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Investigation of lightweight wheel design using alloy materials through structural analysis

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Abstract

Researchers are focusing more on lightweight vehicle design in response to the automotive industry's growing emphasis on energy efficiency and ecological responsibility. Two important considerations, including safety and technical requirements, must be taken into account while constructing a wheel. The rim and spokes make up the construction of the wheel. The creation of cutting-edge wheel and spoke designs for an automobiles is the objective of this paper. The wheel has been subjected to a finite element analysis using ANSYS. Each material's stress and strain performances may be determined by taking into account magnesium alloy, aluminum alloy, and titanium alloy. When analysing the two different designs and three different materials, the findings of the equivalent stress and deformation were compared. This study makes some insightful predictions about the dependability of the structural design, and it offers some helpful references for the design and development of alloy wheels.

Introduction

In response to rising consumer concerns about the environment and the cost of producing vehicles, automakers are paying more attention than ever to how they can reduce fuel consumption and emissions without sacrificing quality. The demand for automobiles is rising as people realize the need of easy transportation to meeting their rising expectations of mobility. The rim wheel is a crucial part of any vehicle since without it, the vehicle cannot move. A rim wheel, also known as a spherical wheel, is a circular component that can revolve on its axis, allowing it to move or transport objects while also supporting them [1]. Rim wheels on vehicles are crucial to their stability and handling. Maximizing vehicle safety with strong rim wheels is possible, but this comes at the expense of performance due to the wheels' mass and inertia. As there are still many wheels out there that do not conform to the criteria, it is important to conduct rim wheel testing in accordance with current regulations. Cracks and other failures in rim wheels are sometimes the result of fatigue. Therefore, routine testing is performed to ensure that particular quality criteria are met [2], [3].

An important part of a vehicle's ability to withstand force is provided by the wheel. To hold the wheel together between the hub and the rim, spokes are often used. The rigidity and strength of these spokes are crucial in preventing the wheel from breaking. Typical modern materials for wheel construction include magnesium alloy, steel, and aluminum alloy. Wheels for vehicles come in a wide variety of designs, and many of them aim to reduce the wheel's weight. Performing a structural analysis of the wheels is sufficient for determining comparable modal considerations during a research of vehicle stability [4]. The primary goals of static analysis are to quantify the resulting displacement and von-Mises stress. Then, using convergent meshing sizes and varying factors like the displacement ratio and the stress ratio, the worth of displacements and stresses was assessed. Different simulation outcomes for various mesh sizes demonstrate that mesh size does, in fact, have an effect on the results of the simulation [5].

This work presents a multi-axial mechanics-based composite elastic–plastic model for off-axis fatigue. Although the difference between on-axis and off-axis fatigue under equivalent load was not great over the same lifespan, testing revealed clear differential damage mechanisms in distinct stress dimensions. Micro damage under off-axis fatigue in wheel steels follows a law that needs more investigation [6]. Performance is of paramount importance in the design and analysis of the many parts that make up the vehicle. The objective is to reduce the vehicle's weight as much as possible so that it can accelerate more quickly and maintain a higher top speed. This report analyses the effects of replacing alloy

wheels with composite ones and describes the design process for doing so. Here, the designing the wheels for both existing and new models of two-wheeled vehicles, with the goal of relieving stress concentrations caused by the former's alloy construction. The wheel can be damaged in several ways during the cyclical motion of riding on varying roadways, one of which being the impact of the rider's weight. Failure typically occurs when the stress value is being removed from the ultimate stress value and fatigue life of the material [1], [7].

Each wheel acts as a primary suspension unit, absorbing both static and dynamic stresses as the vehicle travels. Most wheel makers focus on the rim when it comes to saving weight and money. Today, nearly all wheel manufacturers make wheel rims out of light weight alloys, which decreases unsprang weight and boosts fuel economy. Wheels are often more expensive than tires, but are a good value overall, especially for luxury and racing sports vehicles. The static and dynamic stress and vibrations experienced by a wheel rim during vehicle operation necessitate that it be free of flaws for the vehicle to function properly [8]. Under real-world service conditions, defects like inherent faults and fissures can cause the wheel rim to deform, which can ultimately lead to structural collapse. Because of this, it is important to check that a wheel rim is defect-free before putting it through its paces in actual service, and this is not always achievable [9]. There have been significant attempts in recent times to lower the weight of the components, which in turn reduces the weight of the vehicle as a whole. It has been noticed that a suitable design results in a useful form that distributes the load given to the system in a manner to maintain the applied load, which in turn minimizes the weight of the component. Fatigue study was performed on three spoked wheel designs. Aluminum 6061-T6, a lightweight heat conductor, is used for the wheel rim. Wheel rim dimension is Volkswagen Passat, sedan. For radial endurance test fatigue analysis, SolidWorks and ANSYS construct 3-D wheel rims. Simulation findings include comparable Von-Mises stress, deformation, safety factor, and life cycles [10].

Finite element modelling and solution methods are employed here to perform a detailed structural examination of pre-existing wheels in order to determine their stress levels. After that, we considered the influence of the stress value range we found using FEA to beat the previous wheel expansion pressure calculations. The purpose of this research is to determine how the existing wheels over design can be minimized through the application of the Finite Element Analysis (FEA) approach [11], [12]. After a stress analysis has been performed and a model has been proposed, the bike's specifications will be modified to account for the material's unique features. Tire inflation pressure, rotational speed, and rim moment conditions have all been the subject of extensive study by numerous researchers [13], [14]. Furthermore, research was conducted to determine which of the many potential

rim materials produced the most desirable outcomes in terms of constructing a sturdy wheel rim. In this paper, new design developed for the wheel and spoke designs for the KTM Dukes wheels and it has been subjected to a finite element analysis using ANSYS. Each material's stress and strain performances may be determined by taking into account magnesium alloy, aluminum alloy, and titanium alloy. When analysing the two different designs and three different materials, the findings of the equivalent stress and deformation were compared.

Section snippets

Wheel materials

In most cases, aluminum or magnesium alloys are used to make alloy wheels. Alloy wheels are preferable due to their low weight, superior heat conduction, and aesthetically pleasing design. Alloy wheels are becoming increasingly popular because of their unique characteristics. It was not until the 1980s that aluminum-magnesium alloy wheels were once again widely used in vehicles, despite having been invented in the 1960s. Al and Mg alloys tailored to the needs of alloy wheels have been the focus

Wheel modelling

In this study, the wheel from the KTM DUKE 200 was taken into consideration for the investigation, and it was used as the basis for the design. It had an outer diameter of 462.80 mm, an inner diameter of 200.88 mm, and a hub diameter of 103.95 mm and was a 17-inch wheel. The Fig. 1 shows the base wheel design and Fig. 2 shows the model 1 design with change in spoke design. Fig. 3 shows the dimensional view of model 1 design.

Results and discussion

In this work, the Finite Element model and solution techniques required for the precise computation of structural analysis for finding the value of stress for existing wheels. Afterwards, the stress value range is finding method of FEA we evaluated to overcome acquired from existing calculated wheel allowable expansion pressure is consider impact. The objective of this study focuses on the reduction of over design from existing wheel, which will be calculated by means of FEA method.

The

Conclusion

When it comes to reducing weight and costs, most wheel manufacturers concentrate on the rim. Nearly all wheel manufacturers currently use lightweight alloys for wheel rims, which reduces unsprung weight and improves gas mileage. Wheel rims must be defect-free since they must withstand significant static and dynamic load and vibrations while the vehicle is in use. The design of wheels and spokes for automobiles is an area that may benefit from new design perspectives, and that is the goal of

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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