Design and Analysis of Alloy Wheel Rim Using Finite Element Analysis

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Abstract:
In this paper, we are performing Static, Modal, Harmonic, and Fatigue analysis on alloy wheel using different materials Aluminum, Magnesium alloy, and Structural steel. A four-wheeler vehicle wheel is modelled using CATIA software by doing some set of operations and then it is imported into IGES format which can be imported into Ansys software for performing different analysis to choose the best suitable material for the wheel and to find out different factors influencing them. By comparing multiple materials for alloy wheel, we can eventually end up choosing the best and optimal material that can be suitable for the alloy wheel.

Key Words: Alloy wheel, Wheel Rim, CATIA V5, ANSYS, Magnesium alloy, Aluminum alloy.

Introduction:
Wheels and tyres are obviously crucial components of a car. The vehicle could be pulled if it were without its engine, but without wheels, it would be impossible to move in any direction. Wheels and tyres must support the weight of the vehicle, absorb shock, and cooperate with the steering system. Aluminum and magnesium alloys are often used to create automotive wheel rims, while other metals may also be used. Alloy wheel rims are lighter than standard steel rims, which makes a big difference in handling and speed. Wheel rims for early light-alloy vehicles were built of magnesium alloys.

The paper noted that a fatigue lifespan prediction technique of Aluminum alloy wheels was presented to assure their durability at the early design stage, even though they fail approval on conventional automobiles yet stay renowned in the 1960s.

Using ANSYS 19.2 for static structure analysis. The research confirmed what was already known about the location of the highest stress levels, which was across the region covered by the hub bolts. Thus, the finite element model is able to provide findings that are in agreement with the static load test. CATIA V5 is used to create a CAD model of the wheel rim, which is then sent to ANSYS for further analysis. Bolt circles of wheel rims are fastened while a force of 18000 N is applied radially throughout the circumference of wheel rims composed of Aluminum and structural steel.

![Wheel Rim alloy](image)
LITERATURE SURVEY

P. Meghashyam et al. [1], the rim of an aluminium wheel experiences more stress than one made of forged steel. These pressures are negligible in comparison to the wheel's ultimate strength. In addition, aluminium allows for a greater degree of deflection than forged steel. The forged wheel is the material of choice for the wheel rim in many modern designs.

J. Janardhan et al. [2] to verify the wheel's existence, we looked at the fatigue module. The investigation has spanned a long period of time. Globally, the equivalent (Von-Mises) pressure measured $9.205 \times 10^6$ Pa. Deformation is $0.515 \times 10^{-1} \text{ mm}$ and minimum stress is $0.041 \times 10^6$ Pa after undergoing fatigue cycles. It was during the 1.0109 cycle when he found out about eternal life.

Sourav Das et al. [3], In the design space, the arm's mass and shape may be fine-tuned. The damage area is along the flange part of the rim, and it is intended to bear the vehicle's current load for the factor of protection with the least amount of material and manufacturing cost and damages feasible. The fatigue test results prove beyond a reasonable doubt that the material can sustain $1 \times 10^2$ cycles. A maximum of 0.2% was lost during all $1 \times 10^2$ iterations.

Jaspreet Singh et al. [4], The rim's circumference expanded to accommodate the weight. This wheel had a maximum equal tension of 11.283 MPa. At 200KN, the design is safe because the equivalent stress is below the yield point of the Al alloy everywhere except for the spokes' corners, where it is greatest. The maximum amount of visible distortion in the alloy wheel was 0.033 mm. The diameter of the wheel was the most distorted, while the section of the bolt was the least. Minimum and maximum margins of safety were found at the air pressure hole.

OBJECTIVE

- To compare the strength between different types of wheel rims.
- To make the test of ending endurance and radial test.
- To select best suitable material for wheel rim.
- To give the consumers both safety and comfort of a car with good quality rim.
- To increase the quality and durability rim for consumers.

DESIGN METHODOLOGY

![Figure 2: Methodology adopted](image-url)
DESIGN OF WHEEL RIM

Dassault Systems CATIA (acronym for computer-aided three-dimensional interactive application) is a multi-platform software package for CAD, CAM, CAE, PLM, and 3D modelling built for a variety of platforms. As a result of Dassault’s Mirage fighter jet's usage of the CADAM software at the time, the French aviation company AVIONS MARCEL DASSAULT developed CATIA in-house in 1977. It was subsequently adopted by a variety of other sectors, including aircraft, automobiles, and shipbuilding.

FINITE ELEMENT ANALYSIS

It is also known as the Finite Element Analysis (FEA). An analytical approach known as the Finite Element Method (FEM) may be used to solve and replace complex issues with simpler ones, resulting in approximate solutions. Because of its versatility, the finite element approach is used across a wide range of sectors to address a wide range of real-world engineering challenges. Relative results may be generated using the finite element approach. An engineering simulation software called ANSYS is available for download (computer-aided Engineering). Its techniques include finite element analysis for thermal, static, dynamic, and fatigue, amongst others, all of which are intended to aid in the product’s development. Dr. John A. Swanson started Swanson Analysis Systems, Inc. SASI in 1970. Primary goals were the creation and distribution of structural physics finite element analysis software capable of simulating static, dynamic, and heat transport (thermal) issues.

The exact result in the ANSYS software the internal command setting can be available for mesh generation and above figure shows the process of the meshing and show the model for meshing.

TABLE 8.1: MESHING DETAILS

<table>
<thead>
<tr>
<th>NAME</th>
<th>ELEMENTS</th>
<th>NODES</th>
</tr>
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<tbody>
<tr>
<td>CAM SHAFT</td>
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<td>94613</td>
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</table>
ANALYSIS OF WHEEL

STRUCTURAL STEEL WHEEL RIM

ALUMINUM ALLOY WHEEL RIM

MAGNESIUM ALLOY WHEEL RIM

RESULT SUMMARY

<table>
<thead>
<tr>
<th>Results</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Units</th>
<th>Time (s)</th>
</tr>
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<tbody>
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<td>m</td>
<td>1.</td>
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<tr>
<td>Equivalent Elastic Strain</td>
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<td>5.4522e-003</td>
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<td>Equivalent Stress</td>
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<td>1.0898e+009</td>
<td>Pa</td>
<td>1.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Results</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Units</th>
<th>Time (s)</th>
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<td>1.0944e+009</td>
<td>Pa</td>
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</tr>
</tbody>
</table>
CONCLUSION

At the end of the study and design process, we choose the most reliable and long-lasting wheel rim. This programme automates the design and analysis processes. Modal analysis, dynamic analysis, and performance evaluation of the rim were also conducted. There, they looked at the outcomes of static and model analysis, and they decided that forged steel would be the best option.

REFERENCE


