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"DESIGN & OPTIMIZATION OF ALLOY WHEEL RIM USING ANSYS"

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Abstract:Alloy wheels are automobile wheels which are made from an alloy of aluminum or magnesium metals or sometimes a mixture of both. 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 wheels are made of Aluminum Alloys. In this project, Aluminum alloy are comparing with another Alloy. 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 different 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. Car model is Toyota.

Keywords:Automobile wheel design, Staticdesign,FEM

1. Introduction

The tyre works as a wheel only after it is installed on the rim and is inflated. Therefore, the tyre and wheel assembly influences the function and the performance of the vehicle. The tyre is designed and manufactured to suit a standard rim and once installed on the correct rim the tyre will perform up to its desired level.[1] It is needless to say that the life of the tyre will be shortened if it is installed on an unsuitable rim. The rim is actually the name for the cylindrical part where the tyre is installed. A wheel is the name for the combination between the rim and disc plate. Once the disc plate is installed inside the cylinder this assembly becomes a wheel.[2] Toyo Tyre Talk at this time would like to introduce basic technical knowledge about passenger vehicle rims. The rim used for vehicles is provided depending on each countries standard.[3] This international standard, similar to tyres, provides for a basic dimension for the rim diameter, width, and the flange shape, etc. and is common to every country in the world. Recently the shape of the rim has settled to 5 degree Drop Center Rim to provide for international harmony.

Wheel is generally composed of rim and disc. Rim is a part where the tyre is installed. Disc is a part of the rim where it is fixed to the axle hub. Offset is a distance between wheel mounting surface where it is bolted to hub and the centerline of rim.[4] The flange is a part of rim, which holds the both beads of the tyre. Bead seat comes in contact with the bead face and is a part of rim, which holds the tyre in a radial direction. Hump is bump what was put on the bead seat for the bead to prevent the tyre from sliding off the rim while the vehicle is moving. Well is a part of rim with depth and width to facilitate tyre mounting and removal from the rim.

2. Scope of Work

Objective of the project is the work involves in finding the fatigue life of newly designed aluminum alloy wheel due to static loads. The project mainly involves in modeling of the wheel using MDT and ANSYS, and the analysis is performed on the modeled component using

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ANSYS. Analysis that is performed typically includes static analysis.

3. Methodology of an Alloy Wheels

Reason for Selecting Lighter Materials
The material selections for wheel rim are light alloys and composite material, as the lighter materials reduce the weight of wheel saves material cost and increase the mileage of the vehicle.
Reason for choosing these materials are not only for the reduction of weight of the rim, but also the considerable performance benefits, they are;
a) Reduced unsprung weight.
The term Sprung weight is used to portray the parts of a vehicle that are bolstered by the front and rear springs. They hang up the body, frame, engine, all fluids and the power train over the wheels. These areentirely substantial assemblies.[5]

ALUMINIUM	
Young's modulus	0.71e5 N/mm²
Poisson ratio	0.33
Density	2800 kg/m³

Whereas Unsprung weight incorporates the auxiliary members not upheld by the springs such as tyre and rim, brake and rear axle assemblies and other.[6] This typically incorporates some rate of weight of the suspension itself. It is an important concept because of lessening unsprung weight, wheels give more precisesteering and enhanced rotation attributes.
b) Response on Acceleration and Braking.
Wheels give more response on speeding up and braking, due to reduction in rotational mass of the vehicle
c) Brake cooling is increased
The materials of light alloy and composites will reduce the danger of fade under rash 24riving, because of its brilliant heat conduction and enhanced heat dissipation from the brakes.

Table 1. Design parameter of wheel

Tyre diameter (approx)	560mm
Wheel size	14 inches
Length	86mm
Flange shape	J
Width	5 inches
Wheel type	disc wheel
Flange height	0.68inches
Tyre type	radial
Aspect ratio	65
Off set	80.54

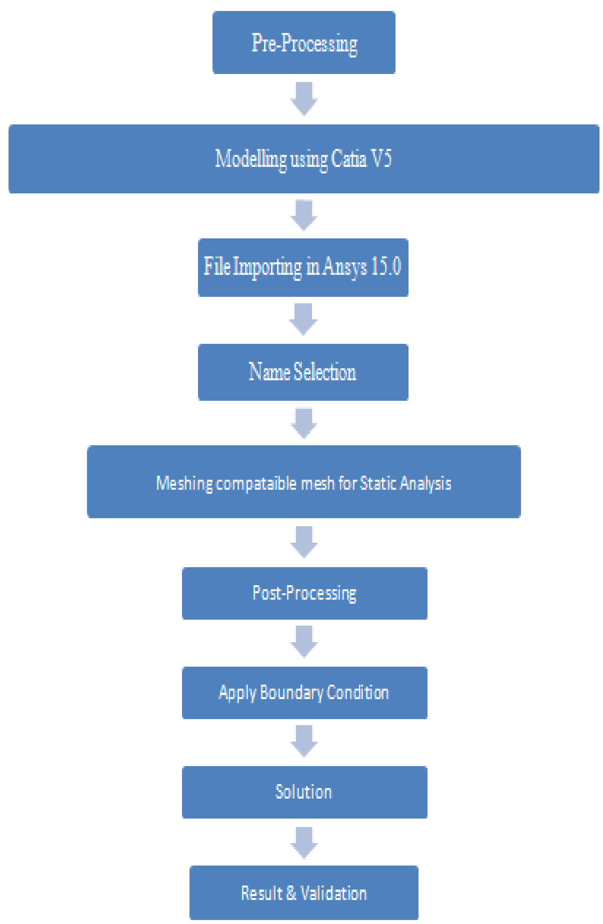

Fig 1: Steps of Working

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Table 2. Material property

CARBON FIBER	
Young's modulus	110000N/mm²
Poisson ratio	0.1
Density	1600 kg/m³
E-POXY	
Young's modulus	69000N/mm²
Poisson ratio	0.37
Density	1300 kg/m³
Circumferential	200 kpa

In figure 3 the model is divided into number of nodes and elements, known as meshing. The figure shows the meshed model of the wheel.

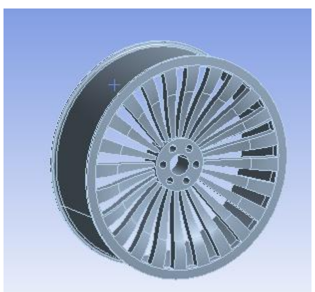

Fig 2: Ansys Model

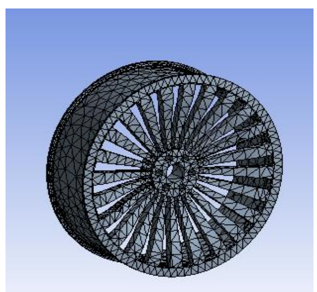

Fig 3: Mesh Model

4. Boundary Conditions

Fixed support

In the figure 3 Fix support is indicated at the nut hole of the wheel. This can be clearly seen in blue color at the center of the wheel.

Pressure applied

In figure 4, force of 2×10^5 Pa is applied on the wheel surface with direction toward the center of wheel. This is indicated in red color as shown.

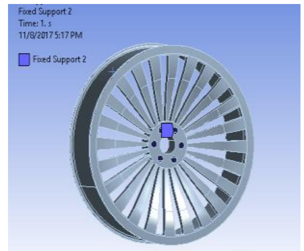

Fig 4: Fixed support

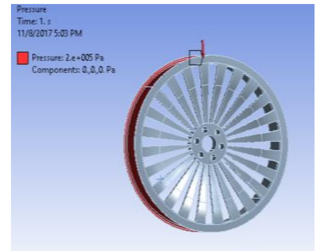

Fig 5: Pressure applied

5. Results

Table 3.Equivalent stress at 200Kpa

	Carbon fiber	Aluminum	E-poxy
150	6.2144e6	6.2144e6	6.2144e6
175	6.2137e6	6.2137e6	6.2137e6
200	6.2184e6	6.2129e6	6.2129e6
305	6.0793e6	6.2098e6	5.3494e6

Table 4. Total deformation at 200Kpa

	Carbon fiber	Aluminum	E-poxy
150	4.0846e-5	2.5621e-5	4.4736e-5
175	4.0846e-5	2.5622e-5	4.4736e-5
200	4.0846e-5	2.5621e-5	4.4736e-5
305	3.9696e-5	2.5621e-5	2.8084e-5

Table 5. Equivalent stress at 279.75Kpa

	Carbon fiber	Aluminum	E-poxy
150	5.7133e-5	3.5838e-5	6.2574e-5
175	5.7133e-5	3.5838e-5	6.2574e-5
200	5.7133e-5	3.5838e-5	6.2574e-5
305	5.7134e-5	3.5838e-5	6.2575e-5

Table 6. Total deformation at 279.75kpa

	Carbon fiber	Aluminum	E-poxy
150	8.6942e6	8.6942e6	8.6942e6
175	8.6935e6	8.6935e6	8.6935e6
200	8.6927e6	8.6927e6	8.6927e6
305	8.6896e6	8.6896e6	8.6896e6

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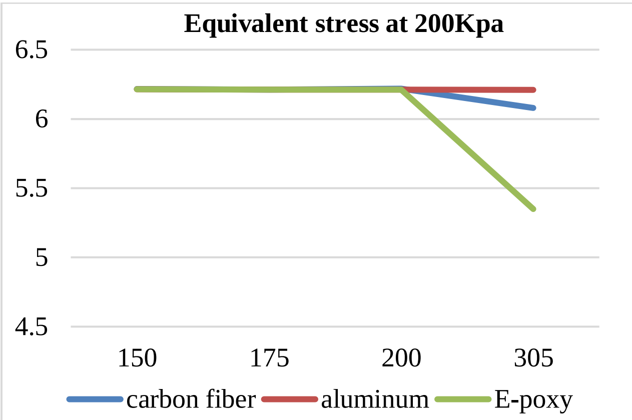

Fig 6: Equivalent stress at 200Kpa

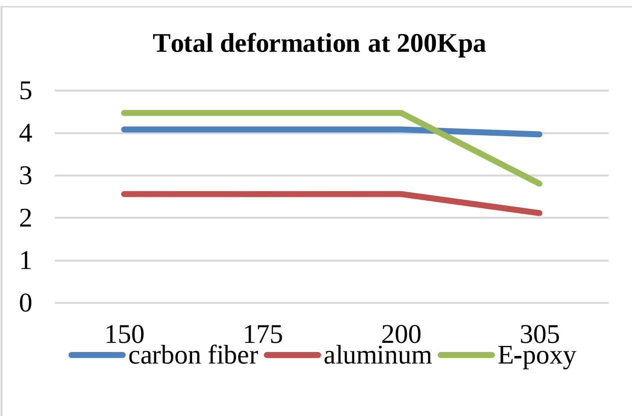

Fig 7: Total Deformation at 200Kpa

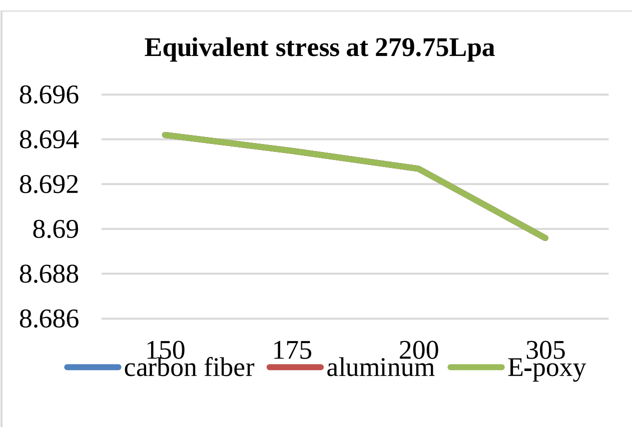

Fig 8: Equivalent stress at 279.75Lpa

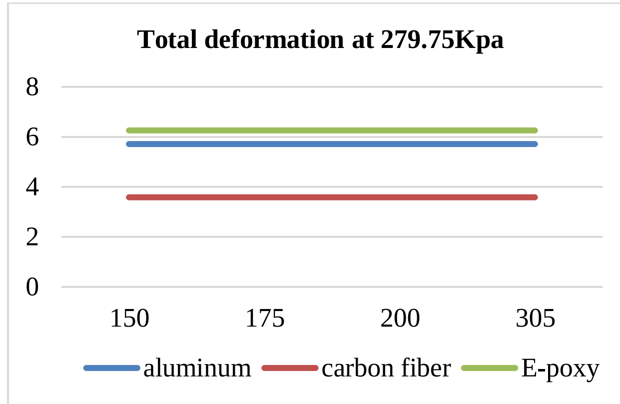

Fig 9: Total Deformation at 279.75Lpa

6. Conclusion and Discussion

a) Carbon fiber is subjected to maximum equivalent stress compared to aluminium and E-poxy under radial loading of 200 kg. Whereas, E-poxy has the minimum stress under radial load of 305 kg.

- Deformation in E-poxy is maximum with radial loadings 150kg, 175kg and 200kg, when compared to other two materialsand the minimum deformation is in aluminium under radial loads 150kg, 200kg, and 305kg.
- Life cycle of E-poxyis lower than Carbon fiber and aluminium. Lower life cycle means lower performance rate.

b) In case 2pressure amount of 279.75kpa is applied along the circumference of the wheel with the same materials as in case 1. The radial loads and fixed part are also kept same as case 1.Following are the conclusions from the results obtained:

- E-poxy is subjected to maximum equivalent stress under all radial loading conditions, i.e. 150kg, 175kg, 200kg, and 305kg, whereas aluminium has the minimum stress under all the radial load conditions.
- Deformation in all the three materials is same i.e. aluminium, carbon fiber and E-poxy and is maximum under 150kg radial load condition. Whereas minimum deformation is same for all the three materials and it is under 305kg radial load condition.

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- Life cycle of E-poxy is lower than Carbon fiber and aluminium. Lower life cycle means lower performance rate**.**

7. Future Direction of Research

In the above proposed work only pressure acting circumferentially on the wheel rim is only considered, this can be extended to other forces that act on the wheel rim and structural analysis is carried out, this can be extended to transient analysis

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