

Deformation Analysis of Automotive Wheel Rim by scrutinizing Equivalent Stress for Different Materials

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Abstract - The main objective of the wheel rim is to provide a stable base to fit the tire. Its physical parameters such as dimensions, shape and size should adequately fit the tire required for a particular vehicle. Design plays a major role influencing the quality of the product. In this project the wheel rim is designed using a 3D modeling software called CATIA v5. The purpose of modeling is to reduce the time taken and risk factor involved in producing complex 3D models. Later the part design of wheel rim is imported to an analysis software called ANSYS. ANSYS is generally used to simulate various physical parameters like forces, pressure acting on the given components. It is also used in calculation of stresses, deflections and other parameters without human intervention. Thereby reducing the time spent on mathematical calculations by humans.

In ANSYS, we are particularly performing static analysis on wheel rim by considering four different materials namely Aluminium alloy 6061, Magnesium alloy, Steel 1008 and Carbon Fibre. Their relative performances have been studied and observed. By comparing the relative results of all the materials in static analysis, we would suggest Carbon Fibre as the best material for the design of the wheel rim.

Key Words: Wheel rim, Catia v5, Static Analysis, Ansys.

1. INTRODUCTION

According to the present historians and archeologists the concept of the wheel is the true beginning of any old civilization. The wheel is the most significant discovery of old times. The wheel has matured from an over-sized bearing to a fully integrated part of a modern transportation vehicle. Wheels are considered as a safety critical component and the design of a wheel is based on international criteria. Materials to manufacture these wheels as per their design and materials can vary from steel to non-ferrous alloys such as magnesium and aluminum. In the past few decades automotive wheels have evolved from early spoken wood designs to alloys. After years of experimentation and research successful designs are modelled. There are two main groups of car wheels. They are steel wheels and alloy wheels. Generally alloy wheels are fitted during the manufacturing of modern vehicles. All steel wheels are composed of two pressed components, the rim and the wheel disk, joined together. Since the 1970's several innovative methods of testing stress on wheels have been initiated. The procedures have been improved through a variety of experimental and analytical methods for structural analysis. In general wheel rims affect the braking performance of a conveyance as result of the following parameters such as size, weight, design or ventilation, materials.

2. FUNCTIONS OF A WHEEL RIM

Wheel rim primarily acts as a transfer element between the tire and the vehicle. The important functions of a wheel rim are:

Transferring torque (braking and acceleration).

Supporting mass (support the mass of the motor vehicle).

Adding mass (damped mass for driving comfort).

Dissipation of heat (from braking).

Absorbing impact (road hazards). [2]

3. STEPS INVOLVED IN PROJECT WORK

Collection of data for the design of wheel rim.

Generation of 3D model using CATIAV5.

Importing the generated 3D model to ANSYS for analysis work.

Static analysis is carried out on the wheel rim to evaluate the performance.

The best material is suggested for the design of the wheel rim based on its equivalent stress and total deformation.

4. 3D MODEL IN CATIA

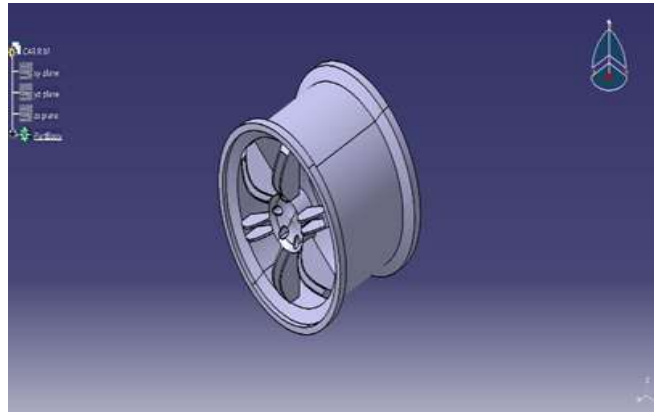


Fig -1: Solid 3D Model

5. GEOMETRY OF THE WHEEL RIM

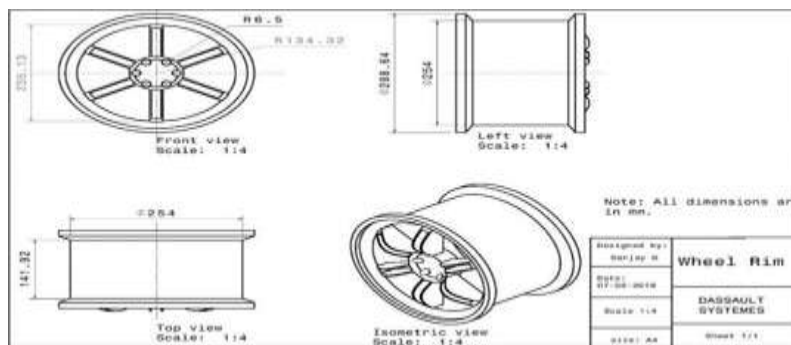


Fig -2: Draft Sheet

6. STATIC ANALYSIS USING ANSYS

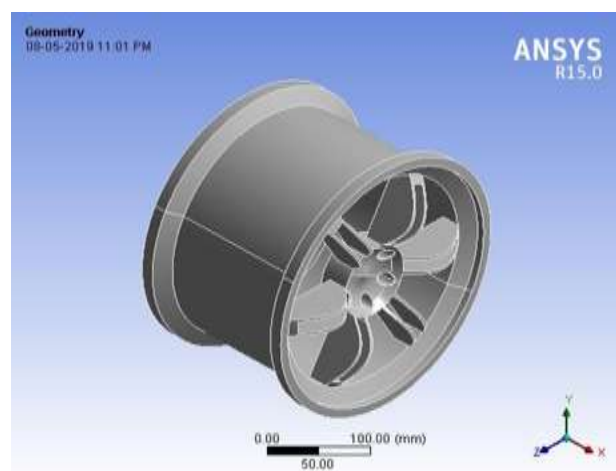


Fig -3: Solid Part in ANSYS

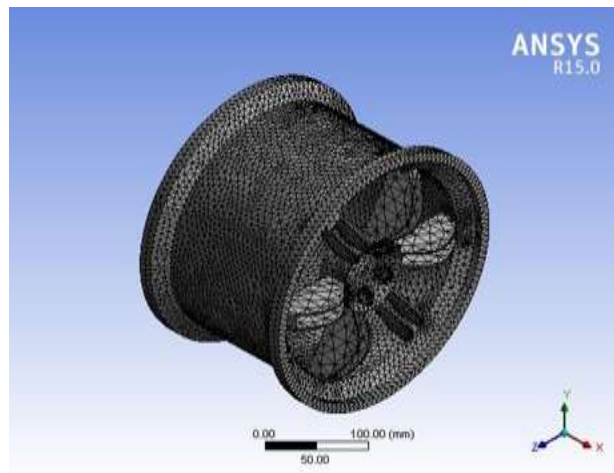


Fig -4: Meshing

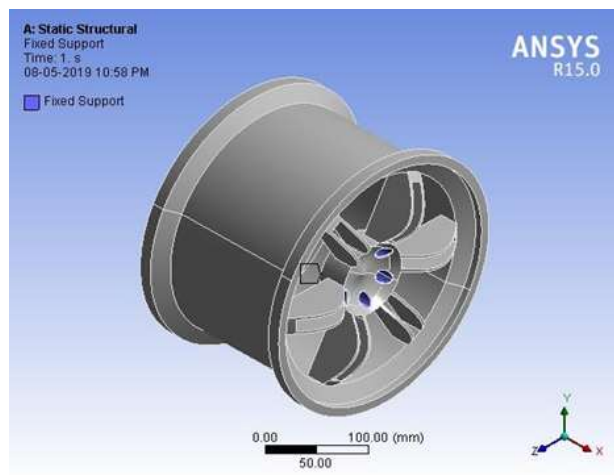


Fig -5: Positioning the fixed support

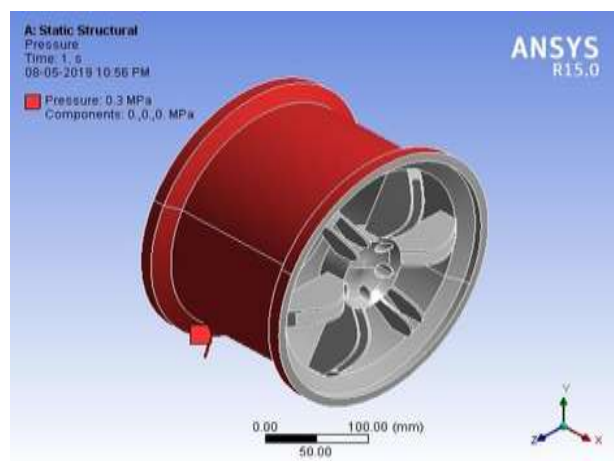


Fig -6: Application of load in terms of pressure

7. AT PRE-PROCESSOR STAGE

Input data for Al Alloy 6061 (T6)

Density: 2.70 g/cm³

Young's modulus: 68.9GPa

Poisson's ratio: 0.33

Tensile strength: 200 MPa

Ultimate tensile strength: 310MPa [4].

Input data for Mg Alloy AM60A/B

Density: 1.8g/cm³

Young's modulus: 45GPa

Poisson's ratio: 0.35

Tensile strength: 220MPa

Ultimate tensile strength: 230MPa [10]

Input data for Steel 1008

Density: 7.86 g/cm³

Young's modulus: 190-210 GPa

Poisson's ratio: 0.29

Tensile strength: 170MPa

Ultimate tensile strength: 305MPa

Input data for Carbon Fibre

Density: 180 g/cm³

Young's modulus: 135 GPa

Poisson's ratio: 0.30

Tensile strength: 2550 MPa

Ultimate tensile strength: 3.5 GPa [11]

8. EQUIVALENT STRESS AND TOTAL DEFORMATION

Material 1- Al Alloy 6061 (T6)

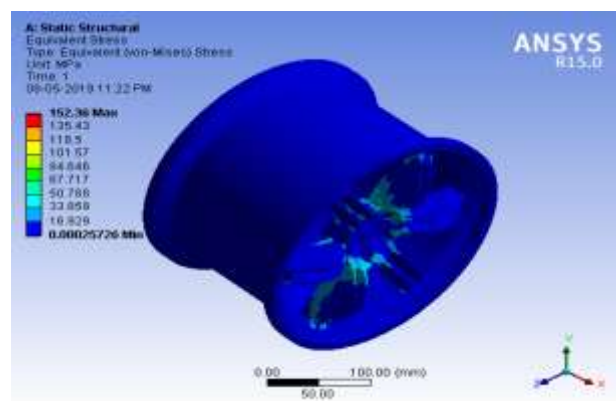


Fig-7: Equivalent Stress

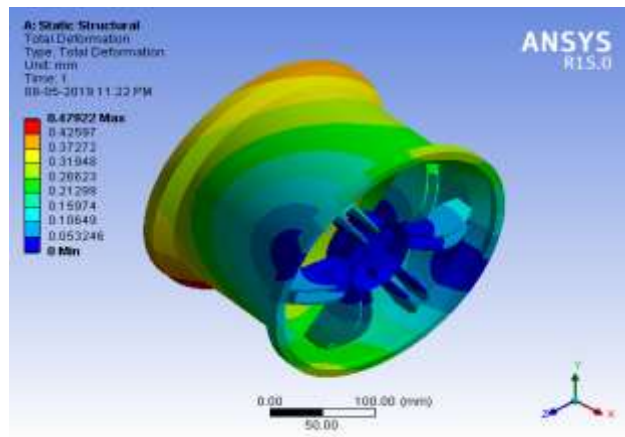


Fig-8: Total Deformation

Material 2- Mg Alloy AM60A/B

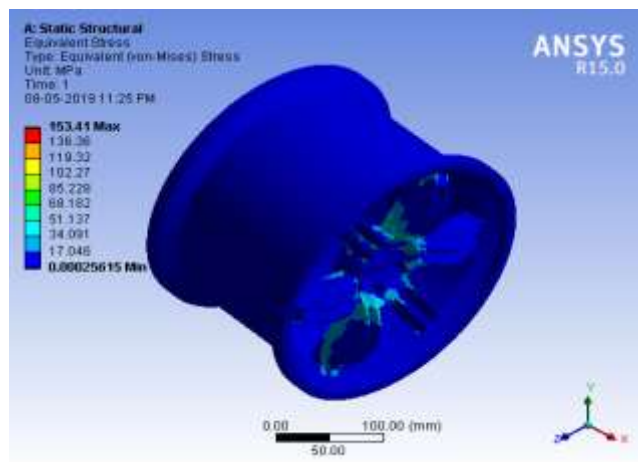


Fig-9: Equivalent Stress

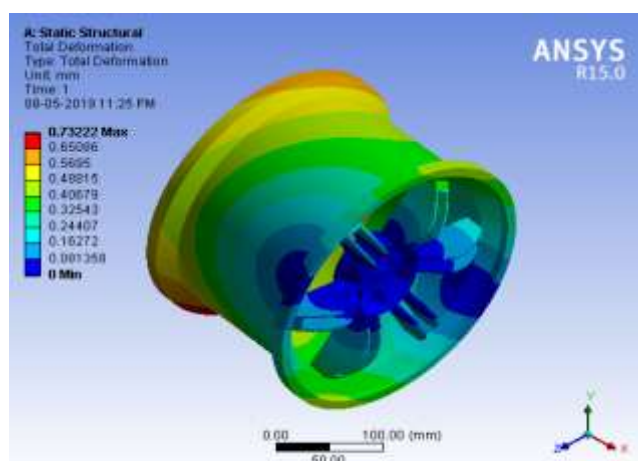


Fig-10: Total Deformation

Material 3- Steel 1008

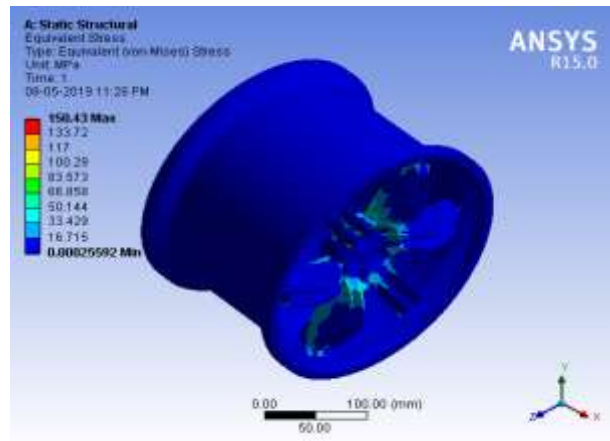


Fig-11: Equivalent Stress

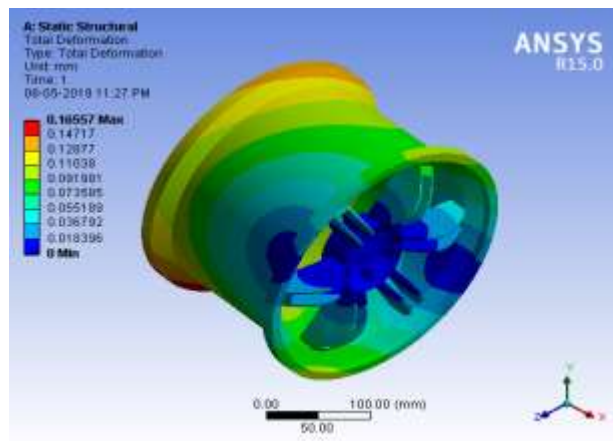


Fig-12: Total Deformation

Material 4- Carbon Fibre

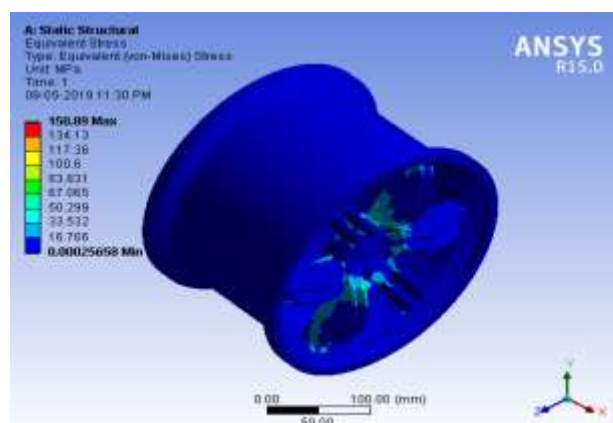


Fig-13: Equivalent Stress

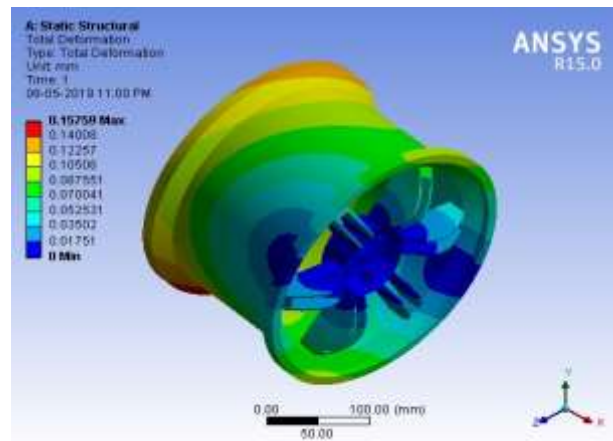


Fig-14: Total Deformation

9. RESULTS

After applying the boundary conditions following results were obtained for different materials used:

Material	Equivalent Stress (MPa)	Total Deformation (mm)
Al alloy 6061	152.36	0.4792
Mg alloy	153.41	0.7322
Steel 1008	150.43	0.1655
Carbon fiber	150.89	0.1575

10. CONCLUSIONS

A CAD model of the wheel rim is generated in CATIA and this model is imported to ANSYS for processing work. An amount of pressure of 0.3Mpa is applied to the wheel rims of different materials such as Aluminium Alloy, Magnesium alloy wheel, Steel 1008 wheel and Carbon fiber wheel. Following are the conclusions from the results obtained:

1. Magnesium alloy wheel rim is subjected to greater stress compared to other materials.
2. Total deformation value is more in Magnesium alloy wheel and very less in Carbon fibre wheel.
3. By Model analysis results, taking deflections into account, Carbon fibre is preferred as the best material for designing wheel rim when compared to other materials.

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