Research Paper on Design Modification and Analysis of Automobile wheel Rim Using Finite Element Analysis

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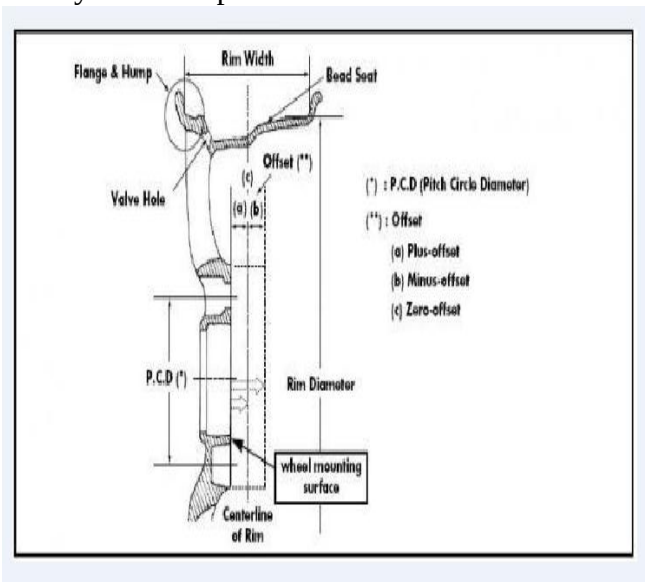
Abstract— Importance of wheel in the automobile is obvious. The vehicle may be towed without the engine but at the same time even that is also not possible without the wheels, the wheels along the tire has to carry the vehicle load, provide cushioning effect and cope with the steering control. Generally wheel spokes are the supports consisting of a radial member of a wheel joining the hub to the rim. Spokes make vehicles look great but at the same time they require attention in maintenance. To perform their functions best, the spokes must be kept under the right amount of tension. If a spoke does break, the wheel generally becomes instantly unbalanced also the hub may break. The purpose of the car wheel rim provides a firm base on which to fit the tire. The motorcycle riders are subjected to extreme vibrations due to the vibrations of its engine, improper structural design of the motorcycle and the bad road conditions. So in this project the attempt has been made to reduce the vibrations of vehicle by providing springs instead of the spokes at the wheel. The springs will work as suspension members at wheels as well as they will provide proper strength that is adequate to proper operation of the wheel. The CAD model of a motor cycle will be made in solidworks and later it is analyzed in ANSYS 14.5. The results of suspension of ordinary wheel rim and spring based rim will be compared.

Key words: Wheel Rim, Solidworks, ANSYS, Stress Analysis

I. NOMENCLATURE OF WHEEL

1) Wheel: Wheel is generally constitute of rim and disc
2) Rim: This is a part where the tire is installed
3) Disc: This is a part of the rim where it is fixed to the axle hub
4) Offset: This is a space between wheel mounting
5) surface where it is bolted to hub and center of the line.
6) Bead Seat: Bead seat approaches in contact with the bead face and it is a part of rim which holds the tire in a radial direction
7) Hump: It is a bump what was put on the bed seat for the bead to prevent the tire from sliding off the rim while the vehicle is moving



II. INTRODUCTION

Several thousand years ago was the start of the history of wheel when the human race began to use the log to transport heavy objects. The original of the wheel were the round slices of a log and it was gradually reinforced and used in this form for centuries on both carts and wagons

There are many different types of wheel rims and they can be divided into many types depending on the manufacturing processes material used etc. As shown in Fig.1 shows different kinds of wheels like steel disk, aluminum alloy and spoke wheel which all are used for different purposes today.

Steel disc aluminium alloy spoke wheel

Fig 1: Types ff Wheel Rim

The steel disk wheel and the light alloy wheel are the most typical installation. The method of manufacturing the light alloy wheel, which has become popular in recent years, is explained here. The manufacturing method for the light alloy wheel is classified into two. They are cast metal or the forged manufacturing methods.

Accordingly they also can be divided into one-piece, two piece and three-piece rims. Wheel rims can be

made by different manufacturing methods like casting and forging.

The present scenario in automobile industry focuses on continually reducing weight of the automobile and maintaining the efficiency constant or increasing it. Different material has been used on the same design for reducing weight of the automobile and still materials or design modifications scope are there to reduce weight as well as maintain efficiency. Another most important aspect is to reduce the vibrations at as least as possible to get a comfortable ride.

III. LITERATURE REVIEW

Saurabh M Paropate* et al.(1) a parametric model was designed for Alloy wheel used in two wheelers from existing model of pulsar 150 cc. For modal analysis, the model was built, loads were applied and solutions were obtained. A fatigue lifetime prediction method of alloy wheels was proposed to ensure their durability at the initial design stage. Aluminum, magnesium, carbon fiber and thermoplastic resin were analyzed for the present model. For all comparing the three materials of stress, displacement, total deformation, weight, and cost of material suggestion was that the thermoplastic resin is best material for wheel rim but due to their high manufacturing cost presently we are not using this material.

S Vikranth Deepak1*, C Naresh and Syed Altaf Hussain(2) In this project a parametric model was designed for Alloy wheel used in four wheeler by collecting data from reverse engineering process from existing model. Car model is Ford Fiesta. Aluminum, zinc and Magnesium materials were compared for model and analysis showed that aluminum alloy was best for the model of wheel rim for load, factor fatigue life, stress, strain, total deformation etc.

Ravi Lidoriya, SanjayChaudhary and Anil Kumar Mohopatra (3) In this project work the entire wheel design of two wheeler was chosen and analyzed by applying different load and redesign the wheel again to minimize the deformation and material will be changed from aluminum to PEEK(polyether ether ketone). After analyzing all the materials it is clear that PEEK 90HMF20 is best material for the replace of Aluminum material.

Saran Theja M1, Shankar G, Vamsi Krishna M(4) A typical alloy wheel configuration of Suzuki GS150R commercial vehicle is chosen for study. Finite element analysis has been carried out to determine the safe stresses and pay loads. The present work attempts to analyse the safe load of the alloy wheel, which will indicate the safe drive is possible. The author derived that stresses induced in 4-Spokes Alloy wheel are less as compared with Al-Alloy of the 5and 6 Spokes. The weights of the Mg alloy with 4-Spokes wheel is less as compared with Al-Alloy of the 6, 5 and 4 Spokes. Fatigue life cycle for the Mg-alloy is more as compared with all Al-alloys materials.

IV. MODELLING OF WHEEL RIM

Initially the 2D drawing of wheel rim is done by using Solidworks according to dimensions specified in the Table

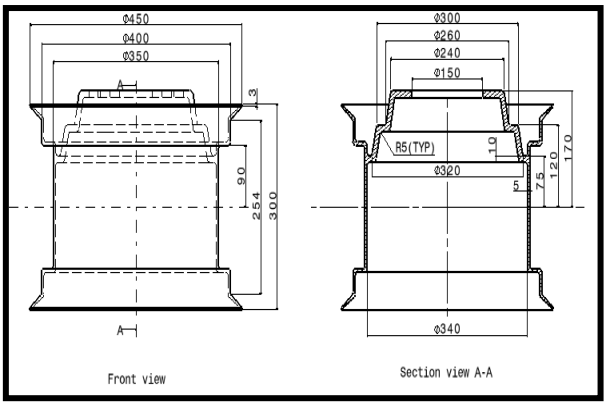


Fig. 2:

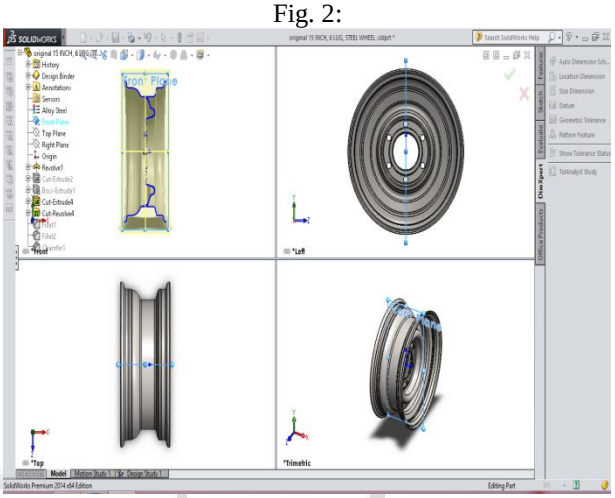


Fig. 3:

V. EXPERIMENTAL INVESTIGATION AND CALCULATION

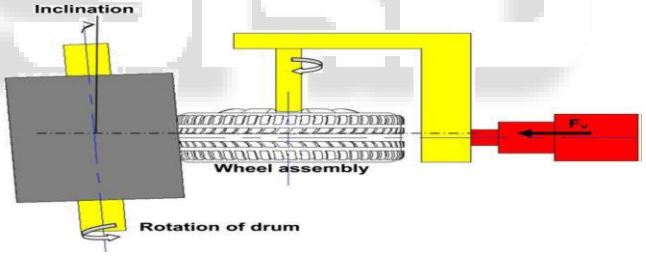


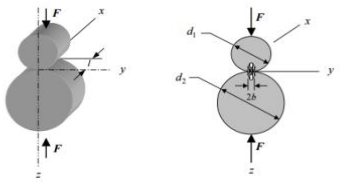
Fig. 4:

Generally the test criteria are for the wheel to complete a minimum number of cycles or miles prior to test termination. The test termination is an inability to support load due to disc crack, loose fasteners, or loss of inflation pressure due to fatigue crack is identified in some specifications. Other specifications use the loss of inflation pressure or inability to sustain the load as the main determination.

After completing 6,00,000 no. of revolutions when the inspection of 8,00,000 cycles was taken then it was found that the crack was initiated near the bolt circle and the fatigue life was so inspected between 6 lacs to 8 lacs cycles and the defined area for crack initiation was the bolt circle of the wheel.

A. Cylinder-Cylinder Contact Stress OR Hertzian Stress

Consider two solid elastic cylinders held in contact by forces F uniformly distributed along the cylinder length l.



(a) Two right circular cylinders held in contact by forces F uniformly distributed along cylinder length l.

(b) Contact stress has an elliptical distribution across contact zone of width $2b$.

$$b = K_b\sqrt{F}$$

$$\text{where } K_b = \left[\frac{2}{\pi l}\frac{(1-\nu_1^2)/E_1 + (1-\nu_2^2)/E_2}{(1/d_1)+(1/d_2)}\right]^{1/2}$$

F = applied force

ν_1, ν_2 = Poisson's ratios for cylinders 1 and 2

E_1, E_2 = elastic modulii for cylinders 1 and 2

d_1, d_2 = diameters of spheres 1 and 2

l = length of cylinders 1 and 2 ($l_1 = l_2$ assumed)

VI. FINITE ELEMENT ANALYSIS

Summary of Parameters used for static and Fatigue Steady

Sr.	Parameters	Symbols	Data
1	Radial test load	F_r	12301.74 N
2	Wheel Design load	F_x	570 kgf
3	Acceleration factor for safety	K	2.5
4	Tire Pressure	P_i	550 kPa
5	Element type	Tetrahedron	Tetrahedron
6	Rotational velocity	ϖ	62.5 rad/s

A. Von Mises Stress Result:

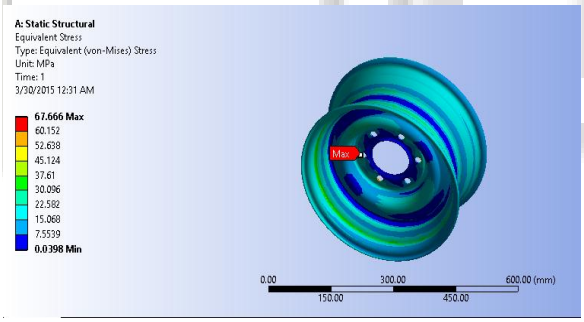


Fig. 5:

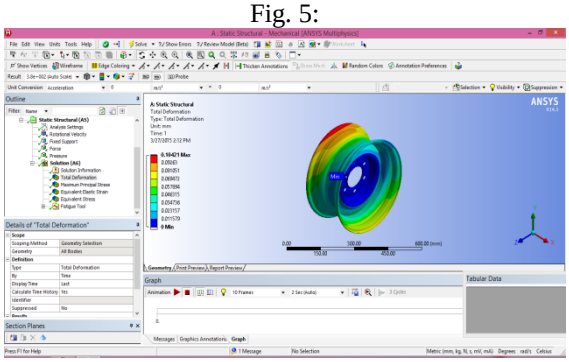


FIG. 6:

B. Total Deformation Result

As we have felt in the practical conditions also the wheel bends at the flange area at which it is connected with tire. It generally bends at the area of the flange which is also a very critical part of the wheel rim, In the below figure also the maximum deformation of 0.10421 mm is occurred through the defined loading condition in the flange area is visible.

VII. NEW DESIGN

So the new design for the wheel has been developed in order to have more suspension effect and the smoother ride. The main parts of the wheel contain wheel hub, wheel spokes or disc and the wheel rim area. In present case for the sake of new design the hub and spokes are redesigned.

- Design of Wheel hub
- Design of the spokes
- Design of wheel rim

The wheel that studied for the project was containing the hub diameter of 350 mm and the width and the hub width as 55 mm the same dimensions were used for making the new hub.

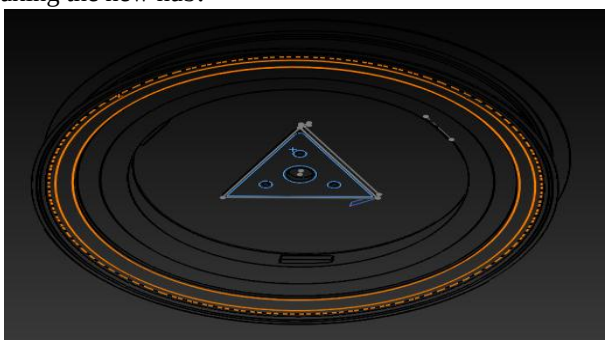


Fig. 7: The Spokes Are Replaced By a Spring Material In New Design

FIG. 8: FINAL FINITE ELEMENT ANALYSIS

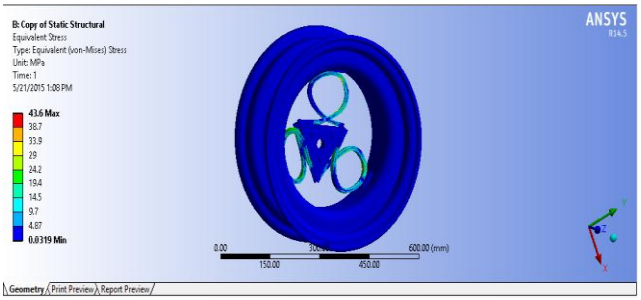


Fig. 9: The Von-Mises Stress:

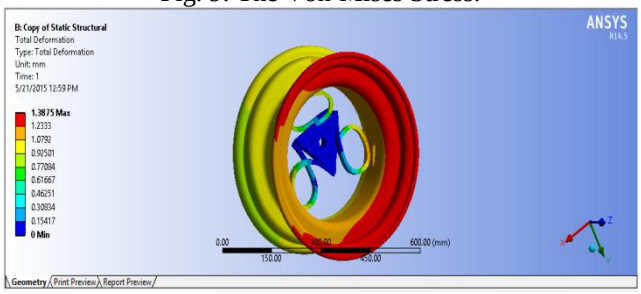


Fig. 10: Total Deformation:

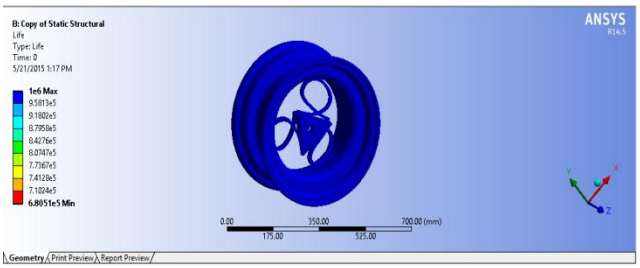


Fig. 11: Fatigue Life

VIII. CONCLUSION

By seeing the effects of new and old designs following points can be concluded:

1) The new design has less weight 1.96 kg per wheel.
2) The new design will have more suspension effects due to the springs instead of spokes
3) The new design is safer by analysis as the von-mises stress is well below the yield strength
4) The fatigue life is satisfactory for new design
5) The new design is easier to manufacture and less complicated.

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