defiling the landscape and find a way to recycle or find something that lasts longer and can be recycled. In the case of airless tyres, it can be the latter. SciTech's airless tyre is said to be able to outlast the car. This has enormous environmental implications because with so many cars on the road, there are many old tyres that have to be disposed of. Because airless tyres mostly use composite materials, there is only a small amount of rubber that actually goes into it. Also, since the tread life of most models is longer than that of pneumatic tyres, the rubber does not have to be replaced very often. This means that there will be less of it to dispose of later.

Conclusion:

Tyres may seem to be a trivial part of an automobile that cannot be improved, but research into airless tyres shows otherwise. This new technology will increase the safety of cars as well as have a positive impact environmentally. Since these tyres are also able to be retreaded, there is the possibility of a smaller cost per tyre- which is always embraced by the consumer. This innovative project is also backed and guided by engineering codes of ethics which will ensure that the development is conducted in a way that it responsible and fair.

It is also important to think about the implications of a technology such as this. This is reinventing the wheel in a way! If engineers can do this, they will think about other things that can be improved. Then we will not only have inventors of entirely new technologies, but also people who can take something already in place and make it even better. This type of innovation will become increasingly valuable in the future which is why researching topics such as this is very important for young people. It gives them a sense of what they can do after all of their hard-working years of schooling and that what they can do will matter.

REFERENCES:

1. M. Mazzoni (2011). Bridgestone Debuts Airless Car Tyre Earth911.com (Online article) http://earth911.com/news/2011/12/06/bridgestone-debuts-airless-car-tyre/
2. Golson, Jordan, Michelin develops new airless tyre, 2019.
3. Anuj Suhag, Rahul Dayal, Static Analysis on Custom Polyurethane Spokes of Airless Tire. International Journal of Scientific and Research Publications, 2013.
4. Bert Bras and Austin Cobert. Life-Cycle Environmental Impact of Michelin tweel tyres for Passenger vehicles.
5. B. Mattmiller. (2008). Airless Tyre Project May Prove a Lifesaver in Military Combat University of Wisconsin news archive.

(Onlinearticle)http://www.engr.wisc.edu/news/archive/2008/Jul08.html

6. D Sherman (2012). Tech Dept. The Latest on the Airless Tyre-and-Wheel Combo Car and Driver

(Online article) http://www.caranddriver.com/features/tech-dept-the-latest-on the airless-tyre-and-wheel-combo-tech-dept

7. E Grabianowski. (2011). How the Tweel Airless Tyre Works How Stuff Works (Online article) http://auto.howstuffworks.com/tweel-airless-tyre.htm
8. Airless Tyre Project SciTech Industries (2012). http://vimeo.com/41741265
9. A. Kwon (2012) Design Spotlight the Auless Tyre. Gear Patrol (Online article).
10.KwameOpam on November18,2013http://www.theverge.com/2013/11/18/5117710/polaris-latest-atv-has-airless-tyres that-can-withstand-50-caliber
11.http://curiosity.discovery.com/question/downside-with-tweel-airless-tyres.