International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 06 | June 2018 www.irjet.net p-ISSN: 2395-0072

MODELING AND STATIC ANALYSIS OF ALLOY WHEEL USING DIFFERENT MATERIALS

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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 catia software, after that static structural analysis is done with different materials (ZA21, AL6061, and CARBON FIBRE), load and boundary conditions using ANSYS Software. At last the results of total deformation, strian and equivalent stresses are obtained for different wheel rim materials and compared with each other. Thus, the best material can be selected for manufacturing of the wheel rim; carbon fiber material is suggested as better material for designing of wheel

Keywords: **Zinc alloys, Aluminum 6061, Wheel rim, carbon fiber, stress,ansys, total deformation, boundary conditions.**

1. 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.

.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.

2.PROJECT OVER VIEW: At present four wheeler wheels are made of Aluminum Alloys. In this theory AL is replaced with ZA21 and carbon fiber material due to its less cost and its density is less compared with that with AL. The stated problem here is to analyze the equivalent stress and deformation, strain for the given on the aluminum alloy wheel. The loading conditions for finding the stress, strain and displacement on the wheel is as stated below. In this theory a wheel is designed used in a four wheeler. Present used material for wheel is aluminum alloys, so in this aluminum alloys are replaced with zinc alloy and carbon fibre materials due to its less cost and its density is less compared with that of aluminum. Due to less density of carbon fibre materials, the wheel weight also gets reduced. And also the carbon fibre is more strengthen than that of aluminum alloys and zinc alloys.

3. METHODOLOGY:

1. Design of Alloy wheel rim, using specification of four Wheel alloy car rim TATA INDICA CAR created.

2. Creation of 3D model of ALLOY WHEEL RIM using CATIA V5 and then Imported in ANSYS 14.5.

3. Analysis of ALLOY WHEEL using FEA method.

4. Comparative performance of ZA 21, A6061, carbonfibre

5. Finally select the best Material for Wheel rim

3.1 WHEEL SPECIFICATION:

TAB 1WHEEL SPECIFICATION

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

3.2CALCULATION:
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

CIRCUMFERENTIAL STRESS /HOOP STRESS:

$\sigma c = P*d/2t$

= 0.5*350/8

=21.87 N/mm2

LONGITUDINAL STRESS: ΣC = P*D/4T

= .5*350/16

= 10.9 N/mm2

3.3 MATERIAL PROPERTIES:

3.3.1 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-to-weight ratio, and is extremely rigid although somewhat brittle.Carbon Fiber for the Top Body Armor Material.

3.3.2 ZA 21 Material:

Zamak alloys are part of the zinc aluminum alloy family; they are distinguished from the other ZA alloys because of their constant 5% aluminium composition. The name zamak is an acronym of the German names for the metals of which the alloys are composed: Zink (zinc), Aluminium, Magnesium and Kupfer (copper). The New Jersey Zinc Company developed zamak alloys in 1929. Zinc alloys are popularly referred to as pot metal or white metal.

3 .3.3 AL6061 Materials:

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

4. MODELING OF ALLOY WHEEL RIM:

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.

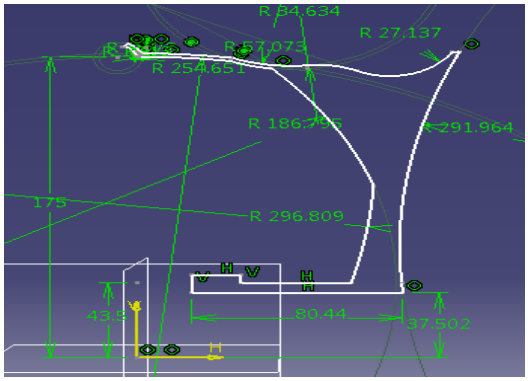


FIG 1ALLOY WHEEL DIMENSIONS

5. STATIC ANALYSIS:

Static analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time.

5.1 ANALYSIS 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

6. BOUNDARY CONDITIONS:

The 3D model 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 Mesh:(Elements:7869, Node:15315).

7. RESULTS AND DISCUSSION:

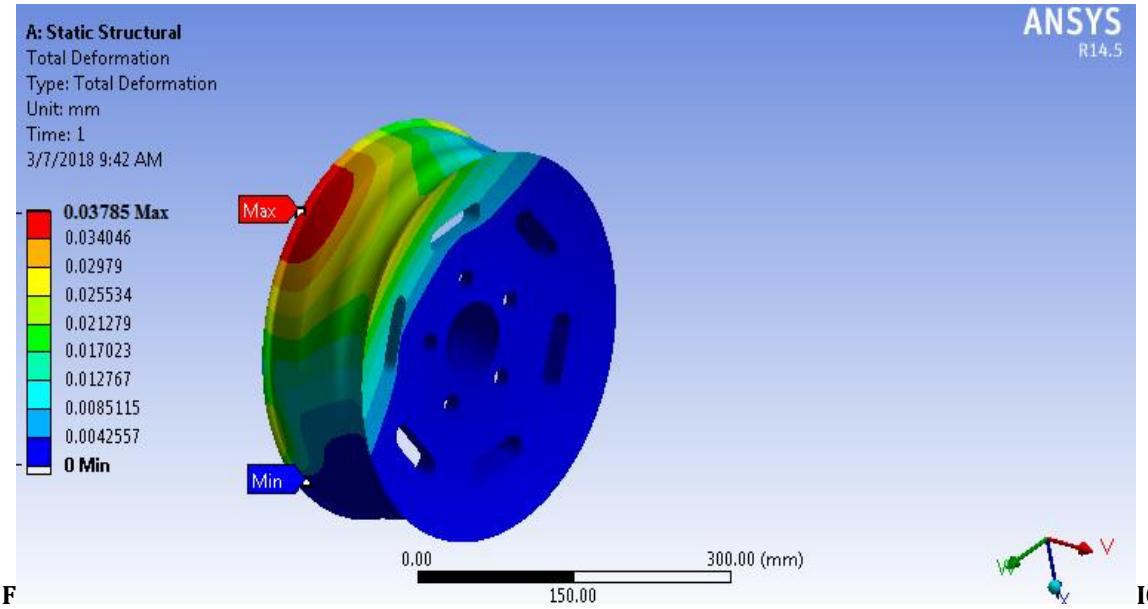
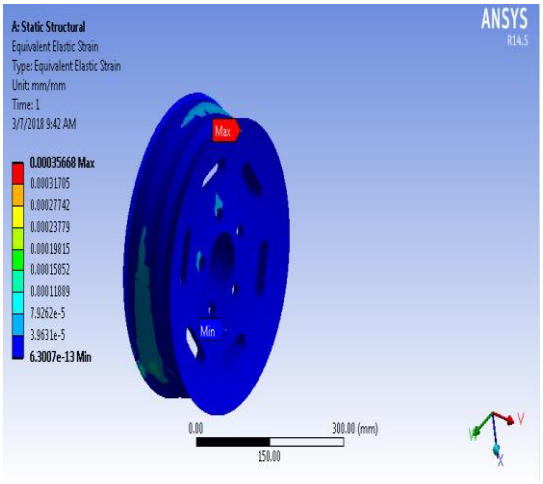


FIG2 DEFORMATIONINCARBONFIBRE



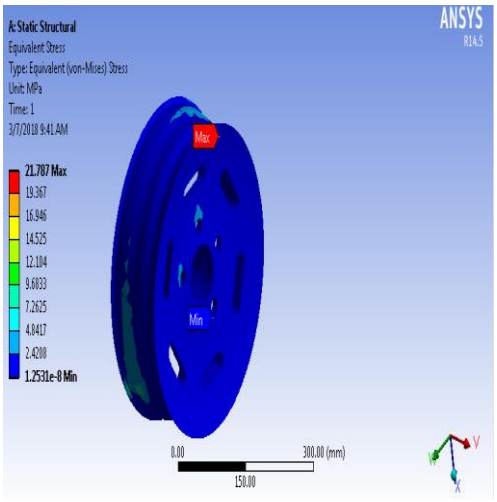


FIG3STRAININCARBONFIBREFIG4STRESSCARBONFIBRE

TAB 2RESULTS COMPARISATION

Material	Stress(mpa)	Total deformation(mm)	Strain
AL6061	23.929	0.042	0.00039
ZA21	22.157	0.038	0.00039
CARBON FIBRE	21.787	0.037	0.00035

Following are the conclusions from the results obtained.

1. Al 6061 alloy wheel rim and ZA21 alloy is subjected to more total deformation compared to carbon fiber.

2. Al 6061 alloy wheel rim and ZA21 alloy spoke wheel is subjected more von-mises stress and compared to carbon fiber.

3.. Carbon fiber has a more life compared to A356.2 Al alloy.

4. Weight of carbon fiber is 40 to 50% less compared to Al 6061 alloy wheel rim and ZA21 alloy.

5. By comparing all result we are suggested that carbon fiber is better material than Al 6061 alloy wheel rim, ZA21 alloy for designing of wheel.

The highest maximum total deformation, Equivalent stress, strain obtained are Al 6061 alloy wheel rim and ZA21 alloy material ,lowest stress, strain, deformation is Carbon material ,Hence it is the best suitable material for manufacturing is carbon material wheel rim. Carbon fibre is a good strength, fatigue life (endurance limit), reliability and reduces the k

ACKNOWLEDGMENTS: I Thanks my guide Dr.K.SURESHBABU (M.E.Ph.D)for his continuous support and encouragement during this work.

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