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Design Optimization and Analysis of Wheel Rim by Using Cero and Ansys

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ABSTRACT

Alloy wheel rims are an important part of the vehicular suspension system and must be strong enough to withstand the loads encountered during vehicle action. The design of alloy wheel rims should take into account factors such as styling, aesthetics, mass, manufacturability, and capability. Finite element Analysis can be used to study the stress and displacement distribution in vehicle wheels subjected to Increase pressure and radial load. The results of finite element analysis can be used to select the best Material for manufacturing the wheel rim and ensure that it is safe and reliable. Alloy wheel rim has been designed using Creo software, after that static structural analysis is done with different materials, Load and boundary conditions using ANSYS Software. At last the results of total deformation and Equivalent stresses are obtained for different wheel rim materials and compared with each other. Thus, the best material can be selected for manufacturing of the wheel rim

Keywords: alloy wheel rim, design considerations, finite element analysis, safety, Material

1. Introduction

The type of wheel rim you choose will depend on your budget, your needs, and your personal preference. If you are looking for a cheap and durable option, then steel rims are a good choice. If you are looking for a lightweight and strong option, then alloy rims or magnesium rims are a good choice. And if you are looking for the lightest and strongest option, then carbon fiber rims are a good choice.

Here are some additional factors to consider when choosing a wheel rim:

I. Size: The size of the wheel rim will affect the overall look of your vehicle, as well as the performance of your tires.

II. Offset: The offset of the wheel rim will determine how far the wheel sticks out from the vehicle.

III. PCD: The PCD (Pitch Circle Diameter) is the number of lug holes on the wheel rim, and the distance between them.

IV. Colour: The colour of the wheel rim can be a personal preference, or it can be chosen to match the colour of your vehicle. When choosing a wheel rim, it is important to make sure that it is compatible with your vehicle. You should also check the manufacturer's recommendations for the size, offset, PCD, and colour of the wheel rim.

2. Design Modelling

The rim wheel design you described has the following dimensions:

I. 9 × 18 in. (228.6 mm × 457.2 mm)

II. Five holes

III. Nut diameter: 15 mm

IV. Pitch circle diameter: 112.5 mm

V. Central hub diameter: 73 mm

VI. Three designs with four, five, and six spokes

VII. Materials: Low alloy steel, Carbon steel, structural steel, and aluminum alloy

The 2D design and 3D illustration of the rim wheel will be shown in Figure. 1 The rim wheel is a critical component of a vehicle, as it helps to keep the tire in place and provides support for the vehicle's weight. The design of the rim wheel must be carefully considered to ensure that it is strong and durable, while also being lightweight and aerodynamic. The materials used in the rim wheel design will also affect its performance. Low alloy steel, Carbon steel, structural steel, and aluminum alloy are all strong and durable materials that can be used to make rim wheels. However, aluminum alloy is the lightest of these materials, which can make the rim wheel more aerodynamic and improve fuel efficiency. The rim wheel design you described is a well-thought-out design that uses a variety of materials to create a strong, lightweight, and aerodynamic rim wheel. The different spoke designs will allow the rim wheel to be customized to the specific needs of the vehicle.

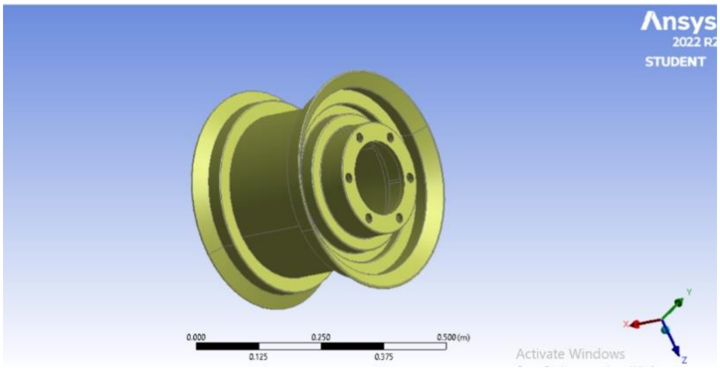

Fig. 1 wheel rim

3. Analysis

TABLE 1 Model Geometry Detail

Object Name	*Geometry*
State	Fully Defined
Definition	
Source	C:\Users\admin\Desktop\Present work\TIESH\final 2.igs
Type	Iges
Length Unit	Millimeters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	308.68 mm
Length Y	442.72 mm
Length Z	442.72 mm
Properties	
Volume	3.3931e+006 mm³
Mass	26.636 kg
Scale Factor Value	1.
Statistics	
Bodies	1
Active Bodies	1
Nodes	36922
Elements	21122
Mesh Metric	None
Update Options	
Assign Default Material	No
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Independent
Parameter Key	ANS;DS
Attributes	No
Named Selections	No

Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	Yes
Compare Parts On Update	No
Analysis Type	3-D
Mixed Import Resolution	None
Import Facet Quality	Source
Clean Bodies On Import	No
Stitch Surfaces On Import	Program Tolerance
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

Boundary Condition

TABLE 2 Model > Static Structural > Rotations

Object Name	*Rotational Velocity*
State	Fully Defined
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Define By	Vector
Magnitude	1000. rad/s (ramped)
Axis	Defined
Suppressed	No

TABLE 3 Model > Static Structural > Loads

Object Name	Fixed Support
State	Fully Defined
Scope	
Scoping Method	Geometry Selection
Geometry	12 Faces
Definition	
Type	Fixed Support
Suppressed	No

TABLE 4 Model > Static Structural > Solution

Object Name	Solution (B6)
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.
Information	
Status	Done
MAPDL Elapsed Time	12. s
MAPDL Memory Used	555. MB
MAPDL Result File Size	13.25 MB
Post Processing	
Beam Section Results	No
On Demand Stress/Strain	No

4. Result

Aluminum alloy

Object Name	Total Deformation	Equivalent Elastic Strain	Equivalent Stress
Minimum	0. mm	2.6855e-005 mm/mm	0.99215 MPa
Maximum	0.56842 mm	2.6778e-002 mm/mm	1848.8 MPa
Average	0.22237 mm	1.0858e-003 mm/mm	72.107 MPa

Carbon steel, 1020

Object Name	Total Deformation	Equivalent Elastic Strain	Equivalent Stress
Minimum	0. mm	2.6619e-005 mm/mm	3.2096 MPa
Maximum	0.52649 mm	2.6042e-002 mm/mm	5531.3 MPa
Average	0.20696 mm	1.0225e-003 mm/mm	208.87 MPa

Low alloy steel, 4140

Object Name	Total Deformation	Equivalent Elastic Strain	Equivalent Stress
Minimum	0. mm	2.6607e-005 mm/mm	3.2096 MPa
Maximum	0.52624 mm	2.603e-002 mm/mm	5531.3 MPa
Average	0.20686 mm	1.022e-003 mm/mm	208.87 MPa

Structural Steel

Object Name	Total Deformation	Equivalent Elastic Strain	Equivalent Stress
Minimum	0. mm	2.7595e-005 mm/mm	2.9847 MPa
Maximum	0.56129 mm	2.7453e-002 mm/mm	5490.6 MPa
Average	0.22037 mm	1.0855e-003 mm/mm	208.81 MPa

The stress-strain test results show that the four materials have different mechanical properties. The aluminium alloy is the most ductile while the carbon steel 1020 is the least ductile, but the strongest. The low alloy steel 4140 and the structural steel have intermediate properties between the aluminium alloy and the carbon steel 1020.This information is important to know when choosing a material for a particular application. For example, if you need a material that is strong and can withstand a lot of deformation, then you would choose carbon steel 1020. However, if you need a material that is ductile and can withstand a lot of stress, then you would choose aluminium alloy.

5. Conclusion

The table you provided shows the results of a stress-strain test on four different materials: aluminum alloy, carbon steel 1020, low alloy steel 4140, and structural steel. The table shows the minimum, maximum, and average values for total deformation, equivalent elastic strain, and equivalent stress for each material.

The following are some observations that can be made from the table:

I. The aluminum alloy has the lowest total deformation, equivalent elastic strain, and equivalent stress. This means that it is the most ductile and least strong of the four materials.

II. The carbon steel 1020 has the highest total deformation and equivalent stress, but the lowest equivalent elastic strain. This means that it is the least ductile, but the strongest of the four materials.

III. The low alloy steel 4140 has similar properties to carbon steel 1020.

IV. The structural steel has intermediate properties between the aluminium alloy and the carbon steel 1020.

Overall, the table shows that the different materials have different mechanical properties. This is important to know when choosing a material for a particular application. For example, if you need a material that is strong and can withstand a lot of deformation, then you would choose carbon steel 1020. However, if you need a material that is ductile and can withstand a lot of stress, then you would choose aluminum alloy.

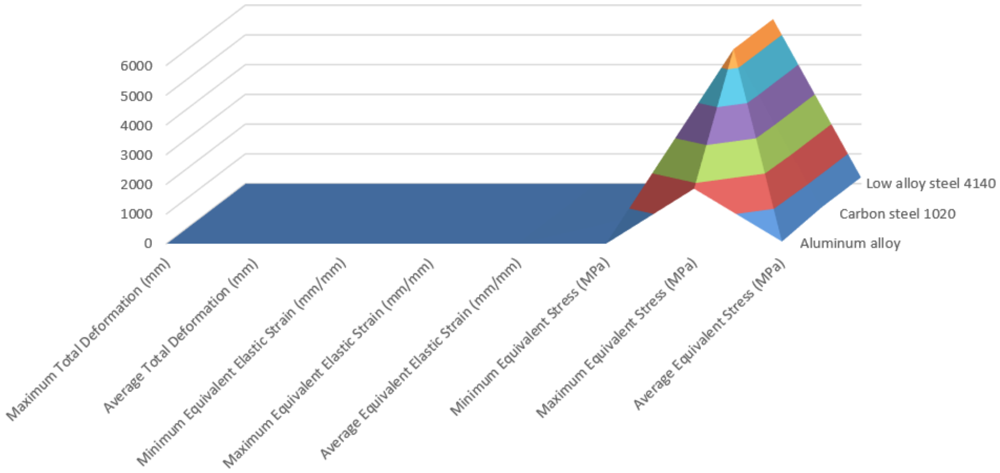

Fig.2 Comparative result according to deformation

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