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Design and optimization of aluminium alloy wheel rim in automobile industry

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Abstract

The unsprung mass of a vehicle is an essential parameter for considering the effective handling of a vehicle. The higher the reduction in the unsprung mass, the higher the handling of the vehicle can be obtained. The part of a wheel that surrounds the circumference of the cylinder and serves as a support for the tyre is called the rim. The rim's primary purpose is to provide support for the tyre and to ensure that it is properly sealed to the wheel. The rim ensures that the tyre fits properly to the rim and maintains the air pressure within the tubeless tyre. The wheel rim is considered for optimization in this project. To reduce the vehicle's unsprung mass and evaluate its steerability, the wheel rim is designed in SolidWorks and the analysis is performed in Ansys academic 2021. The material used for analysis is aluminium alloy Al6061-T4 and the magnesium alloy is AZ80. The parameters such as the pitch circle diameter, lug nut pattern, and the thickness of the rim are considered parameters for design. The existing design is being studied and optimized to get a weight reduction of nearly 58.33 % without any compromise on the safety parameters

of the rim. Considering the cost of the material, it is found that aluminium alloy is comparatively lower in cost than magnesium alloy.

Introduction

Structural steel is said to exhibit the least amount of strain and deformation when subjected to the same static load condition. However, because of its substantial weight, it places a strain on the performance of the engine and ought to be avoided whenever possible. Titanium alloy is the material with the highest stress generation, despite the fact that it is the lightest in weight of all the materials that were considered for this analysis [1], [2], [3], [4]. Titanium alloy is the material with the highest stress generation. Magnesium alloy is another excellent and lightweight material that is highly resistant to corrosion and has found its way into a variety of electronic devices such as cameras, mobile phones, laptop computers, and so on. Magnesium alloy also has a low specific gravity, which makes it easier to transport and store. Aluminum alloys are widely used, lightweight, and cost-effective [5], [6], [7], [8]. These characteristics are a direct result of their large market and higher production.

Due to their synergistic, superior properties, aluminium matrix composites are gaining popularity in a number of industries. In addition to strength, wear resistance is an essential criterion for determining the number of applications for a material. Due to their enhanced mechanical properties, aluminum-based composites are in high demand, especially in the automotive and aerospace industries [9], [10], [11], [12]. Due to its light weight and ease of processing, the synthesis and characterization of aluminium matrix composites have received the most attention of all metal matrix composites. Al6061 was selected as the matrix alloy due to its excellent casting properties, reasonable strength, and suitability for mass production of lightweight metal castings and its widespread applications in industrial sectors, reasonable strength and excellent casting properties [13], [14], [15], [16].

The purpose of this study is to design and optimize the aluminium alloy wheel rim to get maximum weight reduction without any compromise on the safety parameters of the rim.

Section snippets

Methodology

The process of the project starts with the identification of the need for the project and collecting data regarding the future scope in that area of research. The existing design is then selected whose disadvantages are studied from the data collected from the possible methods of eliminating the disadvantage and further enhancing the prime need of the product [17], [18], [19], [20]. A preliminary design is created. This preliminary design is then analyzed with the material selected to get the

Design process

SolidWorks 2021 software is used to for designing the wheel rim. The design process starts with the identification of the need for change or updation in the existing design. The first step of design includes the study of the advantages and disadvantages of the existing design. The existing design is to be optimized in such a way the disadvantages of the existing design are reduced [24], [25], [26]. The second step of the design process includes the parameters to be considered for updating the

Material selection

The materials used for the wheel rim are Aluminum 6061 and AZ80. AZ80 is an alloy of Magnesium consisting of better strength compared to Al 6061 which is an alloy of Aluminum while Al 6061 is cost efficient and easily available compared to AZ80. Both possess better yield strength and are a potential replacement for conventional forged steel (Table 1, Table 2, Table 3).

Analysis

ANSYS 2021 R1 Academic is used for analysis. Businesses are able to solve a wide variety of analysis problems while maximising their existing software and hardware investments with the help of ANSYS Inc.'s flexible, enterprise-wide engineering systems. These systems are provided by ANSYS Inc., which also helps to support the ongoing development of innovative technology. ANSYS, Inc. is still at the forefront of technological advancement. It also supports a process-centric approach to design and

Results

The first set of designs and analyses includes the existing design with varying lug nut patterns. Three designs consisting of 4, 5, and 6 lug nuts have been created and analyzed

using the selected material. From the analysis, the best results are obtained for the design containing 6 lug nut patterns. This result is due to the stress being evenly distributed among the six patterns and the load-carrying capacity is better for the design containing 6 lug nuts.

The second set of designs and analyses

Conclusion

Considering the material used for the design aluminium 6061 provides a factor of safety of 2.09 while the magnesium alloy AZ80 provides a very high safety factor of 4.03. Considering the cost of the material, it is found that aluminium alloy is comparatively lower in cost than magnesium alloy. Also, the fact that Aluminum is furthermore easily available compared to magnesium it can be concluded that aluminium 6061 can be a possible replacement for the conventional forged Steel material. The

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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