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COMPARATIVE ANALYSIS OF AL AND MG ALLOY WHEEL RIM

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Abstract— **In any vehicle, wheel rim is a part which has to bear a continuous high stress. Conventionally used steel rim may subject to torsional and bending loads. A wheel rim should be able to withstand high amount of stress and should have less weight. These factors of cost, weight and performance are the main focus points of the manufacturers now days. There is a continuous searching among the manufacturers for component with lighter weight and higher performance. The lighter weight of the rim and wheels enables better handling, grip and reduce the overall mass of the vehicle which further reduced the fuel consumption. Conventionally steel is being used as a wheel rim material. From an implementation point of view any other alloy material can be used.**

Magnesium has many problems to use, it is vulnerable to pitting, deterioration, cracking and it is also flammable, hence would start to break down in just a few months. Magnesium is used for flares and early flash lamps. Magnesium in bulk is hard to ignite but, once lit, is very hard to extinguish, being able to burn under water or in carbon dioxide, which are common extinguishing materials. Tires that caught fire could soon ignite the magnesium, creating difficulties for fire responders. Magnesium wheels required constant maintenance to keep polished. Apart from these issue Mg cost is much higher than any other alloy wheel material.

In this project, structural analysis of wheel rim with 3 different alloys of Al and one Mg alloy is done. This work mainly focus on implementing a new alloy material for wheel that can bear the same stress value as well as have less cost than other. As a conclusion of the analysis an Al- Si MD20 alloy material is suggested that has less cost than Mg alloy wheel also has suitable properties as an alloy wheel material.

Keywords-wheel rim; pitting; magnesium alloy wheel, Al-Si MD20

I. INTRODUCTION

In this project, author has concluded a comparative analysis of wheel rim by using different alloy materials. Alloy wheels are the automotive wheels that are manufactured by Al or Mg metals or by the combination of both. Properties of alloy wheels are different from normal steel wheels. They have less weight as compared to steel wheels which results in easy handling and reduces the overall weight of the vehicle resulting in lesser fuel consumption. Alloy wheels also have better heat conductivity which allows the fast heat dissipation at the time braking. This comparative study deals with the searching of new cheaper alloy material that can use as an alternative for high cost Mg alloy wheel and can overcome other limitations of pitting, deterioration, cracking and other issues that occurs in Mg based alloy.

Selection of a suitable material for wheel rim is a work of utmost importance because design of rim plays an important role in the performance of the vehicle. During 1960s magnesium was the choice of manufacture as a wheel rim material for racing cars. The magnesium based wheels are similar to the other die-cast wheels.

II. WHEEL RIM

The rim of a wheel is that circular portion of the metal on which the inside edge of the tire is mounted. Main function of the rim is to support and seal the tire to the wheel. It ensures the proper fitting between tire and rim and retains air inside the tubeless tire. A standard steel wheel is manufactured by a rectangular metal sheet. The metal sheet is folded in cylindrical shape with two edges of the sleeve welded together at the end. To obtain a given thickness profile of the sleeve at least one cylindrical flow spinning operation is carried out. To support the cylindrical rim structure disc is manufactured by stamping a metal plate. Appropriate holes for the center hub and lugs are provided in to the disc.

Type of Wheel Rim

Mainly steel and some light alloys are used for normal wheels but some composite materials including glass-fiber are being used for special wheels as mentioned below:

- Wire Spoke wheel
- Steel Disc wheel
- Light Alloy wheel- These are further classified as

1. Aluminum Alloy wheel
2. Magnesium Alloy wheel

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3. Titanium Alloy wheel
4. Composite Material wheel

III. COMPARATIVE ANALYSIS OF ALLOY WHEEL USING DIFFERENT ALLOYS OF AL AND MG

Fuel consumption of a vehicle can be reduced by decreasing the overall weight of the vehicle. By the most appropriate selection of material, weight of the vehicle can be reduced. In this approach aluminum, magnesium and their alloys are the main choices of the manufacturer for automotive vehicle wheel. In this project work a model of a wheel is prepared and analysis in different cases of alloy materials is carried out. For the load application the curb weight of Maruti Suzuki Swift car along with the weight of four passengers is considered. The prepared model is then uploaded in to the ANSYS software where analysis is carried out. The materials which are used in the analysis are alloys of Al and Mg metals. The weight of the wheel, stress and deformation in each case are the main points which are considered in the analysis. Finally, complete content and organizational editing before formatting.

Steps of Working Method

We have considered a model of Maruti Suzuki Swift Car for alloy wheel testing. The further calculations related to the test are as follows:-
Gross weight of the vehicle; 865+4×60 = 1105 Kg
Where, 865= kerb weight of the Maruti Suzuki vehicle;
4= no. of passengers in car,
60= weight of each person
Load on each wheel = $\frac{1105}{4} = 276.25Kg = 276.25 \times 9.81 = 2710.012N$

Pressure Load = $\frac{Load}{Surface\ area} = \frac{2710.012}{0.06325} = 42846.047\ N/m^2$
Where surface area of the rim designed= 0.06325 m^2
Consider 35 psi of air pressure load acting on the outer surface of the wheel.

Finale working pressure= 42846.047+0.241= 42846.288 N/m^2
P= 0.0428 Mpa

A. *Properties of the Material used*

Here in this study the test is carried out with three different materials. Various properties of the materials are mentioned below.

Properties	Al 6061-T6	AZ91 Mg Alloy	AL356.2	Al-Si MD20
Density(gm/cm^3)	2.7	1.8	2.685	2.53
Young Modulus(Mpa)	71000	49913	69000	84000
Poisson's ratio	0.33	0.35	0.33	0.33
Yield Strength(Mpa)	275.00	146	250	390

Table: 1 Properties of the material used

B. *Model of wheel rim*

For this project a car rim is designed using the CATIA V5R20 designing software.

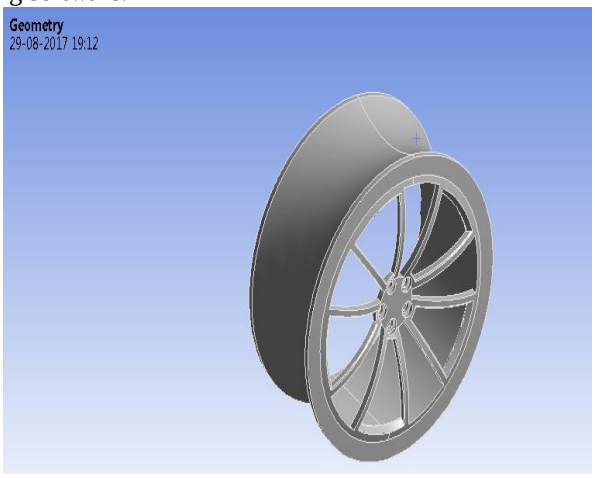

Fig 1: Model of wheel rim

The study was carried out using ANSYS FLUENT tool. The steps for the analysis are shown below

- Import the STEP file of the car rim in the ANSYS FLUENT module.
- After importing the file meshing of the geometry was done. Meshing is the process of breaking the model into number of nodes and elements.

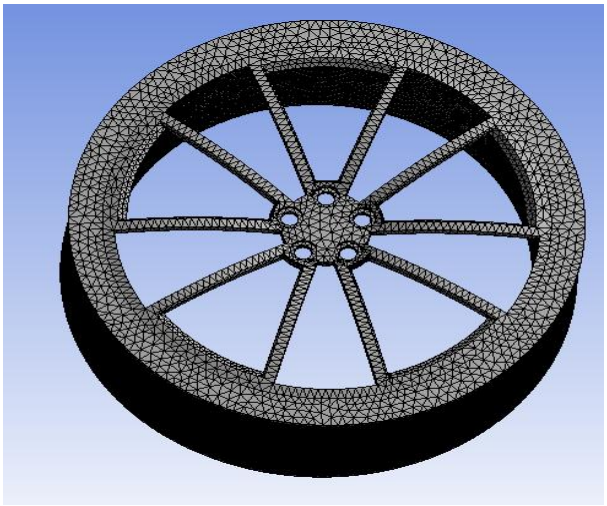

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Fig 2 : Meshing of Rim model

IV. RESULT

The results of the simulation were obtained after applying the load of 0.0428Mpa on the surface of wheel rim. The results are shown below:

A. *Equivalent Von-misses stress*

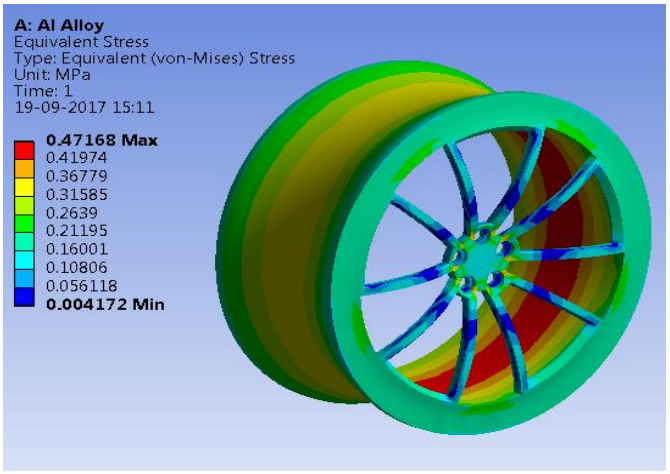

Fig 3: Equivalent von-misses stress for Al alloy AL6061-T6

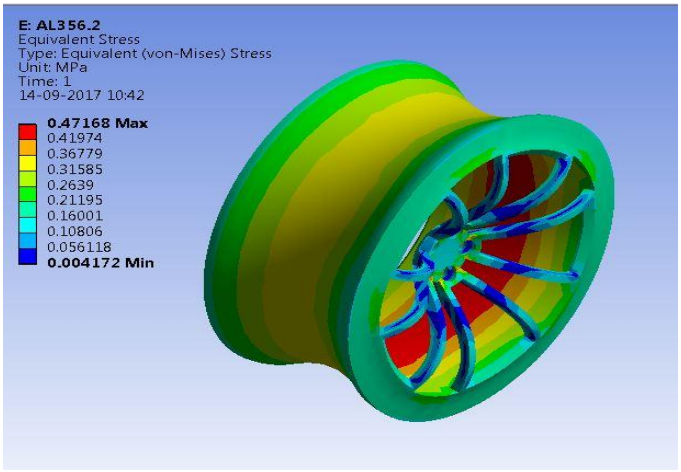

Fig 4: Equivalent von-misses stress for Al356.2

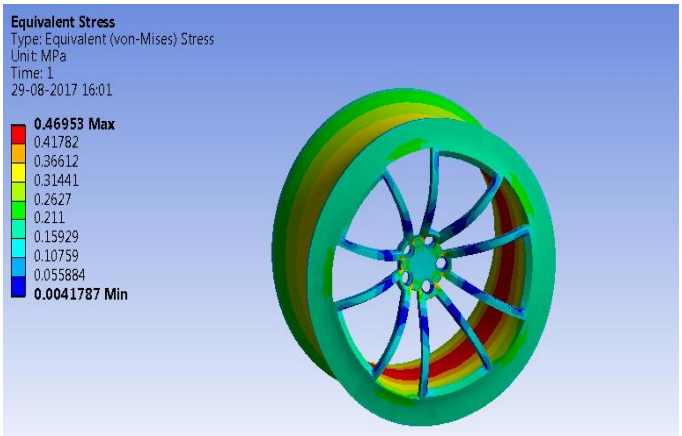

Fig 5: Equivalent von-misses stress for Mg alloy AZ91

Fig 6: Equivalent von-misses stress for Aluminum-Silicon alloy Al-MD20

B. *Total Deformation*

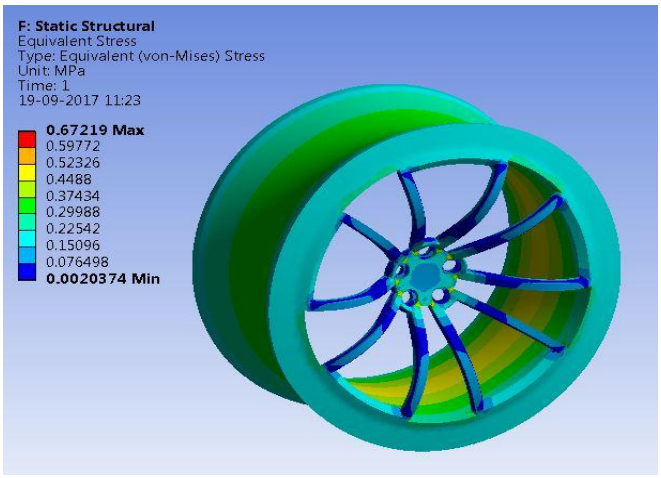

Fig 7: Total Deformation in Al alloy AL6061-T6

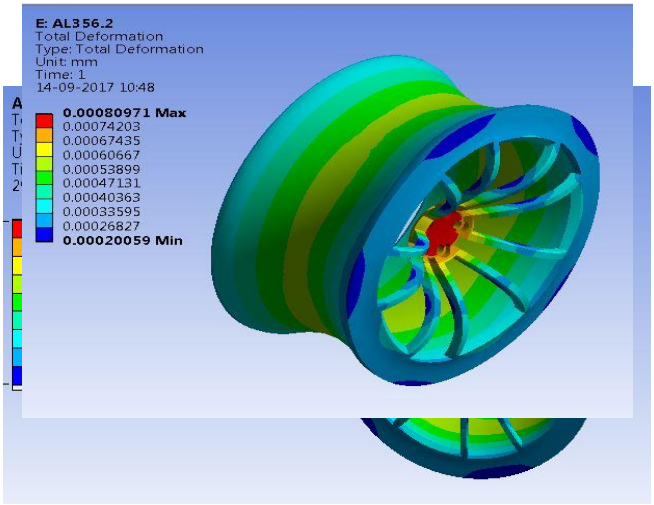

Fig 8: Total Deformation in Al alloy AL356.2

Fig9: Total Deformation in Mg alloy AZ91

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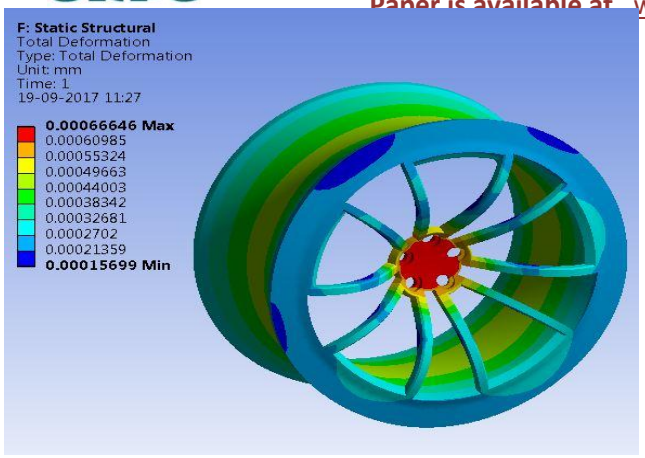

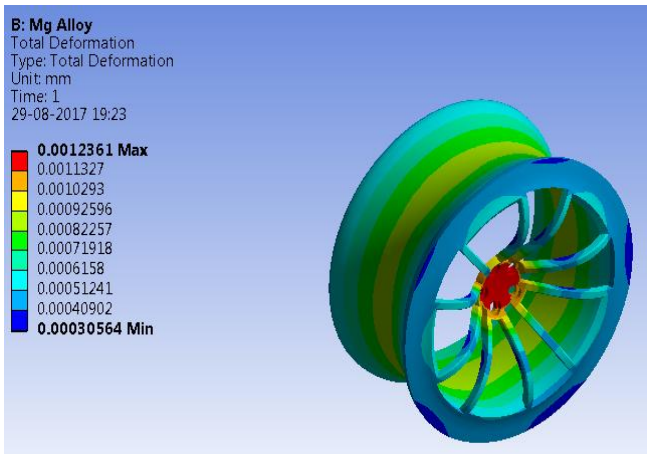

Fig10: Total Deformation in Aluminum-Silicon alloy Al-MD20

Material name	Weight of wheel(kg)	Total Deformation(mm)	Equivalent Von-misses stress(Mpa)
AL6061-T6	2.57	0.00078	0.4716
AL356.2	2.494	0.00080	0.4716
AZ91(Mg Alloy)	1.672	0.0012	0.469
Al-MD20	2.35	0.00066	0.672

Table 2: Values of weight, total deformation and stress obtained with different materials

V. CONCLUSION

Objective of searching an alternative material for high cost Mg alloy wheel has been achieved in the project. Among all available Al alloy material Al-Si MD20 alloy material has the lowest density and then results in decreasing the weight of the wheel. This implementation of Al-Si alloy fulfills two aspects. First it replaces the use of high cost Mg alloy wheel and also overcome all the drawback of pitting, cracking and burning that a normal Mg alloy wheel possesses. Secondary this new Al-Si alloy material also helps in reducing the weight of the wheel that will lead to the less fuel consumption and will further improve the overall performance of the vehicle. Along with this feature this new implemented material will gives better strength and less deformation values as compared to other materials. On the basis of these results it can be concluded that the proper designing of wheel using newly developed Al-Si MD20 material can improve the performance and can also decrease the weight of the vehicle which will further result in reducing the fuel consumption.

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