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MODELLING AND STATIC ANALYSIS OF ALLOY WHEEL RIM USINGCARBON EPOXY COMPOSITE, AL6061 AND STAINLESS

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ABSTRACT

Wheel is a main mechanical term of the vehicular suspension system that supports the static and dynamic loads encountered during vehicle action. Since cars carry heavy loads of occupants as well as self-weight, the alloy wheel rim should be strong enough to withstand this load. Thus, their design should be done very cautiously. While designing such main kind of automotive component taking care of protection and cost are very important concerns so that user can use it safely. Major five technical considerations while modeling any new alloy wheel rim are styling, aesthetic, mass, manufacturability and capability. While analyzing stress and displacement distribution in vehicle wheels subjected to increase pressure and radial load .essential efforts have been taken to discover the Finite Element Techniques. Alloy wheel rim has been designed using SOLIDWORKS software, after that static structural analysis is done with different materials (Carbon epoxy composite, AL6061, Stainless) load and boundary conditions taking in ANSYS14.5 Software. Finally observed results of stress, total deformation, strain and shear stress on different wheel rims materials and compared with each other. Thus, the best design and material can be selected for manufacturing of the alloy wheel.

I. INTRODUCTION

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. Alloy wheels are automobile wheels which are made from an alloy of aluminium or magnesium metals. Historically, successful designs was arrived after years of experience well aided worth extensive field - testing. Since the 1970's several innovative methods of testing and experimental stress measurements have been initiated. In more recent years, the procedures have significantly improved by the emergence of a variety of experimental and analytical methods for structural analysis. Durability analysis, that is: fatigue life prediction and reliability methods, for dealing with various inherent in engineering structures has been used for the study of automotive rims. In its basic form a wheel is a transfer element between the tire and the vehicle. The main requirements of an automobile wheel.

- It should be as light as possible so that unsprung weight is least.
- It should be strong enough to perform the above functions.
- It should be balanced statically as well as dynamically.
- It should be possible to remove or mount the wheel easily.
- It material should not deteriorate with weathering and age. In case, the material is suspected to corrosion, it must be given suitable protective treatment.

Figure 1 alloy wheel

Lighter wheels can improve handling by reducing unsprung mass, allowing suspension to follow the terrain more closely and thus improve grip, however not all alloy wheels are lighter than their steel equivalents. Reduction in overall vehicle mass can also help to reduce fuel consumption.

II. LITERATURE REVIEW

SIVA PRASAD ET AL. [1] does stress and dynamic analysis of car wheel rim by using SOLIDWORKS& ANASYS. To determine best material for wheel so that by design and modifications the stresses can be reduces to improve the fatigue life of wheel rim. During this study, they considered two different materials namely aluminium and forged steel and their relative performances have been observed respectively. Aluminium alloy wheel rim are subjected to more displacement and stresses compared to Forged steel and they are suggested forged steel is better material.

SOURAV DAS ET AL.[2] gives design of aluminium alloy wheel for automobile application which is carried out paying special reference to optimization of the mass of the wheel. The Finite Element analysis it shows that the optimized mass of the wheel rim could be reduced to 26Kg to 12.15kg as compared to the solid disc type Al alloy wheel. The FEM analysis indicated that even after a fatigue cycle of 1×1020, the damage on the wheel is found only 0.2%. And the damage region is found the flange portion of the rim.

RAJARETHINAM P ET AL. [3] presented paper on motorcycle wheel spokes and in this paper wheel rim designed by using designing software SOLID WORKS and later , for analysis 3-D model is imported into ANSYS. • The maximum stress area was located at Spoke-Rim contact. • Stresses induced in 5 Spokes Alloy wheel are less as compared with Al-Alloy of the 6 Spokes. • Material reduction can be done by reducing number of Spokes

LIANGMO WANG ET AL. [4]gives analysis to improve the quality of aluminium wheels, a new method for evaluating the fatigue life of aluminium wheels is proposed in this paper. The ABAQUS software was used to build the static load finite element model of aluminium wheels for simulating the rotary fatigue test. The results from the aluminium wheel rotary fatigue bench test showed that the baseline wheel failed the test and its crack initiation was around the hub bolt hole area that agreed with the simulation. Using the method proposed in this paper, the wheel life cycle was improved to over 1.0×105 .

M. SARAN THEJA ET AL. [5] presented paper deals with the static and fatigue analysis of wheel to analyse the safe load of the alloy wheel A typical alloy wheel configuration of Suzuki GS150R commercial vehicle is used for study.This design is 60% lighter and the overall dimensions are controlled by reducing number of spokes to the alloy wheel with same functioning stability and less weight. The stress and displacements in 4 spoke alloy wheel are lesser than six and five spokes alloy wheels.

N. SATYANARAYANA ET. AL. [6] gives a detailed "Fatigue Analysis of Aluminium Alloy Wheel under Radial Load". During the part of project a static and fatigue analysis of aluminium alloy wheel A356.2 was carried out using FEA package. The 3 dimensional model of the wheel was designed using SOLIDWORKS. Then the 3-D model was imported into ANSYS using the IGES format. The analysis was performed in a static condition.

SUNIL N. YADAV ET AL.[7]gives effect of slip angle on stress distribution and fatigue life of wheel rim of passenger car under radial load condition which arises due to off road field area and road unevenness. The finite element analysis as well as experimental analysis of passenger car wheel rim performed for radial load with the effect of slip angle on stress distribution and fatigue life. • the stresses are much higher in the disc area than the rim area. • the likely failures locations identified in the wheel rim by finite element analysis are stud holes, stiffening bulge and ventilation holes. • the stresses in wheel rim are directly proportional to slip angle i.e. The life of wheel rim decreases as slip angle increase.

S VIKRANTH DEEPAK ET AL. [8]doe's static structural and fatigue analysis of four wheeler vehicle by using finite element analysis. A typical alloy wheel configuration of ford fiesta is used for study. The analysis results showed that the maximum stress area was located in the hub bolt whole area. For all comparing the three materials (aluminium, magnesium and zinc) of stress, displacement, total life, load factor and damage factor they was suggested that aluminium alloy is the best material for the alloy wheel.

OBJECTIVE OF THE PROJECT

At present four wheeler wheels are made of Aluminum Alloys. In this project AL and steel, replaced with and carbon epoxy material due to its less cost and its density is less compared with that with AL. Due to less density, the wheel weight also get reduced due to composite material. Static analysis is done on the wheel rim. Design is optimized by analyzing the different models (elliptical spokes shape, hexagon spokes shape, Triangle spokes shape) in ANSYS. Compositeis light alloy are the foremost materials used in a wheel rim however some special wheels composite materials are being used together with glass-fiber.

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PROBLEM IDENTIFICATION:

Improper design leads to the failure and Weight reduction is a major problems in automobile industries.Every two wheeler and four wheeler is having Alloy wheels and Rim. There are many factors which we need to consider for Problem Statement. The stated problem here is to regular using elliptical spoke shape alloy wheel in this project taking Hexagon shape and triangular spokes shape and analyze static analysis and modal analysisfind out the equivalent stress and deformation, shear stress,strain for the given on the aluminum alloys steel and carbon epoxy wheels. In this theory a wheel is designed used in a four wheeler(TATA INDICA) Present used material for wheel is aluminum alloys, and steel replaced with carbon epoxy composite materials due to its less cost and its density is less compared with that of aluminum. Due to less density of carbon epoxy materials, the wheel weight also gets reduced. And also the carbon epoxy is more strengthen than that of aluminum alloys and steel alloys

III. METHODOLOGY:

1. Design of Alloy wheel rim, using specification of four Wheel alloy car rim TATAINDICA is created.
2. Creation of 3D different models(hexagonal spokes shapes, triangle spokes shape, elliptical spokes shape) of ALLOY WHEEL RIM using SOLIDWORKS and then
3. Imported in ANSYS 14.
4. Static and Modal Analysis of alloy wheel using FEA method.
5. Comparative performance of Carbon epoxy composite, AL6061, Stainless Steel materials
6. Finally select the best design and Material for alloy Wheel rim

WHEEL SPECIFICATION

S.No	Parameters	Value
1	Rim diameter	350mm
2	Bolt circle diameter	87mm
3	Hole circle diameter	240mm
4	Width of rim	122mm

Table1 wheel specification

RIM NOMENCLATURE:

1. Wheel: Wheel is generally composed of rim and disc.

2. Rim: This is a part where the tire is installed.

3. Disc: It is a part of the rim where it is fixed to the axle hub.

4. Offset: This is a space between wheel mounting surface where it is bolted to hub and centre line of rim.

5. Flange: The flange is a part of rim which holds the both beds of the tire.

6. Bead Seat: Bead seat approaches in contact with the bead face and it is a part of rim which holds the tire in a radial direction.

7. Hump: It is a bump what was put on the bed seat for the bead to prevent the tire from sliding off the rim while the vehicle is moving.

8. Well: This is a part of rim with depth and width to facilitate tire mounting and removal from the rim.

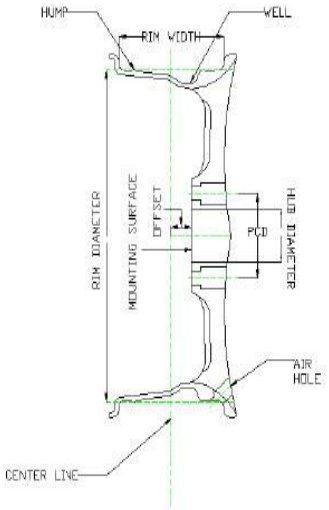


Figure2 wheel nomenclature

CALCULATION

Wheel rim is similar to Pressure vessel hence it is subjected to the following stresses.

RADIAL LOAD:

Fr = F*K Where,

Fr = Radial load

F = 3240 N

K = 2.25 as per Industrial design

Fr = 3240*2.25

=7290 N

ANGULAR VELOCITY:

ω = V/r

V= 80km/hr = 22.22m/s

r = 0.235

ω= 94.55 rad/s

CIRCUMFERENTIAL STRESS /HOOP STRESS:

σc = P*d/2t

= 0.5*350/8

=21.87 N/mm2

LONGITUDINAL STRESS: ΣC = P*D/4T

= .5*350/16

= 10.9 N/mm2

IV. MODELING OF ALLOY WHEEL RIMIN SOLIDWORKS

The 3D model of alloy wheel rim is created in SOLIDWORKS software using the dimension measured form actual 14 inch alloy wheel rim of TATA Indica car. MODELING OF WHEEL SOLIDWORKS is software which is used for creation and modifications of the objects. In SOLIDWORKS design and modelling feature is available. Design means the process of creating a new object or modifying the existing one. Drafting means the representation or idea of the object. Modelling means create and converting 2D to 3D. By using SOLIDWORKS software, create the model of the wheel rim.

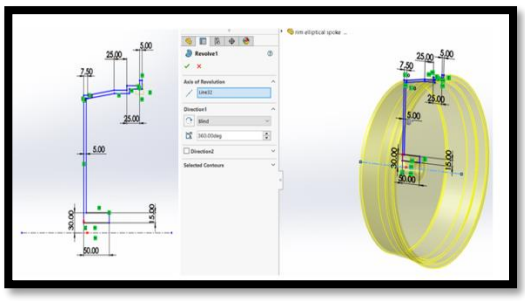


Figure 3dimensions of 4wheel alloy wheel rim

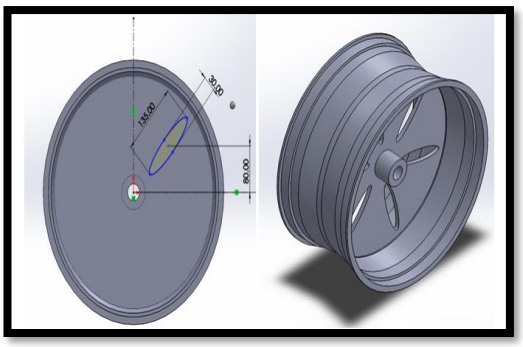


Figure 4elliptical spokes shape alloy wheel rim

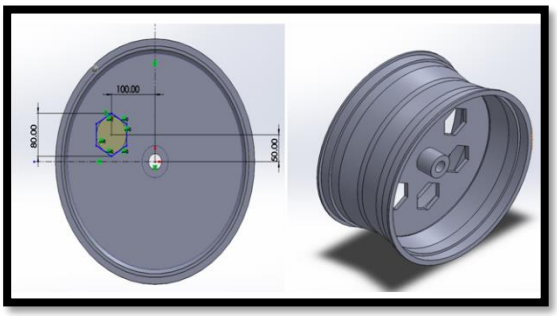


Figure5hexagonal spokes shape alloy wheel rim

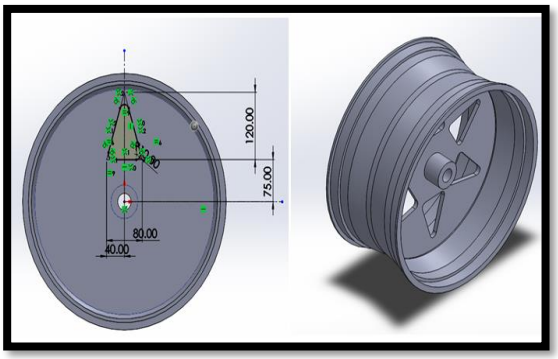


Figure 6triangles spokes shape alloy wheel rim

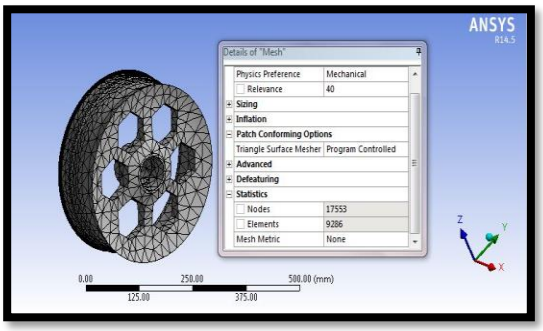


Figure 7 Meshing

(Elements: 9286, Node: 17553)

ISSN PRINT 2319 1775 Online 2320 7876
 Journal Volume 11, Iss 09, 2022

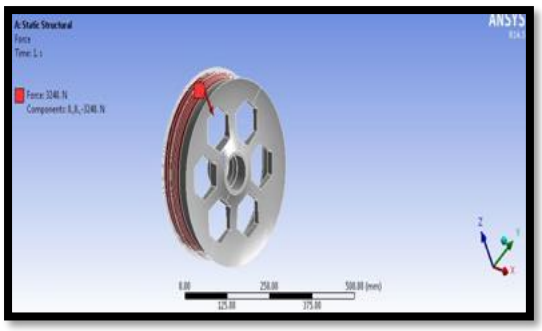


Figure 8 boundary conditions

V. RESULTS AND DISCUSSION

The constructed alloy wheel rims in SOLIDWORKS is analyzed using ANSYS V14.5 and the results are depicted below. The static structural analysis was done by applying Al 6061,Stainless steel, Carbon Epoxy materials result obtained stress , Shear stress, strain deformation are as shown below figures

AL 6061 MATERIAL HEXAGON SPOKE SHAPE ALLOY WHEEL RIM

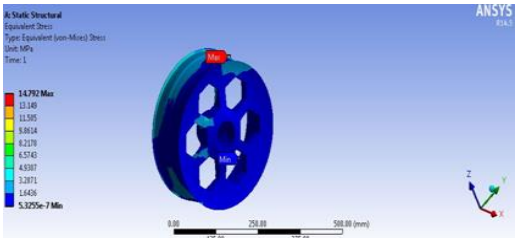


Figure 9 vonmisses stress ofal 6061 material hexagon spoke shape

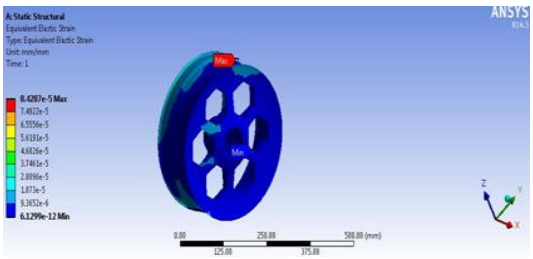


Figure 10 strain ofal 6061 material hexagon spoke shape

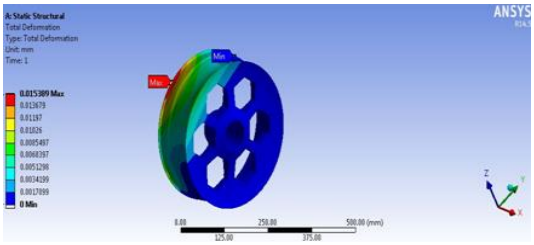


Figure 11 total deformation ofal 6061 material hexagon spoke shape

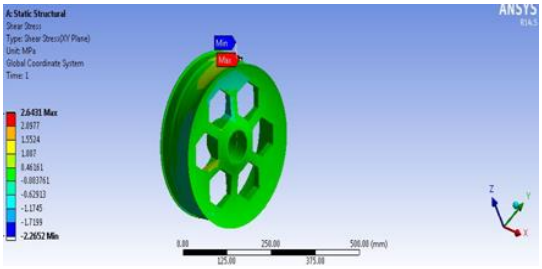


Figure 12 shear stress ofal 6061 material hexagon spoke shape

STAINLESS STEEL MATERIAL HEXAGON SPOKE SHAPE ALLOY WHEEL RIM

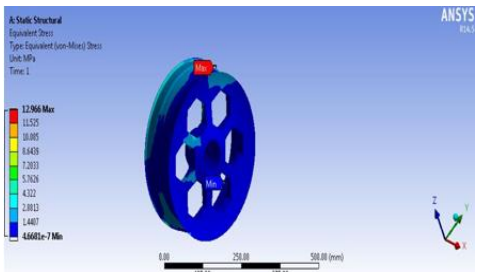


Figure 13 vonmisses stress of stainless steel material hexagon spoke shape

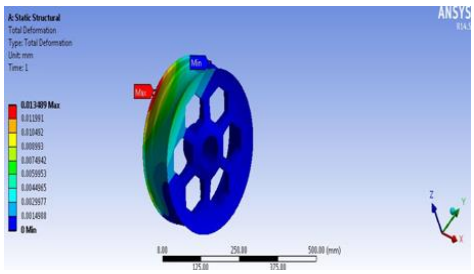


Figure 14 total deformation of stainless steel material hexagon spoke shape

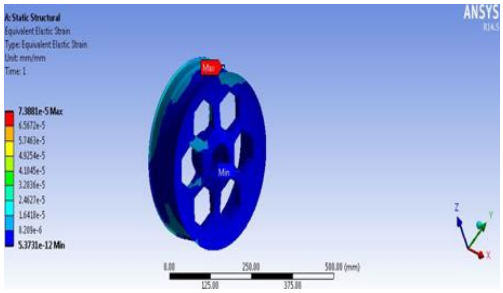


Figure 15 strain of stainless steel material hexagon spoke shape

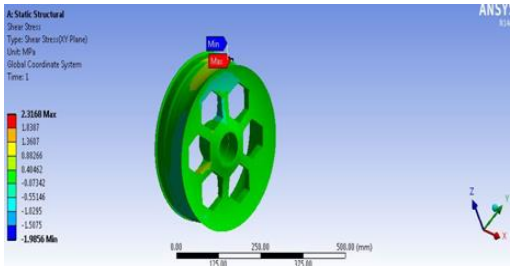


Figure 16 shear stress of stainless steel material hexagon spoke shape

CARBON EPOXY MATERIAL HEXAGON SPOKE SHAPE ALLOY WHEEL RIM:

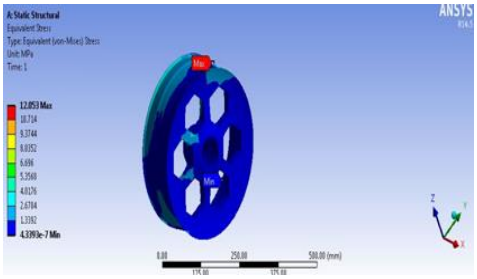


Figure 17 vonmisses stress of carbon epoxy material hexagon spoke shape

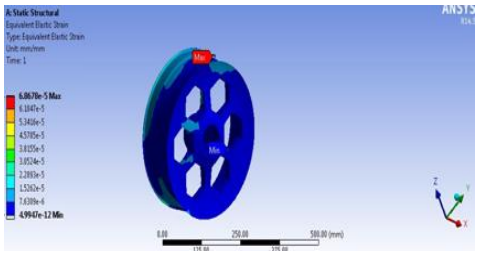


Figure 18 strain of carbon epoxy material hexagon spoke shape

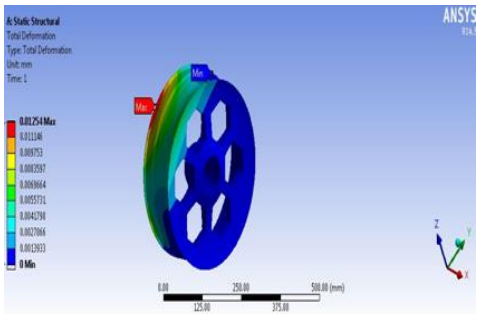


Figure 19 total deformation of carbon epoxy material hexagon spoke shape

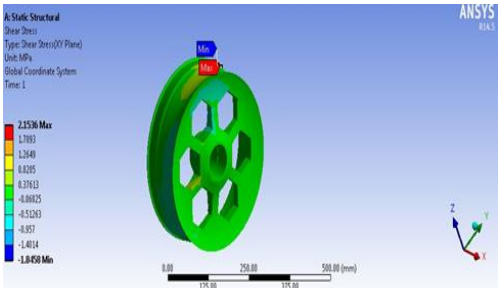


Figure 20 shear stress of carbon epoxy material hexagon spoke shape

MODAL ANALYSIS:

Here find out deformations in different frequencies are obtained by analyzing the Car alloy wheel with triangular spokes shape by using carbon epoxy composite material, as shown in below figures.

CARBON EPOXY COMPOSITE MATERIAL OF TRAINGLE SPOKE SHAPE:

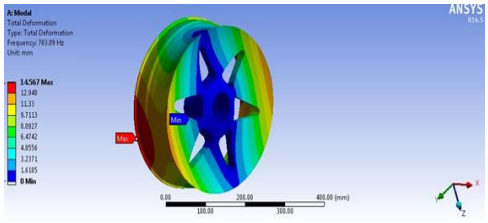


Figure 21first mode

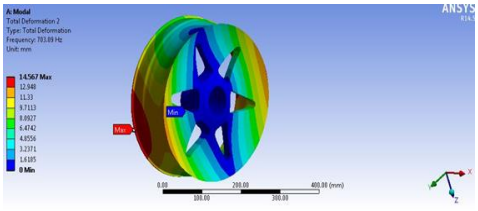


Figure 22second mode

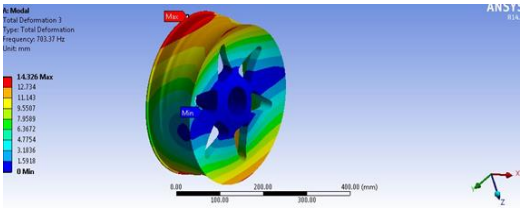


Figure 23third mode

ISSN PRINT 2319 1775 Online 2320 7876
 Journal Volume 11, Iss 09, 2022

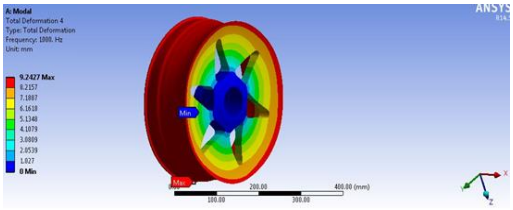


Figure 24 fourth mode

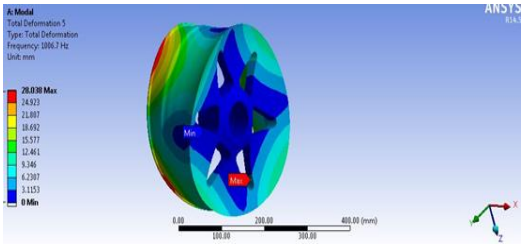


Figure 25 fifth mode

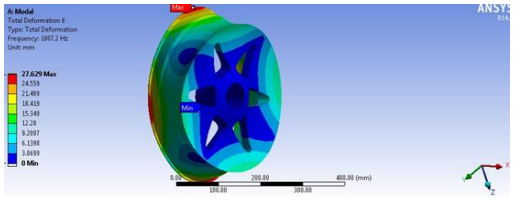
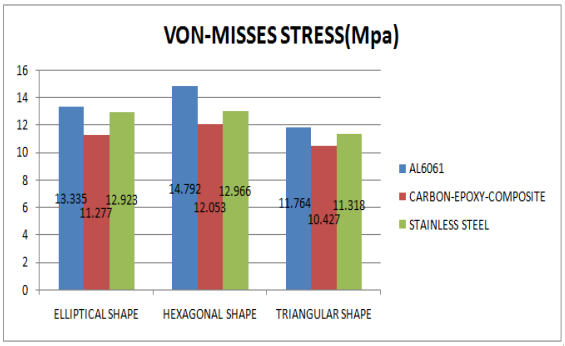


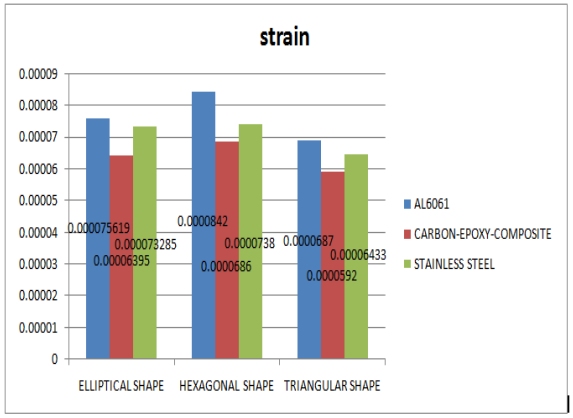
Figure 26 sixth mode

GRAPHS:

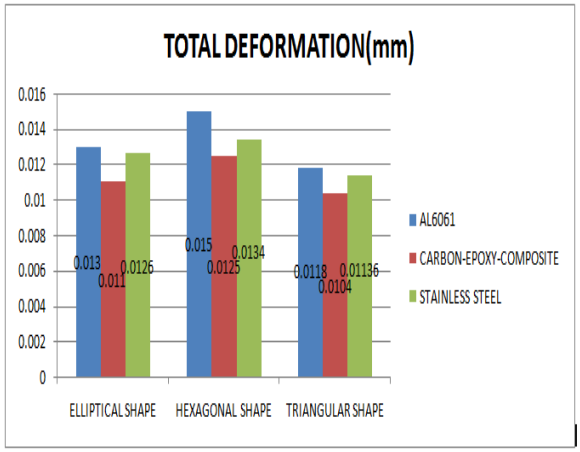
The static structural analysis of AL 6061, STAINLESS STEEL, CARBON EPOXY, are done and results are obtained for Equivalent (Von-Misses) stress, Shear stress, equivalent elastic strain, total deformation. These results are plotted graphically and a comparison is made between these results.



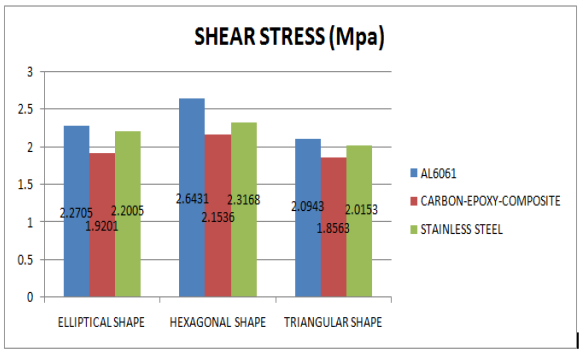
Graph 1 von-misses stress graph



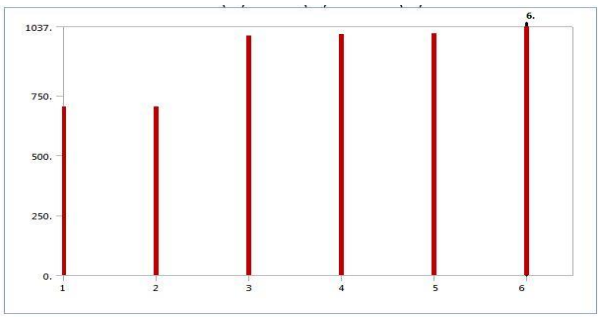
Graph 2 strain graph



Graph 3 total deformation graph



Graph 4 shear stress graph



Graph 5 modal analysis graph

VI. CONCLUSION

Modelling of the different wheel rims(elliptical spokes shape, Hexagon shape, triangle shape is generated in SOLIDWORKS and this is imported to ANSYS (14.5) for processing work. An amount of Radial load 3240N is applied along the circumference of the wheel rims made of both Al 6061Alloy; Stainless steel & Carbon Epoxy material and hub circle of wheel rim is fixed. Following are the conclusions from the results obtained.

1. Al 6061 alloy wheel rim and Stainless steel is subjected to more total deformation compared to carbon Epoxy material.

2. Al 6061 alloy wheel rim and stainless steel spoke wheel is subjected more von-misses stress and compared to carbon epoxy material.

3. Carbon epoxy has a more life compared to remaining materials.

4. Weight of carbon fibre is 40 to 50% less compared to Al 6061 alloy wheel rim and stainless steel.

5. By comparing all result we are suggested that triangle spokes shape carbon Epoxy is better material than Al 6061 alloy wheel rim, Stainless steel alloy for designing of wheel.

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