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Modal Analysis and Design Optimization of Automotive Wheel Rim

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ABSTRACT

The wheel is a device that empowers efficient movement of an object over a surface where there is a force acting on the item to the surface. Though there are various types of wheels are being used, presently each vehicle was composed with composite wheels which are more efficient and effective than the conventional spokes wheels. In this work, the designing of rim is carried out using the CATIA modeling software. There are two variants of wheel rims: the first one, widely known as hub or solid rim, is employed in regular vehicles and the other modified one, commonly known as the modified spokes rim, is being employed in modern vehicles. In this paper, an investigation has been made to optimize the mass of the hub rim through the use of finite element analysis. The rims are analyzed in ANSYS by using three types of materials (i.e., Al alloy, Mg alloy and steel alloy).

KEY WORDS: Wheel rim, Stress, Deformation, Strain Analysis.

1. INTRODUCTION

The general construction of rim consists of a hub, and spokes tires. The combination utilized as a part of the finest street wheels today is a blend of aluminum and different components. Sometime the magnesium wheel used incorrectly to describe the alloy wheels because, Magnesium is generally thought to be an unacceptable composite for street since Magnesium is brittle in nature and corroded easily and fastly. In market, Now- a-days only Aluminum alloys are used. Pure aluminum has a high electrical conductivity, ductile, soft and corrosion in nature. But it is necessary to provide the higher strengths by alloying with other elements. Aluminum composite wheels are thrown into a mold in a hot fluid state and cooled, which makes them more precise in both the heavier and lighter ranges. The end result is a balance that has less weight on the wheel and less stress on the tire. In the case of heavy load condition steel wheels are preferred and for a medium and low load condition Al and Mg are preferred.

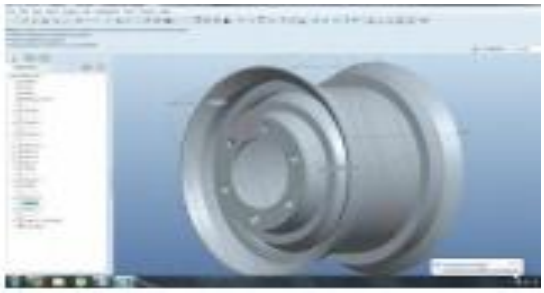

Figure.1. Reference Hub Model

From the Fig.3, the CATIA model of 5-spokes wheel has been invented. From the Figs.4, 5, 6, the stress, deformation and strain for aluminum alloy has been analyzed by using ANSYS, from the Figs. 7, 8, 9, the stress, deformation and strain for steel alloy has been analyzed by using ANSYS, from the Figs.10, 11, 12, the stress, deformation and strain for magnesium alloy has been analyzed by using ANSYS.

Design of Wheel Rim: The CAD configuration of wheel is taking into account the standard classification at the external and the internal dimensions of the wheel (Ravi Kumar, 2013). Below figure shows the CAD design of the wheel rim before optimization.

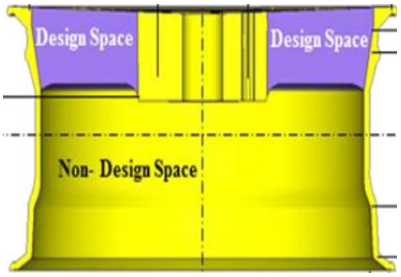

Figure.2. CADD Design

In the optimization of wheel rim, the wheel structure and its features are divided into two types they are, a) design space, b) non design space. The non-design space is the standard design. It cannot be modified. The design space is the region for optimizing the shape and weight of the arms. The design of the wheel space is reduced in order to withstand the load of the vehicle with the factor of safety with a least quantity of material and manufacturing cost and losses.

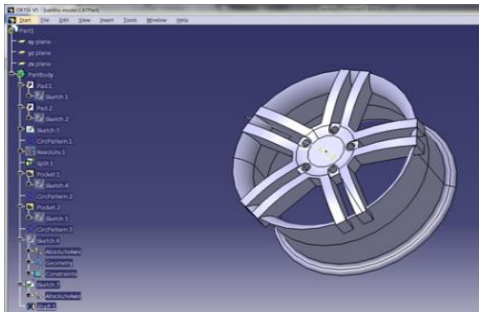

Figure.3. CATIA Model of 5 Spoke Rim

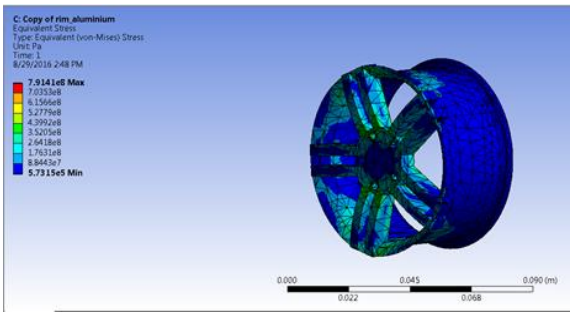

Figure.4. Stress on Al alloy Wheel Rim

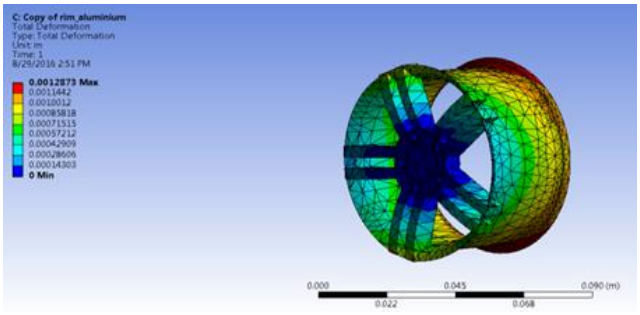

Figure.5. Total deformation on Al alloy Wheel Rim

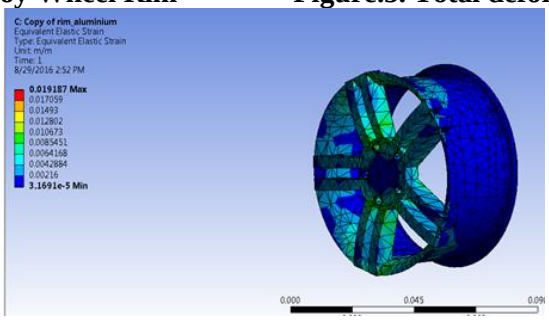

Figure.6. Equivalent strain on Al alloy Wheel Rim

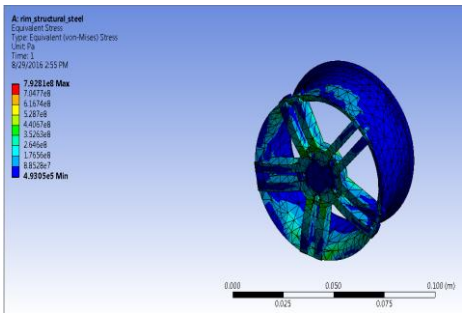

Figure.7. Stress on Steel Wheel Rim

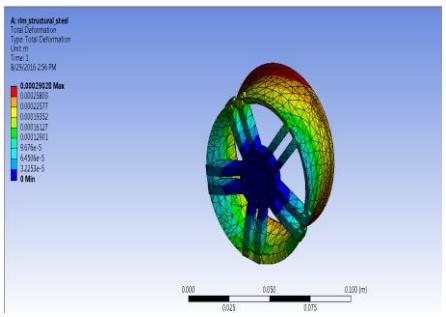

Figure.8. Deformation on Steel Wheel Rim

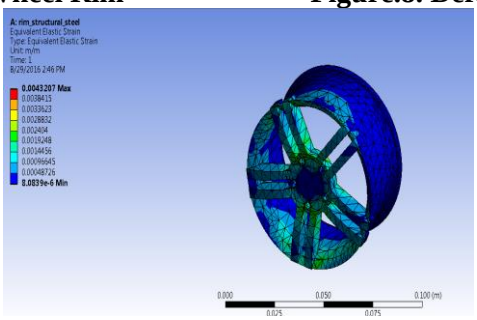

Figure.9. Equivalent Strain on Steel Wheel Rim

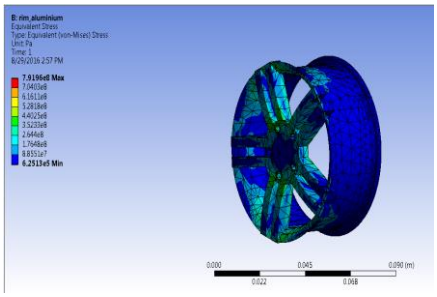

Figure.10. Stress on Mg Alloy Wheel Rim

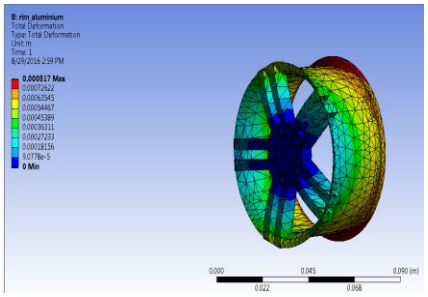

Figure.11. Deformation on Mg Alloy Wheel Rim

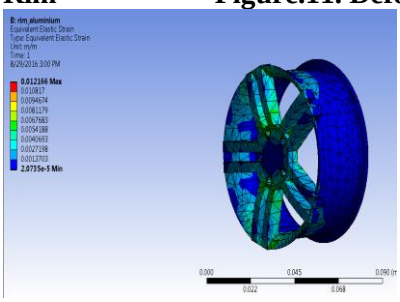

Figure.12. Equivalent Strain on Mg Alloy Wheel Rim

3. RESULTS

Table.1. Results of Static Analysis

Model		Material Used		
		Al alloy	Steel	Mg alloy
Modified-5 spokes model	Stress	7.8146e8	7.928e8	7.829e8
	Deformation	0.001287	0.00029	0.00072
	Strain	0.019187	0.00432	0.01216

4. CONCLUSION

The modeling is done in CATIA and the model was saved in the IGES format and imported into ANSYS. In the ANSYS software the analysis of 5 spokes model done by changing the materials. The results were tabulated and compared in the above table. We came to know that for actual rim the stress values are low for Mg alloy compared to all other alloys, But Mg alloy has lack of ductility, the alloy wheel lost their favor in vehicles. The Al Alloy values are nearer to the Mg alloy. For the adjusted 5 spokes model the values of stress are low for Al compound compare with different composites and the others are almost same for Mg alloy and the circumstance is proceeds as genuine rim model. From this we conclude that steel compound not to suggest for a rim fabricating and the Al combination is useful for a wide range of rim assembling in the second place Mg alloy might be used. In the consideration of models the new optimized 5-spokes can be used by changing the ribs thickness, from this weight of the rim can be reduced.

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