IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 6 Ver. V (Nov. - Dec. 2015), PP 73-82
www.iosrjournals.org

Design and Structural Analysis of Alloy Wheels for Light Weight Vehicles

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Abstract: *Alloy wheels are automobile wheels which are made from an alloy of carbon epoxy , E-glass epoxy and S-glass epoxy is tested individually Or sometimes a mixture of both among them best one is chosen. Alloy wheels differ from normal steel wheels because of their lighter weight, which improves the steering and the speed of the car. Alloy Wheels will reduce the unstrung weight of a vehicle compared to one fitted with standard steel wheels. The benefit of reduced unstrung weight is more precise steering as well as a nominal reduction in fuel consumption. Alloy is an excellent conductor of heat, improving heat dissipation from the brakes, reducing the risk of brake failure under demanding driving conditions.*

At present four wheeler vehicle wheels are made of Aluminum Alloys. In this project, Aluminum alloy wheel are compared with other Composite Alloys. Namely Carbon epoxy, E glass/epoxy, S glass/epoxy .

In this project a parametric model is designed for Alloy wheel used in four wheeler by collecting data from reverse engineering process from existing model. Design is evaluated by analyzing the model by taking the constraints as ultimate stresses and variables as three different Composite Alloy materials and different loads and goals as maximum outer diameter of the wheel and fitting accessories areas like shaft of the axle and bolts PCD of the car. Parametric model is done in Pro-E and analysis is done in Ansys 12.0.

Our design and construction of a bucket air cooler by using solar energy is new alternative to conventional energy sources. We set out to create an air cooler that does not create any harmful emissions in environment and provide no pollution in the surrounding. The solar power as the main energy sources to help in the project work. It is providing to cooling the enclosed space and also measured the temperature levels of before and after in absorbed enclosed space.

Keywords: *Alloy wheel, Carbon-epoxy, E-glass epoxy, S-glass epoxy, Pro-E, Ansys 12.0.*
DC Fan, pipes.

I. Introduction Of Wheel

A **wheel** is a circular device that is capable of rotating on its axis, facilitating movement or transportation while supporting a load (mass), or performing labour in machines. Common examples are found in transport applications. A wheel, together with an axle overcomes friction by facilitating motion by rolling. In order for wheels to rotate, a moment needs to be applied to the wheel about its axis, either by way of gravity, or by application of another external force. More generally the term is also used for other circular objects that rotate or turn, such as a ship's wheel, steering wheel and flywheel.

The wheel is a device that enables efficient movement of an object across a surface where there is a force pressing the object to the surface. Early wheels were simple wooden disks with a hole for the axle. Because of the structure of wood a horizontal slice of a trunk is not suitable, as it does not have the structural strength to support weight without collapsing; rounded pieces of longitudinal boards are required. The spoke wheel was invented more recently, and allowed the construction of lighter and swifter vehicles.

There are only a few types of wheels still in use in the automotive industry today. They vary significantly in size, shape, and materials used, but all follow the same basic principles. The first type of wheel worth mentioning, and by far the most-used wheel, is the steel wheel. This kind of wheel consists of several sheets of steel, stamped into shape and typically welded together. This type of wheel is strong, but heavy. They are found on every kind of vehicle from sports cars to the larger pickup trucks; the wheels look different but are essentially the same device. The second type of wheel to be mentioned is the rally wheel. These are essentially steel wheels but they are made somewhat differently, and tend to of a heavier gauge of steel. While the inner portion of a steel wheel is generally welded to the rim along its entire circumference, a steel wheel's inner portion is cut to resemble the spokes of a mag wheel, and is welded accordingly. Mag wheels are cast and/or milled wheels typically made from aluminum or an alloy thereof. They used to be made of magnesium for their light weight and strength, but magnesium catches fire somewhat easily and is very difficult to put out. This is unfortunate, because it is superior to aluminum in every other way. This tendency also makes it a dangerous

metal to work with, because piles of shavings tend to burst into flame and burn through concrete surfaces when they get too hot. As previously mentioned, **spoke wheels** (sometimes with more than 100 spokes) are still in use today and are popular on roadsters and low-riders. They tend to be fairly low in weight, and are reasonably strong. They have an "old school" appearance and style which is often highly sought after. Various combinations of these technologies can be used to produce other, more unusual wheels. Large earth-moving vehicles such as the more gargantuan dump trucks often have some degree of the vehicle's suspension actually built into the wheel itself, lying between the hub and rim in place of spokes. Also, various companies make wheels which are designed like steel wheels but are made of aluminum –The most famous of these are made by centerline, and the style is actually called the centerline wheel.

II. Specification Of The Problem:

The objective of the present work is to design and analyses, of Aluminum alloy wheels made and also polymeric composite light weight vehicle wheel is made of three different composite materials viz., Carbon/Epoxy, E-glass/Epoxy and S-glass /Epoxy composites. polymeric composite light weight vehicle wheel was created in Pro-E. Model is imported in ANSYS 12.0 for analysis by applying normal load conditions. After analysis a comparison is made between exisisting conventional Aluminum alloy wheels and polymeric composite light weight vehicle wheel viz., Carbon/Epoxy, E-glass/Epoxy and S-glass /Epoxy in terms of deflections and stresses, to choose the best one.

III. Introduction To Materials

Alloy is a mixture of two or more elements where at least one of them is metal. The resulting alloy can be a solution or a solid. If only two components are mixed to produce an alloy, it is known as a binary alloy. If there are three components, it is known as ternary alloy. The amount of element in the alloy is normally measured and given by mass (as percentages). Alloys can be also classified as homogeneous if they have a single phase. If have several phases, those alloys are classified as heterogeneous. If there isn't a distinct phase boundary, then they are known as inter metallic.

Alloys are produced from elements, to have improved qualities than the reactant elements. They have different qualities than the reactant components. Normally alloys have metallic properties, but they differ from pure metal elements. For example, alloys don't have a single melting point. Rather, they have a range of melting points.

A composite material is defined as a material composed of two or more constituents combined on a macroscopic scale by mechanical and chemical bonds. Composites are combinations of two materials in which one of the material is called the "matrix phase" is in the form of fibers, sheets, or particles and is embedded in the other material called the "reinforcing phase".

Another unique characteristic of many fiber reinforced composites is their high interal damping capacity. This leads to better vibration energy absorption within the material and results in reduced transmission of noise to neighboring structures. Many composite materials offer a combination of strength and modulus that are either comparable to or better than any tradional metalic metals. Because of their low specific gravities, the strength to weight-ratio and modulus to weight-ratios of these composite materials are markedly superior to those of mettalic materials.

The fatigue strength weight ratios as well as fatigue damage tolerances of many composite laminates are excellent. For these reasons, fiber composite have emerged as a major class of structural material and are either used or being considered as substitutions for metal in many weight-critical components in aerospace, automotive and other industries.

High damping capacity of composite materials can be beneficial in many automotive applications in which noise, vibration, and hardness is a critical issue for passenger comfort.

IV. Specification Of Existing Heavy Vehicle Chassis:

Table 1 shows the specifications of a Aluminum Alloy light weight vehicle. The typical Copper – 0.25, Magnesium – 0.20 To 0.45, Manganese – 0.35, Silicon – 6.5to 7.5, Iron – 0.6, Zinc – 0.35, Others – 0.05, Aluminum – 87 To 89.

Table: 1 Specifications of light weight vehicle wheel

S.No	Parameters	Value
1	Diameter of the wheel	320.6 mm
2	Area of the wheel	80685 mm^2
3	Perimeter of the wheel	3032.26 mm

4	Weight Of The Car	1.29 T
5	Passengers 5 People	420 KG
6	Extra Load	480KG
7	Total applied weight on the Car	21483.9N
8	Weight applied On the Individual Wheel	5370N
9	Youngs modulus of aluminium wheel	$7.1e^5$ Mpa
10	Density of aluminium wheel	1700 Kg/mm^3
11	Poission's ratio	0.33

V. Structural Analysis Of Light Weight Vehicle Chassis:

Dimensions of polymeric composite heavy vehicle Wheel (PCLWVW) are taken as that of the conventional Aluminum alloy light weight vehicle wheel (ALWVW). PCLWVW consists of 4 layers (thickness of each layer, 1.5mm). Width of the wheel is 190mm. Since the properties of PCLWVW vary with directions of fiber, a 3-D model of wheel is used for analysis in ANSYS 12.0. The loading conditions are assumed to be static. The element chosen is shell layered 46, which is a layered version of the 8-node structural shell model. The element has six degrees of freedom at each node : translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z-axes. The finite element analysis is carried out on Aluminum wheel as well as on three different types of polymeric composite light weight vehicle wheel. From the analysis the equivalent stress (Von-misses stress) and displacements were determined and are shown in figure 1-30. Table 2 - 4 shows the comparative analysis of Aluminum wheel and polymeric composite light weight vehicle wheel of three different materials.

VI. Structural Analysis Of Circular Section:

6.1.1.Loads and boundary conditions:

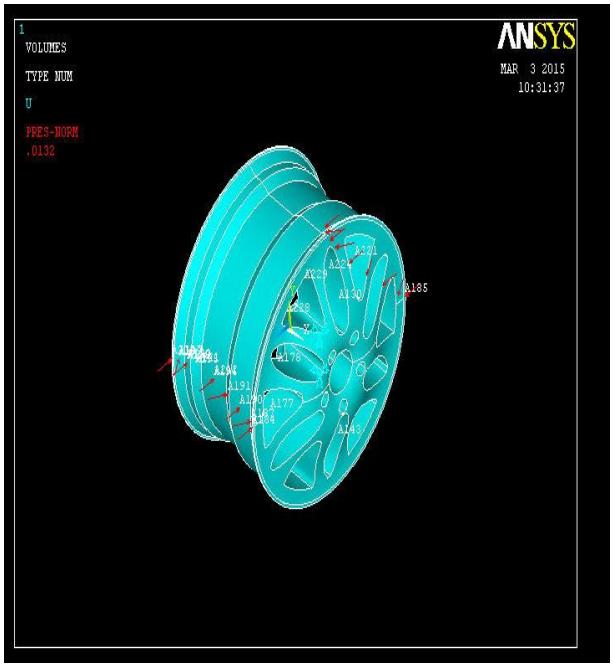

Fig 6.1.1 Loads and boundary conditions

6.1.2. MESHING

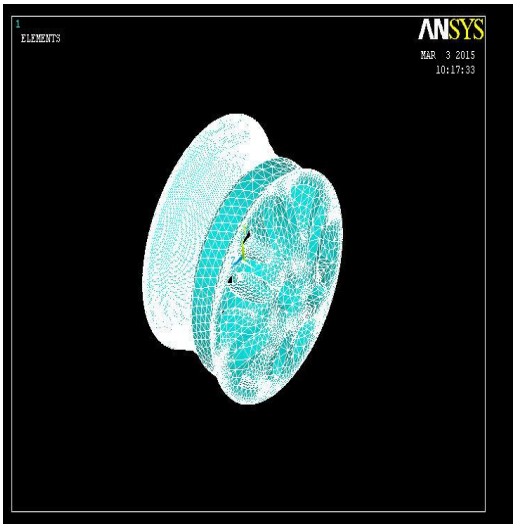

Fig 6.1.2 Meshing

6.2 Al alloy

6.2.1 Equivalent stress

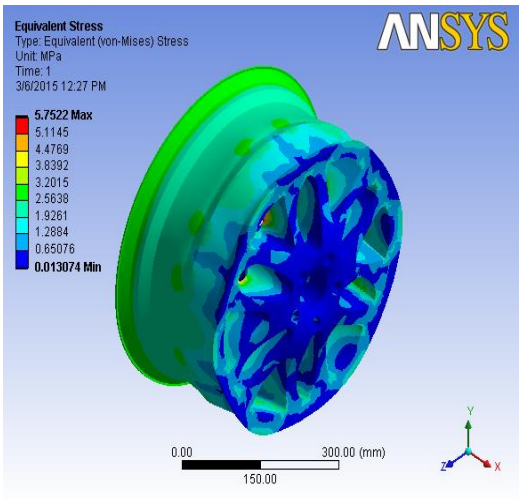

Fig.6.2.1 Equivalent stress

6.2.2 Equivalent elastic strain

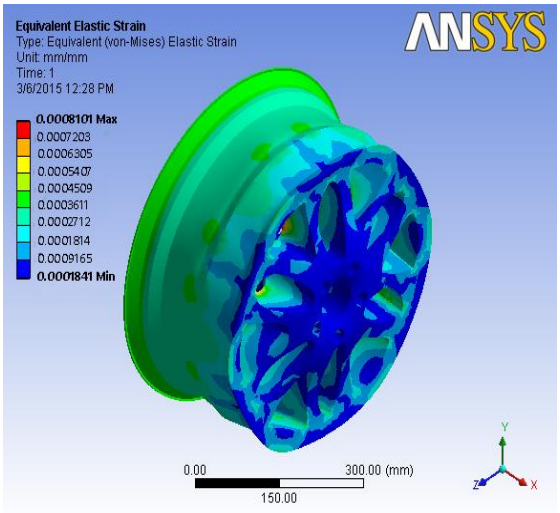

Fig. 6.2.2 Equivalent elastic strain.

6.2.3 Total deformation

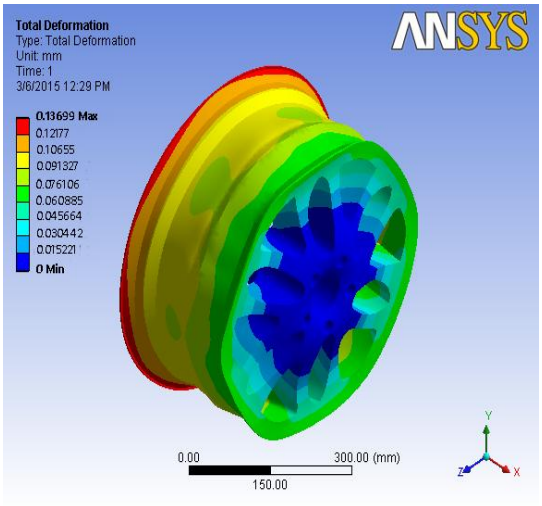

Fig. 6.2.3 Total deformation

6.3 Carbon/epoxy
6.3.1 Equivalent stress

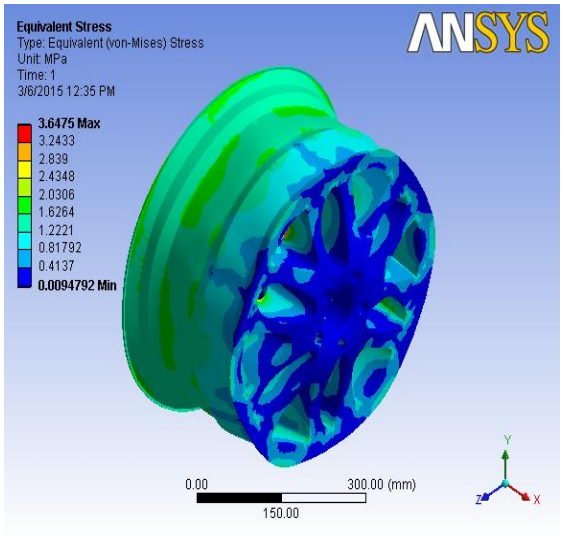

Fig.6.3.1 Equivalent stress

6.3.2 Equivalent elastic strain

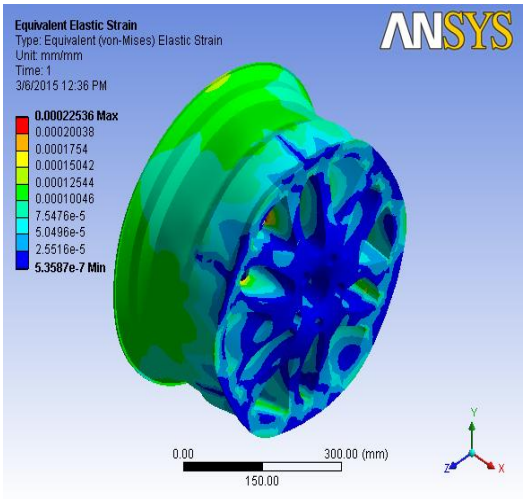

Fig. 6.3.2 Equivalent elastic strain.

6.3.3 Total deformation

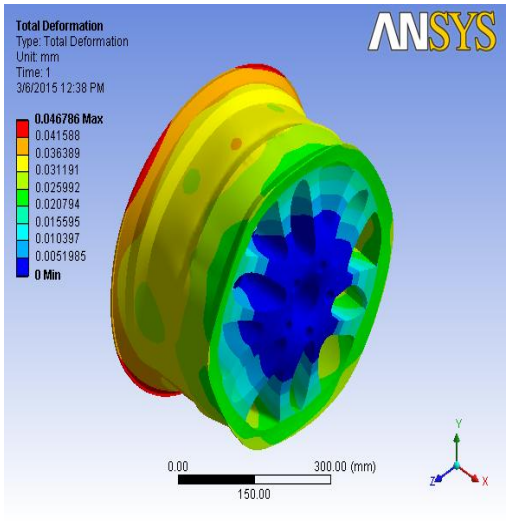

Fig. 6.3.3 Total deformation

6.4 E-glass/epoxy

6.4.1 Equivalent stress

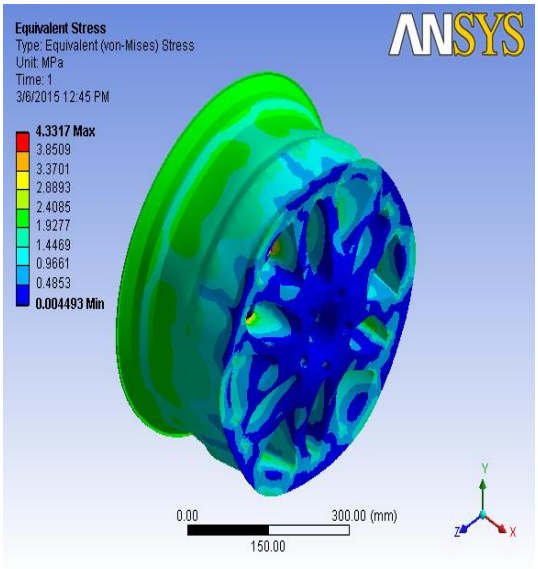

Fig. 6.4.1 Equivalent stress

6.4.2 Equivalent elastic strain

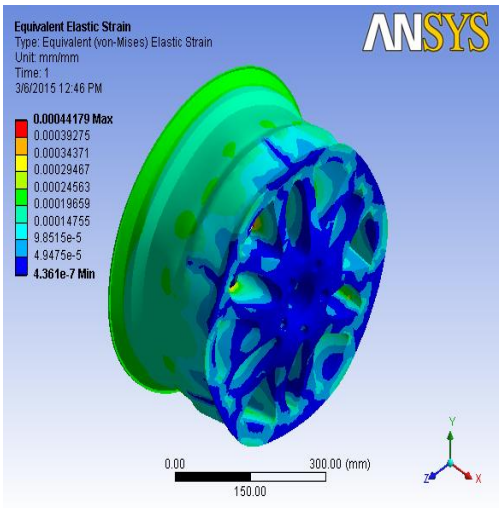

Fig. 6.4.2 Equivalent elastic strain

6.4.3 Total deformation

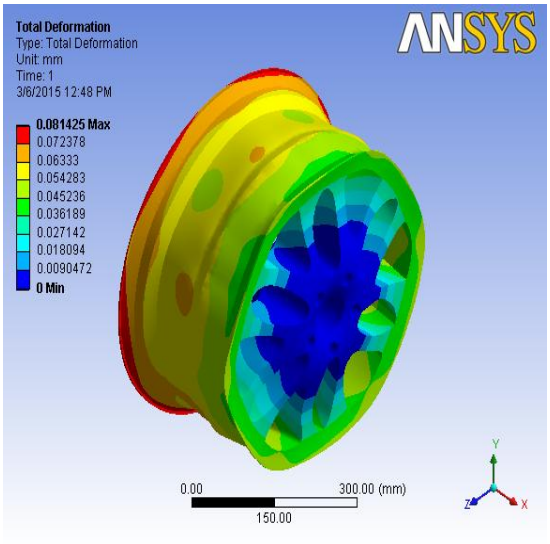

Fig. 6.4.3 Total deformation

6.5 S-glass/epoxy

6.5.1 Equivalent stress

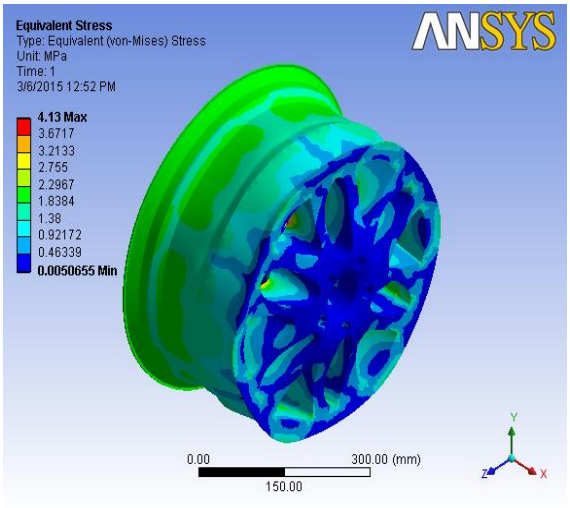

Fig. 6.5.1 Equivalent stress

6.5.2 Equivalent elastic strain

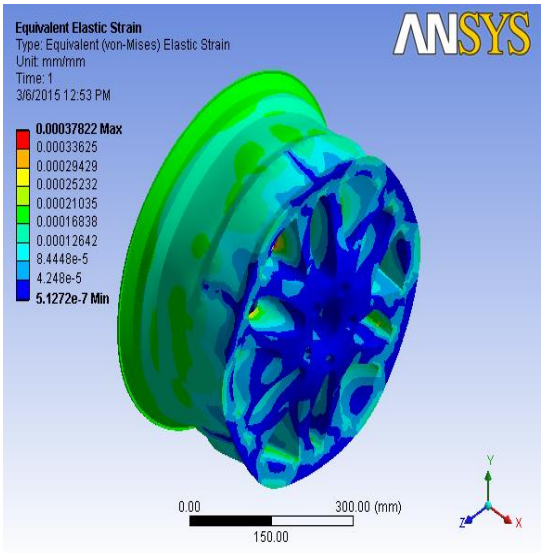

Fig.6.5.2 Equivalent elastic strain

6.5.3 Total deformation

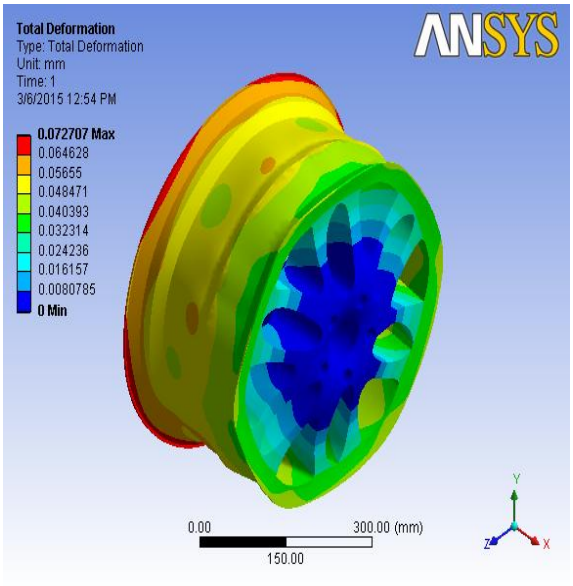

Fig. 6.5.3 Total deformation

VII. Results

Table:2 Comparative Analysis of Al alloy light weight vehicle wheel and polymeric composite material light weight wheel.

S. No	Parameter	AL Alloy	PCM		
			C-1	C-2	C-3
1	Weight (Kgs)	35	14	18	16
2	Stress (N/mm^2)	5.75	3.64	4.3	4.13
3	Displace	0.13	0.04	0.08	0.07
4	Strain	0.0008	0.0002	0.0004	0.0003

Note:

1. PCM= Polymeric composite Materials
2. C-1= Carbon/Epoxy
3. C-2= E-glass/Epoxy
4. C-3= S-glass/Epoxy

VIII. Graphs

8.1 Load Vs Stress:

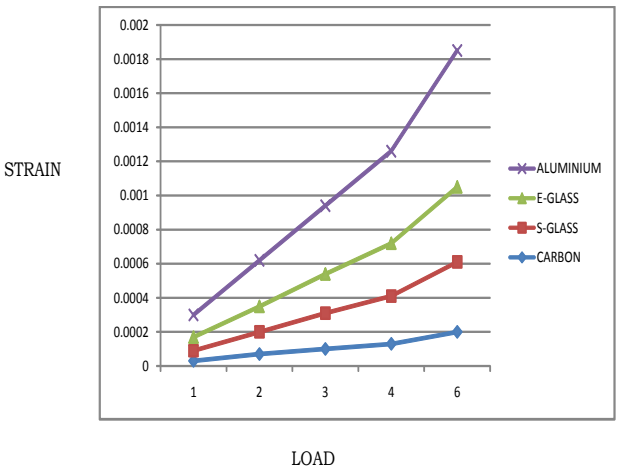

Fig.8.1 Load vs Stress

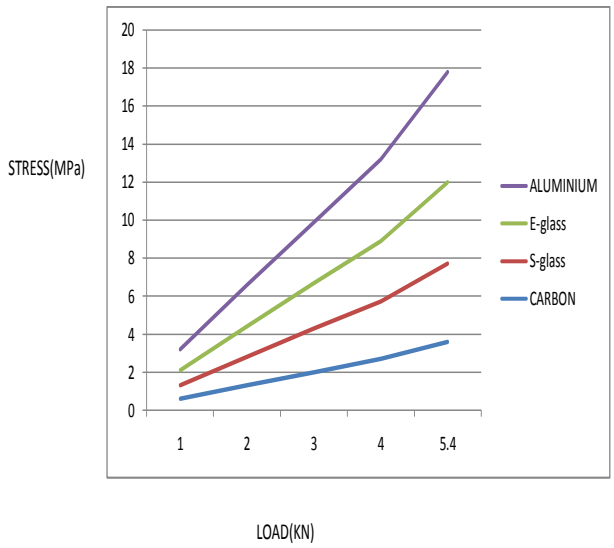

Fig.8.2 Load vs Displacement

8.2 Load Vs Displacement

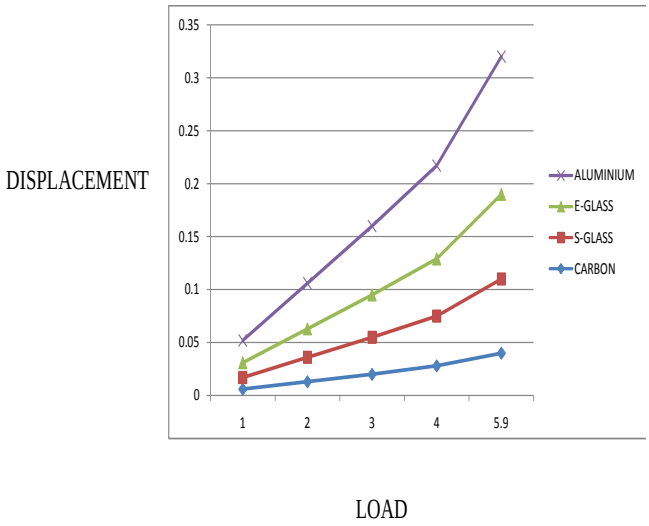

Fig.8.3 Load vs Strain

8.3 Load Vs Strain:

IX. Conclusion

To observe the all results and to compare the polymeric composite material wheel and al alloy wheel with respect to stress, strain and displaement.

By employing a polymeric composite material wheel for the same load carrying capacity, there is a reduction in stress of 35%-40%**,** strain of 70% -75% and displacement upto 70%.

Present used material for alloy wheel is al alloy . I have considered polymeric composites Carbon/Epoxy, E-glass/Epoxy and S-glass /Epoxy for alloy wheel.

Based on the results, it was inferred that carbon/epoxy polymeric composite material wheel has superior strength and stiffness and lesser in weight compared to Al alloy and other polymeric composite materials considered in this investigation.

From the results, it is observed that the polymeric composite material wheel is lighter and more economical than the Al alloy wheel with similar design specifications.

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