DESIGN AND STRUCTURAL ANALYSIS OF AN AUTOMOBILE WHEEL RIM

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ABSTRACT: An automobile car wheel rim is a made using SOLIWORKS 2021. The IGES file of the model is imported to ANSYS WORKBENCH 2021 for load analysis. The results shows the structural analysis of the wheel rim with different materials. The standard size of 18 inch wheel rim is taken for the structural analysis. The analysis has been done by using ANSYS WORKBENCH 2021 software. The 6 nut holes of the wheel rim has been taken as the fixed supports. A pressure of 55 psi (379212 pa) has been applied on the outer surface of the wheel rim. After performing the meshing the different type of materials has been applied on the wheel rim for the structural analysis. The different materials used in the structural analysis are Grey Cast Iron, Structural Steel, Aluminium Alloy, Titanium Alloy, and Magnesium Alloy.

INTRODUCTION

A wheel is a circular frame made of hard material which provides rotary motion while revolving on an axis. A moment is applied on the axis of the wheel either by gravity, or by an external force to revolve. Generally wheels are used in automobiles. The rim of a wheel on which the tire is mounted of a vehicle. Alloy wheel rims are made of different alloys of aluminium, magnesium and titanium metals. Design, performance, weight and safety are the major concerns while designing a wheel. Wheel rim are important structures for the vehicle operations. The main functions of the wheel rim are to absorb impact from the road caused during driving, dissipates heat from the breaks, transforming torque and helps for suspension system of the vehicle. Improvement in the physical properties of the wheel rim can give better braking reliability, longer life, fuel efficiency, increases traction and suspension system improvement which are capable of responding quickly.

METHODOLOGY

The geometric modelling of the wheel rim in SOLIDWORKS. Structural analysis of the model Under load conditions .Finite element method is used to determine the total deformation, equivalent stress and equivalent elastic strain under load conditions using ANSYS WORKBENCH 2021. These analysis where repeated for Grey Cast Iron, Structural Steel, Aluminium Alloy, Titanium Alloy, and Magnesium Alloy. All the analysing results where compared.

MODELING AND ANALYSIS

The wheel rim body is designed and generated in SOLIDWORKS 2021. A standard rim size of 18 inch is taken and analysed as shown in the figure 1. Then the File is saved in IGES format.

Table.1. Wheel Rim Dimensions

Diameter of Rim	457.2 mm
Width of Rim	200 mm
Bolt hole diameter	16 mm
Hub diameter	46 mm

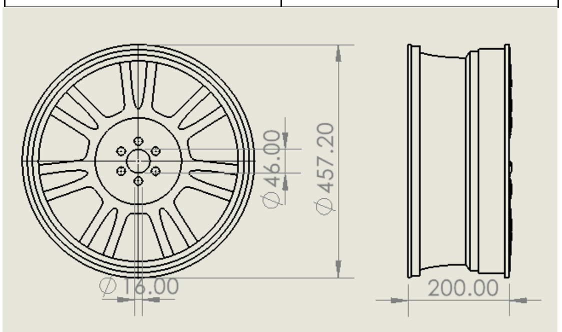

Fig.1. Dimensions sketch of the Wheel Rim model

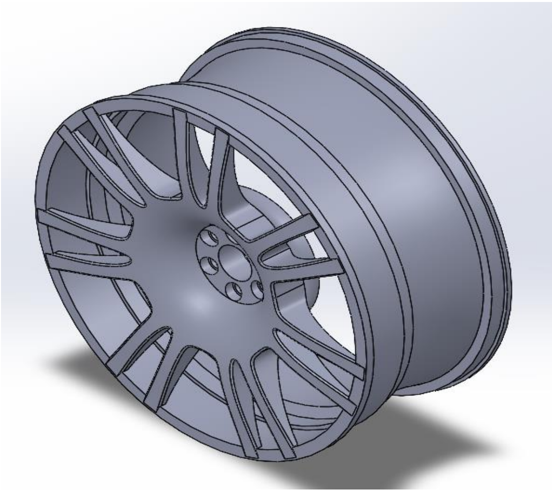

Fig.2. Isometric view of the Wheel Rim

Analysis of static analysis- total deformation, equivalent stress and equivalent elastic strain under boundary conditions. We have taken Grey Cast Iron, Structural Steel, Aluminium Alloy, Titanium Alloy, and Magnesium Alloy for analysis.

Material Properties

- **Grey Cast Iron**
  Young's Modulus (E) = 1.1e+11 pa
  Tensile Yield Strength = 0 pa
  Density = 7200 Kg/m^3
  Mass = 29.454 Kg
- **Structural Steel**
  Young's Modulus (E) = 2e+11 pa
  Tensile Yield Strength = 2.5e+08 pa
  Density = 7850 Kg/m^3
  Mass = 32.113 Kg
- **Aluminium Alloy**
  Young's Modulus (E) = 7.1e+10 pa
  Tensile Yield Strength = 2.8e+08 pa
  Density = 2770 Kg/m^3
  Mass = 11.332 Kg
- **Titanium Alloy**
  Young's Modulus (E) = 9.6e+10 pa
  Tensile Yield Strength = 9.3e+08 pa
  Density = 4620 Kg/m^3
  Mass = 18.899 Kg
- **Magnesium Alloy**
  Young's Modulus (E) = 4.5e+10 pa
  Tensile Yield Strength = 1.9e+08 pa
  Density = 1800 Kg/m^3
  Mass = 7.3634 Kg

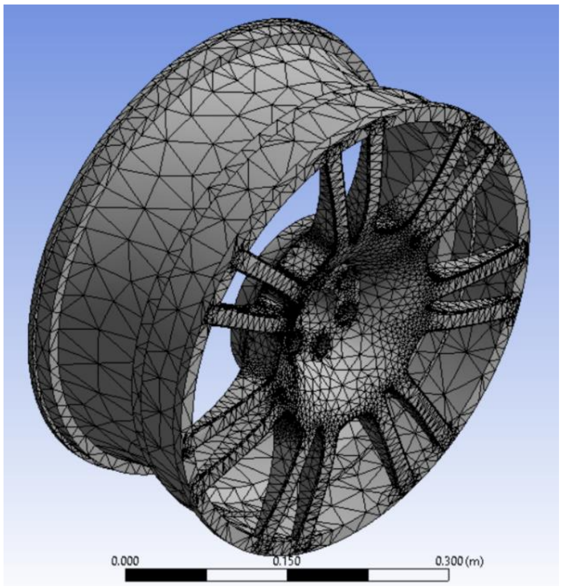

Fig.3. Meshing model of Wheel Rim in ANSYS

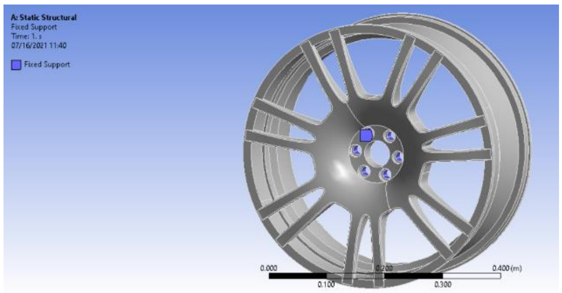

Fig.4. Applying fixed supports to the model

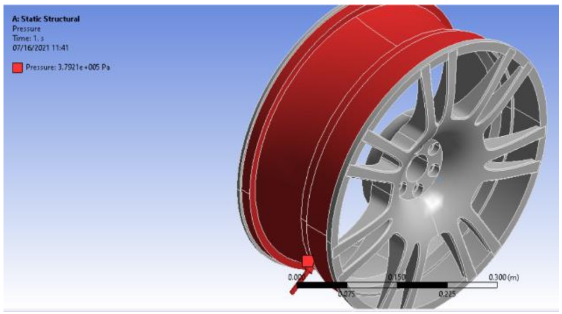

Fig.5. Pressure on the surface of the model

Grey Cast Iron

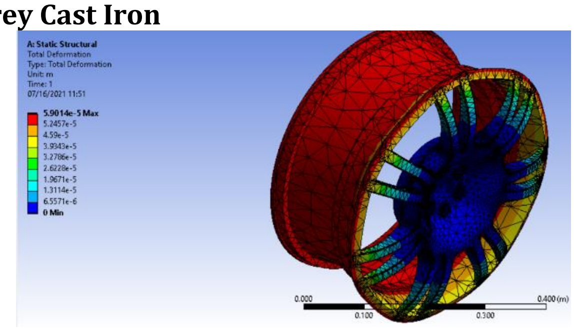

Fig.6. Total Deformation

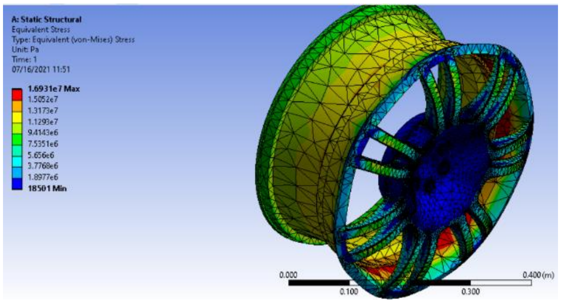

Fig.7. Equivalent Stress

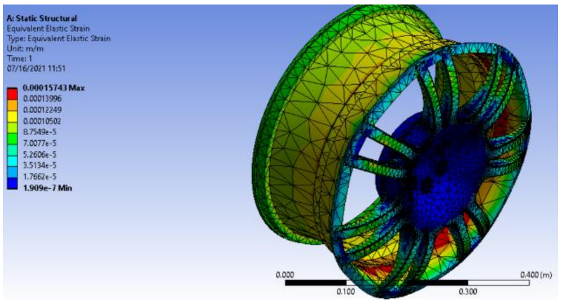

Fig.8. Equivalent Elastic Strain

Structural Steel

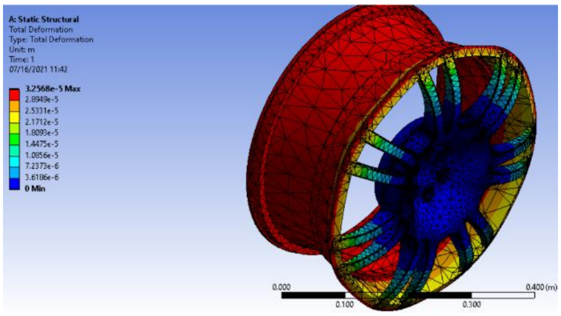

Fig.9. Total Deformation

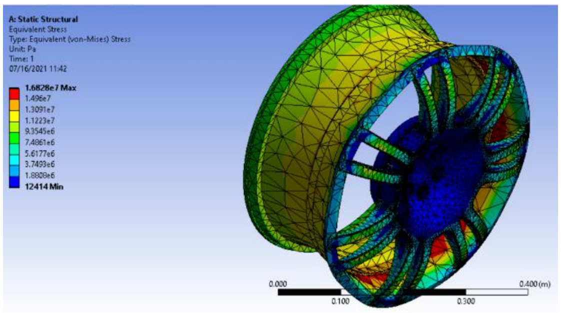

Fig.10. Equivalent Stress

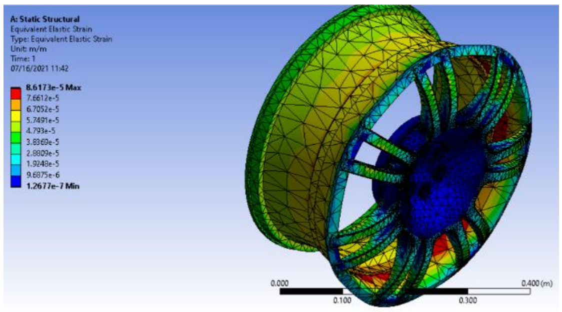

Fig.11. Equivalent Elastic Strain

Aluminium Alloy

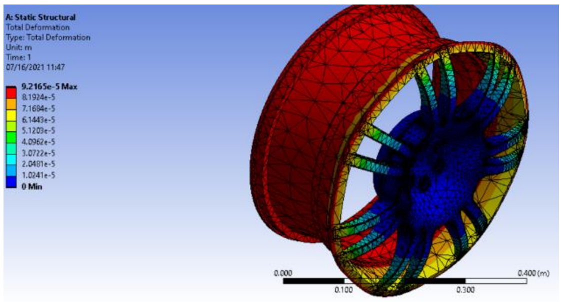

Fig.12. Total Deformation

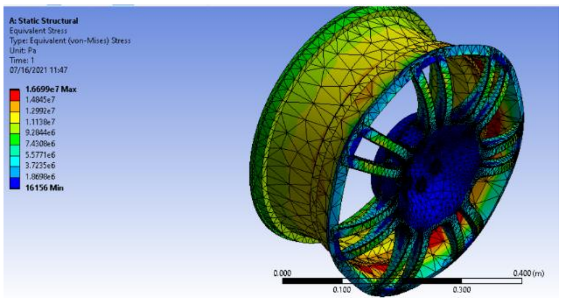

Fig.13. Equivalent Stress

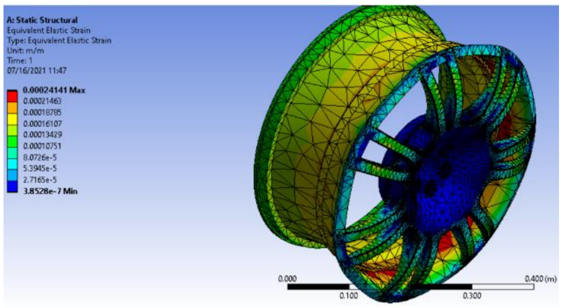

Fig.14. Equivalent Elastic Strain

Titanium Alloy

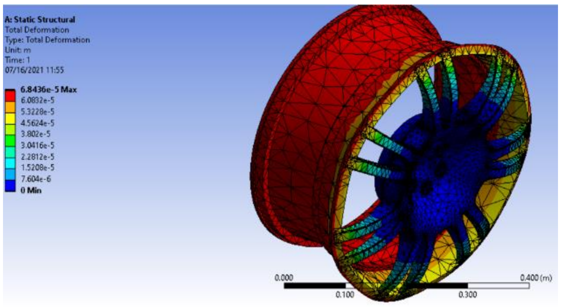

Fig.15. Total Deformation

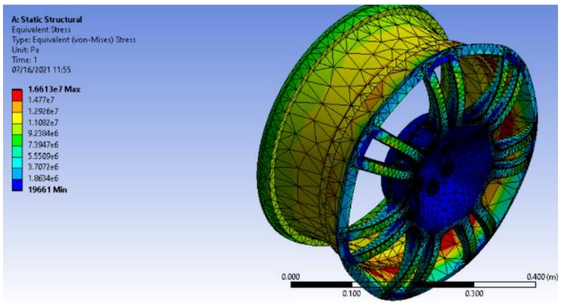

Fig.16. Equivalent Stress

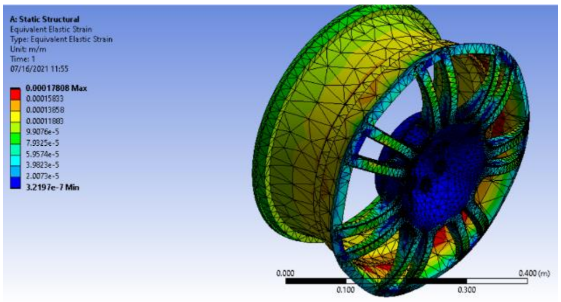

Fig.17. Equivalent Elastic Strain

Magnesium Alloy

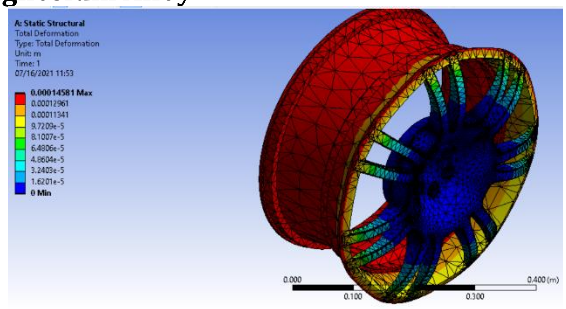

Fig.18. Total Deformation

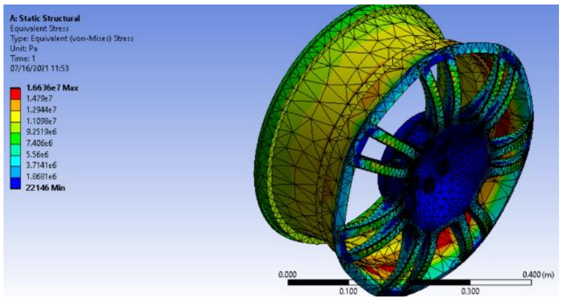

Fig.19. Equivalent Stress

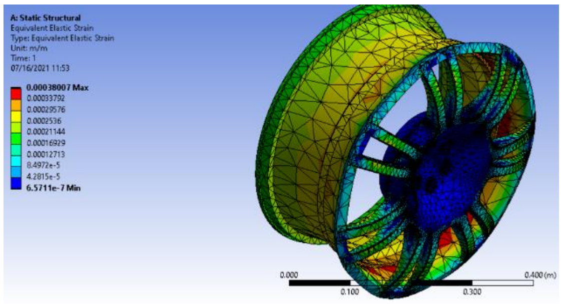

Fig.20. Equivalent Elastic Strain

RESULT

The wheel rim used in automobile is made in SOLIDWORKS and then imported to ANSYS in IGES format is used for analysis. A pressure of 55 psi or 379212 pa is applied on the outer surface of the wheel rim and keeping the bolt holes fixed.

Total number of nodes in meshing is 107235 and total number of elements is 59659.

Table.2.Comparison table of all the materials

MATERIALS	Total Deformation (m)	Equivalent Stress (pa)	Equivalent Elastic Strain (m/m)
Grey Cast Iron	1.1787e-005	3.4811e+006	3.2903e-005
Structural Steel	6.4715e-006	3.479e+006	1.8083e-005
Aluminium Alloy	1.8173e-005	3.4749e+006	5.0871e-005
Titanium Alloy	1.339e-005	3.4695e+006	3.7562e-005
Magnesium Alloy	2.8603e-005	3.4714e+006	8.0179e-005

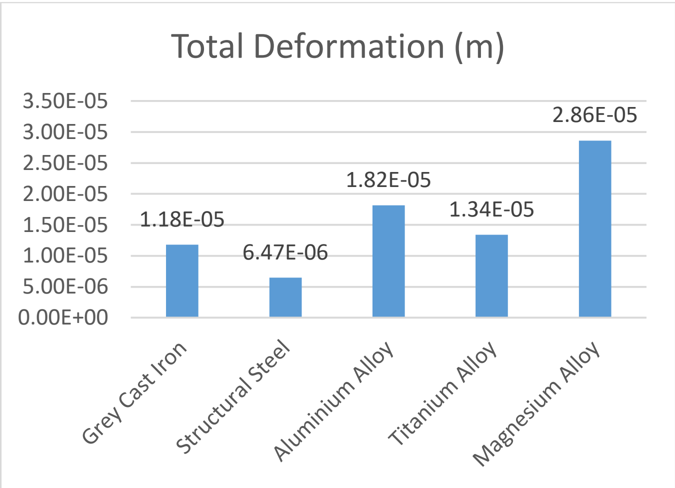

Table.3.Comparison of Total Deformation of all the material

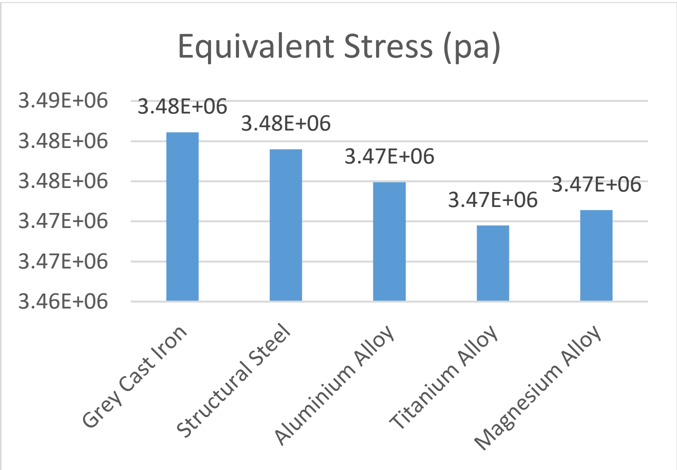

Table.4.Comparison of Equivalent Stress of all the material

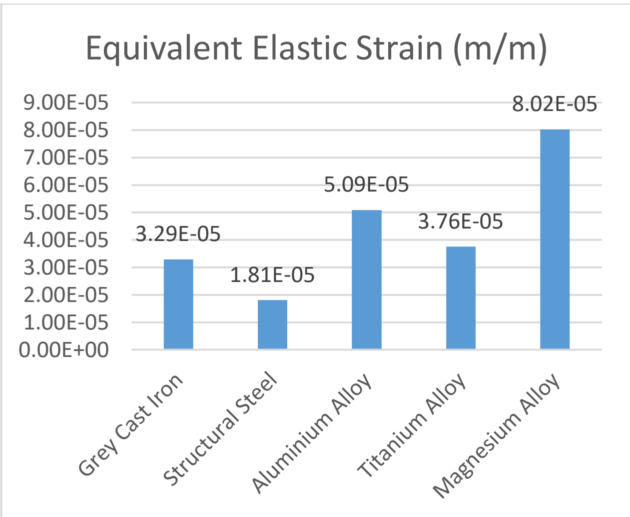

Table.5.Comparison of Equivalent Elastic Strain of all the material

CONCLUSIONS

The research project have analysed the total deformation, equivalent stress and equivalent elastic strain. The wheel rim has been modelled in SOLIDWORKS and then exported to ANSYS for the load analysis. The result shows the different structural behaviour when different material is used for wheel rim model.

Structural Steel has the least deformation and strain compared to all the materials used in the analysis. But its weight is heavy which affects the performance of the engine and should be least considered.

Grey cast iron has the second least deformation and strain of all the material used in the analysis. Its weight is also heavy which effects the performance of the engine. But it's the cheapest material available in the market.

Titanium alloy has the least stress generation when compared to other material used in the analysis. Titanium is high demand and its high cost which makes it not suitable for the commercial purpose.

Aluminium alloy are light weight and very cost efficient due to its high production. It's easy to extract from the earth and it has a great machinability. So a lot of automobile manufactures use aluminium alloy of the manufacturing of the alloy wheels.
Magnesium alloy has the highest deformation and strain compared to other material used in the analysis. It's the lightest material. It is also high resistance corrosion and due to high demand it is high in cost. So it's not suitable for the commercial purpose.

It is concluded that Titanium alloy is best suitable material for the manufacturing of wheel rims if cost is not an issue. Aluminium alloy is best material for the manufacturing of the wheel rims for the commercial purpose due to its cost and performance. Hence Aluminium alloy is good for manufacturing of wheel rim obtained from the research analysis.

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BIOGRAPHY

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