iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** VIII **Month of publication:** Aug 2023

DOI: https://doi.org/10.22214/ijraset.2023.55336

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VIII Aug 2023- Available at www.ijraset.com

Design and FEM-based Analysis of Wheel Rims

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Abstract: The automobile wheel rim's main function is to offer a stable surface on which to mount the tyre. Its size and design should be appropriate to fit the specific tyre that the vehicle needs. This project takes into consideration a tyre for an automobile wheel rim that falls within the disc wheel category. Design is a significant industrial process that affects the product's quality. With the aid of the modelling programme Solidworks, the wheel rim is created. The time required to create intricate 3-D models and the risk associated with the design and production process may both be significantly reduced through modelling. In order to represent the wheel rim, solidworks is used. Later, for analytical purposes, this model is loaded into ANSYS. The most recent programme utilised for modelling the various forces operating on the component, as well as for computing and visualising the results, is called ANSYS. In contrast to the approach of doing mathematical calculations by a human, ANSYS software's solver mode calculates the stresses, deflections, strain, and their relationships without the need for user involvement, saving time. When doing static analysis, ANSYS takes into account four distinct materials: structural steel, aluminium alloy, magnesium alloy, and titanium alloy.
Keywords: Wheel rims, FEM, 3D image of wheel rim, render image of wheel rim, aggreacte deformation, equavilent elastic strain

I. INTRODUCTION

A. Wheel Rim

On wheels, such as those used on cars, the inside edge of the tyre is fixed to the metal's outside circular pattern. The fatigue strength of wheel rims composed of materials such as alluminium alloy, steel alloy, forged steel, and magnesium alloy is analysed. A strong tool or numerical process to find answers to many of the issues found in engineering analysis is the finite element technique. A complicated area defining a continuum is discretized into straightforward geometric forms termed finite elements in this analytical approach. The analyses' study domain is broken down into a number of finite components.. These factors are taken into consideration, and the controlling connection is represented at the corner of each element in terms of unknown values. Constraints will be placed to the rim's circumference during the static analysis of the wheel. MSC's fatigue programme does fatigue analysis using stress or strain data from FE models. The use of MSC fatigue establishes an MCAE environment for integrated durability management and moves fatigue analysis forward in the design-to-manufacturing process. Today's archaeologists and historians consider the invention of the wheel to be the true beginning of any ancient civilisation. The wheel is the most important invention from antiquity. From being an enlarged bearing, the wheel has evolved into a crucial component of every contemporary transportation vehicle. To protect the safety of the passengers, contemporary motor vehicles are constructed in accordance with highly tight regulations. Steel to non-ferrous alloys like magnesium and aluminium, as well as other complex materials, can be used to make these wheels. Over the years, automobile wheels have changed from the original wood and steel spoke designs. Modern cast and forged aluminium alloy rims and stamped metal construction are used in today's autos. Since the 1970s, a number of cutting-edge testing techniques have been developed with the use of experimental stress measurement. . Various experimental and analytical techniques for structural analysis (finite element approach) have enhanced the processes recently. In the past ten years, dependability techniques for coping with changes in engineering structure and durability analysis (fatigue life prediction) have been used to car wheels. Size, weight, design, and materials of the wheel rim have an impact on braking performance. The distance between the wheel rim and brake rotor is determined by the wheel rim's size. There will be greater room for air movement around the brakes and better cooling if the wheel rim diameter is larger. Another crucial factor is the wheel rim's weight. A vehicle's handling is always being enhanced. Wheel flex will be lessened with a rigider wheel. With low aspect ratio, high performance tyres that may produce strong cornering forces, this is crucial. Steel wheels and alloy wheels are the two basic categories for car wheels. Modern automobiles are typically built with alloy wheels as standard equipment.

All steel wheels must consist of a rim and a wheel disc that are both pressed components that are then joined by welding. In the 1930s, Daimler-Benz and Auto-Union racing vehicles were fitted with the first light-alloy sheet aluminium automobile wheels. Porsche started manufacturing sheet wheels in batches in the 1960s; each wheel had a rim and a nave. In Europe, sheet wheel manufacture for Daimler-Benz vehicles began in considerable capacity in 1979.

The manufacturing costs were significantly decreased by further improvement of the production method for wheel rims and naves, allowing an aluminium sheet wheel to be produced in large quantities for the BMW 5 Series from 1995. In order to give them a unique personal touch, passenger automobiles' top class or flagship models were the first to use aluminium wheels. They were mostly cast at this time and began to be factory-installed on mass-produced automobiles in the 1970s.

Currently, wheels account for 15% or so of the average amount of aluminium in passenger cars and light trucks. While styling has been the primary driving force behind the development of primarily cast solutions, the need for weight reduction has resulted in the development of more technical cast solutions as well as orged and fabricated ones.

However, these parts must uphold high standards of design, engineering, and craftsmanship since they serve important safety duties.

II. LITERATURE REVIEW

1) In 2002, Andrew D. Hartz developed a finite element model of the traditional bicycle wheel and compared the outcomes to those obtained using ANSYS. The wheel's displacement, strain, and bending properties were established. The findings suggested that ANSYS modelling may be an effective technique for examining basic structures, such as the traditional bicycle wheel..
2) A novel approach to measuring fatigue life was put out by Liangmo Wang et al. (2009), who utilised the ABAQUS programme to create a static load finite element model of aluminium wheels for rotational fatigue testing. The outcomes showed that the suggested technique, which combined nominal stress and finite element analysis, was effective and reliable for predicting the fatigue life of aluminium wheels..
3) Finite element analysis was used by Alexandru Valentin Raduelescu et al. (2012) to examine the automobile rim under 400 loading conditions. The stress condition in the centre of the rim for the initial and optimised versions was examined in the first step of the finite element analysis. In order to identify the zones with higher stress concentration and to make a better design suggestion, the static stresses are investigated. The outcomes were contrasted with those attained by the use of an experimental stand. Suman N.
4) Yadav and N. S. Hanamapure (2013) examined how camber angle affected the distribution of stress and the fatigue life of a passenger car's tyre rim under radial loads brought on by uneven roads and off-road terrain. In order to analyse the stress distribution and fatigue life of the steel wheel rim of a passenger automobile, finite element analysis (FEA) is performed by simulating the test circumstances.
5) Meghashyam-et.al (2013) suggested utilising CATIA for the modelling of the wheel rim. Later, for analysis purposes, this CATIA model is loaded into ANSYS. The most recent tool for simulating forces and pressures operating on a component, as well as for computing and visualising results, is called ANSYS. Two distinct materials, forged steel and aluminium, are taken into account for the static analysis work done by ANSYS, and their relative performances have been noted accordingly. In addition to this, the performance of the rim is evaluated after it has undergone vibration study (also known as modal analysis). In this research, the optimal material is indicated to be forged steel based on the findings of both static and modal analyses.
6) Finite Element Techniques are reportedly utilised to determine stress and displacement distribution in vehicle wheels subjected to increased pressure and radial load, according to Karthik A.S. et al. (2016). The study was carried out using the finite element software "Ansys workbench" and the model was created using "CATIA V5". After comparing the outcomes of several Material models, such as titanium, magnesium, and aluminium, are used to assess the wheel's capability. 7. According to Jaspreet Singh, et al. (2015) they analyzed Alloy Wheel by static loading The main point of this paper was that FEA was carried out on an aluminum alloy wheel using Ansys15.0. Calculations were used to determine the von-Misses stress, safety factor, and overall displacement. Additionally, employing the results of reverse engineering is acceptable for the design. According to Meghashyam-et.al (2013) [3], CATIA software was used to model the wheel rim. Later, for analytical purposes, this CATIA model was imported into ANSYS. The various pressures and forces acting on the component may be calculated with the aid of the ANSYS program. Two various materials, such as aluminum and forged steel, were taken into consideration for the ANSYS static analysis study, and their respective relative performances were noted. Rim also underwent modal analysis, a component.

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Volume 11 Issue VIII Aug 2023- Available at www.ijraset.com

III. MODELLING

A. Pattern OF RIM

By choosing the front plane and creating a half section of the rim while providing the specifications, we create the rim in solid works according to those dimensions. We next enter the workbench and pick the revolved command before choosing the plane and drawing a wheel hub and bolt hole in the rim.

Crust diameter	15.88inch
periphery diameter	14.77 inch
Pit hole diameter	1.78 inch
Shank hole diameter	0.38 inch

B. 3D Model of Wheel Rim

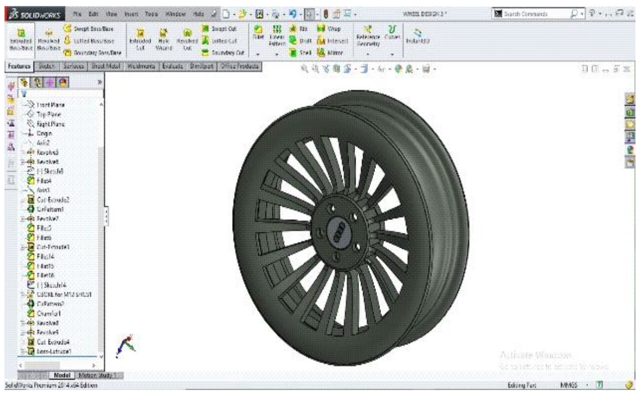


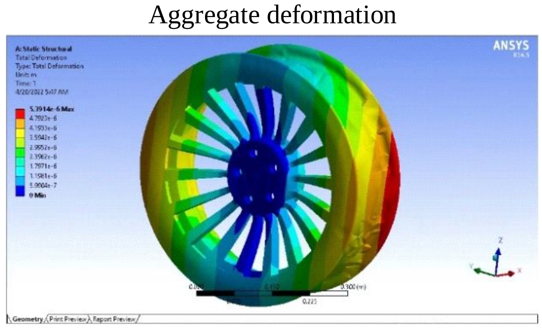
Fig no. 3.2 3D image of wheel rim

Fig no. 3.2(1) render image of wheel rim

IV. RESULT AND DISCUSSION

A. Material: Aluminium Alloy

Aggregate deformation



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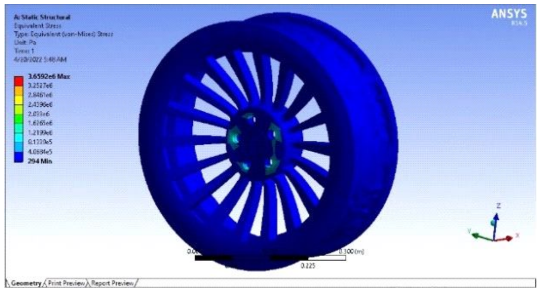
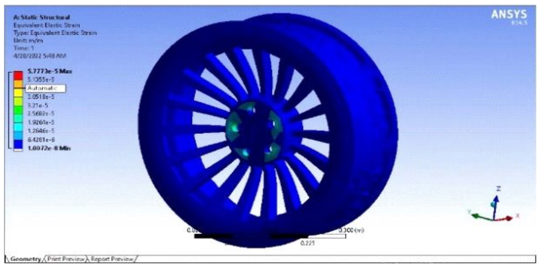
Comparable von-misses stress

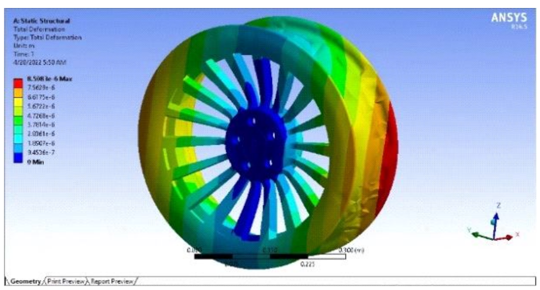


Equivalent elastic strain

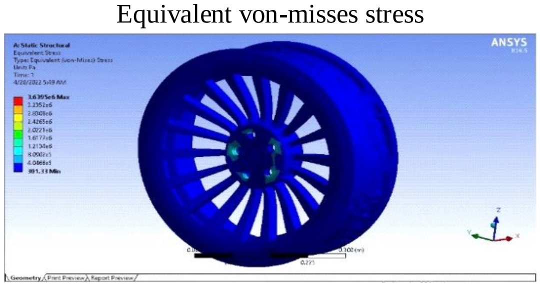


B. Material: Magnesium Alloy

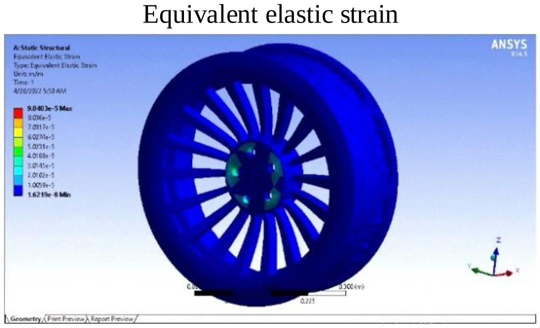
Total deformation



Equivalent von-misses stress



Equivalent elastic strain



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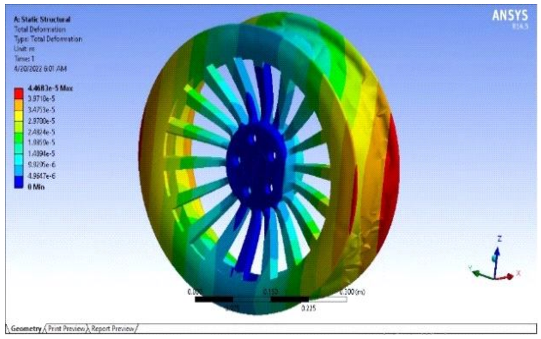
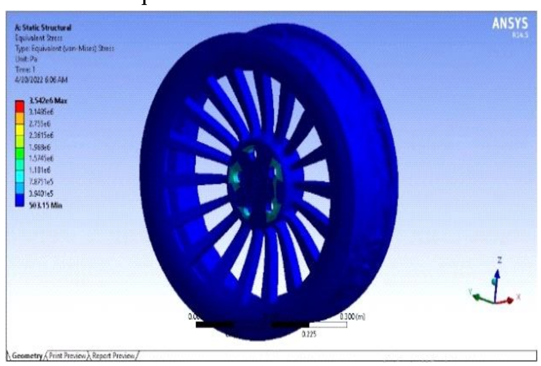
C. Material: Structural Steel

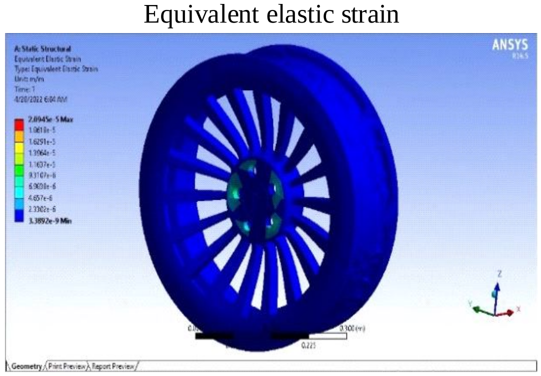
Total deformation



Equivalent von-misses stress

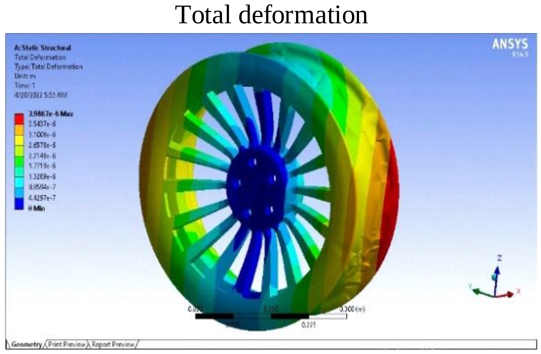


Equivalent elastic strain



D. Material: Titanium Alloy

Total deformation



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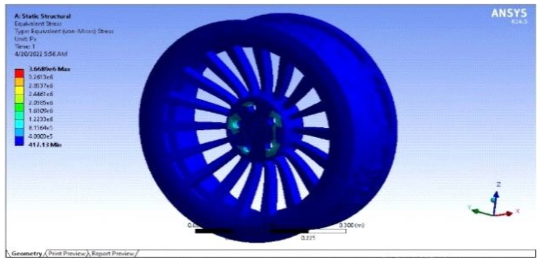
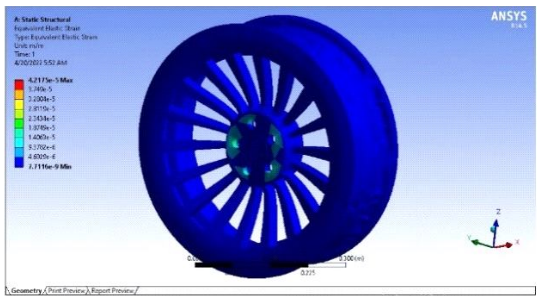
Comparable octahedral-shaear-stress



Identicalresilleint strain



E. Comparison Of Results

Properties / Materials	Stress(pa)	Strain	Deformation(m)
Aluminium alloy	**3.6592x10^6**	**5.777x10^-5**	**5.3914x10^-6**
Magnesium alloy	**3.6395x10^6**	**9.0405x10^-5**	**8.5083x10^-6**
Titanium alloy	**3.6689x10^6**	**4.2175x10^-5**	**3.9867x10^-6**
Structural steel	**3.542x10^6**	**2.0945x10^-5**	**4.4683x10^-5**

V. CONCLUSION

Four material properties—aluminum alloy, magnesium alloy, titanium alloy, and structural steel—are used in our examination of the wheel rim. Titanium alloy has lower deformation values than aluminum alloy, magnesium alloy, titanium alloy, and structural steel, which have total deformation values of 5.3914 x 10-6, 8.50 x 10-6, 3.98 x 10-6, and 4.46 x 10-5, respectively. As a result, we draw the conclusion that titanium alloy can withstand more loads than the other three material.

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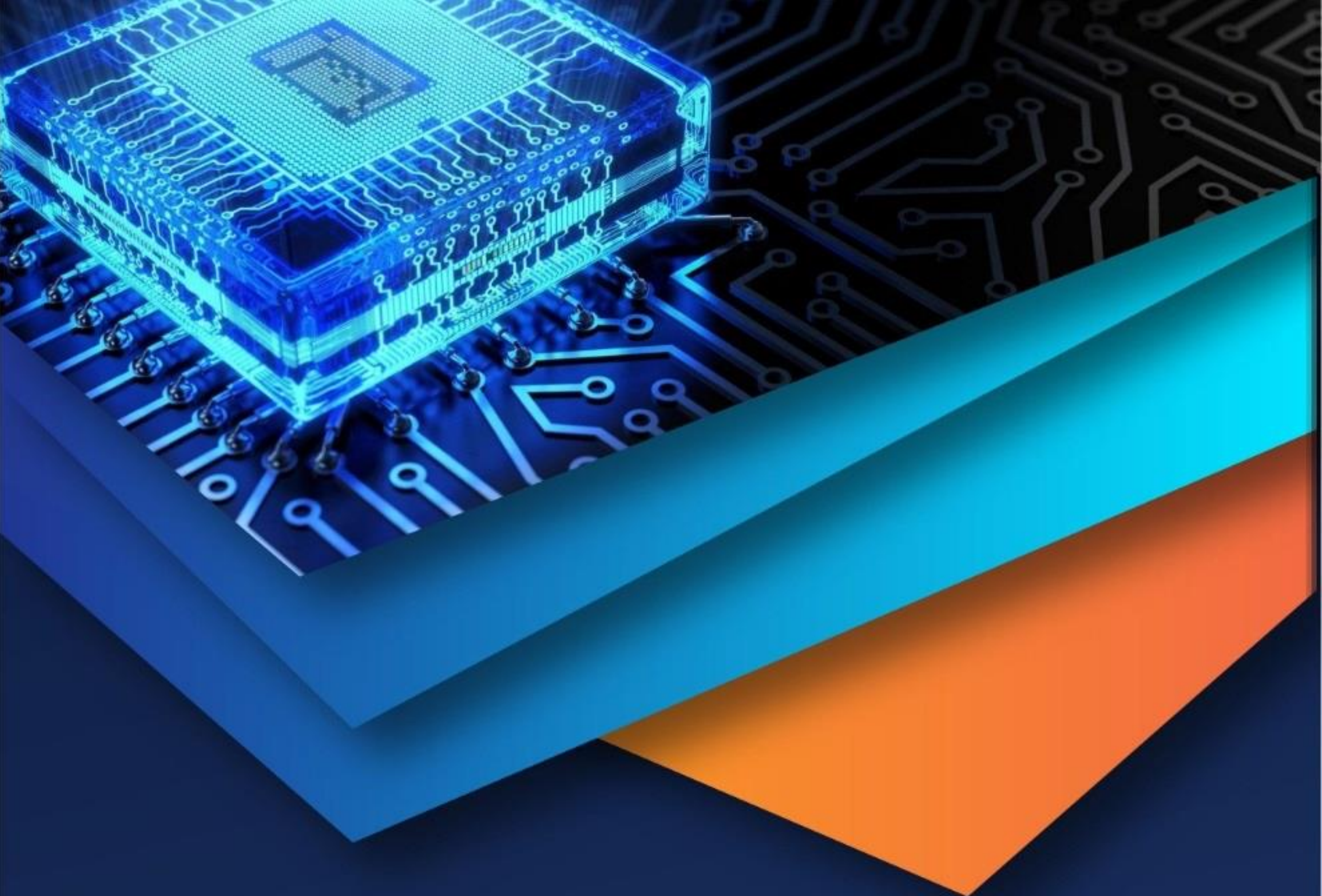

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