INVESTIGATIVE DESIGN AND ANALYSIS OF FOUR WHEELER AIRLESS TIRE

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Abstract: The airless tire is a single unit replacing the pneumatic tire, wheel and tire assembly. It replaces all the components of a typical radial tire and is comprised of a rigid hub, connected to a shear band by means of flexible, deformable polyurethane spokes a nd a tread band, all functioning as a single unit. The Tweel, a kind of airless tire, though finds its generic application in military and earth moving applications due to its flat proof design can also render the pneumatic tire obsolete in domestic cars. Our proj ect involves design and analysis of an airless tire for domestic cars; this will be followed by a stress analysis study. The model will be do in Pro E and analysis will do in Ansys.

I. INTRODUCTION

The Tweel (a portmanteau of *tire* and *wheel*) is an airless tire design concept developed by the French tire company Michelin. Its significant advantage over pneumatic tires is that the Tweel does not use a bladder full of compressed air, and therefore it cannot burst, leak pressure, or become flat. Instead, the Tweel assembly's inner hub connects to flexible polyurethane spokes which are used to support an outer rim and these engineered compliant components assume the shock-absorbing role provided by the compressed air in a traditional tire.

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 tires, something that has become more prevalent in the past few years. A few tire companies have started experimenting with designs for non pneumatic tires including Michelin and Bridgestone, but neither design has made it to mass production. Creating a new non pneumatic design for tires has more positive implications than one might think. For one thing, there are huge safety benefits. Having an airless tire means there is no possibility of a blowout, which, in turn, means the number of highway accidents will but cut significantly. Even for situations such as Humvees in the military, utilizing non pneumatic tires has a great positive impact on safety. Tires are the weak point in military vehicles and are often targeted with explosives. If these vehicles used airless tires, this would no longer be a concern. There is also an environmental benefit to using this type of tire. Since they never go flat and can be retreaded, airless tires will not have to be thrown away and replaced nearly as often as pneumatic tires. This will cut down landfill mass significantly. Because of the benefits, I believe that it is extremely important that research and production of airless tires 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.

Tire Technology

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

Pneumatic Tires

The basic design of all pneumatic tires 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 tire has not gone flat, a person will usually replace it at this point.

A main reason for using pneumatic tires is the deformation that occurs during rotation. As the tire rolls, the weight of the car pushing down on it causes the tire to flatten slightly. This, in turn, causes the tire 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 tire makes.

Pneumatic tires 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 tire) is a major concern because they have the tendency to cause severe accidents. The task of regulating tire pressure is also a disadvantage because consumers are usually not very good at it. Although it may help with traction to have the tires a little flat, it comes at the price of handling. When there is not enough air pressure in the tire, the sidewalls flex causing the tire to not quite follow the desired line of steering.

It is because of these disadvantages that tire companies have taken an interest in designing airless tires.

Airless Tires

Although each company has a different design approach to the airless tire, most share the same basic concepts. The main concept that must be considered when trying to design a non pneumatic tire is the issue of deformation. The tire must be strong enough to hold the car and withstand a large amount of abuse, as well as be able to deform slightly when it comes in contact with the road. Most companies that have designed airless tires have used a strong, metal core with supports radiating outward made of some type of composite material. The tire is then usually treaded with a rubber compound.

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 tire.

Advantages of airless tires

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

Disadvantages of airless tires

- 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 tires, enabling very responsive handling.
- Not as 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.

- 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.
- 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 tires

- They are used on some small vehicles such as riding lawn mowers and motorized golf carts.
- They are also used on heavy equipment such as backhoes, which are required to operate on sites such as building demolition.

Types of tires

Different design approaches

The following are approaches to making an airless tire 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 tire was in 1970 for NASAs Apollo Lunar Roving Vehicle. The tires 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 tires), 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.

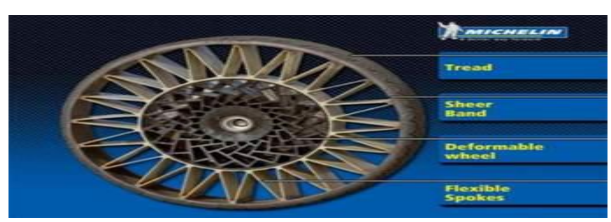
NASA and the Apollo Lunar Rover

Michelin

The next main attempt at creating an airless tire was called the Tweel (combination of tire and wheel) by the tire 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 tire would last about two times longer than a standard pneumatic tire 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.



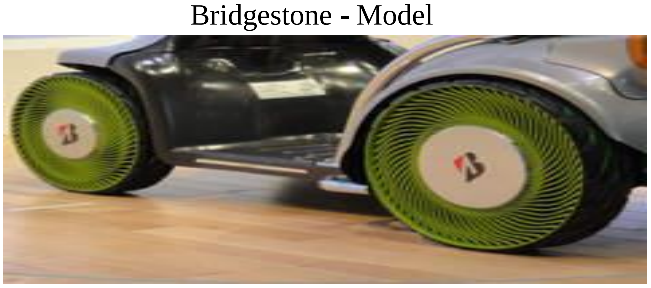
Michelin – Model

Michelin - Use

Bridgestone

Another model for the non pneumatic tire came from the well known tire company, Bridgestone. Although very similar in concept to Michelins Tweel, there are some key differences. The core is made 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 tire. 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.

Bridgestone - Model



Bridgestone - Use

Resilient Technologies, LLC

As stated before, the production of airless tires would be extremely beneficial to the military. The group Resilient Technologies, LLC is working with the military to develop such a tire for Humvees. To meet the requirements of heavy loads and rough terrain, these tires 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 tire. This design causes the tire 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.

Resilient Technologies, LLC – Model

Resilient Technologies, LLC - Use

SciTech

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

There are a hundred supports in every tire and nine are in contact with the road at any one time. There is also a secondary support system in order to distribute load to all of the supports which have 550 pounds of strength each and are made of a thermoplastic glass fiber composite material. Because SciTech's tire has closed sidewalls and no spokes, there is no noise or overheating issue as well as no problems with debris.

SciTech

Benefits of creating an airless tire

Although it may seem excessive to rethink such a trivial part of an automobile, there are many benefits of continued research and development of non pneumatic tires. The goals are to eliminate flats, lengthen tread life, facilitate recycling, and improve handling. These goals cover two main areas: safety and environmental concerns, each of which is very important to our everyday lives.

Safety

As stated before, the main danger of pneumatic tires is the chance of a flat or blowout that usually occurs at highway speeds. A blowout is when a tire 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 tires, 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 tire).

The assurance of never having a flat tire 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 tires of Humvees are often targeted when under attack, as they are the weakest part of the vehicle. If the tires are blown, the vehicle cannot go anywhere. Airless tires in this sense can save the lives of troops riding in Humvees because the tires 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 tire to make the cargo 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 tires are also expected to have a positive environmental impact. As of now, tire companies must address the growing mountain of bald tires defiling the landscape and find a way to recycle or find something that lasts longer and can be recycled. In the case of airless tires, it can be the latter. SciTechs airless tire 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 tires that have to be disposed of. Because airless tires 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 tires, the rubber does not have to be replaced very often. This means that there will be less of it to dispose of later.

Ethical considerations

Although creating and developing airless tires may not seem to have many ethical concerns, codes must be followed in order for products, as well as the manufacturers reputation, to be reliable. Codes of ethics are very important in engineering and are used to reinforce a company's ambitions as well as guide them in the way of conduct.

Reinforcement

One of the fundamental cannons of the Engineering Code of Ethics states that engineers shall hold paramount the safety, heath, and welfare of the public. In creating airless tires, engineers are upholding this cannon because the prime reason for the development is to increase safety. It is extremely important that this cannon is considered when developing new technologies because it can be very tempting to get caught up in the profit aspect and not give enough attention to the effects of marketing such a product. If they are upholding this cannon, companies will make serving the public their top priority and thus, their products (i.e. airless tires) will be of excellent quality.

The National Society of Professional Engineers(NSPE) Code of Ethics also reinforces the ambition of any company who is developing airless tires through its sustainability clause. It states, Engineers are encouraged to adhere to the principles of sustainable development in order to protect the environment for future generations. In addition to promoting safety, engineering codes promote the development of products that positively impact the environment. Because of this fact, it can be said that the development of airless tires is reinforced by the code.

Guidance

It is important that when developing a new technology, certain guidelines are followed to ensure that it is gone about in an honest way. For example, the American Society of Mechanical Engineers (ASME) says that engineers shall respect the proprietary information and intellectual property of others. This is important in developing products such as airless tires because it prevents the issue of companies stealing ideas from each other. It forces them to think of their own solutions to the problem and thus, encourages healthy competition. This is clearly shown in the number of companies that have attempted to develop non pneumatic tires.

They each had different designs aimed at accomplishing the same thing. In the same vein of keeping companies honest, these codes also ensure that the public is kept truthfully aware of the developments. If the public is to be deceived, products may be bought and used that may not be of decent quality. This is could potentially put the safety of the consumer at risk, in the case of airless tires. If facts about the development were skewed, the product could potentially be put on the market with design flaws. This, in turn, could result in product failures or the need for recall neither of which is good for business. The NSPE strives to eliminate this occurring by the following clauses in their Code of Ethics: Engineers shall avoid all conduct that deceives the public and Engineers shall acknowledge their errors and shall not distort or alter the facts. The main purpose for engineers is to create new technologies that will increase the quality of life of the public. If they deceive or manipulate the public for their own personal gain, they are not doing their job. For this reason, I believe that it is extremely important for engineers to look to these codes for guidance when developing something new. If applied correctly, these codes ensure that quality products are produced from a reputable company.

Personal interest in this topic

For most of my life, I must admit that I had absolutely no interest at all in cars. It was only during my senior year of high school when I started driving frequently that I became interested. The car that I drove most of the time was a big Chevrolet Suburban truck that had many problems. At one point during the year, I started hearing a squeak coming from somewhere in the front near the engine that just kept getting worse as time went on. It had really started to bother me, so I told my brother about it. My brother, a mechanical engineer, is extremely knowledgeable about cars (he has fixed all of the ones we own many times) and enjoys working with them as a hobby. I asked him to explain to me what he thought the problem was, and asked if I could help him fix it. It ended up being a very fun project because we couldn't figure out what was wrong for the longest time there was much trial and error. Since then, I have become very interested in the mechanics of how cars work. So later that summer, my brother and I bought a car to work on. I find it to be such a fun project because I love learning hands on and seeing how things work firsthand. I chose to write about this topic because I am very interested, not only in cars, but also in new technologies. I think that it is fascinating that something as simple as a tire or wheel can be completely rethought to be improved. After my years at the University, I want to work in the automotive field, and after learning about this revolutionary piece of technology, I was inspired become involved in these types of projects later in my professional life.

Education and engineering

An engineer, as one might expect, should be extremely knowledgeable in areas such as mat and the sciences. It is also true, however that engineers are people who can convey their ideas in ways that can be well understood by others. In this way, I believe that doing research projects is extremely important for freshman engineering students during the course of their education. Because writing a paper such as this requires a great deal of time to research and compose, it forces students to think more as an intellectual and become more informed about what is currently happening in society.

Design

The Tweel consists of a band of conventional tire rubber with molded tread, a shear beam just below the tread that creates a compliant contact patch, a series of energy absorbing polyurethane spokes, and an integral inner rim structure. Both the shear beam and the polyurethane spokes can be designed to provide a calibrated directional stiffness in order that design engineers are able to control both how the Tweel handles and how it handles loads. The inner hub structure may be either rigid or compliant, depending on the application requirements, and as such may contain a matrix of deformable plastic structures that flex under load and subsequently return to their original shape. By varying the thickness and size of the spokes, Michelin can manipulate the design elements to engineer a wide array of ride and handling qualities. The tread can be as specialized as any of today's tires and is replaceable when worn.

Benefits and Drawbacks

Potential benefits of the Tweel include not only the obvious safety and convenience of never having flat tires, but also, in automotive applications, the Tweel airless tire has the potential to be able to brake - a significant performance compromise that is inherent to pneumatic tires. Unlike a pneumatic tire, a Tweel can be designed to have high lateral stiffness while simultaneously having low vertical stiffness. This can be achieved because, in the design elements of a Tweel, the vertical and lateral stiffness are not inseparably linked and can thus be optimized independently. Because there is no air bladder under the tread, tread patterns can, if desired, even incorporate water evacuation through holes in the design thus eliminating or significantly reducing hydroplaning. Michelin expects the tread to last two to three times as long as a conventional tire. Because the tread rubber around the outer circumference is replaceable when worn (as opposed to disposing of a whole worn tire), the potential environmental impact of a Tweel airless tire can be less than that of a conventional pneumatic tire.

Tweel is useful for: "vehicles that don't have suspensions like lawn mowers - those low speed specialty vehicles that don't have suspensions. The comfort is quite good and better than inflated tyres" said Terry K. Gettys, Executive Vice-President, Research and Development, and member of the Group Executive Committee at French tire company Michelin. Military testing has indicated that the Tweel deflects mine blasts away from the vehicle better than standard tires and that the Tweel remains mobile even with several spokes damaged or missing.

Although it is acknowledged that the initial prototype automotive Tweel tires did demonstrate flaws with regard to noise and high speed vibration and produced 5 percent more friction compared to a radial tire, these early issues were resolved in subsequent prototypes and current automotive Tweel prototype products have been shown to be well behaved and reliable. As a demonstration of Tweel viability and reliability, three highway driven vehicles (a 2012 Honda CR-Z, a resto-modded 1955 Morris Minor Traveler, and an Alumna brand trailer hauling a Polaris ATV which was also equipped with Tweel tires) successfully participated in the entire 2013 Hot Rod Power Tour long distance road trip event in June 2013.

Applications

The iBOT mobility device and Segway's Concept Centaur were both introduced with Tweel airless tires. Michelin also has additional projects for the Tweel concept on small construction equipment, such as skid steer loaders, for which it seems well-suited.

NASA has contracted Michelin to develop a wheel for the next generation Lunar_Rover based on the Tweel concept. This has resulted in the Lunar Rover Initiative AB Scarab wheels.

In October 2012, Michelin North America Inc. began commercial sales of the Michelin 12N16.5 X Tweel for skid-steer loaders used in landscaping, construction, contracting, refuse/recycling and agricultural industries.


Humvees skid steer loaders

II. REINFORCEMENTS

The reinforcements are solid part of the composites, which are reinforced in to the matrix. They determine the strength and stiffness of the composites. Most common reinforcements are fibres, particles and whiskers. Fibre reinforcements are found in both natural and synthetic forms. Fibre composite was the very first form of composites, using natural fibre such as straw was reinforced in clay to make bricks that were used for building.

Fibre Reinforced Polymer

Fibre-reinforced plastic (FRP) (also fibre-reinforced polymer) is a composite material made of a polymer matrix reinforced with fibres. The primary function of fibre reinforcement is to carry load along the length of the fibre and to provide strength and stiffness in one direction. Fibre reinforced polymer composites are different from traditional construction materials like steel or aluminium.

FRP composites are anisotropic (properties apparent in the direction of applied load) whereas steel or aluminium is isotropic (uniform properties in all directions, independent of applied load) and FRP have maximum material stiffness to density ratio of 3.5 to 5 times that of aluminium or steel. The FRP have high fatigue endurance limits; can absorb impact energies, light weight and high strength**.** The main disadvantage of FRP materials is their relatively high cost compared to wood or unpainted low-carbon steel. Limited experience with FRP materials in the construction and design industry. FRP can be applied to strengthen the beams, columns, and slabs of buildings and bridges. FRPs are commonly used in the aerospace, automotive, marine, and construction industries.

Types of Fibre Reinforcements

- The following are the kinds of fibre reinforcements:
- Glass Fibres
- Carbon Fibres
- Natural Fibres
- Boron Fibres
- Fibres based on Silica
- Fibres based on Alumina
- Armed fibres
- High-Density Polyethylene Fibres

Material Properties

Properties	Nylone4-6	Polyethylene
Young's Modulus (GPa)	4.8	2.7
Poisson's Ratio	0.4	0.4
Density (kg/m^3)	1150	1400

Properties of Materials

III. INTRODUCTION TO DESIGN

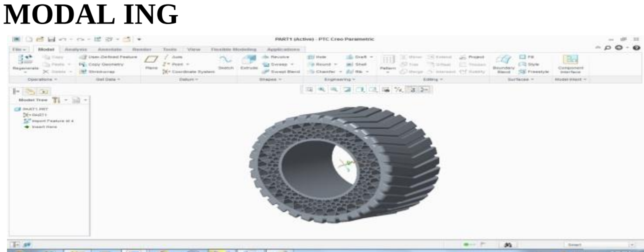
Computer Aided Design (CAD)

Computer Aided Design (CAD) is the use of wide range of computer based tools that assist engineering, architects and other design professionals in their design activities. It is the main geometry authoring tool within the product life cycle management process and involves both software and sometimes special purpose hardware. Current packages range from 2D vector based drafting systems to 3D parametric surface and solid design models.

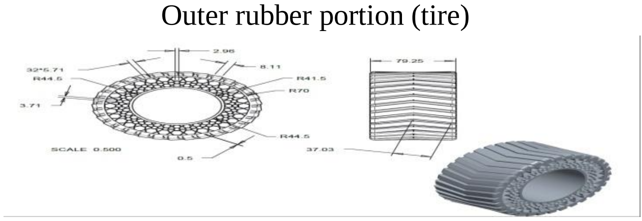
Introduction to PRO/E

PRO/E is the industry's de facto standard 3D mechanical design suit. It is the world's leading **CAD/CAM /CAE** software, gives a broad range of integrated solutions to cover all aspects of product design and manufacturing. Much of its success can be attributed to its technology which spurs its customer's to more quickly and consistently innovate a new robust, parametric, feature based model. Because that **PRO/E** is unmatched in this field, in all processes, in all countries, in all kind of companies along the supply chains.**PRO/E** is also the perfect solution for the manufacturing enterprise, with associative applications, robust responsiveness and web connectivity that make it the ideal flexible engineering solution to accelerate innovations. ***PRO/E*** provides easy to use solution tailored to the needs of small medium sized enterprises as well as large industrial corporations in all industries, consumer goods, fabrications and assembly. Electrical and electronics goods, automotive, aerospace, shipbuilding and plant design. It is user friendly solid and surface modeling can be done easily.

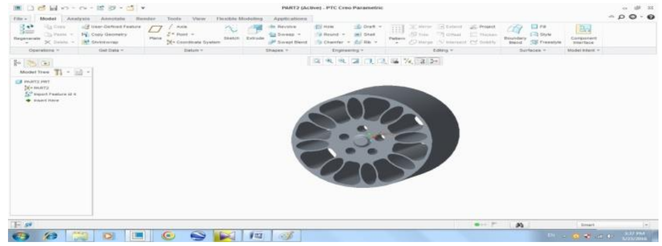
MODAL ING



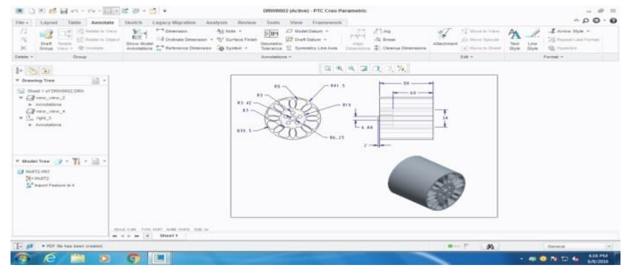
Outer rubber portion (tire)



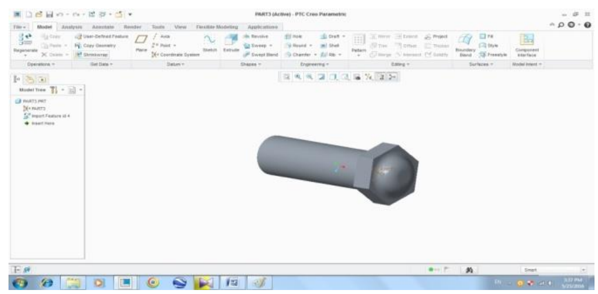
Detail view of outer rubber portion (tire)



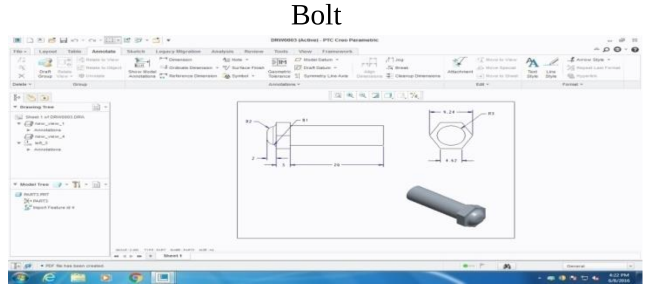
Metal Rim



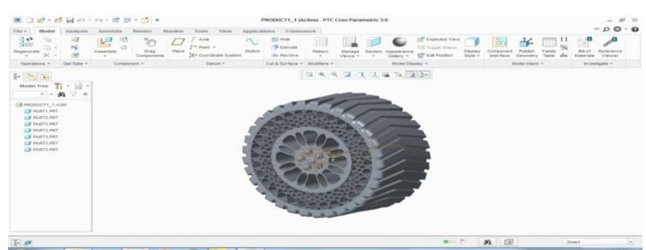
Detail view of Metal Rim



Bolt



Detailed view of Bolt



Total Assembly view of Air less tire

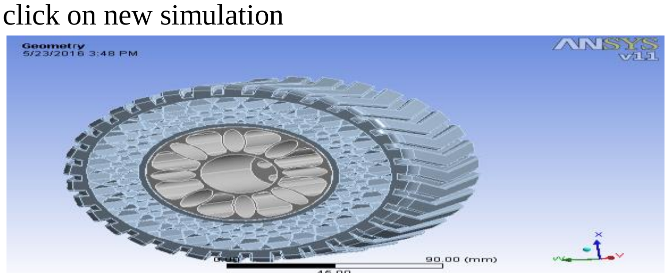
FINITE ELEMENT METHOD / ANALYSIS (FEM/A)

The finite element method is numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in almost every industry. In more and more engineering situations today, we find that it is necessary to obtain approximate solutions to problem rather than exact closed form solution. It is not possible to obtain analytical mathematical solutions for many engineering problems. The finite element method has become a powerful tool for the numerical solutions of a wide range of engineering problems. It has been developed simultaneously with the increasing use of the high- speed electronic digital computers and with the growing emphasis on numerical methods for engineering analysis. This method started as a generalization of the structural idea to some problems of elastic continuum problem, started in terms of different equations.

Procedure

Importing the Model

In this step the PRO/E model is to be imported into ANSYS workbench as follows, In utility menu file option and selecting import external geometry and open file and click on generate. To enter into simulation module click on project tab and click on new simulation



Imported model from Pro/E

Defining Material Properties

To define material properties for the analysis, following steps are used. The main menu is chosen select model and click on corresponding bodies in tree and then create new material enter the values again select simulation tab and select material.

Defining Element Type

To define type of element for the analysis, these steps are to be followed, Chose the main menu select type of contacts and then click on mesh-right click-insert method

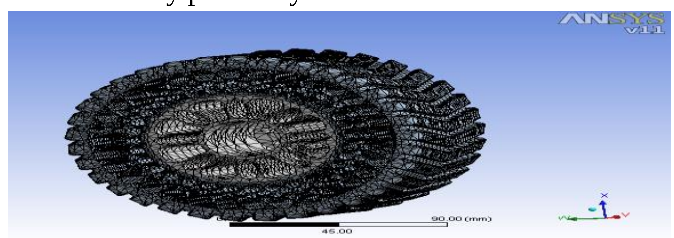
Method - Tetrahedrons

Algorithm - Patch Conforming

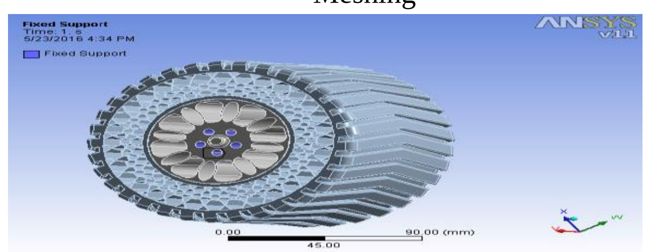
Element Mid side Nodes – Kept

Meshing the model

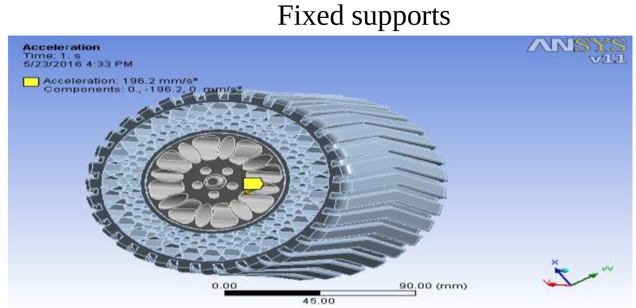
To perform the meshing of the model these steps are to be followed, Chose the main menu click on mesh- right click- insert sizing and then select geometry enter element size and click on edge behavior curvy proximity refinement



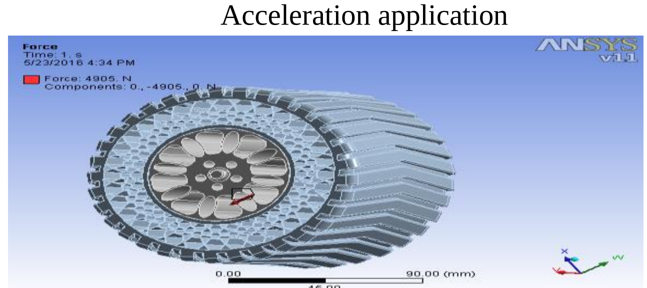
Meshing



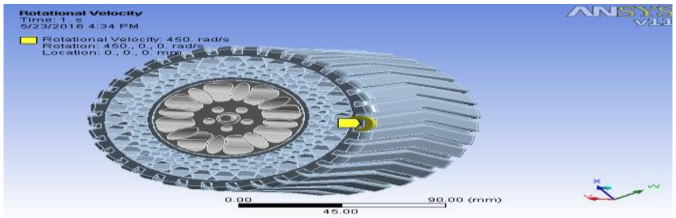
Fixed supports



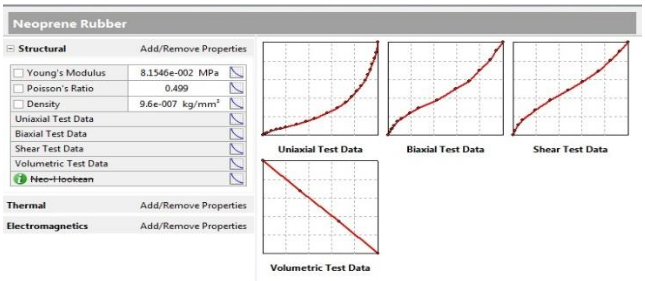
Acceleration application



Force application

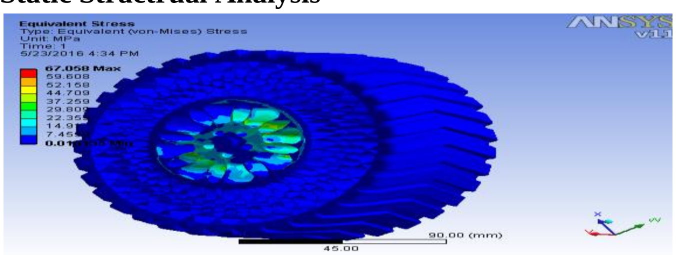


Rotational velocity

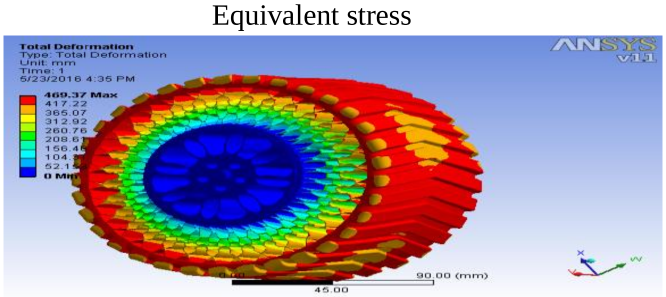


Material Properties of neoprene Rubber

Static Stractrual Analysis

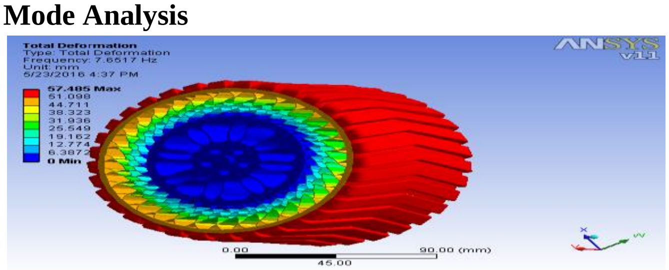


Equivalent stress

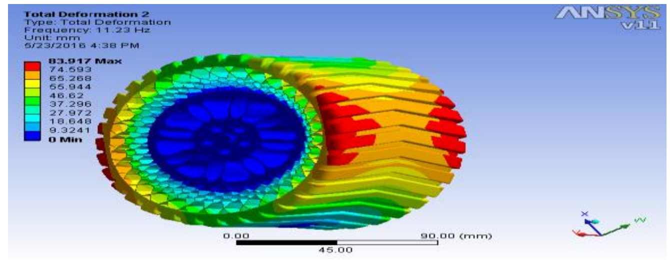


Total Deformation

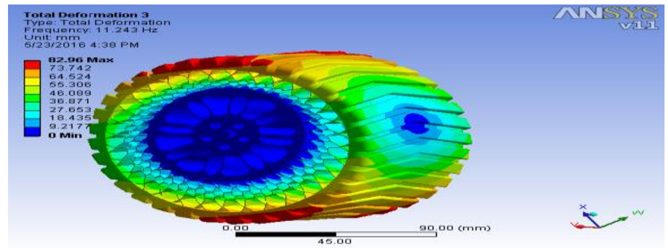
Mode Analysis



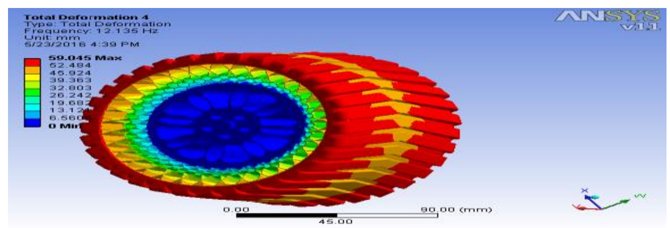
At Mode 1



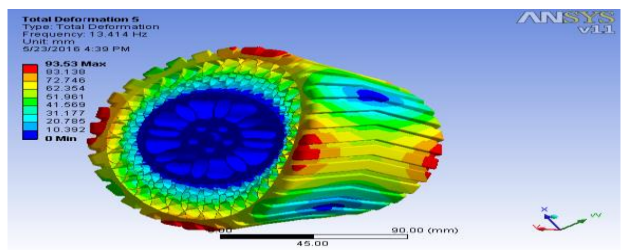
At Mode 2



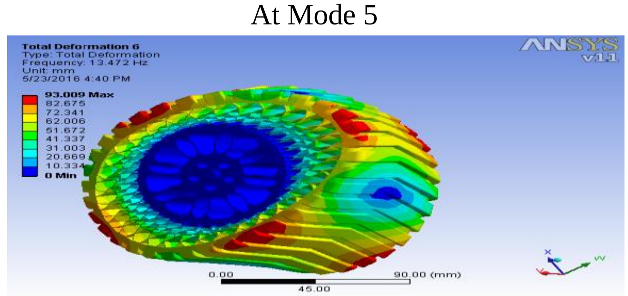
At Mode 3



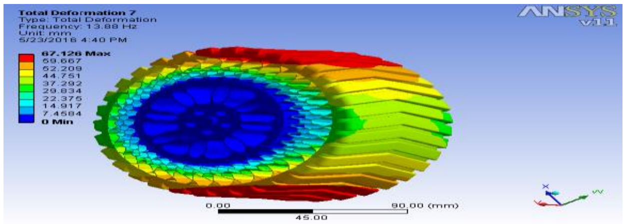
At Mode 4



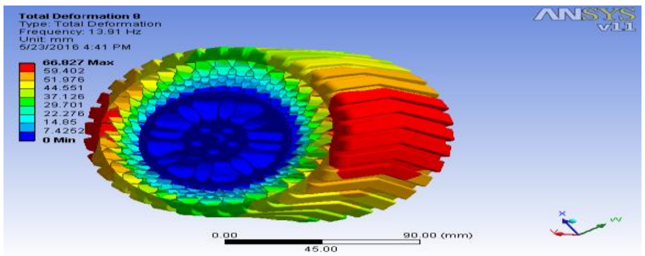
At Mode 5



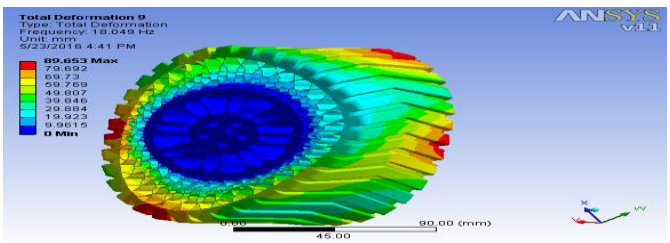
At Mode 6



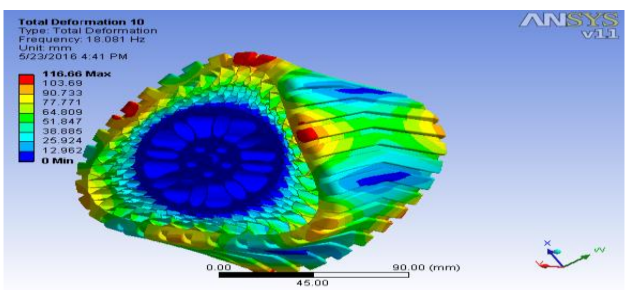
At Mode 7



At Mode 8

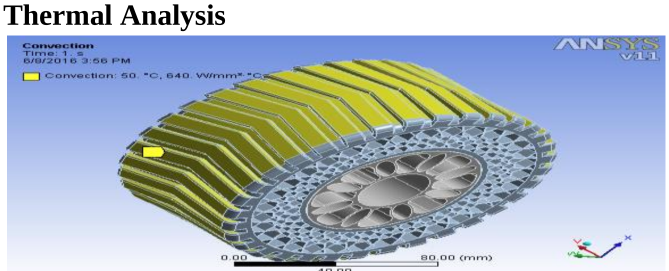


At Mode 9

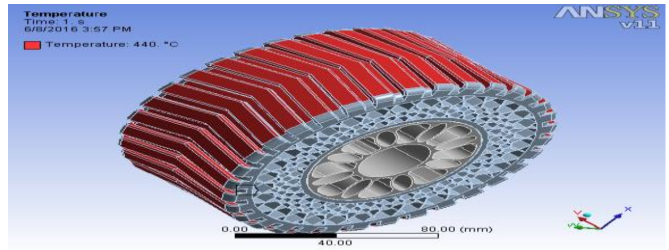


At Mode 10

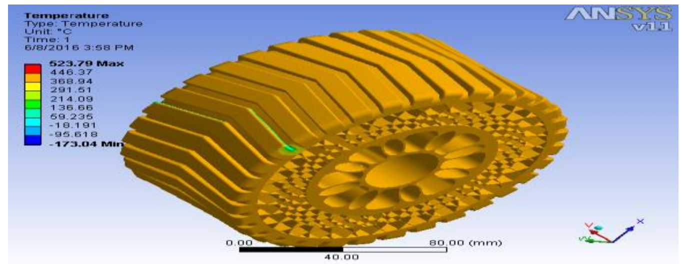
Thermal Analysis



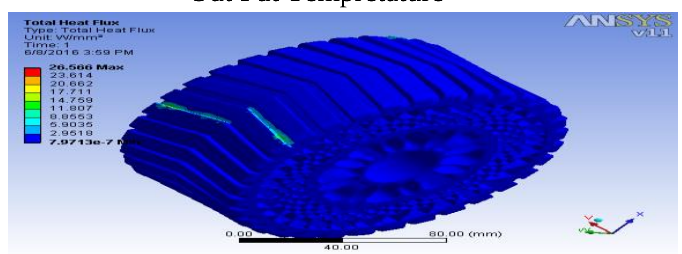
Heat convection



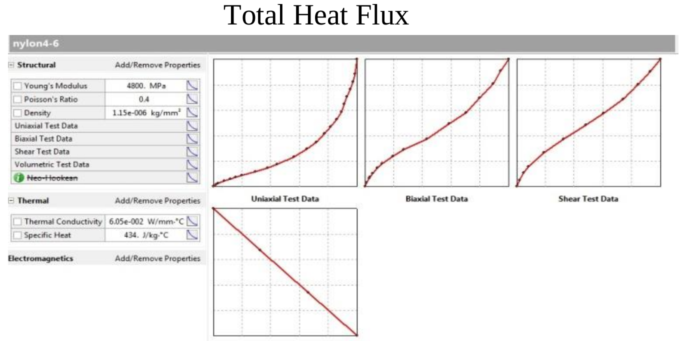
Temperature



Out Put Tempretature

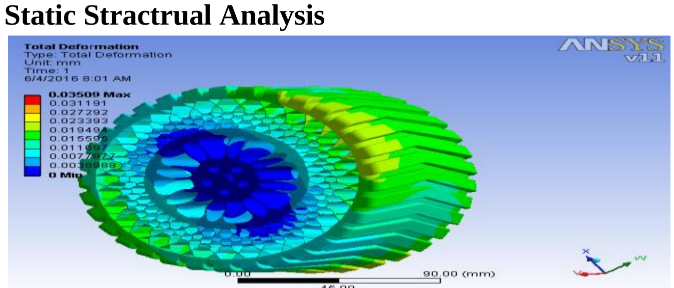


Total Heat Flux

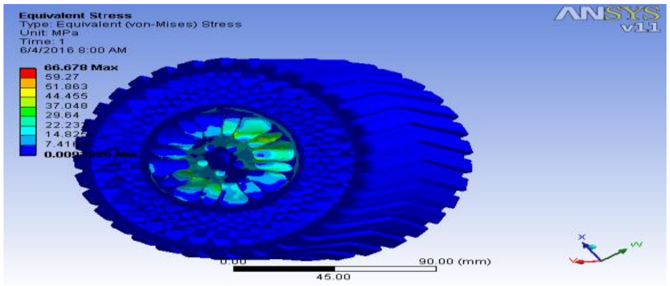


Material Properties of nylone4-6

Static Stractrual Analysis

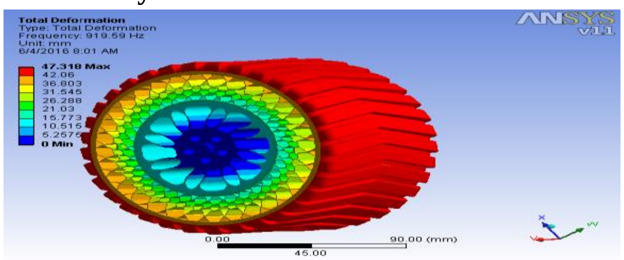


Total Deformation

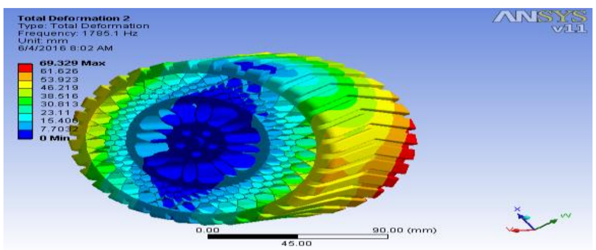


Stress

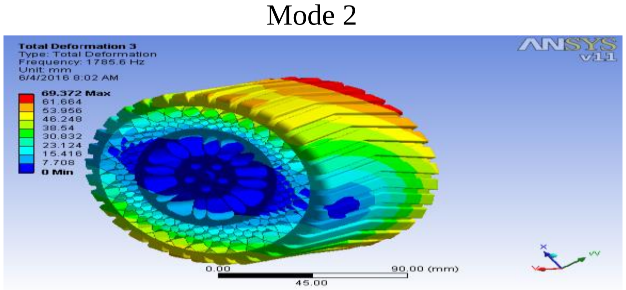
Mode Analysis



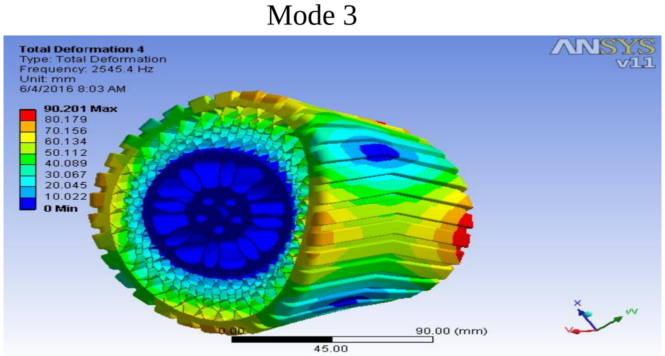
Mode 1



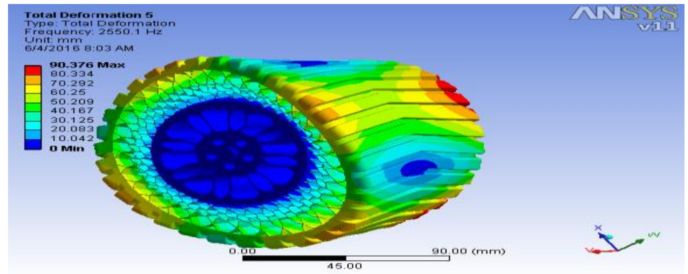
Mode 2



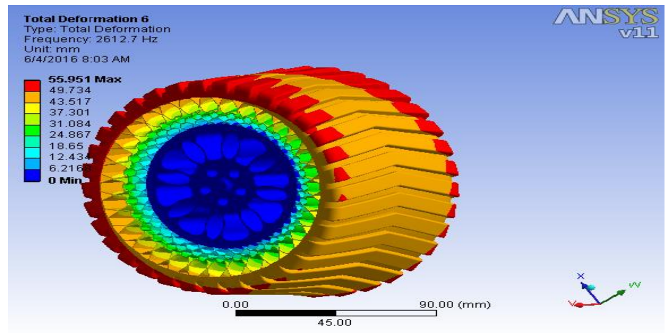
Mode 3



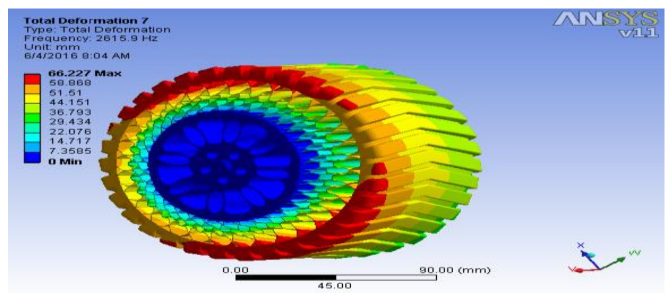
Mode 4



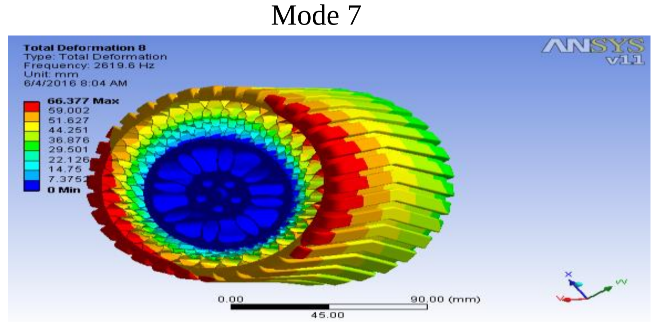
Mode 5



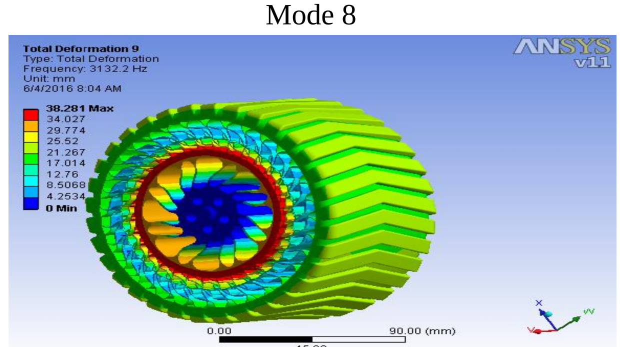
Mode 6



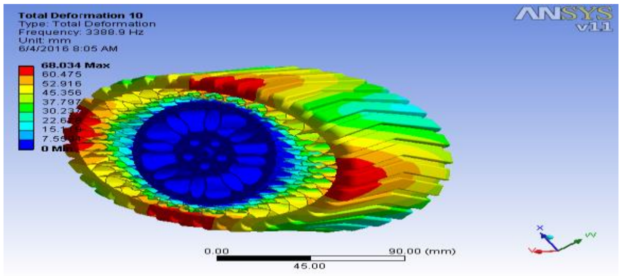
Mode 7



Mode 8

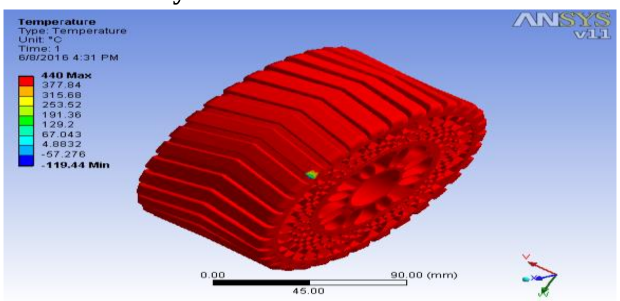


Mode 9

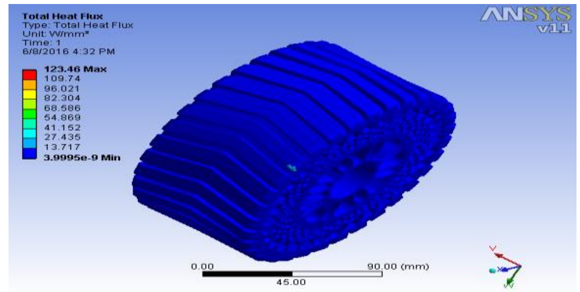


Mode 10

Thermal Analysis



Out Put Tempereture



Total heat flux

IV. RESULTS

Total deformation mode table

Modes Material	Neoprene Rubber	Nylon 4-6
Mode 1	57.485	47.318
Mode 2	83.917	69.329
Mode 3	82.96	69.372
Mode 4	59.045	90.201
Mode 5	95.53	90.376
Mode 6	93.009	55.951
Mode 7	67.126	66.227
Mode 8	66.827	66.377
Mode 9	89.653	38.281
Mode 10	116.66	68.034

Total deformation mode

Total deformation & stress table

Material	Total deformation (mm)		Stress (Mpa)	
	Minimum	**Maximum**	**Minimum**	**Maximum**
Neoprene Rubber	0	469.37	0.01635	67.058
Nylon 4-6	0	0.03509	0.009	66.678

Total deformation & stress

Heat Flux & Temprature table

Material	Heat Flux (w/mm2)	Temprature (*c)
Neoprene Rubber	26.566	573.79
Nylon 4-6	123.46	440

Heat Flux vs Temprature

The results from analysis can be replaced the air tire by Air-less tire. Air eliminated in the tire that provides good traction, cushion effect. The air less tire is analyzed by the FEA with two materials like **Neoprene Rubber** and **Nylon 4-6**. Analysis parameters of Air-less-tire are

Material	Total deformation (mm)		Stress (Mpa)		Heat Flux (w/mm2)	Temprature (*c)
	Minimum	Maximum	Minimum	Maximum		
Neoprene Rubber	0	469.37	0.01635	67.058	26.566	573.79
Nylon 4-6	0	0.03509	0.009	66.678	123.46	440

From the above table we are concluded that, the material Nylon 4-6 is preferable one, by comparing to Neoprene Rubber.

From modal and thermal analysis also we are concluded that , the material Nylon 4-6 is preferable one, cause the material Nylon 4-6 is got less deformation at high frequency and heat flux also high.

V. CONCLUSION

Design and development of air-less tire eliminates air in the tire. Air-less tire can provide uniform traction and uniform wear while absence of air. The 4 side honey comb design satisfies the main functions of the tire. Air-less tire has two components that are outer band and flexible inner band. In the air-less tire design manufacturing point of view, material saving is obtained by replacing outer band only after tread wear. The flexible inner band repeated use obtained green engineering and also reduce the environmental pollution. The driver mind-stress may reduce by using air-less tire in automobile by avoiding air related problems in the tire.

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