

## Modification of Design and Analysis of Motor Cycle Wheel Spokes

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**Abstract:** Spoke is one of some number of rods radiating from the center of a wheel connecting the hub with the round traction surface. The term originally referred to portions of a log which had been split lengthwise into four or six sections. The radial members of a wagon wheel were made by carving a spoke into their finished shape. Eventually, the term spoke was more commonly applied to the finished product of the wheelwright's work, than to the materials he used.

The radial, lateral, and tangential stiffness of spokes motorcycle wheels depends upon the rim's bending inertia, torsion inertia, the spoke sizes, and the spoke geometry. The spokes of three rear bicycle wheels 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. Spoke strains due to radial loads

Spoked bicycle wheels are efficient, highly evolved, structural systems. A useful analogy for a bicycle wheel supporting vertical loads is that of a circular beam on a pre stressed elastic foundation, fixed at the center and loaded radially at the circumference.

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.

**Key Words:** Motorcycle wheel, Spokes, Modified design, Lightweight alloy-wheel, Stress analysis.

### I. Introduction

Aluminum wheels should not fail during service. Their strength and fatigue life are critical. In order to reduce costs, design for light-weight and limited-life is increasingly being used for all vehicle components. In the actual product development, the rotary fatigue test is used to detect the strength and fatigue life of the wheel. Therefore, a reliable design and test procedure is required to guarantee the service strength under operational conditions and full functioning of the wheel.

Design is an important industrial activity which influences the quality of the product. The wheel rim is designed by using modeling software SolidWorks v2012. In modeling the time spent in producing the complex 3-D models and the risk involved in design and manufacturing process can be easily minimized. So the modeling of the wheel rim is made by using Solid Works. Later this Solid Works model is imported to ANSYS for analysis work. ANSYS software is the latest used for simulating the different forces, pressure acting on the component and also for calculating and viewing the results. A solver mode in ANSYS software calculates the stresses, deflections, bending moments and their relations without manual interventions, reduces the time compared with the method of mathematical calculations by a human.

### II. Objective

To create simulations of various no of spokes on the alloy wheel designs that focus on reducing the mass of the current design and selecting better material. The new designs include reducing on the Weight of spokes, and modifying the circular intersection at the intersection of the spoke and the hub. The main objective is reducing the weight of the wheel and also reducing on stress without exceeding allowable stress on the specified material.

### III. Material Properties of Aluminum Alloy 6061 Wheel

Aluminum is a metal with features of excellent lightness, thermal conductivity, corrosion resistance, characteristics of casting, low temperature, machine processing and recycling, etc. This metals main advantage

is reduced weight, high accuracy and design choices of the wheel. This metal is useful for energy conservation because it is possible to re-cycle aluminum easily.

Table 1. Al alloy Material Properties

Mechanical Property	Value
Proof Stress	270 MPa
Tensile Strength	310 MPa
Elongation	12 %
Hardness Vickers	100 H
Shear Strength	190 MPa
Elastic Modulus(GPa)	71
Poisson's Ration	0.33
Mass Density (kg/m3)	2800
Yield Strength (MPA)	225

#### IV. Modeling of Wheel Rim

SOLIDWORKS is software which is used for creation and modifications of the objects. In SOLIDWORKS and design and modeling feature is available. Design means the process of creating a new object or modifying the existing one. Drafting means the representation or idea of the object. Modeling means create and converting 2D to 3D. By using SOLIDWORKS software, create the model of the wheel rim.

Table2. Shows Geometric Properties of alloy wheel

Hub Diameter	120mm
Hub thickness	8mm
Rim thickness	6mm
Rim outer diameter	500 mm
Spoke Length	155 mm
Spoke fillet radii □ at hub 5R	Spoke fillet radii □ at hub 5R

at outer rim 7R & 13R

##### A. Steps Involved In Design

- 1) Draw the profile diagram of the wheel rim
- 2) Now revolve the profile body with respect to y-axis.
- 3) By selecting the face of wheel, the required design is drawn on the surface is removed by using Cut operation.
- 4) By using circular pattern the specific design is obtained all over the rim. Once again selecting the face draw the circle for and rotate them using circular pattern.
- 5) From holes using cut option.
- 6) And finally using the EDGE FILLET option the side edges are made filleted for final finishing

#### V. Structural Analysis Of Alloy Wheel

Static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. A static analysis, however, includes steady inertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads

##### A. Analysis


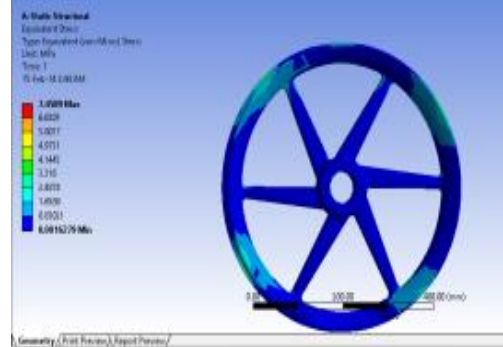

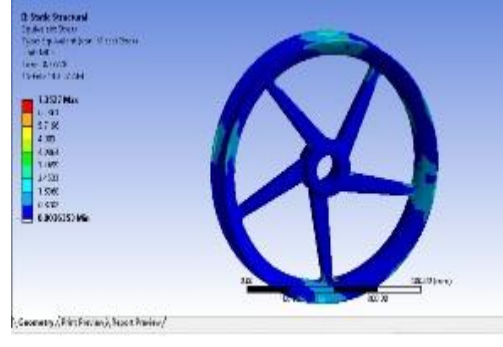

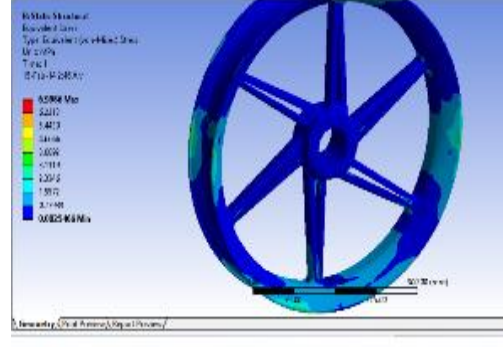
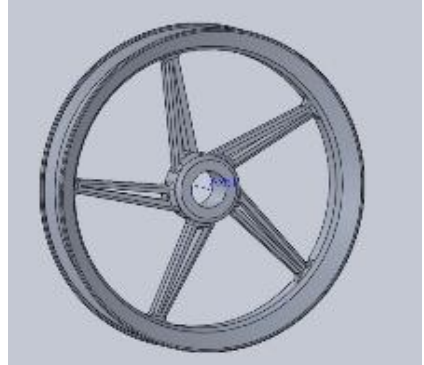

Designers and engineers primarily use structural simulation to determine the strength and stiffness of a product by reporting component stress and deformations. The type of structural analysis performs depends on the product being tested, the nature of the loads, and the expected failure mode. A short/stocky structure will most likely fail due to material failure (that is, the yield stress is exceeded).For the given below specification of the allow wheel, the static analysis is performed using solid works to find the maximum safe stress and the corresponding pay load. After geometric modeling of the alloy wheel with given specifications it is subjected to analysis. The Analysis involves the following discretization called meshing, boundary conditions and loading.

##### B. About analysis with ANSYS

The reliability of ANSYS software proved by doing valediction problem in simply supported beam, which is shown appendix 1. The theoretical values of simply supported beam compared with ANSYS values and its

almost same. So we consider ANSYS software for our analysis to get accurate results. The ANSYS computer program is a large-scale multipurpose finite element program. ANSYS is used for solving several engineering analyses. The analysis capabilities of ANSYS include the ability to solve static and dynamic structural analyses, steady-state and transient heat transfer problems, mode frequency and buckling eigen value problems, static or time varying magnetic analyses and various types of field and couple field application.

Table:III Simulation result details

Design	No of Spokes	Isometric view	Stress Analysis
Normal Design	6		
	5		
Modified Design	6		
	5		

**C. Analysis for strength needed**

Mass of Bike, Dead Weight of Bike =143kg

Other Loads = 20 Kg

Total Gross Weight =143 + 20 = 163 Kg  
= 163X 9.81 N

Tires and Suspension system reduced by 30% of Loads

$W_{net} = 163 \times 9.81 \times 0.7 \text{ N} = 1119.32\text{N}$

Reaction Forces On Bike=Nr = 1119.32N

Number of Wheels: 2

But by considering total Reaction Force on only one wheel FT =1119.32N

Rim surface area which is having 6 spokes: A6 = 48299.69 mm<sup>2</sup> (this can be obtained from selecting faces on rim by using measuring tool in solid works)Stress on the each Rim = = 0.02321 N/mm<sup>2</sup>

Rotation velocity = v/r

For men accelerate motorcycle from 0 to 80km/hr

Rotation velocity = 22.22/.250

= 88.88 rad/sec

**D. Applying Braking Torque**

In general Acceleration of the street motorcycle:  $a = (v_f - v_i) / t$

$v_f$ - final velocity= max of 60miles in 3.5sec

$v_i$ - initial velocity = 0 miles,

$\Rightarrow a$  - acceleration = 7.6636m/s<sup>2</sup>

Brake force is required to estimate the load on the wheel hub.

Now Total force acting on the vehicle:

Mass of the vehicle including rider and other five more persons M= 163+65X6

$F_{total} = M \times a = 4237.9 \text{ N}$

**VI. Results and Discussions**

Stress analysis values for 6 and 5 Spokes Al alloy wheels are in Table 4 . The modified spokes on the wheel Stresses induced in the 6,5 Spokes Al Alloy wheel (6.9959MPa,7.686MPa)is less as compared with the Stresses induced in the 5, 6 Spokes of the motorcycle Al alloy (AM60A), and also the modified design has to been achieved on the weight reduction.

**VII. Conclusions**

- 1) The maximum stress area was located at Spoke-Rim contact.
- 2) Stresses induced in 5Spokes Alloy wheel are less as compared with Al-Alloy of the 6 Spokes.
- 3) The modified design to the wheel are less than normal design of the Al-alloy wheel of the rim.
- 4) Induced Stress due to braking torque in the 5 Al-Spoke wheel are lesser than the remaining wheels.
- 5) Material reduction can be done by reducing number of Spokes. The objective was to reduce the weight of the alloy wheel has been achieved.
- 6) The current design is 8.31,7.3567% lighter than the original design (Table 5 & 6).
- 7) The objective was to reduce the weight of the alloy wheel has been achieved.

Table IV: Stress analysis values for 6,5 Al alloy wheels

Design	No. of Spokes	Load MPa	Rim Pressure N/mm <sup>2</sup>	Stress on the Rim N/mm <sup>2</sup>		Deformation mm
Normal design	6	1119.32	.023	7.4589	.0006279	1.335 e <sup>5</sup>
	5			7.3527	.0036353	1.3308 e <sup>5</sup>
Modified Design	6	1119.32	0.023	6.9986	.0025466	1.4178 e <sup>5</sup>
	5			7.2936	.00010103	1.4093e <sup>5</sup>

Table V: Weight (N) reduction in the model

No. of spokes on the wheel	Weight for Normal design	Weight for Modified design	% o weight reduction
6	22331.875	20474.1567	8.3181
5	21043.529	149495.413	7.3567

### REFERENCES

- [1] Saran Theja , Shankar G, Vamsi Krishna , Design Analysis of Two Wheeler Lighter Weight Alloy Wheel, Indian Journal of Engineering, Volume 6, Number 15, November 2013
- [2] Angmo Wang, Yufa Chen, Chenzhi Wang, Qingzheng Wang. Fatigue Life Analysis of Aluminum Wheels by Simulation of Rotary Fatigue Test thesis in School of Mech Engineering, Nanjing University of Science & Technology, China, 2009
- [3] Satyanarayana N, Sambaiah Ch. Fatigue Analysis of Aluminum Alloy Wheel under Radial Load. IJMIE, 2012, 2(1), 1-6
- [4] Wei-Chan Chang “Modeling for Impact Test of Aluminum Wheels”, Department of Mechanical Engineering National Central University Jhong- Li 32001, Taiwan, R.O.C, 2008.
- [5] Riesner M, DeVries RI. Finite Element Analysis and Structural Optimization of Vehicle Wheels. In Proceedings of International Congress & Exposition - SAE, Detroit, MI, 1993
- [6] Saurabh M Paropate, and Sameer J Deshmukh, Modelling And Analysis Of A Motorcyclewheel Rim, Int. J. Mech. Eng. & Rob. Res. 2013.
- [7] P. Meghashyam, S. Girivardhan Naidu and N. Sayed Baba, Design and Analysis of Wheel Rim using CATIA & ANSYS, IJAEMVolume 2, Issue 8, August 2013 ISSN 2319 - 4847
- [8] Alexandru Valentin RADULESCU, Sorin CANANAU, Irina RADULESCU, Mechanical Testing methods concerningTHE STRESS ANALYSIS FOR A VEHICLE WHEEL RIM, Mechanical Testing and Diagnosis ISSN 2247 – 9635, 2012 (II), Volume 2, 33-39.
- [9] Amalia Ana DASCĂL, Daniel CĂRĂULEANU, WHEELS AUTO MODELING USING FINITE ELEMENT METHOD, ANNALS OF FACULTY ENGINEERING HUNEDOARA – International Journal Of Engineering, Tome IX (Year 200 2011). Fascicule Extra. ISSN 1584 – 2673.
- [10] .Rohit Rajvaidya1, Amit Kushwaha2, Shyam Barode3, Shubham Sharma4, Application of PEEK Material in Alloy Wheel and its Static Analysis, International Research Journal of Engineering & Applied Sciences www.irjeas.com, Volume 1, Issue 1, Jan 2013 – Mar 2013, ISSN: Applied for Page 21-28.
- [11] [http://en.wikipedia.org/wiki/Alloy\\_wheel](http://en.wikipedia.org/wiki/Alloy_wheel)