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Review of Design and Analysis of Automotive Wheel Rim using Finite Element

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ABSTRACT

The basic function of an automobile wheel rim is to provide as a stable platform for the installation of a tyre. It should have dimensions and a form that are appropriate for the vehicle's specific tyre. Our primary goal is to examine the design process and acquire some key parameters through finite element analysis. Modeling programme catiav5r17 is used to create the wheel rim. The time and risk associated in the design and manufacturing process can be greatly reduced by using this software. CATIA is used to model the rim of the wheel. CATIA modal is afterwards loaded into ANSYS for analytical purposes. Two different materials, aluminium and forged steel, were used in the ANSYS static analysis work, and their relative performance was noticed for each.

Keywords: Drive shaft, Failure analysis, Composite material, FEM

INTRODUCTION

Because of the bending and torsion that it endures, the wheel rim is a particularly vulnerable part of an automobile. Material and manufacturing method selection is critical in rim design because of the long lifespan and severe stresses, as well as the necessity to reduce weight. Materials and manufacturing techniques are in competition with one another because of their cost, performance, and weight. An increasing demand for lighter and more efficient parts in the industry has resulted in the development of new materials that are both lighter and more durable.

The radial fatigue test and the cornering fatigue test are the most regularly used methods for evaluating the fatigue life of aluminium wheel design for passenger cars.

Analytical methods have a tough time evaluating the fatigue life of alloy wheels because of their varied styles and more complex geometries than conventional steel wheels. An accelerated fatigue test is used to determine how long the newly constructed wheel will last in the laboratory. It is based on these results that further modifications to the wheel design are made for increased strength and weight reduction. However, a probability-based model for the prediction of automotive wheel rim fatigue failure will not produce the optimal wheel design as specified by stress analysis. The three most essential materials used in the casting and subsequent production of wheel rims are aluminium alloys, magnesium alloys, and structural steel. All three of these components have varying fatigue lives. Each of these materials has a fatigue life that must be taken into consideration. You can achieve the best parametric design by carrying out experiments. For each of these materials, the thickness of the rim can be changed. For different materials, it is claimed that by altering the thickness level, we can achieve different fatigue strengths. In order to maximise strength without shortening the rim's fatigue life, it is suggested that you utilise optimum thickness. Weight loss might result in cost savings.

Fig. 1 Schematic diagram of wheel rim.

LITERATUREREVIEW

In this part, we'll talk about recent studies that we think are relevant to our current project. This section is dedicated to papers that have been published.

Mangire et al. [1]studied the old rim and compared it to the new rim modelled by him. The rims of a car are absolutely critical. It is the wheel that moves the thing on the surface when the force exerted on it is effective. Alloy wheels, which are more efficient than spokes wheels, are now standard on all modern vehicles. SOLIDWORKS was used to create a paper rim model based on available measurements. One is a standard rim, one is a modified version of a new rim that may be used in new vehicles, and one is a modified version of a new rim that is used on a daily basis.

Patel et al. [2]A report proposes an evaluation of the fatigue life of steel rims. Static findings on steel wheels are obtained through the use of the ANSYS software programme. Aluminum and structural steel are the two main materials employed. This is used to predict the fatigue life of both wheels. Analyses have revealed that the baseline wheel failed the test and that the crack was initiated near the hub in that case as well.

Dr. Torgal et al. [3]The primary goal of this research is to investigate the causes of rim failure. Cracks and bends appear on the rim's surface. An increase in vibration might be caused by tyre damage. An imperfection on the surface of the wheel that could lead to structural collapse due to vibration, pressure, or even rust. According to the research, the rim can experience a variety of failures. This study discusses the use of analysis tools to calculate von-misses stresses and deflections.

Das et al. [4]The paper explains how an aluminium alloy wheel for automobile use might be designed with a focus on reducing the wheel's mass. According to the FEA, it is possible to lower the optimum mass of the wheel rim by as much as 30%. The FEA demonstrates that the optimised component's stress is lower than the alloy's actual yield stress. Component S-N curves show that the component's endurance limit is 90 MPa, which is below the yield stress of the material.

Chaitanya et al. [5]Component weight reduction is being prioritised by car manufacturers in an effort to cut fuel costs. The product's weight can be reduced by the use of new materials and production methods, as well as through a redesign. Because the tyre absorbs the vehicle's entire weight and provides cushioning, reducing the weight of the wheel is more beneficial than reducing the weight of other parts. Unsprung mass reduction can be achieved through weight reduction, which reduces inertia loads and overall weight while increasing performance and fuel efficiency. In this investigation, composites are used instead of aluminium alloy to see if they can lower the weight of the wheel. Wheel rim mass can be reduced by 50% compared to current alloy wheels, according to finite element simulations. Researchers found that following optimization, rim stress will be lower than yield stress, resulting in less stress on the wheel. This led to the development of a new method for optimising passenger automobile wheel rims. An ANSYS and CATIA model is used in this project for analysis.

Parmar et al. [6]Modeling chemical and physical reactions in wheels is discussed in this work. They're critical to the vehicle's security as well, so regular maintenance is required to ensure their longevity. Growth in the automobile industry has an impact on the design, materials, and production processes of rims. In order to improve wheel design, it is necessary to understand how the rims are loaded. Papers using the FEM to assess different boundary conditions are reviewed in this study. For the purpose of improving the rim's life cycle and presenting a modified design solution, stress and fatigue life predictions are evaluated.

Kale et al. [7]An automobile's wheel rim is an essential component. Vehicle propulsion and practical situations such as turning and braking, climatic conditions are some of its primary duties. Wheel rims experience alternating fatigue stress due to the constant rotation that occurs during vehicle propulsion while wheels are rotating continually. It is essential that wheel materials be of high quality in order to withstand a wide range of loads and practical situations. Wheel rim materials and their properties, such as thermal conductivity and corrosion resistance, price, availability and upkeep as well as rim manufactureability from that material, availability and manufacturing processes, are discussed in this paper. Additionally, benefits and drawbacks of various materials are also discussed.

Bawne et al. [8]Wheel rims' primary job is to act as a stable foundation. Their dimensions and form should be appropriate for the vehicle's specific tyre. In this project, a disc wheel rim is taken into consideration. Software is used to create the rim. CATIA is used to create the wheel rim model, which is then loaded into ANSYS for analysis.

K. Venkateswara Rao, Dr. T. Dharmaraju [9] It was determined that steel alloy, which has a higher tensile strength and a greater number of cycles, was found to be the most durable of the several alloys tested, including aluminium alloy, magnesium alloy, and forged steels. He went on to discuss how lowering the rim's thickness can help it perform better.
As more iterations were performed on each of the four materials, the stress distribution and fatigue life of the wheel rim were summarized. The aluminum alloy outperforms the other three materials in terms of the number of cycles it takes to fail, but the steel alloy comes in last. By lowering material consumption, the life of the material can be extended by optimizing the thickness of the material.

Karan Valetava, Paramjethava [10]Here, the author concentrated on the rim's structural behaviour and fatigue life.. Two different materials, aluminium alloy (A356.2) and carbon fibre, are subjected to testing. Analysis is done in ANSYS and the model is built in CATIA. The deformation, alternative stresses, and primary stresses were observed when the load was applied to the material in a static state. The life, safety factor, and spoke wheel damage were all taken into account in the fatigue analysis. In both circumstances, carbon fibre is recommended for a better design, according to the conclusion.

N. Satyanarayana [11]the author calculated the aluminium wheel's overall deformation under radial load conditions to be 0.2833mm. Due of the differing boundary conditions, stress levels of 163 and 0.038% are generated. Fatigue testing at 1.7667106 cycles below the yield strength of aluminium alloy can be used to determine the maximum and minimum wheel life at the cross sectional area of the wheel. Finally, this result was reached by comparing the material's strength to the safe design of the rim.

Siva Prasad [12]Car wheel rim stress and harmonic analysis is performed by Siva Prasad using ANSYS software. "The structural behaviour of an automobile rim is examined in this article under various operational loading circumstances. Between 170 Hz and 420 Hz, 21.3KPa is applied to the perimeter of the wheel rim. The design is safe in all aspects, and aluminium alloy is the best material for the rim because of this.

Sourav das [13]the optimization of the rim mass is given considerable attention in this paper. When altering the rim mass and running numerous iterations to improve rim life, it is important to take into account the finer dimensional factors. A radial load at 00 degrees from the bolt axis and a radial load at 360 degrees from the bolt axis were used to measure the effects. The distortion will be decreased if the load is applied to the rim.

P. Meghashyam et al. [14]forged steel and aluminium wheel rims were subjected to static and Eigenvalue Buckling analysis. Von-misses stresses are less than ultimate strength in both analyses of forged steel and aluminium wheel rims. Aluminum rims have higher deflections than forged steel rims. When compared to aluminium wheels, forged steel rims were shown to be more effective.

Kalpesh et al. [15]built a TATA Indica alloy wheel in CATIA and ran an analysis on it with ANSYS software. Alloy wheels were subjected to a static structural investigation using three distinct materials: aluminium (AL 6061), zinc (ZA 21), and magnesium (Mg) (Mg). Their research focused on alloy wheels, namely ZA 21, which showed the least amount of overall deformation and equivalent stresses compared to the other two materials.

Samuel OnoriodeIgbudu et al. [16]performed a series of tests on an aluminium alloy wheel with a stipulated load of 4750N by maintaining up various weights of 0.3, 0.15, and 0 Mpa, respectively. Different loads and experimental data are used to explore von misses stresses.

G. Ashok Kumar et al. [17] CATIA & ANSYS were used to design an alloy wheel rim and conduct analysis on the results. CATIA was used to perform analyses on aluminium and forged steel wheel rims under a variety of loads and pressures. ANSYS is used to do both static and vibrational analysis, and the results are analysed. They came to the conclusion that forged steel wheel rims have less deflection and recommended them as the optimum material.

Andrew D. Hartz [18]Modeled the classic bicycle wheel using finite elements and compared it to published data. Displacement and strain measurements were made on the wheel. We found that ANSYS modelling was an effective method of investigating simple structures like an old-fashioned bicycle wheel.

Liangmo Wang et.al [19]evaluated fatigue life using a novel method that was proposed Static load finite element models of aluminium wheels for rotary fatigue tests were built using ABAQUS software. For the prediction of aluminium wheel fatigue life, the results showed that merging finite element analysis and the nominal stress approach was effective.

Sunil N. Yadav and N. S. Hanamapure[20]under radial load conditions caused by unevenness in off-road field areas and road camber angle effects on stress distribution and fatigue life of passenger car tyre rims. By replicating actual test conditions, 1259 IJERT ISSN: 2278-0181 IJERTV3IS10570 www.ijert.org uses finite element analysis (FEA) to examine how stress is distributed and how long a steel passenger car wheel rim will last under various levels of fatigue.

III. CONCLUSION & OUTCOME

If experimental and finite element analysis is used to improve the geometry and material optimization, failure of the wheel rim will be avoided. A radial load test on the wheel rim will be used to verify the results and determine the fatigue life of the rim. We came to the following conclusions after examining all of the research.

- It is possible to create wheel rims made out of tungsten, aluminium alloy, zinc alloy, and other composite materials.
- Composite materials let cars go farther on a single charge by reducing their overall weight.
- To determine the exact wheel rim lifecycle, a fatigue life study must be conducted in conjunction with a stress analysis.
- In today's world, comfort and reduced vibration are two of the most significant factors, hence design adjustments are necessary.
- Changes in wheel rim parameters, such as rim diameter, camber angle and caster angle as well as changes in hub diameter and hub width, must be made.

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