# Mass Optimization of Automobile Wheel Rim

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***Abstract:*** *Automotive organizations are paying their major interest in the weight reduction of components to minimize fuel cost. This weight can be reduced by introducing new materials and manufacturing processes with optimization of design. Minimizing the weight in the wheel is more effective than minimizing the weight in other components because of its rotational moment of inertia effect during its motion and also the tyre take the overall vehicle load and provides cushioning effect. By reducing the weight we can achieve the objective the reducing of unsprung mass, by which the inertia loads and overall weight are reduced with improvement of performance and fuel economy. In this paper an attempt is made to minimize the weight of the wheel by replacing the aluminium alloy with composites. From the finite element calculations it is found that the mass of the wheel rim can be reduced to 50% from the existing alloy wheels. The analysis also shows that after the optimization the stresses generated from the wheel rim will be below the yield stress. This gave a new approach in the field of optimization of passenger car wheel rim. In this work the modelling is done by using CATIA V5 R20 and analysis is made by using ANSYS15.0.*

**Keywords***: Optimization, Finite element method, Unsprung..*

## I. INTRODUCTION

Wheels have a vital importance for the safety of the vehicle and special care is needed in order to ensure their stability. The advancement of the wheel has strongly influenced the design, material selection and the manufacturing process. They are loaded in a complex manner and further improvement in the wheel design will be possible only if their loading will be better implicit. In order to achieve an optimum design of the wheel, the accurate knowledge of the loading, the mechanical properties and allowable stresses of the material is required. The wheel along the tire plays an important role in passengers comfort. To reduce this mass the materials are changed from the existing materials without compromising the strength of the wheel. By using the lighter wheels the handling can be improved because of the reduced unsprung mass and allowing the suspension to follow closely along the path and thus improving the grip.

The use of light weight materials for body and wheels in an area of automobiles will significantly improve the fuel economy and gas emission. Alternative materials such as alloys of aluminium and magnesium, polymer matrix composites (PMCs) instead of steel are considered for design and analysis.

## II. DESIGN OF WHEEL RIM BY USING CATIA

### WHEEL RIM NOMENCLATURE

Rim Designation:

For every rims there will designations on them to identify easily.

6 ½-JJ-15 50 5 96.0

This means

- 6 ½ - Rim Width (inch)
- JJ - Flange Shape
- 15 - Rim Diameter(inch)
- 50 - Offset(mm)
- 5 - number of holes
- 96.0 - Pitch Circle Diameter(mm)

Parameters for modelling wheel rim:

| S.no | **Parameters Taken For Modelling** | |
|---|---|---|
| 1 | Rim Nomenclature | 7 -JJ-14 50 5 96.0 |
| 2 | Flange Shape | JJ |
| 3 | Rim Diameter | 14 inch |
| 4 | Rim Width | 7 inch |
| 5 | Offset | 70mm |
| 6 | Pitch Circle Diameter | 98mm |
| 7 | Hub Diameter | 48mm |
| 8 | Number Of Bolt Holes | 5 nos. |
| 9 | Number Of Spokes | 5 nos. |

By using modelling software wheel rim is designed by taking dimensions as per the standard dimensions.

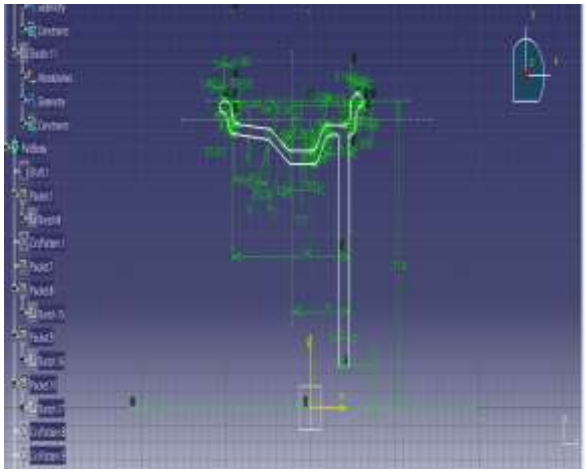

Fig. 1 Modelling of Wheel Rim with J Contour

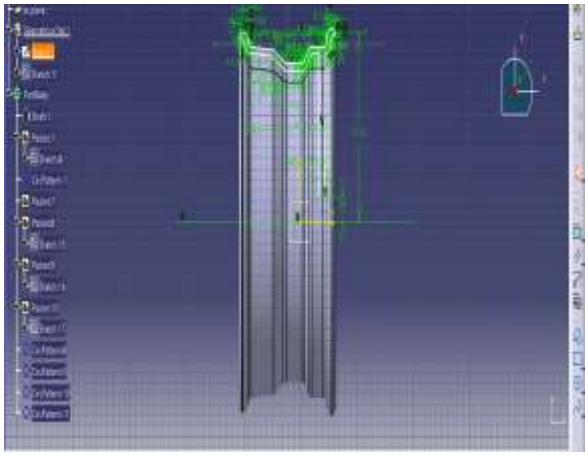

Fig. 2 Front View of Wheel Rim

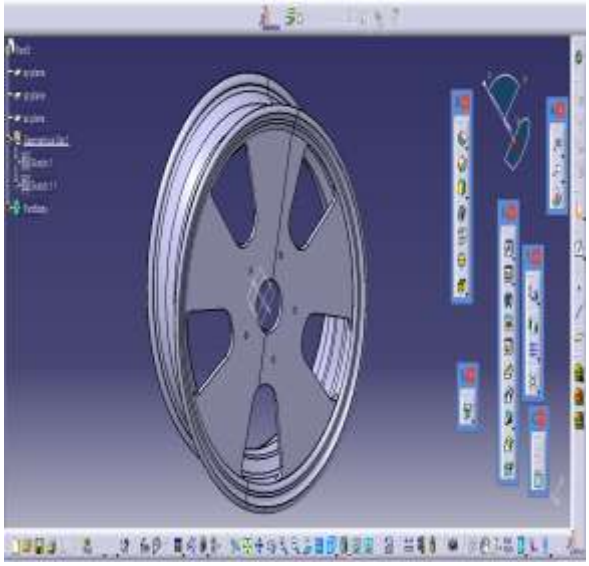

Fig. 3 Front View of Wheel Rim

## III. ANALYSIS OF WHEEL RIM BY ANSYS

### A. *Material Properties:*

Wheels are based on the use of light metals, such as aluminum and magnesium has come to be popular in the market. The advantages of each light alloy wheel are:

- Aluminum alloy is a metal with features of excellent lightness, thermal conductivity, physical characteristics of casting, low heat, machine processing and reutilizing, etc. This metal main advantage is decreased weight, high precision and design choices of the wheel.
- Magnesium alloy is about 30% lighter than aluminum and also admirable as for size stability and impact resistance. However its use is mainly restricted to racing, which needs the features of weightlessness and high strength. It is expansive when compared with aluminum.
- Titanium is an admirable metal for corrosion resistance and strength about 2.5 times compared with aluminum, but it is inferior due to machine processing, designing and more cost. It is still in developed stage.
- Composite material wheel is different from the light alloy wheel, and it is developed mainly for low weight. However this wheel has inadequate consistency against heat and for best strength. For analysis in this paper polyether ether ketone is taken as polymer matrix composite and reinforced with 30% carbon.

### B. *Analysis:*

Auto mesh is done in ANSYS workbench to solve the differential equations which are a combination of structured and unstructured mesh. The imported file geometry undergoes meshing after which boundary conditions are applied to the physical domain.

The edge length is taken as 0.00075813m and the transition ratio is about 0.272 for meshing. Wheel rim is considered as it is in static condition and the boundary conditions like loads and pressures are applied. Approximately 5200N load is applied on wheel rim. As the problem is taken in statics, the entire load on the wheel rim will be distributed throughout the rim because of the air.


Figure 4 Meshing of Wheel Rim

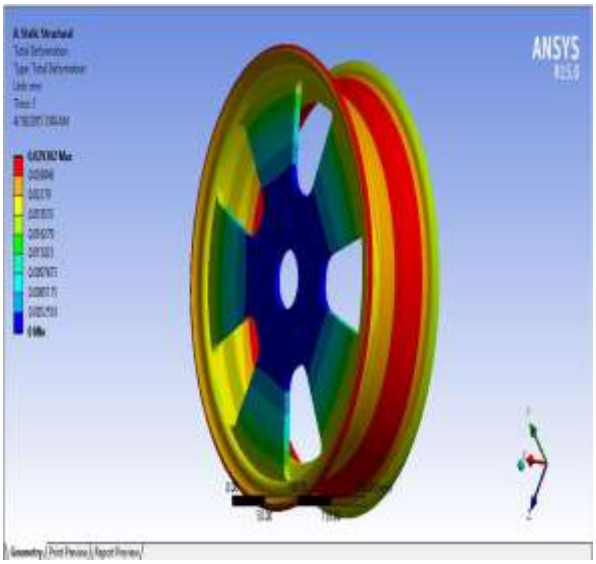


Figure 6 Deformations on Aluminum Alloy Wheel Rim

The air is a medium which circulates the entire force acting on the rim. The air pressure on the wheel rim is taken circumferentially with a pressure of 0.25bar.

**Results for aluminium alloy**

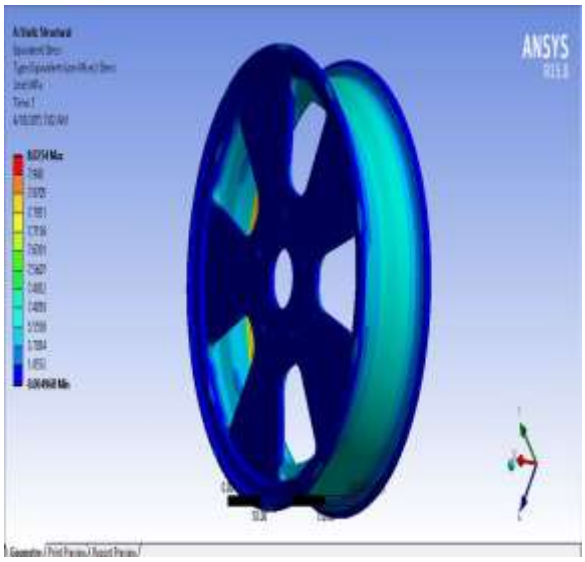


Figure 5 Von-Mises Stress on Aluminum Alloy Wheel Rim

**Results for magnesium alloy**

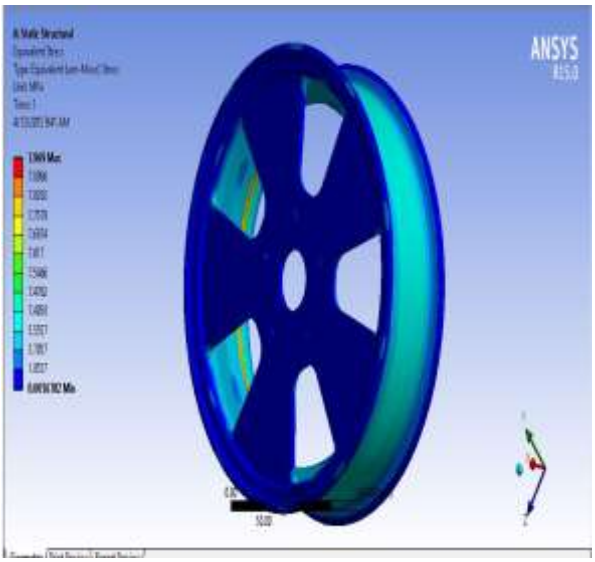


Figure 7 Von-Mises Stress on Magnesium Alloy Wheel Rim

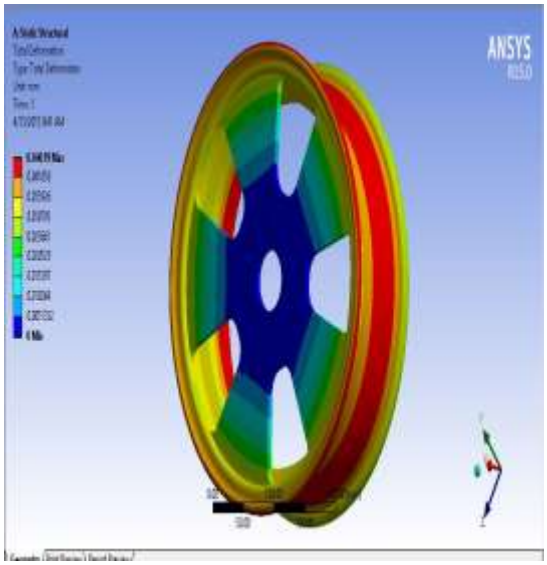


Figure 8 Deformations on Magnesium Alloy Wheel Rim

**Results for titanium alloy**

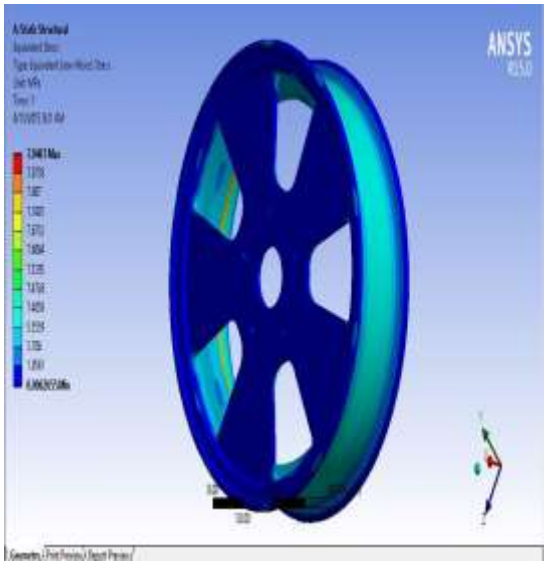


Figure 9 Von-Mises Stress on Titanium Alloy Wheel Rim

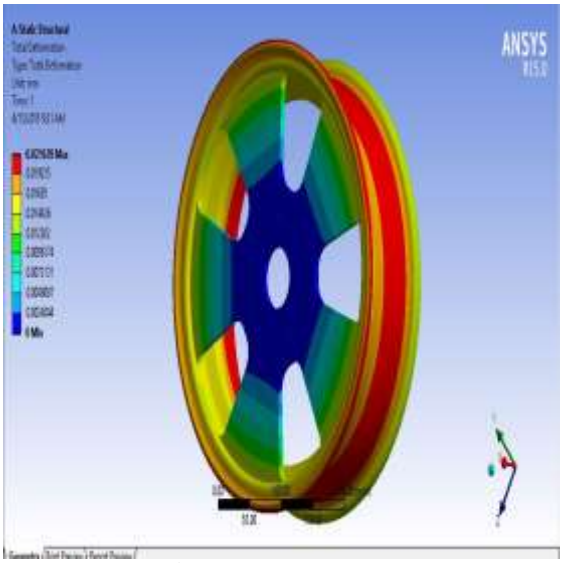


Figure 10 Deformations on Titanium Alloy Wheel Rim

**Results for polyetheretherketone with 30%carbon reinforced**

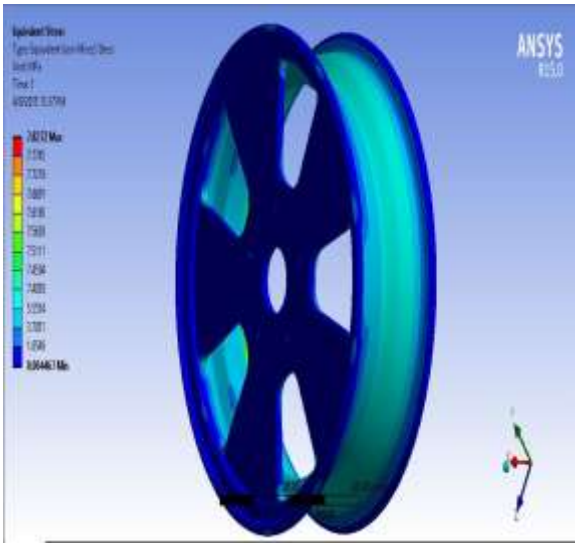


Figure 11 Von-Mises stress on PEEK with 30% of Carbon Reinforced

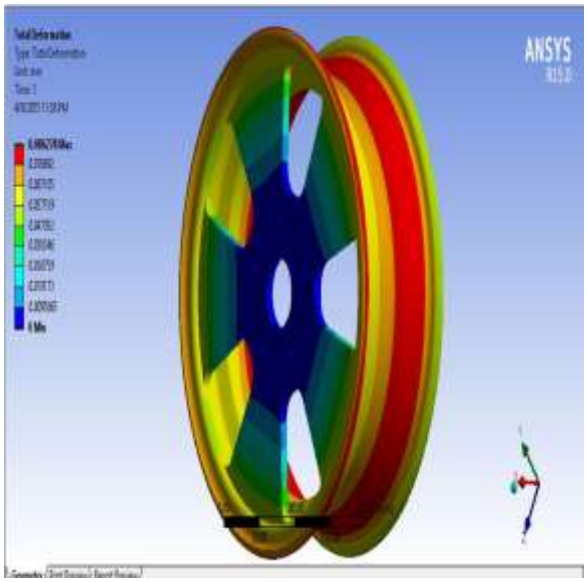


Figure 12 Deformation on PEEK with 30% of Carbon Reinforced

**TABLE II**

**STRESS AND DEFORMATION OF MATERIALS**

| s.no | Materials | Vonmises (MPa) | Deformation (mm) | Weight (KG) |
|---|---|---|---|---|
| 1 | Aluminum alloy | 8.0254 | 0.029302 | 5.308 |
| 2 | Magnesium alloy | 7.969 | 0.04619 | 3.449 |
| 3 | Titanium alloy | 7.9407 | 0.021639 | 8.853 |
| 4 | Peek with 30% carbon reinforced | 7.8272 | 0.086278 | 2.74 |

## IV. RESULTS AND DISCUSSIONS

The stresses in the wheel rim are maximum at bolt holes and it is less than the yield stress. As observed from the figures, stresses in titanium and magnesium alloys are minimum when compared to the aluminium alloy. The usage of magnesium alloy is very dangerous when it is in the form of dust or powder because of its low density and also there is a high risk for fire. By replacing the materials on the wheel rim the stress is minimum at PEEK with 30% carbon reinforced. By considering weight it is concluded that PEEK with 30% carbon reinforced is best material form wheel rim.

## V. CONCLUSIONS

The scope of the present investigation is concerned for the development of wheel rim by performing mass optimization. By changing the materials with Polymer Matrix Composite and taking the stress and weight into account PEEK with 30% carbon reinforced is suggested as best material to replace the aluminium alloy. By using this material the mass optimization is achieved.

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