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Structural Analysis and Optimization of Two Wheeler Alloy Wheel by Using FEA Approach

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ABSTRACT

In the automobile sector, the industries are going to explore the composite material to achieve reduction of weight without significant decrease in vehicle quality and reliability. It is fact that reduction of unstrung weight leads to more precise handling and minimizing the fuel consumption. Aluminum alloys are presently used material for manufacture of two wheeler alloy wheel. Composites are the only materials that cater to the never ending demand of the material technology. Aluminum composite materials are the most widely used composite materials in auto mobile sectors due to their light weight and superior strengthability. Presently aluminum alloys are using for manufacturing of two wheeler alloy wheel that was replaced for steel wheels. Hence, the aim of the project is presenting the new material for two wheeler alloy wheel by using composite materials. Hybrid composite of Al-8%si-3%Al203-9%coconut shell ash was prepared using stir casting method and compared with the existing aluminum alloy wheel by using FEA approach. Geometry of alloy wheel was optimized to get reduction in weight by reducing number of spoke .New composite of Coconut shell ash and Alumina(Al203) reinforced Al-8%Silicon(Si) can be successfully applicable for manufacturing of two wheeler alloy wheel.

Keywords *- Alloy wheel, Coconut shell ash (CSA), Aluminium composite, Silicon (Si), Alumina (Al203), FEA.*

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. In the early years wheels were simple wooden disks with a hole for the axle and because of the structure of wood a horizontal slice of a trunk is not suits, because of it does not have the structural strength to support weight without collapsing and a rounded pieces of longitudinal boards are required. So that spoke wheel was invented more recently and allowed the construction of lighter and swifter vehicles. The Alloy wheels are automobile wheels which are made from an alloy of aluminum or magnesium metals (or sometimes a mixture of both).

In automotive industries Components which are manufactured from cast alloys have been widely utilized, due to its high strength to weight ratio, low cost and better fuel consumption. Now in recent years, aluminum alloy wheels have been significantly used in transport vehicles because they are important safety components in vehicle suspension systems that support static and dynamic loads encountered during vehicle operation.

The Automotive wheels have complicated geometry and must satisfy manifold design criteria, such as style, manufacturability, weight, and performance. With the addition of fascinating stylish wheel, wheel design also needs to accomplish a lot of engineering objectives which includes some necessary performance and durability requirements. However, in order to ensure driving comfort and road handling characteristics, the wheel must be as light as possible. So that reduction in wheel weight is a major concern in wheel industry. Hence researches are concentrating on reducing the weight by using composite material.

2. MODELING AND ANALYSIS

With the help of measuring instrument reverse engineering approach is used to take all the dimension of the Aluminum alloy wheel. As per the dimensions and profile of the three dimensional model is created using the modelling software called CATIA. Meshing was done with HYPERMESH tool and the FE Analysis is carried using ABAQUS.

Fig 1: 3D model of 5 spoked alloy wheel

Fig 2: 3D model of 4 spoked alloy wheel

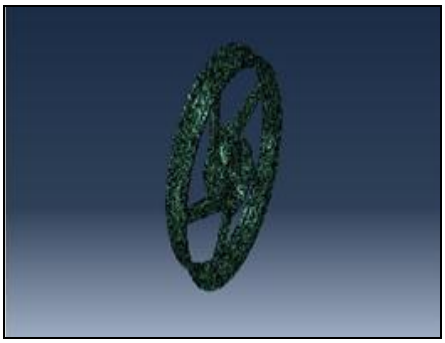

Fig 3: Meshed model of 5 spoke alloy wheel

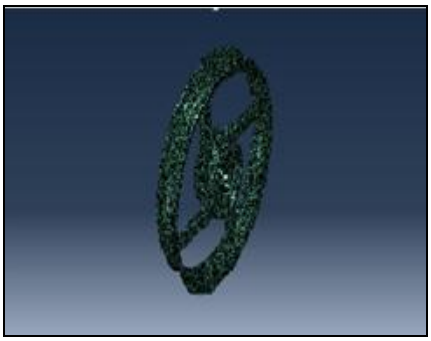

Fig 4: Meshed model of 4 spoke wheel

Type Of Wheel Model	5 Spokes	4 Spokes
Type of mesh	Solid-Tetra mesh	Solid-Tetra mesh
Element size	5 mm	5mm
Total number of nodes	67157	63564
Total number of elements	21245	20239

Table 1.1: FEM details of 5 spokes and 4 spokes alloy wheel

2.1 Loads and Constraints

To ensure the reliability of the analysis in ABAQUS, the total weight of the motorcycle including weight of two persons was applied to the rear wheel alone. Considering, the maximum applicable load is equal to weight of motorbike and weight of two persons. Tyres used in the analysis are of common type with inner tube filled with air pressure and uniformly distributed on the exterior ring surface of wheel.

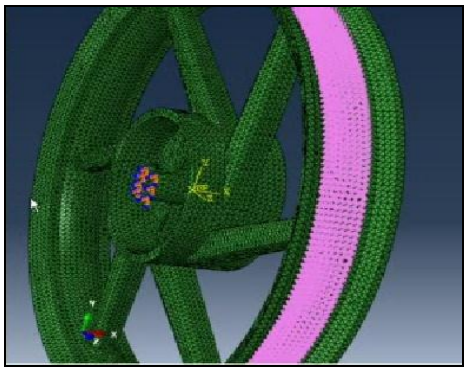

Fig 5: Boundry Condition with Pressure

3. PRESSURE CALCULATIONS AND MATERIAL PROPERTIES FOR THE ANALYSIS

3.1 Pressure Calculations:

Dead Weight of Bike =143 kg (mass of bike)

And consider other Loads = 20 Kg

Considering average weight of one person= 65 kg

The total Weight = 143 + 20 + 65x2 = 293 Kg

The total weight in Newton= 293X 9.81 N=2874.33 N

30% of Loads by Tires and Suspension system reduced

Therefore net weight W_{net} = 2874.33 X 0.7 N = 2012.031N

Hence Reaction Forces On Bike=Nr = 2012.031N

No of wheels=2

Considering total Reaction Force on only one wheel Ft =2012.031N

Area of rim surface: A = 49000.23 mm^2

Pressure on the each Rim =Ft/A= 0.04106 N/mm^2

3.2 Material Used for the Structural Analysis.

The analysis is carried out for three different materials, Aluminum Alloy-201.0-T43a which is presently using to manufacture the alloy wheel of two wheeler, this is compared with stir casted Al-8%Si-3%Al2o3-9%CSA composite material.

S.l No	Parameters	Existing material	New material
		Al Alloy-201.0-T43	Al-8%Si-3%Al2o3-9%Csa
1	Ultimate tensile strength (Mpa)	273	380
2	Yield strength (Mpa)	225	293
3	Young's modulus(Gpa)	71	81
4	Poisson's ratio	0.33	0.34
5	Density (Gm/cc)	2.8	2.56

Table 2: Material properties

4. STATIC ANALYSIS

4.1 Analysis for 5 Spokes Existing Al Alloy Wheel

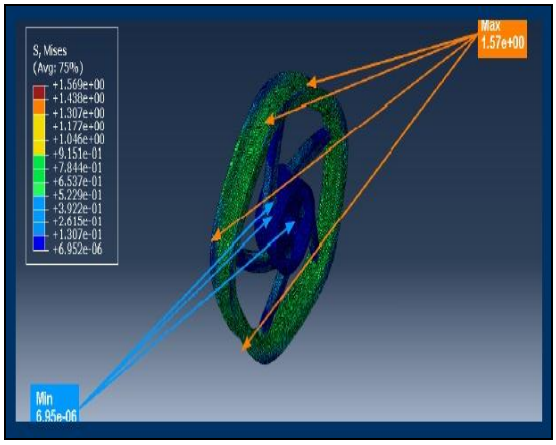

Fig 6: von-Mises stress distribution plot

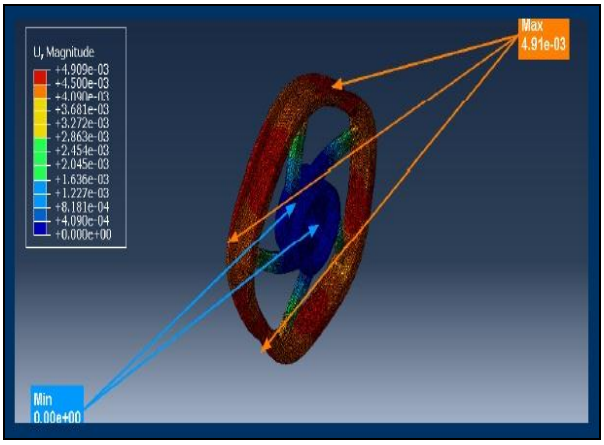

Fig 7: Displacement plot

4.2 Analysis for 5 Spokes New Material Al-8%Si-3%Al2o3-9%Csa Alloy Wheel

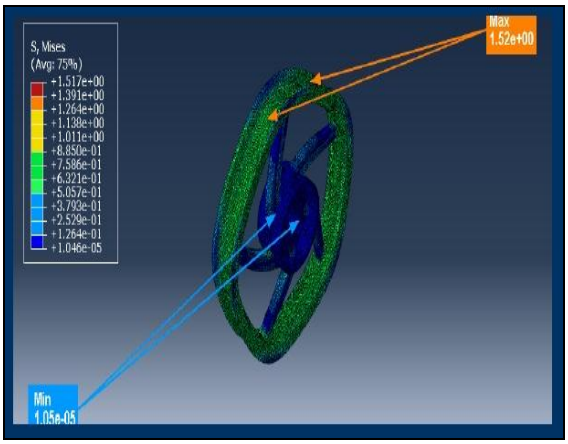

Fig 8: von-Mises stress distribution plot

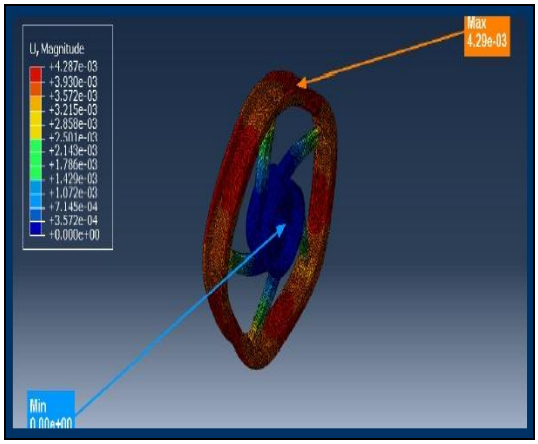

Fig 9: Displacement plot

4.3 Analysis for 4 Spokes Existing Al Alloy Wheel

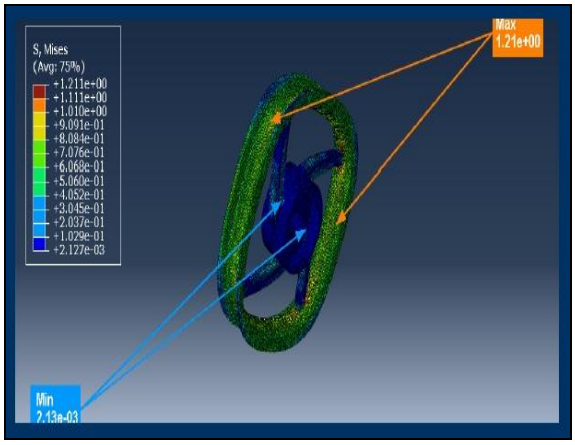

Fig 10: Von-Mises distribution stress plot

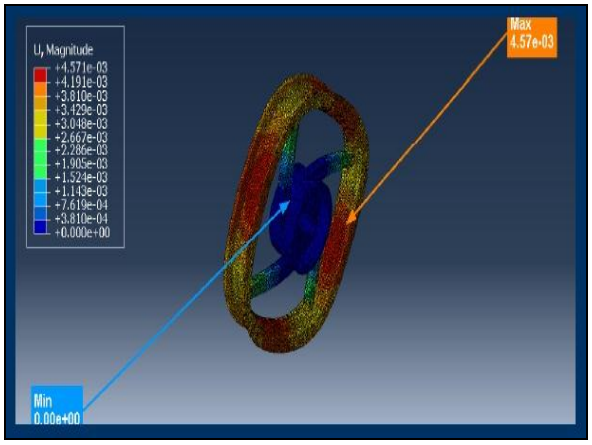

Fig 11: Displacement plot

4.4 Analysis for 4 Spokes New Material Al-8%Si-3%Al2o3-9%Csa Alloy Wheel

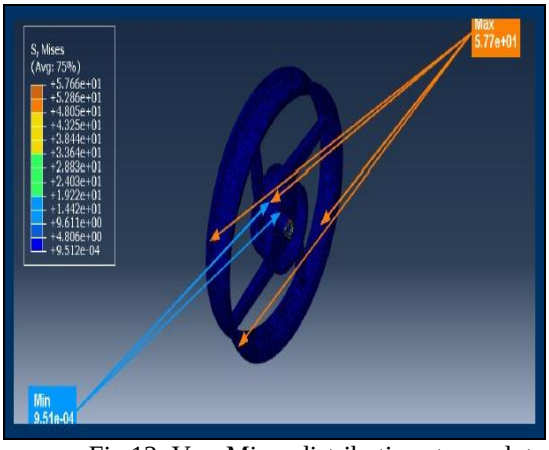

Fig 12: Von-Mises distribution stress plot

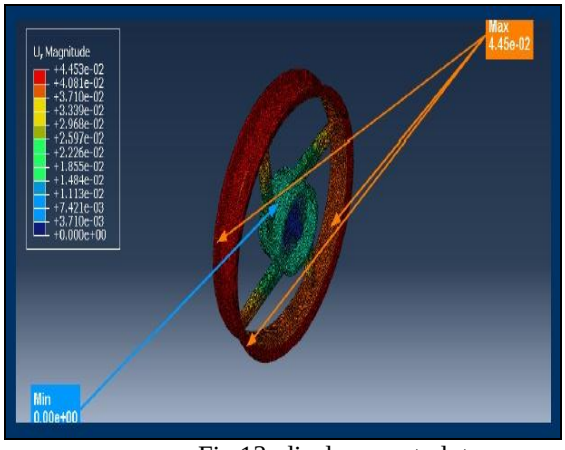

Fig 13: displacement plot.

4.5 Stress Analysis Values for 5 And 4 Spokes Wheels

Sl No	Material used	Load (N)	Pressure on rim (MPa)	Stress (Mpa)	
				5 spoke wheel	4 spoke wheel
1	Al alloy wheel (existing)	2012.031	0.04106	1.569	1.24
2	Composite alloy wheel (Al-8%Si-3%Al2o3-9%Csa)	2012.031	0.04106	1.517	1.195

Table 3: Stress Analysis Values for 5 And 4 Spokes Wheels

4.6 Displacement Values for 5 And 4 Spokes Alloy Wheel

S.l No	Material used	Pressure on rim (Mpa)	Displacement (mm)	
			5 spoke wheel	4 spoke wheel
1	Al alloy wheel (existing)	0.04106	0.004909	0.004571
2	composite alloy wheel (Al-8%Si-3%Al2o3-9%Csa)	0.04106	0.004287	0.003993

Table 4: Displacement Values for 5 And 4 Spokes Alloy Wheel.

4.7 Weight and Stiffness of Wheel

S.l No.	Materials used	Weight (Kg)		Stiffness (Kg/mm)	
		5 spoke wheel	4 spoke wheel	5 spoke wheel	4 spoke wheel
1	Al alloy wheel (existing)	4.42	4.2	900.38	918.38
2	composite alloy wheel (Al-8%Si-3%Al2o3-9%Csa)	4.04	3.84	942.38	962.68

Table 5: Weight and Stiffness of Alloy Wheel

5. CONCLUSION

- Stress induced in wheel rim is lesser in 4 spoke composite alloy wheel.
- The displacement of wheel under pressure also lesser and well safe in composite material wheel than in existing aluminium alloy material.
- The weight of the 4 spoke composite alloy wheel is reduced in considerable amount by comparing with existing material 5 spoke wheels.
- Stiffness of the wheel is comparatively more in optimized 4 spoke composite wheel.

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