International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 7; Issue 6(C); June 2018; Page No. 13289-13291
DOI: http://dx.doi.org/10.24327/ijcar.2018.13291.2362

Research Article

TOPOLOGY OPTIMIZATION OF WHEEL RIM OF HEAVY VEHICLE

Pratyush Deshmukh*

Amity School of Engineering and Technology, Amity University Mumbai

A R T I C L E I N F O

Article History:

Received 8th March, 2018
Received in revised form 24th April, 2018 Accepted 16th May, 2018
Published online 28th June, 2018

Key words:

Topology, optimisation, simulation, rim

A B S T R A C T

The study is mainly focused on improvisation and optimisation of mass of wheel rim of heavy vehicles such as fleet trucks, trailers, earth moving vehicles, tractors, dump trucks, concrete transport vehicles, etc. Vast amount of mass optimisation research has been done on wheel rims of light commute vehicles or sports cars however little or negligible amount of research has been done on wheel rims of heavy vehicles. Primary objective is to decrease the weight if the wheel by which the overall performance and efficiency of the vehicle is increased. The material assignment to the base model is structural steel. Post design optimisation, the rim is subjected to material optimisation wherein the optimised design is assigned multiple competitive materials and analysed and observed under same boundary conditions. Solid modelling of base model and redesigning is done on Solid Works. Static Structural Analysis and Topology Optimisation simulations are executed on ANSYS Workbench software.

INTRODUCTION

Automotive Wheels have developed over decades since inception. The ancient wheel rims were made of wood and stone. As research and development flourished during the industrial revolution, the wheel rim being a critical and crucial part of the vehicle was focused on with excessive effort. In today's date the wheel rim is majorly made of two materials namely Structural Steel and Aluminium or Aluminium Alloy. The heavy vehicles however are a scope of optimisation which has been ignored by the researchers. In the age where composite materials are replacing the traditional metal alloys due to their due to their high strength and low mass, they can be tested for possible replacement for certain parts in the automotive sector.

LITERATURE REVIEW

Dhondiram Pawar, Vidyasagar Bajaj in their paper worked to reduce the weight of wheel without affecting its primary function. It is based on optimization of wheel rim by changing Material with polymer matrix composite and taking stress and weight into consideration [1].Research of Mayur Khule, P. Bhaskar deals with shape optimization including stress analysis and weight reduction. In their paper different variants of FORD ECOSPORT has been taken as a benchmark in order to modify its dimensions [2]. S. Chaitanya, B.V. Ramana Murty worked to minimize the weight of the wheel by reducing the weight of wheel rim. With the help of finite element calculation it is found that mass of the wheel rim can be reduced by 50%. Stress generated from rim after optimization is below yield stress [3]. K. Venkateshwar Rao, Dr. T. Dharmaraju in their paper presented detailed static analysis displacement, maximum and minimum von-mises stresses and fatigue analysis of wheel rim under radial loads has been done [4]. Project work of Dr.Santhosh Kumar, Jaya Kumar, ShajinMajeed aims to Modal Analysis and Design Optimization of Automotive Wheel Rim. The designing of rim is carried out using the CATIA modelling software & are analysed in ANSYS by using three types of materials (i.e., Al alloy, Mg alloy and steel alloy). In the case of heavy load condition steel wheels are preferred and for a medium and low load condition Al and Mg are preferred. The model was saved in the IGES format and imported into ANSYS [5]. Mr.P.H.Yadav, Dr.P.G.Ramdasi in their work optimized the wheel by reducing the weight of the rim using finite element analysis. Thickness of rim was reduced from 3mm to 2mm (outer) & 2.5mm (inner) which reduced 13.28% of weight of the rim [6]. Saurav Das designed an aluminium alloy wheel is meeting all the design standards. Topology optimization is carried out on 5 cyclic cases on Abacus software [7]. The aim of this project carried out by S. Chaitanya, B.V Ramana Murty was to optimize the weight of wheel rim of automobile using Mass Optimisation technique. The author had considered different materials as competitive replacement materials of aluminium alloy i.e. magnesium alloy. Titanium alloy & PEER 30% of carbon reinforce [8]. The objective of the paper presented by Ch. P.V. Ravi Kumar and Prof. R. Satya Meheris Topology optimization of cast aluminium alloy wheel by increasing the thickness of wheel rim until the plastic strain value is below 4%. Main objective is to generate finite element model using Hyper mesh V10.0 [9]. Hasnain Habibstudied the feasibility of a component made of unconventional materials.

Corresponding author:* **Pratyush Deshmukh
Amity School of Engineering and Technology, Amity University Mumbai

They have carried four different types of tests: Try alternative bending, Try rolling, and Try alternating torque, Side impact test. Solid work software was used for 3d modelling. Manipulation of geometric model to prepare it and turn it into mathematical model was done in ANSYS mechanical [10].

METHODOLOGY

Designing of Base Model

The dimensions of the wheel rim were obtained by reverse engineering and a solid model of the wheel rim was generated on Solid Works 18. The solid model of the base design can be seen in Figure 1.

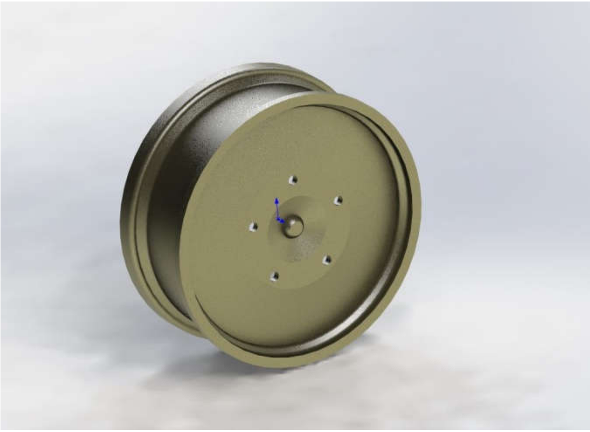

Figure 1 Base Design

Calculation of Loading Condition
Radial Load:
Weight of vehicle
Radial load per wheel= GVW/6
(Where GVW= NVW+ Payload)
GVW= 25000kg= 245.25kN
Radial load per wheel= 245.25/6= 40.875kN

Meshing for Structural Analysis

A .STEP file of the wheel rim model was saved in Solid Works. For the static structural analysis this external geometry file was imported in ANSYS Workbench 18. A medium size tetrahedron global mesh is suitable and more adaptable for complex geometries such as that of wheel rim and was therefore applied for the finite element analysis. A uniform medium size meshed model can be seen in Figure 2.

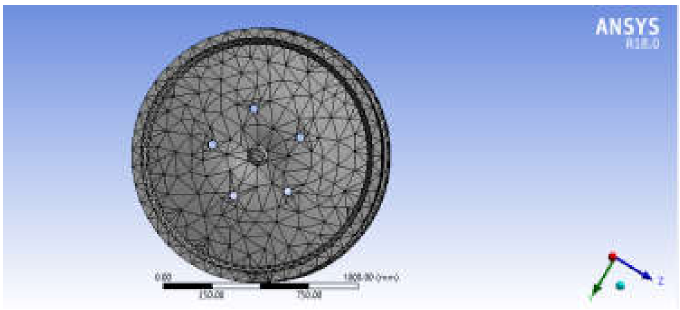

Figure 2 Meshed Model

Boundary Conditions

A fixed support was applied in the areas where the wheel rim will be bolted and fixed to the hub assembly. A Remote Load of 40.875kN was applied on the face at which load of the vehicle is maximum.A graphical understanding of the boundary conditions for the analysis can be obtained from Figure 3.

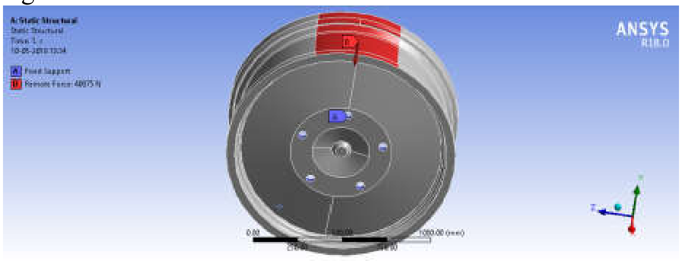

Figure 3 Boundary Conditions

Solution of Static Structural Analysis

Since Von Mises theory satisfies the behaviour of both ductile and brittle materials, Von Mises Stress is calculated in the solution along with total deformation. Figure 4 and Figure 5 describe the Equivalent Von Mises stress and Total Deformation results on the base model respectively. It is observed that the bolted regions are the critical areas where the stress is maximum.

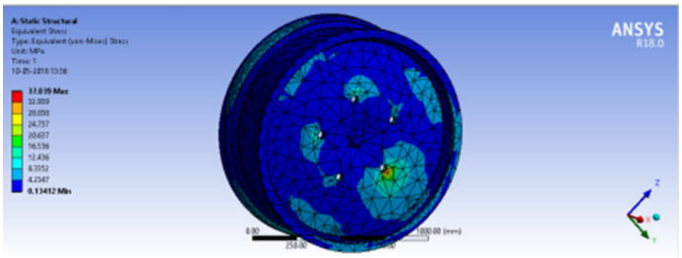

Figure 4 Equivalent Von Mises Stress

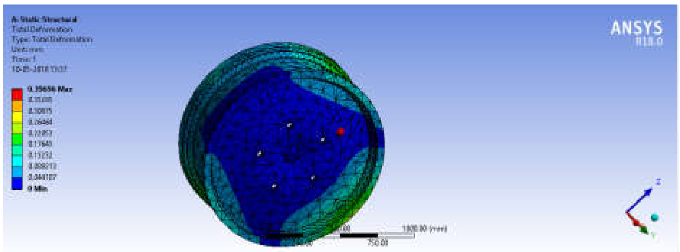

Figure 5 Total Deformation

Topology Optimisation

The results of static analysis were imported in topology optimisation simulation on ANSYS Workbench. Designable and non-designable areas were defined for the topology optimisation by manual geometry selection of surfaces. The outer surfaces of the rim and bolted areas are defined as exclusion region of the topology optimisation simulation to maintain the shape of the wheel rim and avoid interference with tyre or other parts of the hub assembly. The percentage of mass to retain was defined as 50% and the results were obtained after 18 iterations. Taking reference from the result of topology optimisation simulation, 4 patterns of geometries were generated to remove the material from the base design. After performing static structural analysis of all the optimised models, the model with the least weight was taken as an optimised model. The solid model of the optimised model can be seen in Figure 6.

Figure 6 Optimised Model

Material Optimisation

A post modification, the optimised model was subjected to 4 static analysis simulations where in the 4 different materials were assigned to the optimised model and were further evaluated for mass and other characteristics. The materials are Magnesium Alloy, Aluminium Alloy, Grey Cast Iron and FR4 Epoxy Material.

RESULTS AND CONCLUSION

Behaviour of competitive materials on the optimised geometry can be seen in the simulation result table of competitive materials in Table 1.

Table 1 Simulation result chart of Competitive Materials

Material(s)	Mass (kg)	Equivalent Von-Mises Stress (MPa)	Total Deformation (mm)
Magnesium Alloy	139.67	31.610	2.9182
Aluminum Alloy	214.93	31.447	1.8555
Grey Cast Iron	558.66	31.110	1.2037
FR-4	142.66	33.608	7.5904

From the results it can be concluded that the Magnesium Alloy gives the best result. The Equivalent Von-Mises Stress for Magnesium Alloy is 31.610MPa which is less than the yield stress and the Total Deformation is 2.9182mm which is under the safe conditions.The main focus is to optimize the mass of the wheel rim in order to reduce the fuel cost efficiency and performance of the vehicles. The mass of the wheel rim is reduced from 725.80kg for Structural Steel to 139.67kg for Magnesium Alloy which is around 80.73% reduction in mass. Therefore magnesium alloy is the most suitable material for the wheel rim.

References

1. P.H. Yadav, P.G. Ramadasi, "Optimization of Car RIM Using OptiStruct", *Journal of Environmental Science, Toxicology, and Food Technology*, 2012, Vol. 2, PP. 10-15.
2. Ch. P V Ravi Kumar and R. Satya Meher, “Topology Optimization of Aluminum Alloy Wheel”, *International Journal of Modern Engineering Research,* 2013, Vol. 3, PP. 1548-1553.
3. Sourav Das, "Design and Weight Optimization of Aluminum Alloy Wheel", *International Journal of Science and Research Publications,* 2014, Vol. 4, PP. 2250-3153.
4. S. Chaitanya, B.V.Ramana Murty, “Mass Optimization of Automobile Wheel Rim”, *International Journal of Engineering Trends and Technology* (IJETT) – Volume 26, Number 3- August 2015
5. D. Santhosh Kumar, Jaya Kumar, Shajin Majeed, “Modal Analysis and Design Optimization of Automotive Wheel Rim”, *Journal of Chemical and Pharmaceutical Sciences* January - March 2017, 667 JCPS, Volume 10, Issue 1
6. Dhondiram Pawar , Vidyasagar Bajaj, “ Optimisation of Wheel by Wheel Disc Flow Forming Technology”, *International Journal of Innovative Research In Technology* 182 © July 2016, IJIRT, Volume 3, Issue 2
7. Mayur Khule , P. Baskar, “Stress Analysis and Shape Optimization of Wheel Rim”, *International Journal for Research in Applied Science & Engineering Technology* (IJRASET) ©IJRASET, Volume 4, Issue V, May 2016
8. Mr. Sushant K. Bawne, Prof. Y. L. Yenarkar, “Optimization Of Car Rim”, *Int. Journal of Engineering Research and Applications,* Vol. 5, Issue 10, (Part - 2) October 2015
9. Hasnain Habib, “Shape Optimisation of Automotive Wheel Rim”, *International Journal of Engineering and Scientific Research*” Vol6, Issue 10, September 2016
10. Truck Dekho. (n.d.). *Trucks*. Retrieved from Truck Dekho: https://trucks.cardekho.com/en/trucks/mahindra/blazo-25

How to cite this article:

Pratyush Deshmukh (2018) 'Topology Optimization of wheel rim of Heavy Vehicle', *International Journal of Current Advanced Research,* 07(6), pp. 13289-13291. DOI: http://dx.doi.org/10.24327/ijcar.2018.13291.2362

****