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DESIGN AND STRUCTURAL ANALYSIS OF CAR ALLOY WHEEL USING WITH VARIOUS MATERIALS

[1] Mr. CHINTAPALLI SHEKHAR, [2]Mr. B.V.V.V.B LAKSHMIPATI RAO, [3] Mr. V.V.RAMA KRISHNA

[1]M.Tech Student, Dept. of Mechanical Engineering, Pydah College of Engineering, Patavala, Kakinada Andhra Pradesh
[2] Associate professor, Dept. of Mechanical Engineering, Pydah College of Engineering, Patavala, Kakinada, Andhra Pradesh
[3] Associate professor, Head of the Dept. of Mechanical Engineering, Pydah College of Engineering, Patavala, Kakinada, Andhra Pradesh

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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, shear stress 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 Catia software, after that static analysis is done with different materials (Carbon epoxy composite, AL6061, Mg alloy) load and boundary conditions taking in ANSYS14.5 Software. Finally observed results of stress, total deformation, shear stress on different wheel rims(Hexagon spoke shape and Elliptical spoke shape) materials and compared with each other. Thus, the best design and material can be selected for manufacturing of the alloy wheel.

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I INTRODUCTION

The wheel is a gadget that empowers effective development of an article over a surface where there is a power squeezing the item to the surface. Early wheels were basic wooden circles with a gap for the pivot. Due to the structure of wood a level cut of a trunk isn't reasonable, as it doesn't have the basic solidarity to help weight without falling; adjusted bits of longitudinal sheets are required. The spoke wheel was developed all the more as of late, and permitted the development of lighter and swifter vehicles. Compound wheels are vehicle wheels which are produced using an amalgam of aluminum or magnesium metals. Truly, fruitful plans was shown up following quite a while of experience all around supported worth broad field - testing.

Since the 1970's few imaginative techniques for testing and exploratory pressure estimations have been started. In later years, the methodology have fundamentally improved by the rise of an assortment of exploratory and investigative techniques for basic examination. Toughness investigation, that is: weakness life forecast and unwavering quality techniques, for managing different characteristic in designing structures has been utilized for the investigation of car edges. In its fundamental structure a wheel is an exchange component between the tire and the vehicle.The primary prerequisites of a car wheel.

II LITERATURE REVIEW

A Survey on Modeling and Analysis of Car Wheel Rim utilizing CATIA and ANSYS by According to **Karthik A.S. et al. (2018) [1]** Finite Element Techniques are utilized to discover pressure and uprooting conveyance in vehicle wheels exposed to expand weight and spiral burden. The model was made utilizing "CATIA V5" and the investigation was done through "Ansys workbench" limited component bundle. In the wake of looking at the aftereffects of various Material model chosen like magnesium, aluminum, and titanium are utilized to check the limit of the wheel.

As per **Jaspreet Singh, et al. (2019) [2]** they examined Alloy Wheel by static stacking utilizing Ansys15.0 and the summery of this Paper was, FEA was performed on aluminum combination wheel. The aftereffects of the von-misses pressure, factor of security, and absolute dislodging were determined. Additionally utilizing figuring out outcomes got are fine for the structure.

As per **Meghashyam-et.al (2017) [3]** model of the wheel edge was made with the assistance of CATIA programming. Later this CATIA model was imported to ANSYS for examination work. With the assistance of ANSYS programming the various powers, pressure following up on the segment and furthermore for computing the outcomes. ANSYS static examination work was finished by two distinct materials mulling over like aluminum and fashioned steel and their relative exhibitions have been watched separately. Likewise edge was exposed to modular examination, a piece of dynamic investigation was performed and execution was watched. In this they watched the consequences of static and model examination, and manufactured steel was proposed as best material.

Siva Prasad et al.[1] does pressure and dynamic examination of vehicle wheel edge by utilizing CATIA and ANASYS. To decide best material for wheel so that by plan and changes the burdens can be decreases to improve the exhaustion life of wheel edge. During this examination, they considered two unique materials to be specific aluminum and produced steel and their relative exhibitions have been watched separately. Aluminum composite wheel edge are exposed to greater removal and stresses contrasted with Forged steel and they are proposed manufactured steel is better material.

Sourav das et al.[2] gives structure of aluminum compound wheel for vehicle application which is done paying exceptional reference to streamlining of the mass of the wheel. The Finite Element examination it shows that the advanced mass of the wheel edge could be decreased to 26Kg to 12.15kg when contrasted with the strong plate type Al composite wheel. The FEM investigation showed that significantly after a weakness pattern of 1×1020, the harm on the wheel is discovered just 0.2%. What's more, the harm district is discovered the rib bit of the edge.

Rajarethinam P et al. [3] introduced paper on cruiser wheel spokes and in this paper wheel edge planned by utilizing structuring programming SOLID WORKS and later , for examination 3-D model is brought into ANSYS. • The most extreme pressure territory was situated at Spoke-Rim contact. • Stresses actuated in 5 Spokes Alloy wheel are less as contrasted and Al-Alloy of the 6 Spokes. • Material decrease should be possible by lessening number of Spokes

Liangmo Wang et al.[4] offers examination to improve the nature of aluminum wheels, another technique for assessing the weakness life of aluminum wheels is proposed in this paper. The ABAQUS programming was utilized to construct the static burden limited component model of aluminum wheels for reenacting the rotational weakness test. The outcomes from the aluminum wheel revolving exhaustion seat test demonstrated that the gauge wheel bombed the test and its break inception was around the center point jolt gap territory that concurred with the reenactment. Utilizing the strategy proposed in this paper, the wheel life cycle was improved to over 1.0×105 .

M. Saran Theja et al. [5] gave paper bargains the static and weakness investigation of wheel to break down the protected heap of the combination wheel A normal amalgam wheel setup of Suzuki GS150R business vehicle is utilized for study.This configuration is 60% lighter and the general measurements are constrained by diminishing number of spokes to the composite wheel with same working soundness and less weight. The pressure and relocations in 4 talked amalgam wheel are lesser than six and five spokes combination wheels.

N. Satyanarayana et. al.[6] gives a definite "Weariness Analysis of Aluminum Alloy Wheel under Radial Load". During the piece of venture a static and weariness investigation of aluminum compound wheel A356.2 was done utilizing FEA bundle. The 3 dimensional model of the wheel was planned utilizing CATIA. At that point the 3-D model was brought into ANSYS utilizing the IGES position. The examination was acted in a static condition.

Sunil N. Yadav et al.[7] gives impact of slip edge on pressure appropriation and weakness life of wheel edge of traveler vehicle under outspread burden condition which emerges due to go 4x4 romping field region and street lopsidedness. The limited component examination just as trial investigation of traveler vehicle wheel edge performed for spiral burden with the impact of slip edge on pressure circulation and weakness life. • The anxieties are a lot higher in the plate zone than the edge region. • The possible disappointments areas recognized in the wheel edge by limited component investigation are stud openings, solidifying lump and ventilation gaps. • The worries in wheel edge are legitimately corresponding to slip edge for example the life of wheel edge diminishes as slip point increment.

S Vikranth Deepak et al.[8] does static basic and exhaustion examination of four wheeler vehicle by utilizing limited component investigation. An ordinary compound wheel design of passage holiday is utilized for study. The investigation results indicated that the most extreme pressure territory was situated in the center point jolt entire zone. For all contrasting the three materials (aluminum, magnesium and zinc) of stress, relocation, all out life, load factor and harm factor they was recommended that aluminum compound is the best material for the amalgam wheel.

P. V. Ravi Kumar et al.[9] have considered paper depicts sway test and geography enhancement of cast aluminum compound wheel with oblige of plastic strain. the bomb estimation of plastic strain for standard cast aluminum combination wheel is 4.0%, splits will show up if the Plastic Strain esteem is more noteworthy than 4%. Geography advancement is completed by expanding the thickness of the edge until the plastic strain esteem is underneath 4%. Effect investigation is completed utilizing LS-Dyna programming to foresee the plastic strains during sway test. They reasoned that thickness of cast aluminum compound wheel ought to be 5.9mm which will be perform acceptable.

S. Ganesh et al.[10] gives investigation of compound wheels which are produced using an amalgam of aluminum or magnesium metals or some of the time a blend of both. They utilize four wheeler wheels are made of Aluminum Alloys. They are gathering information from figuring out procedure from existing model. On account of bowing test ordinary worry along Y-hub shows pressure on the top rib and strain on the base rib and pressure on the base rib. On account of weight stacking, typical worry along X-hub shows pressure on the top

edge and within segment of the edge there is a progressive change from pressure to strain.

III PROJECT OVER VIEW

3.1 OBJECTIVE OF THE PROJECT

At present four wheeler wheels are made of Aluminum Alloys and structural steel. In this project Aluminum and steel, replaced with carbon fiber, Mg alloy, materials due to its less cost and its density is less compared with that with AL6061. Due to less density, the wheel weight also get reduced due to composite material. Select Static analysis and modal analysis on the wheel rim. Design is optimized by analyzing the different models (elliptical spokes shape, hexgon spokes shape) in ANSYS. Composite is light alloy are the foremost materials used in a wheel rim however some special wheels composite materials are being used together

3.2 PROBLEM IDENTIFICATION:

Improper design and material 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 analysis find out the equivalent stress and deformation, shear stress, for the given on the aluminum alloys,mg alloy. 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 fiber E-Glass epoxy materials due to its less cost and its density is less compared with that of aluminum. Due to less density of carbon fiber material, the wheel weight also gets reduced. And also the carbon fiber is more strengthen than that of aluminum alloys and steel alloys

3.3 METHODOLOGY:

1. Design of Alloy wheel rim, using specification of four Wheel alloy car rim TATA INDICA is created.
2.Creation of 3D different models(hexagonal spokes shapes, elliptical spokes shape) of ALLOY WHEEL RIM using CATIA V5 and then Imported in ANSYS 14.5.
3. Static and Modal Analysis of alloy wheel using FEA method.
4. Comparative performance of Carbon Fiber, Mg alloy, AL 6061 materials.
5. Finally select the best design and Material for alloy Wheel rim

3.4 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

Figure 1WHEEL SPECIFICATION

3.5 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:

$\omega = V/r$
V= 80km/hr = 22.22m/s
r = 0.235
ω= 94.55 rad/s

3.6 MATERIAL PROPERTIES:

3.6.1 CARBON FIBERS:

Carbon fibers are usually combined with other materials to form a composite. When impregnated with a plastic resin and baked it forms carbon-fiber-reinforced polymer (often referred to as carbon fiber) which has a very high strength-toweight ratio, and is extremely rigid although somewhat brittle.Carbon Fiber for the Top Body Armor Material.

3.6.2 MAGNESIUM ALLOY:

Magnesium is around 30% lighter than aluminium and furthermore honourable with respect to measure steadiness and effect resistance. However,its utilize is for the most part confined to hustling, which needs the elements of weightlessness and high quality to the detriment ofweathering resistance and design decision, and so on contrasted and aluminium. As of late, the innovation for throwing and fashioning is enhanced, and the erosion resistance of magnesium is likewise making strides. This material is getting uncommon consideration because of the recharged enthusiasm for vitality preservation.

3.6.3 AL6061 Material:

AL6061 Materials: Excellent joining characteristics, go acceptance of applied coatings. Combines relatively high strength, good workability, and high resistance corrosion; widely available.

MATERIALS PROPERTIES			
PROPERTIES	AL 6061	CARBON FIBER	MG ALLOY
DENSITY(Kg/m³)	2700	1600	1800
YOUNGS MODULES (Mpa)	68900	110000	**45000**
POSSION'S RATIO(μ)	0.33	0.10	0.35

Figure 2MATERIAL PROPERTIES

The T8 and T9 tempers offer better chipping characteristics over the T6 temper. Applications: Aircraft fittings, camera lens mounts, couplings, marines fittings and hardware, electrical fittings and connectors, decorative or misc. hardware, hinge pins, magneto parts, marine Propellers brake pistons, hydraulic pistons, appliance fittings, valves and valve parts; bike frames.

3.7 DIMENSIONS OF THE ALLOY WHEELS :

3.7.1 ELLIPTICAL SPOKE SHAPE:

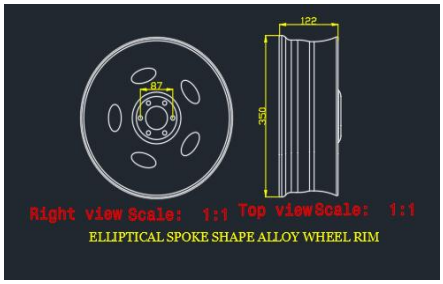

Figure 3 DIMENSIONS OF THE elliptical ALLOY WHEEL

3.7.2 HEXAGON SPOKE SHAPE :

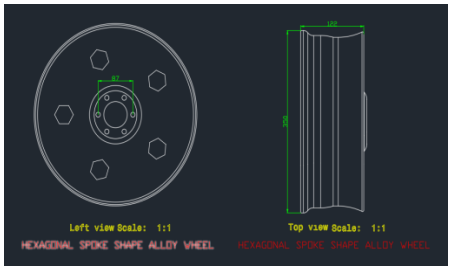

Figure 4 DIMENSIONS OF THE HEXGONAL ALLOY WHEEL

IV DESIGN PROCEDURE IN CATIA:

4.1 MODELING OF ALLOY WHEEL RIM:

The 3D model of alloy wheel rim is created in CATIA V5 software using the dimension measured form actual 14 inch alloy wheel rim of TATA Indica car

MODELING OF WHEEL CATIA is software which is used for creation and modifications of the objects. In CATIA 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 CATIA software, create the model of the wheel rim.

4.2 STEP INVOLVED IN DESIGN:

1. Draw the profile diagram of the wheel rim.

2. Now revolve the profile body about respect to axis.

3. By selecting the face of wheel, the required design is drawn on the surface is removed by using Cut operation.

4. Now selecting face draw circle and rotate them using circular pattern about axis so, spokes are obtained all over the rim.

5. And finally using round option the side edge are made filleted for final finishing.

4.3 ELLIPTICAL SPOKES SHAPE ALLOY WHEEL RIM:

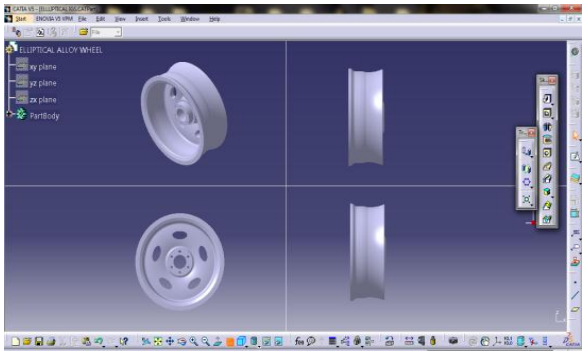

FIGURE 5 ELIPTICAL SPOKE SHAPE DESIGNED IN CATIA WORKBENCH

4.4 HEXAGONAL SPOKES SHAPE ALLOY WHEEL RIM:

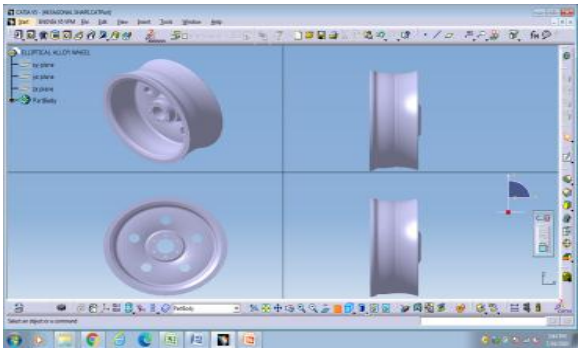

Figure 6 HEXAGONAL SPOKES SHAPE ALLOY WHEEL RIM

VANALYSIS PROCEDURE IN ANSYS:

Designed component in catia workbench after imported into Ansys workbench now select the steady state thermal analysis.

1. ENGINEEERING MATERIALS (MATERIAL PROPERTIES).
2. CREATE OR IMPORT GEOMENTRY.
3. MODEL (APPLY MESHING).
4. SET UP (BOUNDARY CONDITIONS)
5. SOLUTION
6. RESULTS

5.1 BOUNDARY CONDITIONS:

The 3D models alloy wheel rim created using CATIA software is imported in ANSYS 14.5 software. It was meshed and applied boundary conditions as shown below figures .Boundary conditions are applied to the meshed alloy wheel rim which includes force 3240N(Radial direction) boundary conditions and restriction boundary condition

5.2 HEXAGONAL SPOKES SHAPE MESH :(Nodes, Elements: 16942, 9222

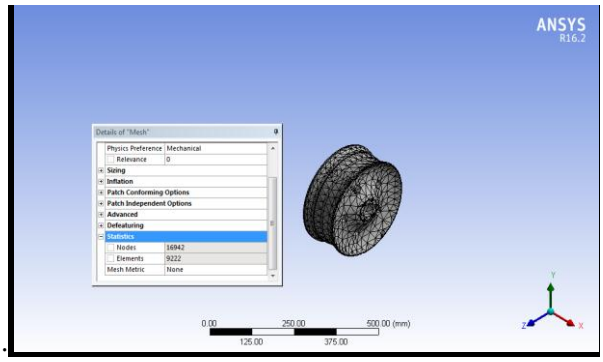

Figure 7HEXAGONAL SPOKES SHAPE MESH

5.3 ELLIPTICAL SPOKES SHAPE ALLOY WHEEL:

Nodes, Elements: 17106, 9370

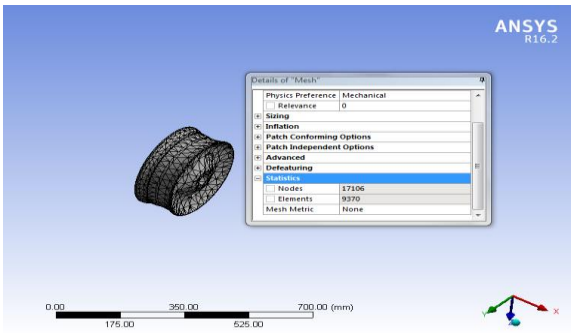

Figure 8 ELLIPTICAL SPOKES SHAPE MESH

5.4 BOUNDARY CONDITIONS:

ELLIPTICAL SPOKES SHAPE

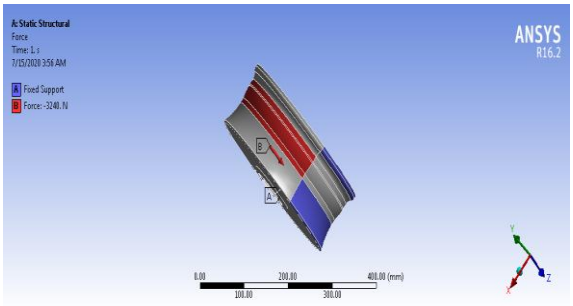

Figure 9ELLIPTICAL SPOKES SHAPE

5.5 HEXAGONAL SPOKES SHAPE

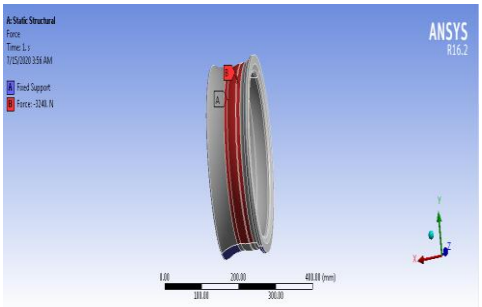

Figure 10 HEXAGONAL SPOKES SHAPE.

VI RESULTS AND DISCUSSION

The constructed different alloy wheel rims in catia is analyzed using ANSYS V16.5 and the results are depicted below. The static structural analysis was done by applying Al 6061, Mg alloy, Carbon Fiber result obtained Von-misses stress , Shear stress, deformation are as shown below figures

6 .1 ELLIPitical SPOKE SHAPE ALLOY WHEEL RIM of AL 6061 :

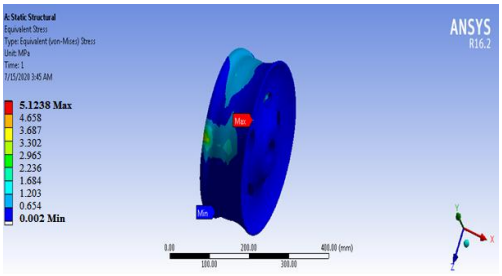

Figure 11VON-MISSES STRESS OF AL 6061 ELLIPSE SPOKE SHAPE

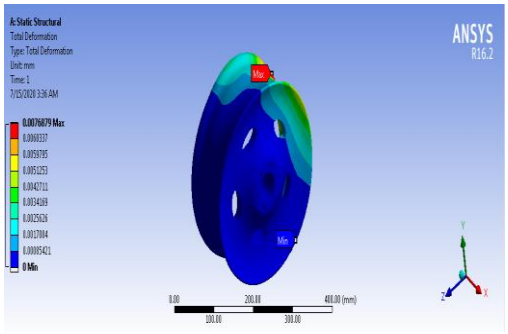

Figure 12 TOTAL DEFORMATION OF AL 6061 ELLIPSE SPOKE SHAPE

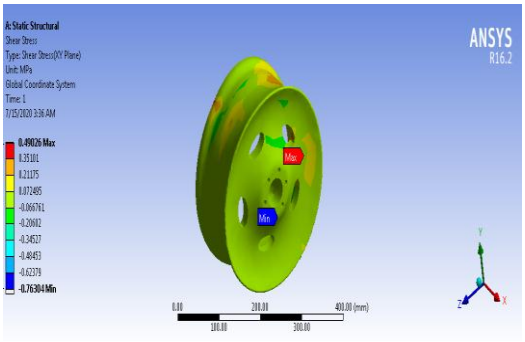

Figure 13 SHEAR STRESS OF AL 6061 ELLIPSE SPOKE SHAPE

6.2 carbon fiber HEXAGON SPOKE SHAPE ALLOY WHEEL RIM

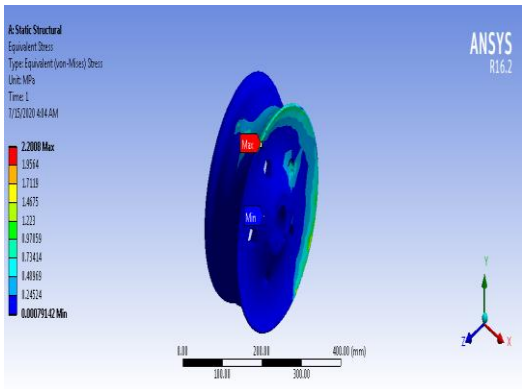

Figure 14 VONMISSES STRESS OF CARBON FIBER MATERIAL HEXAGON SPOKE SHAPE

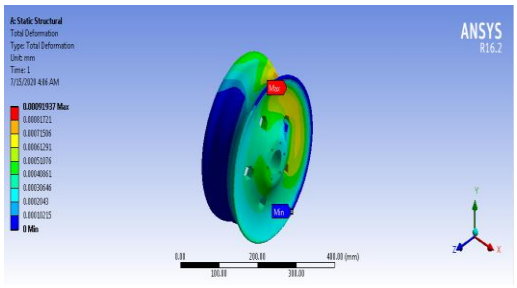

Figure 15 TOTAL DEFORMATION OF CARBON FIBER HEXAGON SPOKE SHAPE

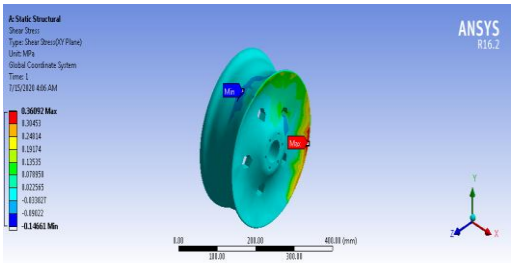

Figure 16 SHEAR STRESS OF carbon fiber MATERIAL HEXAGON SPOKE SHAPE

6.3 mg alloy HEXAGON SPOKE SHAPE ALLOY WHEEL RIM:

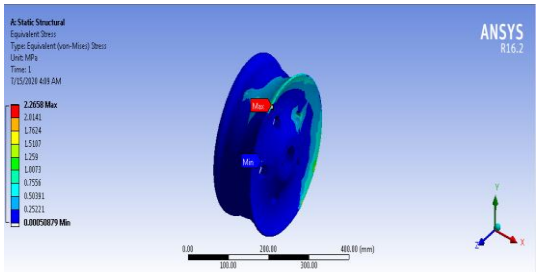

Figure 17 VONMISSES STRESS OF mg alloy MATERIAL HEXAGON SPOKE SHAPE

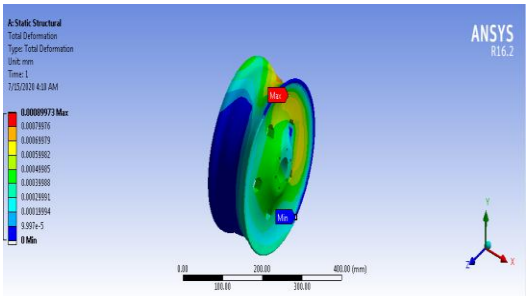

Figure 18 TOTAL DEFORMATION OF mg alloy MATERIAL HEXAGON SPOKE SHAPE

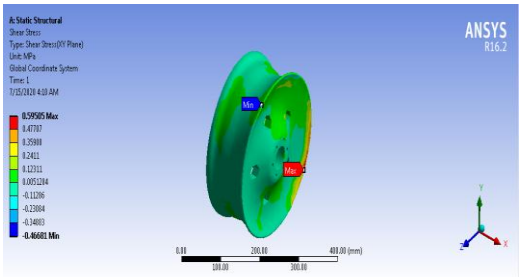

Figure 19 SHEAR STRESS OF MG ALLOY MATERIAL HEXAGON SPOKE SHAPE

VII GRAPHS:

7.1 STATIC ANALYSIS GRAPHS:

The static structural analysis of AL 6061, MG ALLOY,CARBON FIBRE are done and results are obtained for Equivalent (Von-Mises) stress, Shear stress, total deformation. These results are plotted graphically and a comparison is made between these results.

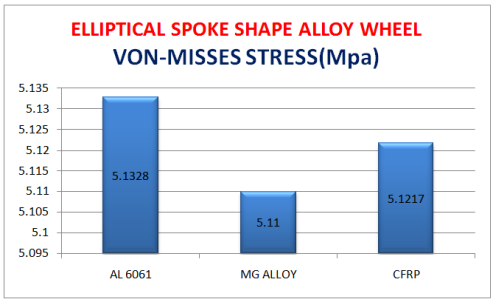

Figure 20 VON-MISSES STRESS GRAPH of elliptical spoke shape wheel

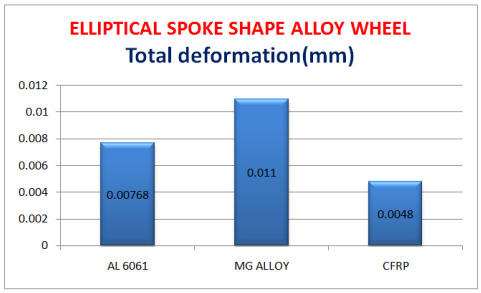

Figure 21 TOTAL DEFORMATION GRAPH elliptical spoke shape wheel

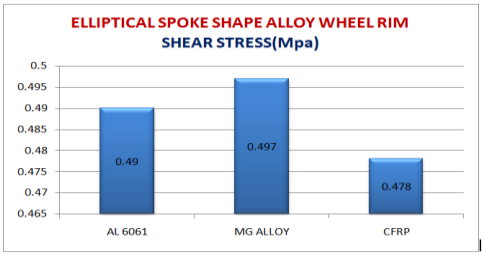

Figure 22SHEAR STRESS GRAPH elliptical spoke shape wheel

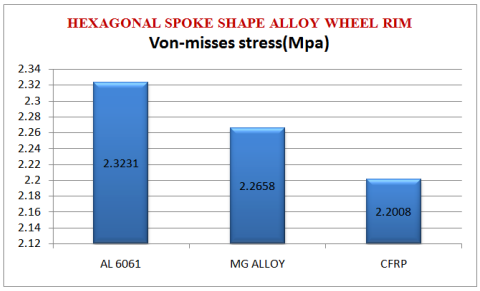

Figure 23 VON-MISSES STRESS GRAPH of hexagonal spoke shape wheel

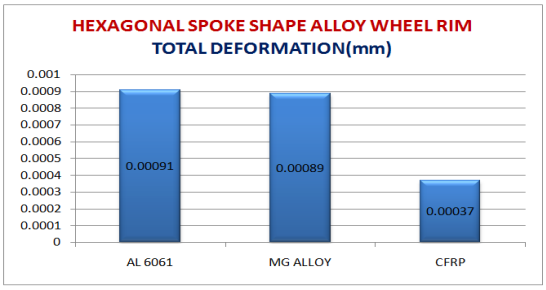

Figure 24 TOTAL DEFORMATION GRAPH hexagonal spoke shape wheel

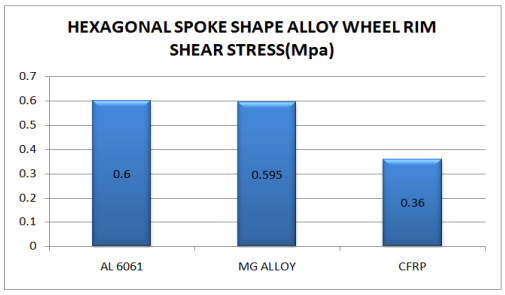

Figure 25SHEAR STRESS GRAPH hexagonal spoke shape wheel

7.2 Modal analysis table:

TABEL 1

HEXAGON SPOKE SHAPE OF MG ALLOY :

MODES	FREQUENCY(Hz)	DEFORMATION(mm)
MODE 1	730.1	13.845
MODE 2	1530.1	9.391
MODE 3	733.71	13.817
MODE 4	1062.6	19.499
MODE 5	1062.8	19.495
MODE 6	1246.5	9.1028

TABLE 2

HEXAGON SPOKE SHAPE OF CARBON FIBRE :

MODES	FREQUENCY(Hz)	DEFORMATION(mm)
MODE 1	820.1	12.693
MODE 2	1632	9.256
MODE 3	750	12.52
MODE 4	1066.82	18.63
MODE 5	1184.89	18.33
MODE 6	1388.5	8.96

VIII CONCLUSION

Modeling of the different wheel rims(elliptical spokes shape, Hexagon shape)is generated in CATIA and this is imported to ANSYS(14.5) for processing work. Alloy wheel rim has been designed using catia software, after that static and modal analysis is done with different materials(Carbon Fiber,Mg Alloy, Al 6061) boundary conditions taking in ANSYS14.5 Software. Taking boundary conditions on alloy wheel Radial load 3240N is applied along the circumference of the wheel rims Finally observed results of stress, total deformation, and shear stress on different wheel rims and materials and compared with each other. Thus, the best design and material can be selected for manufacturing of the alloy wheel.

1. AL6061 with Elliptical spoke shape have subjected to more total deformation compared to Remaining materials 2 materials.carbon fiber have less deformation .
2. AL 6061 with Elliptical spoke shape have subjected more von-mises stress & shear stress compared to Remaining materials 2 materials, carbon fiber have less vonmisses stress and shear stress.
3.. Carbon fiber has a more life compared to remaining materials.
4. Weight of carbon fiber is 40 to 50% less weight compared to remaining materials
5. By comparing all result we are suggested that carbon fiber with hexagon shape is better material compared to remaining material it is suitable material and this shape manufacturing of Alloy wheel.

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