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Design and Performance Analysis of Multiple Spokes of Car Alloy Wheels

C Manoj Kumar[1], S C Sireesha[2]
PG Student[1], Assistant professor[2], Department of Mechanical Engineering, Malla Reddy Engineering College[1,2]
Email: c.manojkumar99@gmail.com[1], sireesha_singapati@yahoo.co.in[2]

Abstract- Alloy wheels are made of alloy of aluminium or magnesium metals because there are different from normal steel wheels due to lighter weight, it will improve the vehicle speed and the steering. Alloy wheels has the ability to reduce the weight compared with steel wheels. 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 weight leads to more precise handling and minimizing the fuel consumption. The aim of the project is to take 4 spokes, 5 spokes and 6 spokes of alloy wheels and suggesting a new composite material Aluminium alloy A356,and Magnesium composite alloy AZ91E, Magnesium alloy AM60A to the alloy wheels and performing the ANSYS in the Structure analysis. A model is designed for Alloy wheel used in four -wheeler by collecting data from existing model and reverse engineering process. Alloy wheel models are designed in Catia V5 software, then converted into IGES format and imported into ANSYS Workbench for analysis. Finally, by comparing each spoke and material the best withstanding of spoke and material will be taken.

Index terms- Wheels, CATIA, ANSYS.

1. INTRODUCTION TO WHEELS

1.1 Wheel

A wheel is a circular device it will provides movement on its axis.
[1]. For a wheel to rotate, about its axis a moment needs to applied it can act by the internal or external force or by the gravity. When wheel rotates it will create power to the axle and axle will reduce the friction by rolling motion.
[2]. Thesuspension support is an important tothe vehicle because when vehicle is in motion the static and dynamic loads will act.
[3]. It is generally used for other circular objects such as flywheel and steering wheel. Manufacturability, weight and performance are the major issues related to the design of a new wheel.

1.2 Types of Wheels

- *Steel Wheel*

Earlier steel wheels are more used for wheels and it is first kind of wheels. Steels wheelsis manufactured by comprising many sheets of steel and it is moulded to a well-shaped, afterit is welded together. These are heavy and strongwheels. It has more weight when compare to alloy wheels such as aluminium wheel, magnesium wheel.

- *Rally Wheel*

Rally wheels are also steel wheels but second kind of wheels. It is higher than steel wheelsand used higher strength. The steel wheel at the inner section is welded to the rim with its entire circumference.

- *Alloy Wheel*

Now a days an alloy wheels are more used material for cars, trucks manufacturing. These wheels are made up of combination of alloy of aluminium and magnesium metals.
Advantages of an alloy wheels:
1. It is lighter in weight but same strength.
2. Good heat conductors.
3. It excellent appearance.
4. It can improve vehicle handling and performance.
5. It has good contact in between tire and road.

As the wheels are lighter it will improve the handling and it can reduce the un-sprung mass. This makes the suspension to follow the ground more closely and it provides more grip. It will also reduce fuel consumption when compare to steel wheels. Good heat conduction will have less heat loss at the brakes due to air flow freely and it will improve the braking system in the driving conditions.

1. *Aluminium Alloy Wheels*

Aluminium is a material commonly used for making alloy wheels. It has heat reduction, light weight, corrosion resistance, it will save fuel consummation due to light weight and more ductile and softer. These metals main advantage is to reduce weight, high accuracy and design choice of wheel.

2. Magnesium Alloy Wheel

This material is about 30% light weight than aluminium and Magnesium alloy wheels improved the corrosion resistance and it has improved the forging and casting process. Magnesium alloys possesses attractive properties compared with theAl alloys such as low density, high specific strength and good cast ability.Magnesium alloy material will reduce the oil consumption and usprung mass and it has impact resistance andexcellent for size stability. Mg Alloy Wheel will absorb the vibrations and noise emission

Magnesiumproperties of alloy wheels:

1. It is light weight material
2. it can perform highly
3. it has lower density (1.8 g/cm^3)
4. it can sustain corrosion resistance

2. PROBLEM DEFINITION AND OBJECTIVE

2.1 Problem Definition

In the vehicles now-a-days the most used material is aluminium alloy wheelsbecause it results excellent thermal conductivity. It has drawbacks is corrosion resistance, it will increase the fuel consumption and the usprung mass. By using magnesium alloy, the wheel weight can be reduced compared to aluminium alloy wheel and fuel consumption can be reduced.

2.2 Objective

- New composite material (Magnesium alloy AZ91E, Magnesium alloy AM60A, Aluminumalloy A356) as an alloy wheel material
- Comparing of 4 spokes, 5 spokes and 6 spokes of alloy wheels.

3. LITERATURE SURVEY

[1] M.K. Surappa (2003), Aluminium matrix composites: Challenges and Opportunities. The study Aluminium matrix composites materials systems processing, microstructures, properties, advantages and disadvantages and limitations and applications. Further usages of materials concluded.

[2] S Vikranth Deepak (2012), Modelling and analysis of alloy wheel for four-wheeler vehicle. In this project a parametric model of Aluminium Alloy used in four -wheeler is designed. Design is evaluated by analysing the model and Aluminium alloy are comparing with another Alloy.

[3] Sourav Das (2014), Design and weight optimization of aluminium alloy wheel. In this paper it will provided the design of aluminium alloy wheels in the automobile application. It has provided aluminium alloys; magnesium alloys are light weight and heat conductor. Ductility of magnesium alloys are very low compared to the aluminium alloys.

[4] RujulaDalu (2015), Aluminium alloys in Automotive the objective of this paper is to study material properties required for automotive, different materials used and their properties, most effective material for automotive and welding processes for joining it. From this paper it is observed that Al alloys is the most preferred new light weight material.

[5] Sasank Shekhar Panda, Jagdeep Gurung, Saichandan Sahoo (2016), Modelling and fatigue analysis of Automotive wheel rim. The objective was to reduce the weight of the disc wheel rim has been achieved. compered the stresses and strains during static and dynamic conditions in case of Aluminium and Magnesium alloy and found that in case of Aluminium alloy the stresses are acting less and also having higher FOS in the model design.

4. MODELLING OF ALLOY

CATIA (Computer Aided Tridimensional Interactive Application) is to create an innovative and inspiring smart way to design. CATIA is the founder of the Dassault Systems programming suite.

Table 1: Specifications of alloy wheel

Wheel Specifications	
Rim Diameter	14"
Rim width	5.5"
Offset	43mm
PCD	4×100
Centre Bore	54.1mm

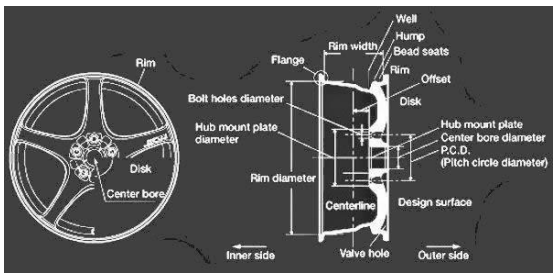


Fig.1: Wheel specifications

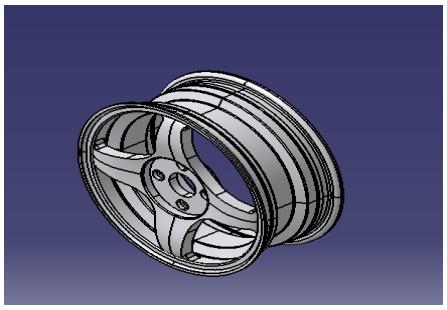


Fig 2: 4Spokesmodel of car wheel:

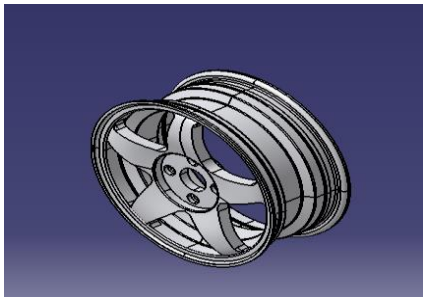


Fig 3: 5Spokesmodel of car wheel:

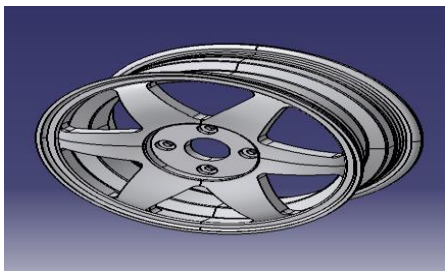


Fig 4: 6Spokesmodel of car wheel

5. ANALYSIS OF ALLOY WHEEL

The spokes are converted into IGES format and imported into the ANSYS 16 and it is analyzed by static structural analysis. In the step by step process

1. In the ANSYS workbench, select the static structural.
2. Assign the materials in the engineering data.
3. Import the spokes in the geometry, create for mesh in the model and apply the boundary conditions.
4. In the solution select the total deformation, equivalent elastic strain, equivalent strain, strain energy.
5. Solve the solutions for theabove reaction and obtain the results.

5.1. Materialcompositions and properties:

In the engineering data this material is assigned.

- *Aluminium alloy A356*

In this A356 alloys, aluminium (Al) is the major component of metal. It has alloying elements are copper, magnesium, manganese, silicon and zinc. A356 alloys are more used in aircraft and automobile due to their high strength-to-weight ratio. Its specific rigidity and tensile strength are more than the other aluminium alloys. It will provide less weight aircraft and better fuel economy. A356 alloys are based on the development of hardness, ductility, strength, elongation and toughness. A356 alloys are used in the engineering components and structures where light weight and corrosion resistance needed.

Chemical Composition of Aluminium alloy A356*:*

Aluminium alloy A356.0 consists of 7% Si, 0.3% Mg alloy with 0.2%Fe (max) and 0.10% Zn (max).

Table 2: Material properties

Property	Value
Yield strength	195 N/mm^2
Elastic modulus	72000 N/mm^2
Mass density	2.7gm/CC
Poisson's ratio	0.33

- *Magnesium Composite alloy AZ91E*

Magnesium has good strength, lowdensity. It is a recyclable process with reducing CO2 emissions. But pure magnesium is not used more because of poor properties and highly reactivate. The addition of zinc and aluminium to magnesium will overcome its drawback. AZ91Ehas good casting and with wide range materials properties at room temperature.

Chemical Composition of Magnesium Composite:

Base metal- Al 9%, ZN 1% and remaining is Mg.

Table 3: Material properties

Property	Value
Yield strength	146N/mm2
Elastic modulus	49913N/mm2
Mass density	1.85gm/CC
Poisson's ratio	0.35

5.2. Mesh model:

After importing in the geometry, create for mesh

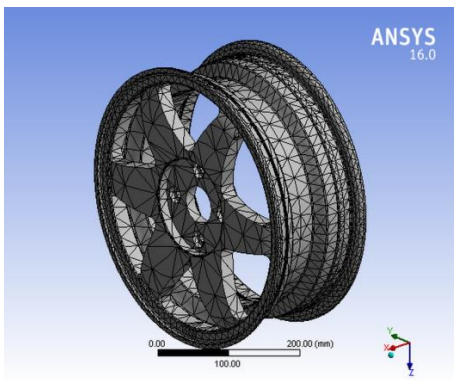


Fig 5: Meshed model

Fig 5 shows the meshed model on each element.

5.3. Loading & boundary conditions for static Analysis:

In this boundary conditions and loads are applied

- Fixed Supports: The pitch circle holes are constrained.
- Pressure:0.207 N/mm2 is applied on the outer surface of wheel
- Force Load:4500N is applied throughout the inner surface of wheel

Maximum weight of car is 1462kg to 1825kg
Consider in this Mass = 1825 kg
We have F = M * A (A=9.81 N / KG)
F = 1825 * 9.81
F =17908 N
Total Force of 4 wheels in a car is
17908 N
For 1 wheel in a car is 17908/4
= 4500N

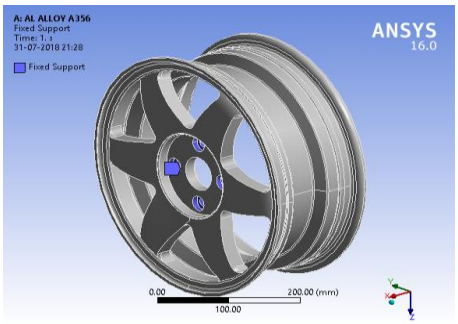


Fig 6: Fixed supports

In the above fig 6 it shows the fixed supports.

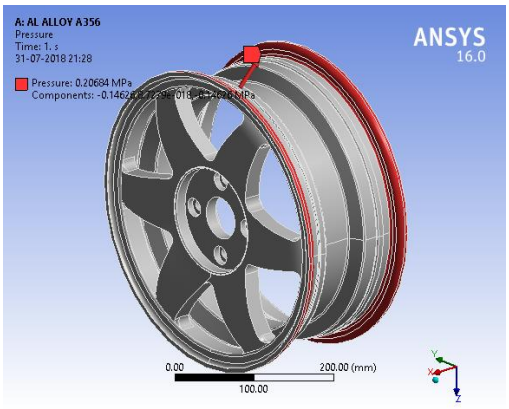


Fig 7: Pressure

In the above fig 7 it shows the pressure.

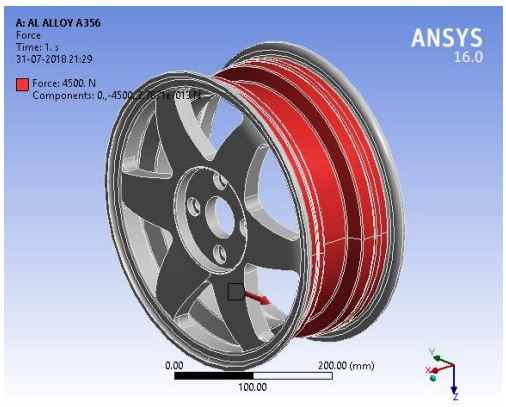
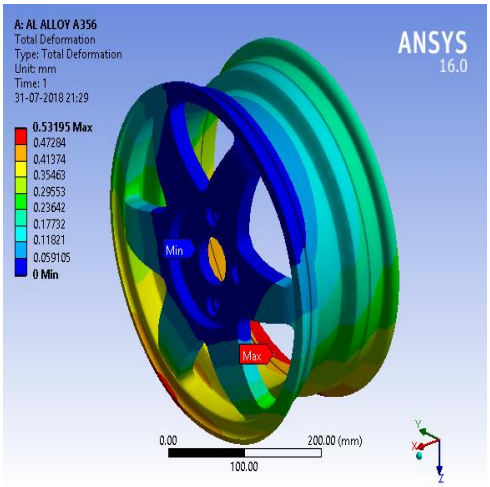
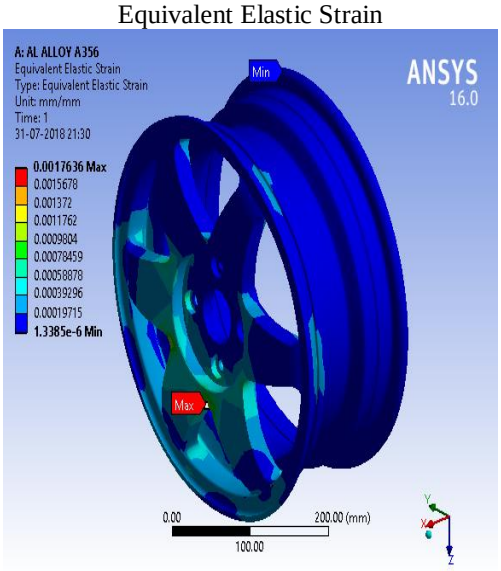
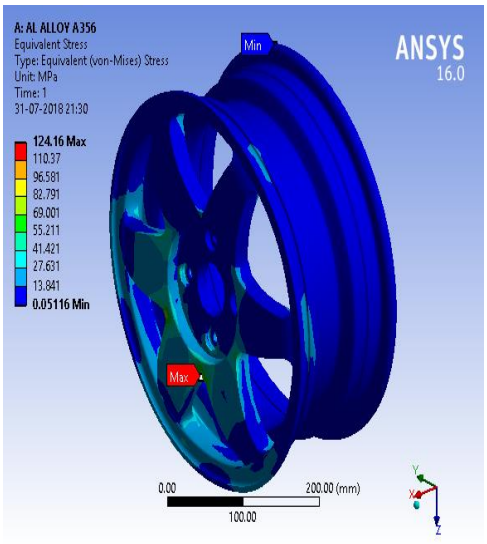


Fig 8: Force load

In the above fig 8 it shows the force load

5.4.Results for Structure Analysis:

Table4Results of Al Alloy A356

	6 Spokes Of Aluminium Alloy A356
1	Total Deformation  Max:0.53195mm, Min:0 mm
2	Equivalent Elastic Strain  Max:0.0017636mm/mm Min:1.3385e-6mm/mm
3	EquivalentStress  Max:124.16MPa Min:0.05116MPa

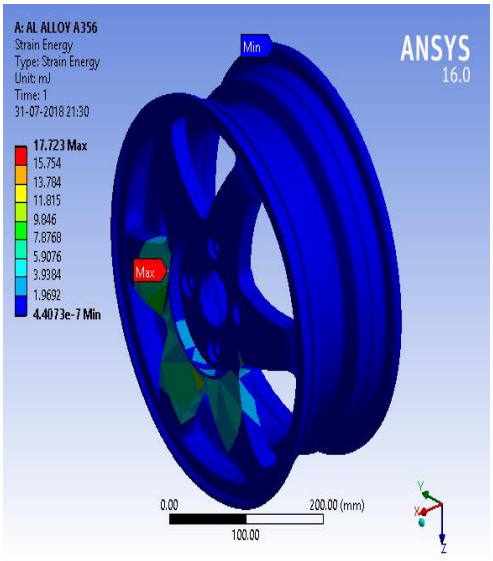
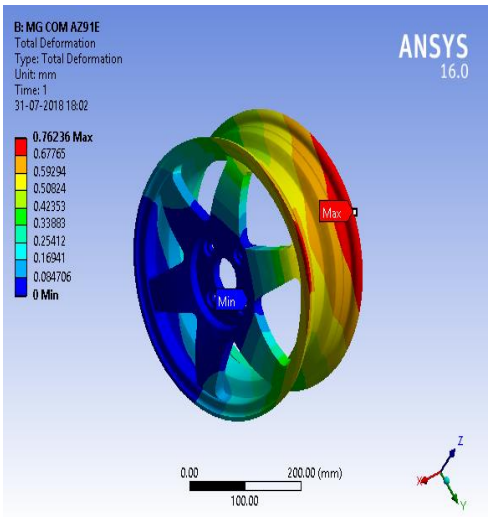
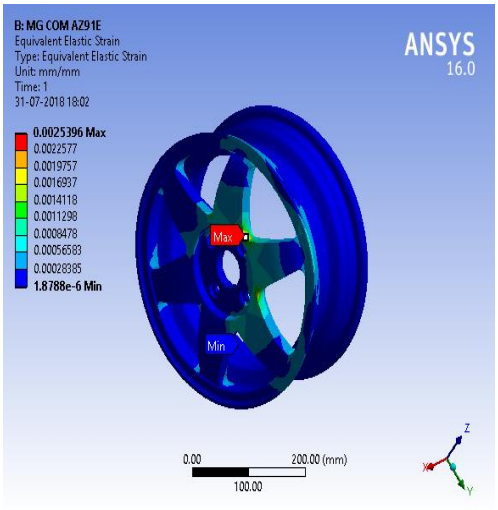
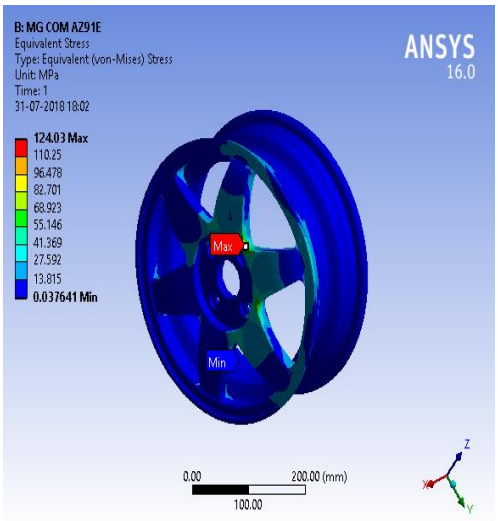
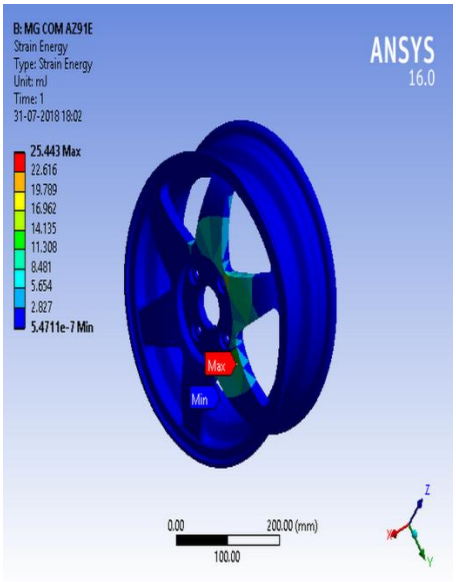
4	Strain Energy  Max:17.732ml Min:4.4073e-7ml

Table5 Results of Mg composite ALLOY AZ91E

	6 Spokes ofMagnesiumComposite Alloy AZ91E
1	Total Deformation  Max:0.76236mm Min:0mm

2	Equivalent Elastic Strain  Max:0.0025396mm/mm Min:1.8788e-6mm/mm
3	EquivalentStress  Max:124.03MP Min:0.037641MP

4	Strain Energy  Max:25.443ml Min:5.4711e-7ml

From the above two solutions the analysis results are displacement, equivalent elastic strain, equivalentstress, strain energy. In the above two tables the total deformation is show in the tables box 1, it is maximum at the rim flanges and minimum at the hub area due to the bolts are fixed. The equivalent elastic strain is show in the above tables in the box2, it is maximum at the middle and minimum at the spokes. The equivalent stress (von misses) is shown in the tables in the box3, it is maximum at the middle and minimum at the spokes. The strain energy is show in the tables in the box4, the maximum and minimum act at the spokes.

6. RESULTS ANDDISCUSSIONS

From the static analysis of 6 Spokes for the material AL alloy A356 the minimum deformation is 0mm and maximum deformation is 0.53195mm and the equivalent elastic strainis minimum is1.3385e-6mm/mm and maximum are 0.0017636mm/mm and the equivalent stress maximum and minimum values are 124.16MPa and 0.05116MPa and strain energy maximum and minimum values are 17.732ml and 4.4073e-7ml.

For the 6 Spokes of Magnesiumcomposite alloy AZ91E material, for total deformation maximum is 0.76236mm and minimum is 0mm, for equivalent elastic strain maximum is 0.0025396mm/mm and minimum are 1.8788e-6mm/mm, for the equivalent stress maximum is 124.03MPa and minimum is 0.037641MPa, for strain energy maximum is 25.443ml and minimum is 5.4711e-7ml

7. CONCLUSION

By comparing each material and each spokes the stress and strain and deformation obtained in the static analysis of alloy wheel best in the Magnesiumcomposite alloy AZ91E material for the 6 spokes where within the yield strength so the material and design of alloy wheel is safe and load distribution is more at the spoke's intersection.

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