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STUDY ON VARIOUS MATERIALS FOR SELECTION OF SUITABLE MATERIAL FOR WHEEL RIM IN AUTOMOTIVE APPLICATIONS-A REVIEW

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Abstract: -

This research paper work involves the study of different materials that can be used in the automotive applications for the manufacturing of wheel rim. So for the better knowledge of materials and their properties a detailed literature survey was performed. With the selection of material for the wheel rim a study on design and analysis of automotive wheel rim using Ansys software can be carried out to have the exact results.

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Introduction: -

A wheel rim is known to be a highly stressed component in an automobile as it is subjected to bending and torsional loads at the time of running condition of vehicles. Because of the long life and high stresses, as well as the need for weight reduction, material and manufacturing process selection is important in rim design. There are competitions among materials and manufacturing processes, due to cost performance, and weight. This is a direct result of industry demand for components that are lighter, to increase efficiency, and cheaper to produce, while at the same time maintaining deformation, stress, strength and other functional requirements.

Literature Review: - Jitendra et al.[1]

involves the design and analysis of automotive wheel rim using Ansys software. we have design this wheel rim using Catia and imported into ansys software for further analysis. In this work we are going to carry out the radial load fatigue test on newly designed rim with material and design optimization. Also validate the results experimental results.

A Review on Modelling and Analysis of Car Wheel Rim using CATIA & ANSYS by **Siva**

Prasad et al.[2] does stress analysis of car wheel rim by using CATIA & ANASYS. To determine best material for wheel so that by design and modifications the stresses can be reduces to improve the fatigue life of wheel rim. During this he considered two different materials namely aluminium and forged steel and their relative performances have been observed respectively. In addition to wheel rim is subjected to modal analysis, a part of dynamic analysis is carried out its performance is observed. In this paper they concluded that by observing the results of both static and dynamic analysis obtained forged steel is suggested as best material.

Sourav Das et al.[3] gives design of aluminum alloy wheel for automobile application which is carried out paying special reference to optimization of the mass of the wheel. The Finite Element analysis it shows that the optimized mass of the wheel rim could be reduced to 26Kg to 12.15kg as compared to the existing solid disc type Al alloy wheel. The FE analysis carried out which shows that the stress generated in the optimized component is well below the actual yield stress of the Al alloy. The Fatigue life estimation by finite element analysis, under radial fatigue load condition, is carried out to analyze the stress distribution and resulted displacement in the alloy wheels. S-N curve of the component depicts that the endurance limit is 90MPa which is well below the yield stress is 185MPa of the material and safe for the application. The FE analysis indicated that even after a fatigue cycle of 1×1020, the damage on the wheel is found only 0.2%. And the damage region is found the flange portion of the rim.

Rajarethinam P et al. [4] presented paper on motorcycle wheel spokes. The radial, lateral, and tangential stiffness of motorcycle wheels spokes depends upon the rim's bending inertia, torsion inertia, the spoke sizes, and the spoke geometry. The spokes of rear bicycle wheel of different spoke patterns were instrumented with strain gauges in order to investigate the effect of the spoke pattern on the spoke strain and fatigue resistance properties of the wheels. Analytical and numerical studies show that spoke strains due to radial loads and in service conditions are insensitive to the spoke pattern. Small variations in the spoke strains between the wheels in the road tests can be attributed to variations in the loads, but do not significantly affect the fatigue life of the wheels.

S. Ganesh et al.[5] gives analysis of alloy wheels which are made from an alloy of aluminum or magnesium metals or sometimes a mixture of both. At present four wheeler wheels are made of Aluminum Alloys. In this project a parametric model is designed for Alloy wheel used in four wheeler by collecting data from

reverse engineering process from existing model. Design is evaluated by analyzing the model by changing the design of rim styles to be strong and balanced. The wheel is analyzed for the calculated loading condition and the stress plot is obtained. In the case of bending test normal stress along Y-axis shows compression on the top rib and tension on the bottom rib and compression on the bottom rib. In the case of pressure loading, normal stress along X-axis shows compression on the top rim and on the inside portion of the rim there is a gradual transition from compression to tension. Normal stress along Y-axis shows bending stress coming on to ribs because when the rim is getting compressed, it forces the rib to move outwards. In the case of vertical loading normal stress along Y-axis shows tension on the outer rib and compression on the outer side of the rib. When a section plot is taken it will show a gradual transition from tension to compression.

Hongyu Wang et al. [6] gives the parametric three dimensional model of the rim section is built based on Solid Works, the finite element method is used to analyze stress and displacement distributions in a variable cross-section rim subject to the conjoint influence of radial load and inflation pressure. The optimization methods which combined multi island genetic algorithm (MIGA) with sequential quadratic programming (NLPQL) is used for exploration. By adjusting control parameters of the rim shape quality is optimized. The results show that the optimization effect is good.

Numerical simulation of steel wheel dynamic cornering fatigue test by **Shu-Qin Pan et al. [7]** presented a computational methodology is proposed for fatigue life and failure prediction of automotive steel wheel by the simulations of dynamic cornering fatigue test. The fatigue life and crack initiation locations are calculated using effective strain, Brown–Miller damage criterion, rainflow counting method and Palmgren–Miner cumulative damage rule. They concluded that according to stress analysis of the key locations based on the critical plane theory, two principle stresses are not proportional and unstable principle planes are changing with loading direction. Principle planes variation changes a little, varying from -400 to 300, and the stress states of automotive steel wheel are in biaxial tensile and compression stresses during dynamic cornering fatigue test. and it is conservative and considerable to observe that fatigue test cycles and crack initiation locations are predicted using Brown–Miller damage criterion, which are close to the actual test results, and the minimum error is -4.4%.

Fatigue life prediction of a heavy vehicle steel wheel under radial loads by using finite element

analysis by **N.S. Kuralay et al.[8]** gives analysis about The origin of fatigue failure that occurs on the air ventilation holes of a newly designed heavy commercial vehicle steel wheel in dynamic radial fatigue tests is studied. In these tests, all of the test samples failed in the same regions. The cause of this damage was studied via finite element analysis. In order to determine the reason of the fatigue failure, stress analysis was performed via the finite element method. In this way, stress concentrated regions, where fatigue failure is expected, were determined. Mechanical properties of the wheel material were determined by tensile tests and hardness measurements. The fatigue life of the damaged wheel was estimated using the stress–life (S–N) approach, utilizing the ultimate tensile strength of the processed wheel material and the Marin factors determined for the critical regions. To extend the life of the wheel disc and delay the onset of fatigue, design enhancement solutions were applied.

Liangmo Wang et al.[9] explain how To improve the quality of aluminum wheels, a new method for evaluating the fatigue life of aluminum wheels is proposed in this paper. The ABAQUS software was used to build the static load finite element model of aluminum wheels for simulating the rotary fatigue test. The equivalent stress amplitude was calculated based on the nominal stress method by considering the effects of mean load, size, fatigue notch, surface finish and scatter factors. The fatigue life of aluminum wheels was predicted by using the equivalent stress amplitude and aluminum alloy wheel S-N curve. The results from the aluminum wheel rotary fatigue bench test showed that the baseline wheel failed the test and its crack initiation was around the hub bolt hole area that agreed with the simulation. Using the method proposed in this paper, the wheel life cycle was improved to over 1.0×105 and satisfied the design requirement. The results indicated that the proposed method of integrating finite element analysis and nominal stress method was a good and efficient method to predict the fatigue life of aluminum wheels.

Sunil N. Yadav et al.[10] gives effect of camber angle on stress distribution and fatigue life of wheel rim of passenger car under radial load condition which arises due to off road field area and road unevenness. Finite element analysis (FEA) is carried out by simulating the test conditions to analyze stress distribution and fatigue life of the steel wheel rim of passenger car. Experimental analysis performed by radial fatigue testing machine for evaluation of fatigue life under influence of camber angle. For radial fatigue testing SAE J328 standard is use. This SAE recommended practice provides minimum

performance requirements and uniform procedures for fatigue testing of wheels intended for normal highway use and temporary use on passenger cars. The finite element analysis as well as experimental analysis of passenger car wheel rim performed for radial load with the effect of camber angle on stress distribution and fatigue life.

Conclusion: -

With growing demand on off road vehicles wide range of materials are used for the manufacturing of wheel rims. New design of wheel rims is common craze among the young generations of users. For the manufacturing of vehicle rim various materials are available in the market which can give robust strength and structure to the wheel rims. Among the common variety Al alloy and Mg alloys are used in wide range. But changing the material can provide the strength in the rim structure but at the same time it also increases the overall weight of vehicle decreasing the efficiency and performance of vehicles. So in this study various materials are considered for the study which can provide the multiple benefits of strength as well as low weight. During the literature survey various materials were studied to have the detailed knowledge of mechanical and thermal properties of materials.

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