COMPARISON OF PROPERTIES OF CARBON FIBRE REINFORCED PLASTIC, GLASS FIBRE REINFORCED PLASTIC WITH BASALT FIBRE COMPOSITE BY DESIGN AND ANALYSIS OF COMPOSITE LOOP WHEELS

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Abstract

The usually used spokes wheels in a bicycle increases weight of the bicycle because the steel material is used for its construction except the tyres and tubes and also it does not absorb shocks received from the road whenever the bicycle is passing over the bumps and potholes. It transmits the shock loads directly to the rider as the steel is stiff thereby it increases the uncomforting of the rider. Loop wheels are new type of bicycle wheels that have been designed to make cycling more comfortable. Instead of spokes, the Loop wheel uses three looped carbon composite springs that run from the hub to the rim. One of the advantages of Loop wheels is the fact that unlike a suspension fork, they can absorb shocks delivered not just from underneath or above but also from the front. Loop wheels also reduce the overall weight of the bicycle. The present work is focused on replacing of carbon fibre reinforced plastic with Basalt fibre composites as it has good mechanical properties. The Basalt fibre composite has high strength, and cheaper than carbon fibre reinforced plastics. Hence basalt fibre is suitable as low weight, cheaper, and tough composite materials. The loop wheel also has been changed its design from loop to arc shape to increase the strength with Basalt composites. Further the composite wheel is modeled by using CATIA and analyzed by using ANSYS softwares under static load conditions for Basalt composites, Carbon fibre reinforced plastic and Glass fibre reinforced plastic. Finally the results of analysis of carbon fibre reinforced plastic, glass fibre reinforced plastic and basalt fibre composite wheels are compared.

Keywords: Loop wheels, carbon fibre reinforced plastic, basalt fibre, Glass fibre reinforced plastic, CATIA, ANSYS.

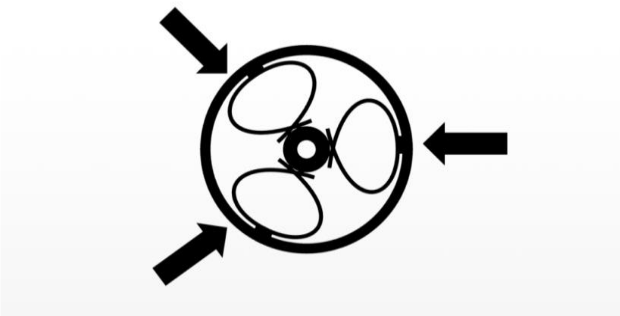
1. Introduction

Existing wheels of a bicycle: The conventionally used spokes in a bicycle increases weight of the bicycle because the steel material is used for its construction except the tyres and tubes. Also it does not absorb shocks received from the road whenever the bicycle is passing over the bumps and potholes. It transmits the shock loads directly to the rider as the steel is stiff thereby it increases the uncomforting of the rider.

New type of wheels: Loop wheels are new type of bicycle wheels that have been designed to make cycling more comfortable. Instead of spokes, the Loop wheel uses three looped carbon composite springs that run from the hub to the rim. Loop wheel springs are made from a carbon composite material, carefully developed and tested to give optimum compression and lateral stability as well as strength and durability. One of the advantages of Loop wheels is the fact that unlike a suspension fork, they can absorb shocks delivered not just from underneath or above but also from the front (as might happen when running into a curb head-on) which provides suspension – cushioning the rider from bumps and potholes in the road. The springs also absorb road noise, reducing vibration through the frame and into the rider's arms. Because of the suspension within the wheel, the high-pressure or puncture-resist tyres can be used. The composite Loop wheels also reduce the overall weight of the bicycle.

Present work: The present work is focused on replacing of carbon fibre reinforced plastic with Basalt fibre composites as it has good mechanical properties. The Basalt fibre composite has high strength, and cheaper than carbon fibre reinforced plastics. Hence basalt is suitable as low weight cheaper tough composite materials. The existed loop wheel is changed its design from loop to arc shape to increase the strength with Basalt composites. Further the composite wheel is modelled by using CATIA and analyzed by using ANSYS software under static load conditions for Basalt composites, Carbon fibre reinforced plastic and Glass fibre reinforced plastic.

Loop Wheel Technology: Loop wheel springs are made from a carbon composite material, carefully developed and tested to give optimum compression and lateral stability as well as strength and durability. Specially-designed connectors attach the springs to the hub and rim. There are three springs in each wheel, which work together as a self-correcting system. The spring configuration allows for the torque to be transferred smoothly between the hub and the rim.



Tangential suspension

Front and rear loop wheels have different spring rates. Most of the weight of the rider is at the rear of the bicycle, so the rear loop wheel is stiffer. A front and rear loop wheel can be used together as a set, or you can use a single loop wheel alongside a conventional spoke wheel. So Loop wheels provide suspension on a bike which has none, or can be fitted in addition to suspension forks. Either way, rider get a smoother, more comfortable ride.

3.Material Properties And Selection

The most commonly used composite materials in the field are the glass/epoxy, graphite/epoxy, carbon/epoxy, Aramid, silicon carbide/Epoxy etc. The material properties are different for each. Some of the advantages and disadvantages of the above materials are listed in the Table 5.1.

Table 5.1: Features of various composite materials.

Composite material	Advantages	Disadvantages
1.E Or S-Glass/Epoxy	High strength Low cost	Low stiffness Short fatigue life High temperature Sensitivity
2. Boron/Epoxy	High stiffness High compressive strength	High cost
3. Ceramic/Epoxy	High stiffness	Low strength
4. Graphite/Epoxy	Very High stiffness	Low strength High cost
5. Carbon/Epoxy	High stiffness High strength	Moderately High cost

BASALT FIBRE:Industry is always striving to find new and better materials to manufacture new or improved products. With this in mind energy conservation, the environment, corrosion risk and sustainability are important factors when a product is changed or a new product is manufactured. A few examples of problem overviews that relate to some of these important factors are explained below. High voltage towers have, almost from the beginning, been designed as steel truss towers and in the next few years will need to be replaced. Therefore there is now the opportunity design a new type of tower made of a new material that is strong, light and has minimum risk of corrosion. In this sense the energy required for the production of basalt fiber is around 5KWh/kg while or carbon steel product is about 15 KWh/kg.However, this research focused on the use of basalt fiber reinforced polymer composites. A range of basic mechanical tests evaluated polymer composites reinforced with basalt fibers.

Tests were also done with glass-reinforced composites using the same polymer as the basalt specimens to permit direct comparison between the two reinforcing materials. Subsequent tests examined the effects of environmental exposure on the composite material behaviour. One of the benefits of using Fiber Reinforced Polymer (FRP) as a strengthening material in concrete is that it is non-corrosive. In places where concrete structures are close to the sea, like houses or bridges, the maintenance of the concrete is needed on regular basis. In such conditions the common rebar is in constant danger of corrosion and therefore could become weak and hazardous in a short period of time.Basalt rock can be used to make not only basalt bars but also basalt fabrics, chopped basalt fiber strands, continuous basalt filament wires and basalt mesh.

Properties of Basalt: Basalt is fine-grained, extrusive, igneous rock composed of plagioclase, feldspar, pyroxene and magnetite, with or without olivine and containing not more than 53 wt% SiO2 and less than 5 wt% total alkalis. Many types of basalt contain phenocrysts of olivine, clinopyroxene (augite) and plagioclase feldspar. Basalt is divided into two main types, alkali basalt and tholeiites. They have a similar concentration of SiO2 but alkali basalts have higher content of NA2O and K2O than tholeiites. The plutonic equivalent of basalt is gabbro.

Basalt Fiber

Table 3.1: Comparison of typical properties for some common fibers.

Materials	Density (g/cm^3)	Tensile Strength (MPa)	Young modulus (GPa)
E-Glass	2.55	2000	80
S-Glass	2.49	4750	89
Alumina	3.28	1950	297
Carbon	2.00	2900	525
Kevlar	1.44	2860	64
Basalt	2.65	4100	136

4. MODELING AND ANALYSIS:

4.1 Modeling of wheels by using CATIA :

CATIA(Computer Aided Three-dimension Interactive Application is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company_Dassault Systems written in the C++ programming language. CATIA is the cornerstone of the Dasault Systems product lifecycle management software suite.CATIA competes in the high end CAD/CAM/CAE market with Siemens NX.

4.1.1 Modeling of loop shape wheel

Fig 4.1 Catia model of loop wheel

4.1.2 Modeling of arc shape wheel

Fig 4.2: Catia model of Arc shaped wheel

4.2 Analysis by ANSYS Software

ANSYS is general-purpose finite element analysis(FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements.

4.2.1 Analysis Procedure

- Design and Defining Material Properties
- Importing
- Creating the Model Geometry
- Meshing
- Apply Loads and Obtain the Solution

4.3 Solutions

4.3.1 Loop wheels

Deformation of basalt fibre loop wheel

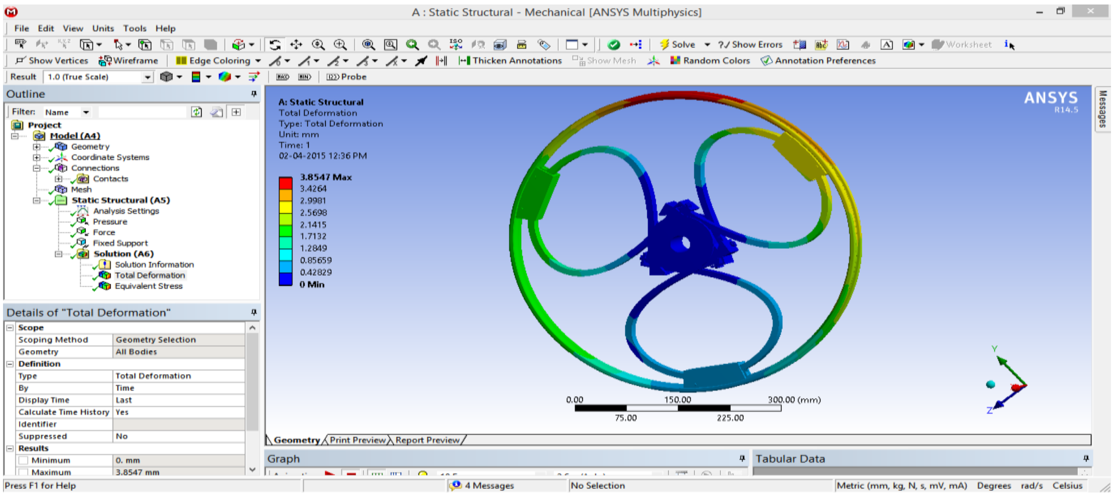


Fig. 4.3: Deformation of Basalt fibre loop wheel

Deformation of CFRP composite loop wheel

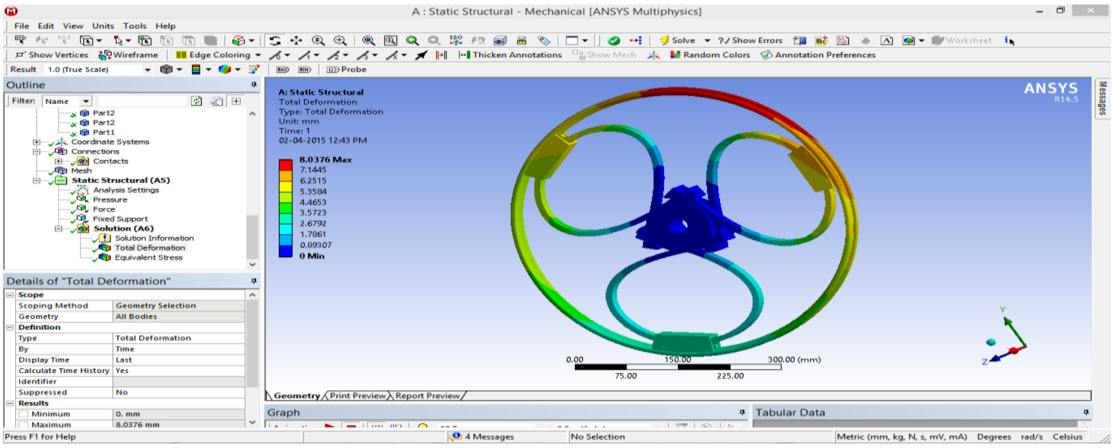


Fig. 4.4: Deformation of CFRP composites loop wheel

Deformation GFRP composites loop wheel

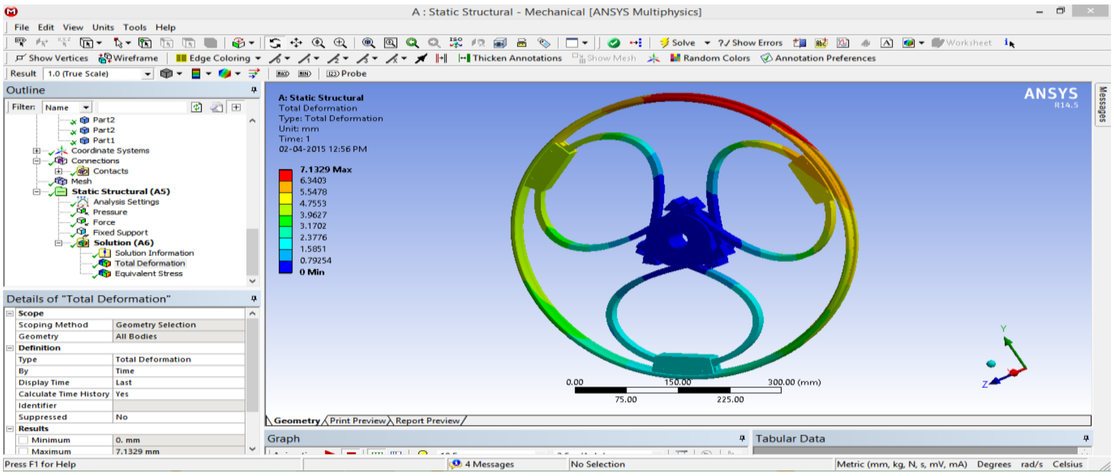


Fig. 4.5: Deformation of GFRP composites loop wheel

Vonmisses stresses:

Stresses of Basalt Fibre composite loop wheel

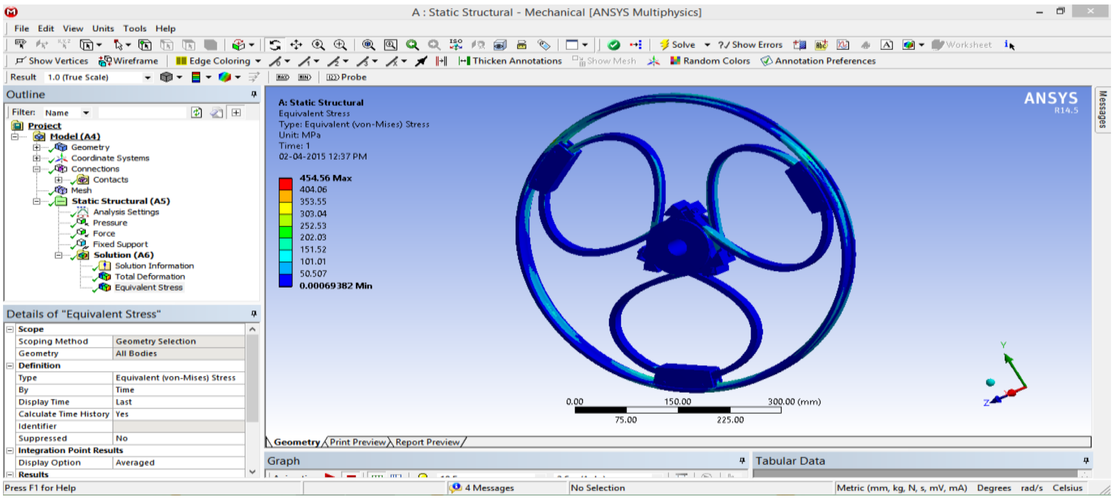


Fig. 4.6: Stresses of Basalt fibre composites loop wheel

Stresses of CFRP composites loop wheel

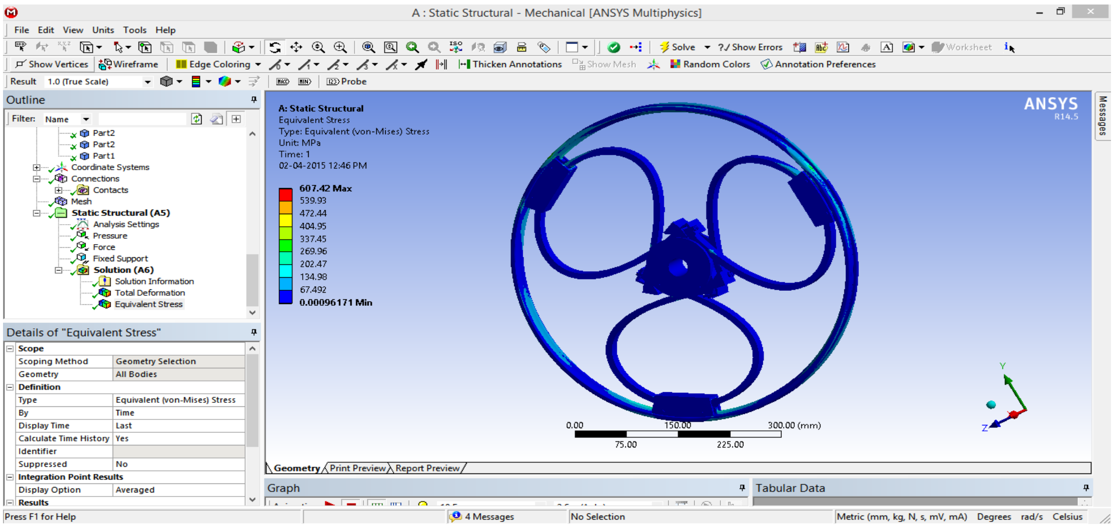


Fig. 4.7: Stresses of CFRP composites loop wheel

Stresses of GFRP composite loop wheel

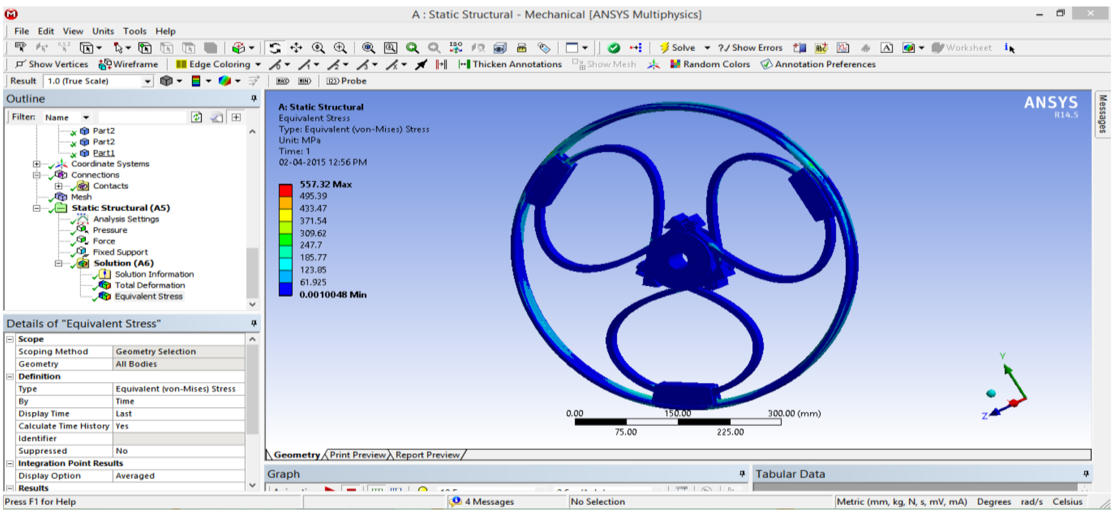


Fig. 4.8: Stresses of GFRP composites loop wheel

4.3.2 Arc shaped composite loop wheel

Deformation in basalt fibre composite arc shaped wheel

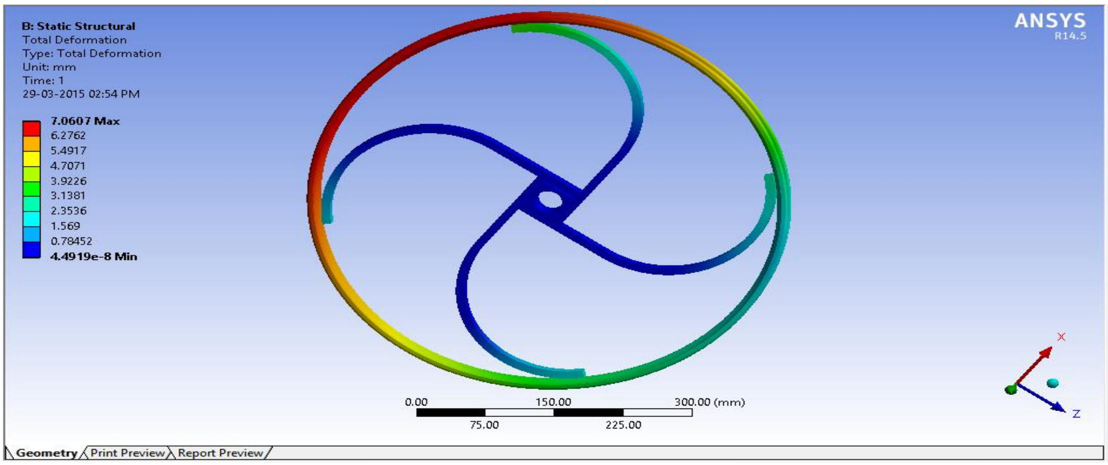


Fig. 4.9: Deformation in basalt fibre composite arc shaped wheel

Deformation in CFRP composite arc shaped wheel

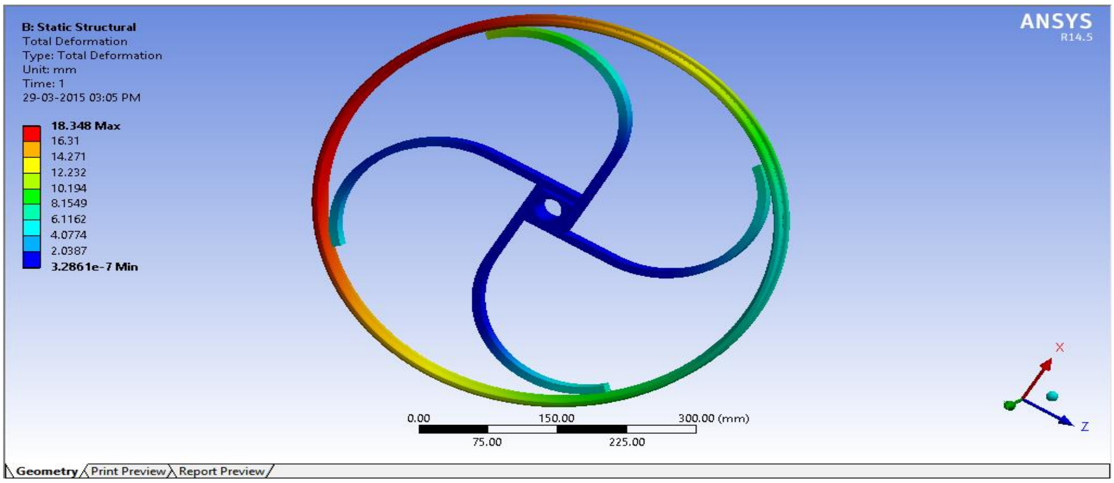


Fig. 4.10: Deformation in CFRP composites arc shaped wheel

Deformation in GFRP composite arc shaped wheel

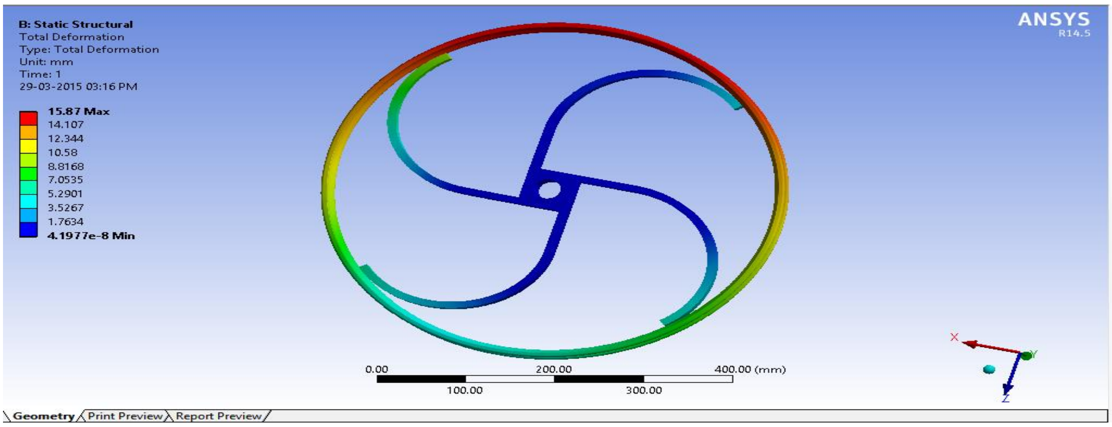


Fig. 4.11: Deformation in GFRP composite arc shaped wheel

Stresses of basalt fibre composites arc shaped wheel

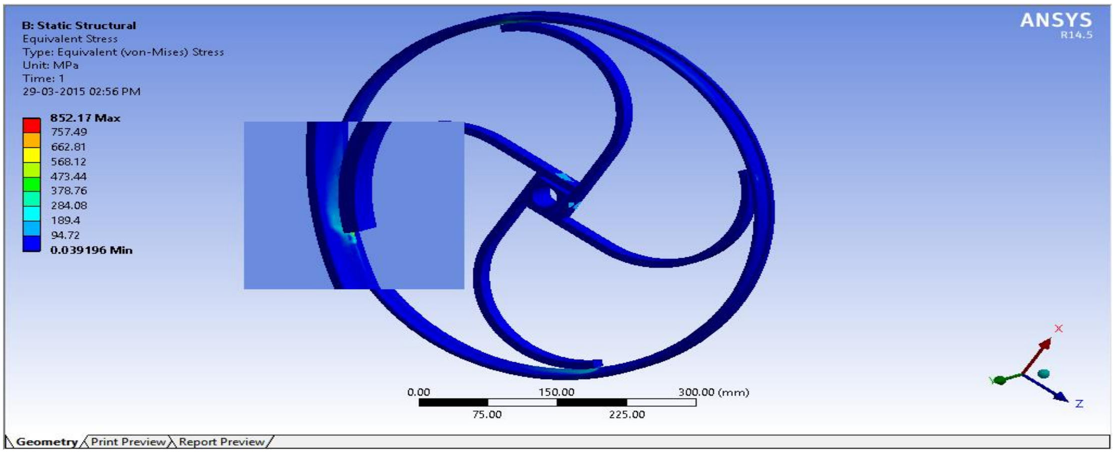


Fig. 4.12: Stresses of basalt fibre composites arc shaped wheel

Stresses of CFRP composites arc shaped wheel

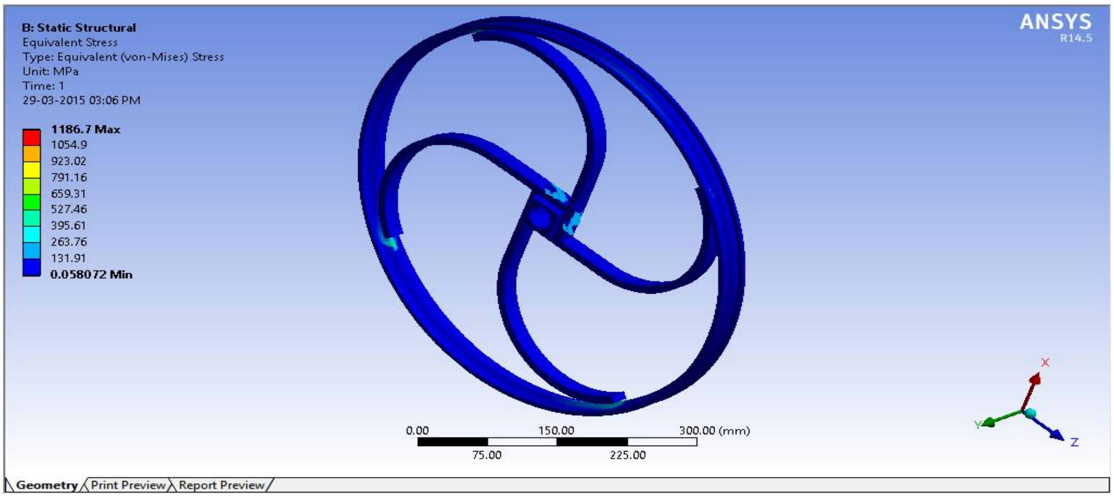


Fig. 4.13: Stresses of CFRP composites arc shaped wheel

Stresses of GFRP composites arc shaped wheel

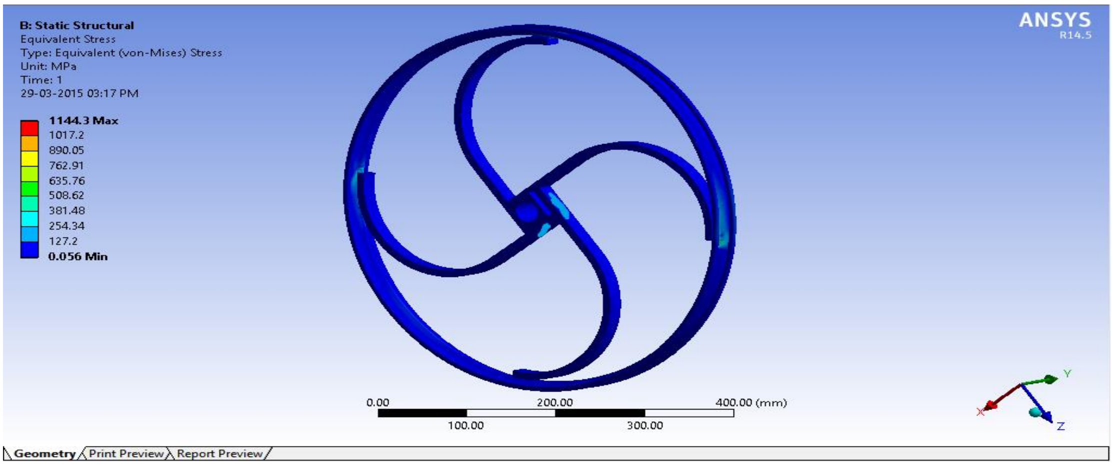


Fig. 4.14: Stresses of GFRP composites arc shaped wheel

5. Results and discussions:

Loop shaped Wheel:

Deformation:

Table 5.1: Deformation results of loop shaped composite loop wheel

Material	Max. Deformation(mm)
Basalt fibre	3.8547
Glass reinforced fibre	7.1329
Carbon reinforced fibre	8.0376

Vonmisses stresses:

Table 5.2: Stress results of loop shaped composite loop wheel

Material	Max. Stress (MPa)
Basalt fibre	452.56
Glass reinforced fibre	607.42
Carbon reinforced fibre	557.32

Arc shaped Wheel

Deformation:

Table 5.3: Deformation Results of arc shaped composite wheel

Material	Max. Deformation(mm)
Basalt fibre	7.067
Glass reinforced fibre	15.87
Carbon reinforced fibre(e-glass)	18.348

Vonmisses stresses:

Table 5.4: Stress results of arc shaped composite wheel

Material	Max. Stress(MPa)
Basalt fibre	852.17
Glass reinforced fibre	1144.3
Carbon reinforced fibre	1186.7

Comparison of Weight:

Table 5.5: Comparison of Weight

Material	Weight (kg)
Basalt	0.327
Carbon	0.315
Glass	0.338

6. Conclusions:

As the usage of bicycle is increasing day by day, it is important to provide comfortable ride to the rider. The existing looped wheel and proposed arc shaped composite wheel is modelled using CATIA and analyzed for various materials (CFRP, GFRP, Basalt fibre) by using ANSYS for deformation and stress values under static load condition.

On comparing the obtained results, it is proposed to replace the carbon fibre reinforced plastic with Basalt fibre composites as it has low deformation and stress values and also loop wheel is converted into arc shaped wheel.

- On comparing the deformation and stress results, the deformation and stress values of basalt fibre are low than carbon and glass fibre.
- The cost of the basalt fibre is also low when compared to glass fibre and carbon fibre.
- Although carbon has a slight weight reduction when compared to basalt fibre, basalt fibre can be selected as a better material due to its good other properties.

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