Modeling and Fatique Analysis of Automotive Wheel Rim

Sreenivasulu. B
M.TECH(Machine Design)
Sphoorthy Engineering College

Ch. Vijaya Kumar (M.TECH) CAD/CAM
student in TKR Engineering College
MEERPET(V), Saroornagar Mdl, R.R Dist.

ABSTRACT

Wheel rim is one of the main parts which are used as protection for passengers from front and rear collision. The aim of this study was to analyze and study the structure and material employed for car wheel rim in one of the national car manufacturer. In this study, the most important variables like material, structures, shapes and impact conditions are studied for analysis of the wheel rim in order to improve the crashworthiness during collision. The simulation of a bumper is characterized by impact modeling using pro-e. According to the result of Displacement, stress of the wheel rim at various materials that is given in order to analyses the results. This speed is according to regulations of Federal Motor Vehicle Safety Standards, FMVSS 208- Occupant Crash Protection whereby the purpose and scope of this standard specifies requirements afford to protection for passengers. In this research, the four types of materials were selected the materials are alloy steel,aluminium alloy,magnesium alloy and forged alloy

INTRODUCTION

In hundreds of years ago humans was to make the wheel using wooden material and wheel rim are also same material as a wood to make the rim. After introducing reinforced material replace the material to make the wheel disc made of reinforced material. Spokes were replaced with a disc made of steel plate. This material still being used to in this days.

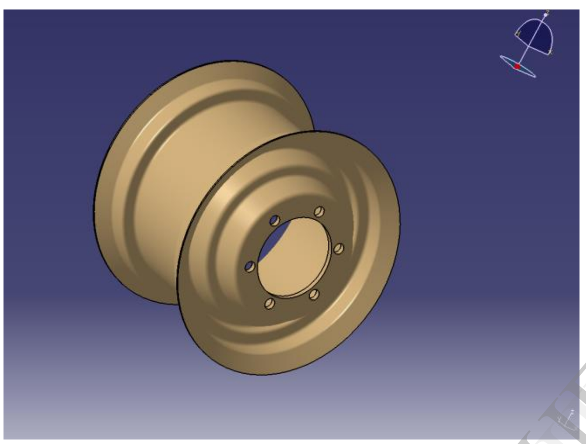
Standard automotive wheel rim is made by rectangular sheet metal. The metal is bent to produce a cylindrical sleeve. Car wheels need to be durable and able to carry around weight. So we required materials are good stability and high strength, good durability.The rim of a wheel is the outer circular design of the metal on which the inside edge of the tyre is mounted on vehicles such as automobiles. A standard automotive steel wheel rim is made from a rectangular sheet metal. The metal plate is bent to produce a cylindrical sleeve with the two free edges of the sleeve welded together. To support the cylindrical rim structure, a disc is made by stamping a metal plate. It has to have appropriate holes for the center hub and lug nuts. The radial outer surface of the wheel disk has a cylindrical geometry to fit inside the rim. The rim and wheel disk are assembled by fitting together under the outer seat of the rim and the assembly welded together.

In this project, wheel rim made of five materials that are steel alloy, aluminium alloy, and high-strength magnesium alloy is studied by crash simulation analysis to determine the stress, displacement. The main characteristics are compared between all the materials to find best material and structure. The results show that a magnesium alloy can minimize and reduce the stresses compare to other material. Commercial bumpers, Have studied that accidental always occur in front side. Applied load on rim in to ansys and meshed in order to get a simulation results. The energy absorption capability of the composite materials offers a unique combination of reduced weight and improves crashworthiness of the vehicle structures magnesium alloy rim show the good result for better performance compare to other materials.

WHEEL RIM DIMENSIONS

Outer diameter	450 mm
Hub hole diameter	150 mm
Bolt hole diameter	20 mm
Rim width	254 mm

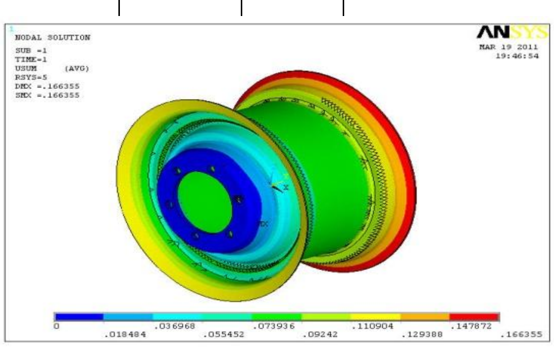
MODEL OF THE RIM



DISPLACEMENT PLOTS

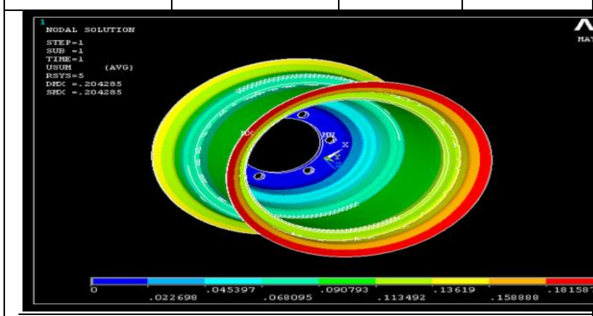
STEEL ALLOY

name	type	minimum	maxi
DISPLACEMENT	RESULTANT DISPLACEMENT	0.018 mm	0.166 mm



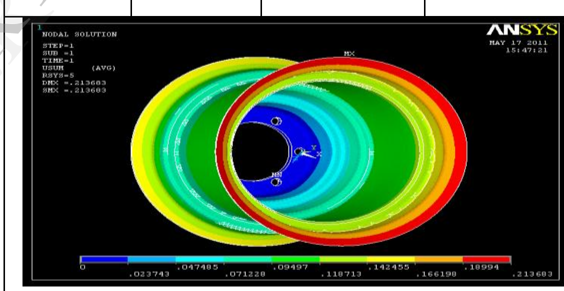
ALUMINIUM ALLOY

name	type	minmum	aximum
displacement	Resultant displacement	0.02	0.20



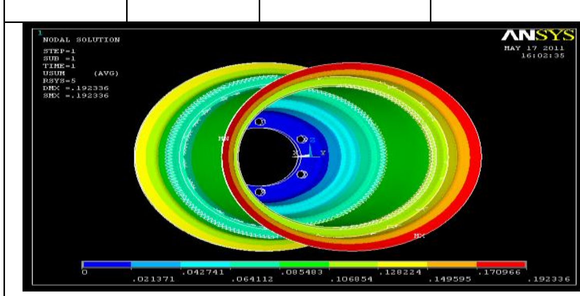
Magnesium alloy

name	type	minimum	maximum
stress	Von-misses stress	0.02374	0.21 36



FORGED STEEL

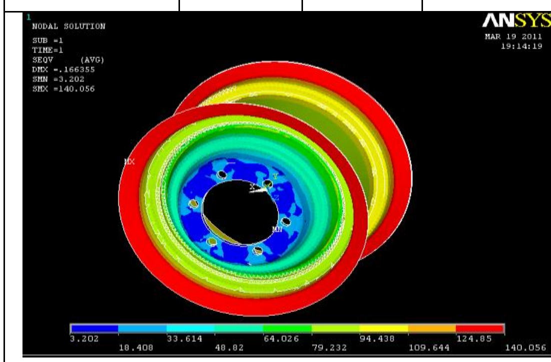
name	type	minimum	maximum
stress	Von-misess stress	0.0213	0.1923



ANALYSIS OF STRESSES

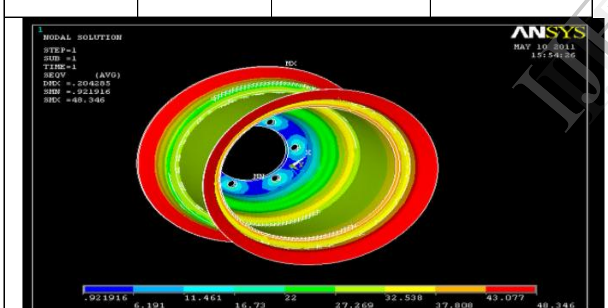
STEEL ALLOY

name	type	minimum	maximum
stress	Von-misess	3.02 Mpa	140.056 Mpa



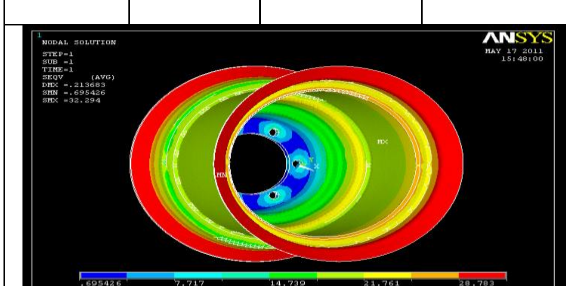
ALUMINIUM ALLOY

name	type	minimum	maximum
stress	Von-misess	0.921	48.34



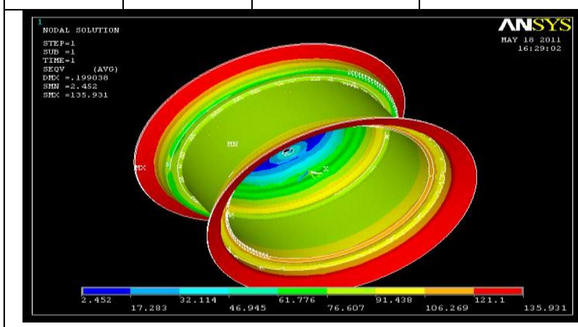
MAGNESIUM ALLOY

name	type	minimum	maximum
stress	Von-misess	0.6954	32.2 9



FORGED STEEL

name	type	minimum	maximum
s tress	Von-misess	2.452	135.93



RESULD AND DISCUSSION

Material properties

Steel alloy:

Young's modulus (E) =2.34*10^5 N/mm^2

Yield stress=240 N/mm^2

Density =7800kg/m^3

- **Aluminum alloy:**

Young's modulus (E) =72000 N/mm^2

Yield stress=160 N/mm^2

Density =2800kg/m^3

- **Magnesium alloy:**

Young's modulus (E) =45000N/mm^2

Yield stress=130 N/mm^2

Density =1800kg/m^3

- **Forged steel:**

Young's modulus (E) =210000N/mm^2

Yield stress=220 N/mm^2

Density =7600kg/m^3

Results obtained from softwares:

Steel alloy:-

Von misses stress (σ_v) =140.056 N/mm^2

Aluminum alloy:-

Von misses stress (σ_v) =48.326 N/mm^2

Magnesium alloy:-

Von misses stress (σ_v) =32.204 N/mm^2

Forged steel:-

Von misses stress (σ_v) =135.931 N/mm^2

RESULT Table

material	displacement (mm)	vonmisses stress (mpa)	fatigue strength (cycles)
Steel alloy	0.1663	140.056	$2.17*10^5$
Aluminium alloy	0.204	48.326	$1.32*10^5$
Magnesium alloy	0.2136	32.29	$1.2*10^5$
Forged steel	0.1923	135.931	$1.97*10^5$

CONCLUSION

1) The von misses stresses developed in steel alloy during static analysis is 140.056 N/mm^2 at load 21.3KN the stress is below yield stress of material for these stress range we have to find at what number of cycles the component is yielding or crack is going to initiates
2) The von misses stresses developed in aluminum alloy during static analysis is 48.326 N/mm^2 at load 21.3KN the stress is below yield stress of material for these stress range we have to find at what number of cycles the component is yielding or crack is going to initiates
3) The von misses stresses developed in Magnesium alloy during static analysis is 32.294 N/mm^2 at load 21.3KN the stress is below yield stress of material for these stress range we have to find at what number of cycles the component is yielding or crack is going to initiates.
4) The von misses stresses developed in Forged steel during static analysis is 135.931 N/mm^2 at load 21.3KN the stress is below yield stress of material for these stress range we have to find at what number of cycles the component is yielding or crack is going to initiates
5) From results we can make out, in steel alloy the Number of cycles to failure (N_f)= $2.17*10^5$Cycles is greater than Aluminium, Magnesium, Forged steel. Hence Steel alloy is more feasible to use than aluminum.
6) Hence steel alloy have more life and durability compared to aluminum.

REFERENCES

ACA., 2000. Model Year Passenger Car and Truck Thermoset Composite Components. Automotive Composite Alliance, Troy, Michigan.

Busch, J., 2000. Composite Technologies: An Overview of Business Potentials. IBIS Associates, Inc., Wellesley, Massachusetts.

Cheon, S.S., D.G. Lee and J.H. Choi, 1995. Development of the composite bumper beam for passenger cars. Composite Struct., 32: 491-499.

Fuchs, E.R.H., F.R. Field, R. Roth and R.E. Kirchain, 2008. Strategic material selection in the automobile body: Economic opportunities for polymer composite design. Composites Sci. Technol., 68: 1989-2002.

Hosseinzadeh, R., M. Shokrieh and L.B. Lessard, 2005. Parametric study of automotive composite bumper beams subjected to low-velocity impacts. J. Composite Struct., 68: 419-427.

Kim, J.K., 2008. Impact Experimental Analysis and Computer Simulation. Department of Mechanical Engineering, Louisville.

Marzbanrad, J., M. Alijanpour and M.S. Kiasat, 2009. Design and analysis of automotive bumper beam in low speed frontal crashes. Thin-Walled Struct., 47: 902-911.

Mazurkiewrcz, M. and Y.L. Tien, 1997. Crash simulation of car bumper. Comput. Struct., 26: 141-741.

Ramakrishna, S. and H. Hamada, 1998. Energy absorption characteristics of crash worthy structural composite materials. Eng. Mat., 141-143: 585-622.

Sheshadri, A., 2006. Design and analysis of a composite beam for side impact protection of occupant in a sedan. M.Sc. Thesis, Wichita State University, College of Engineering, Dept. of Mechanical Engineering. http://soar.wichita.edu/dspace/handle/10057/292.

Sujit, D., 2001. The Cost of Automotive Polymer Composites: A Review and Assessment of DOE's Lightweight Materials Composites Research. Oak Ridge National Laboratory, USA.

Yuxuan, L., 2003. Automobile body light weighting research base on crashworthiness numerical simulation. Ph.D. Thesis, Shanghai Jiao Tong University, China.

CH.VIJAYA KUMAR(M.TECH) CAD/CAM

P.G Research scalar,