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A Review on Modelling and Analysis of Scooter Wheel Rim Using CATIA & ANSYS

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ABSTRACT

Wheel rim is important part of any automobile which is used in a bicycle, cars, heavy vehicles, also farm vehicles such as tractor, harvesters. Movement of any vehicle is dependent on wheel rim assembly it consist of complex parts rim and disc and over the rim a tyre is mounted. Therefore proper design of rim is very important. In this work we will study the basic details of rims such as nomenclature terms, various types of rims, construction, and advanced materials used for rim as well as advanced manufacturing processes of rim. Also investigate the effect of number of spot welds on stress distribution and life of wheel rim of scooter, under radial load condition which arises due to off road field area and road surface irregularities. Rim 3D model is created using CATIA and Finite element analysis (FEA) is to be carried out by simulating the test conditions to analyze stress distribution and life of wheel rim of Scooter.

Keywords- **FEA, ANSYS, CATIA, Alloy wheel, stress, Fatigue life, spot weld.**

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I. INTRODUCTION

Wheel was evolved in an ancient periods, we get reference of it in Mahabharata. Wheel used in that periods are made from high qualities of woods such as deodar, spine, mahogany etc, spokes of such wheels are made from a wood over which an iron circular ring was fitted like a rim profile. In last century wheel evolution takes place after evolution of first car by Mercedes. Initially wire spokes steel wheel was used over which a tube less tire was mounted. Evolution of wheel accelerated the developments in human life as well as society. Generally requirements of wheel rims are high reliability, good appearance, and higher fatigue life, stylish, low cost, and light in weight, corrosion resistance. Weight of vehicle affect on the sprung weight as well as fuel consumption. Wide varieties of materials are used for wheel rim such as light alloys, steel. Light alloy wheel include magnesium, aluminium, titanium, composite material, carbon fibre etc. Each type of material has some advantageous over the other. Like magnesium is good strength but it is very difficult to remove bend, practically impossible therefore such wheels are casted again by melting into a furnace. All alloy wheels has good surface finish, excellent appearance as well as corrosion resistance. Due to evolution of wide varieties of testing methods and analysis methods excellent qualities of wheel rims can be manufactured right now.

I. LITERATURE REVIEW

T. Siva Prasad et. al [1] studied the essence of car wheel rim which provides a firm base on which to fit the tire. Its dimensions, shape should be suitable to adequately accommodate the particular tire required for the vehicle. N.Satyanarayana et. al [2] a static and fatigue analysis of aluminum alloy wheel A356.2 was carried out using FEA package. The S–N curve approach for predicting the fatigue life of alloy wheels by simulating static analysis with cyclic loads is found to converge with experimental results. Safety factors for fatigue life and radial load are suggested by conducting extensive parametric studies. Sourav Das [3] has carried out design of aluminum alloy wheel for paying special reference to optimization. Optimized mass of the wheel rim could be reduced to around 50% as compared to the existing solid disc type Al alloy wheel. Emmanuel M. Adigio [4] during the static analysis of the steel wheel, it was discovered that the maximum stress concentration occurred at the spokes and ventilation hole of the rim under loads and the fatigue crack propagates at the point of maximum stress concentration.

II. BASICS OF WHEELS

Wheel assembly consist of disc and rim profile. Rim manufactured by rolling process while disc manufactured by press working operation. Tyre is mounted over the rim profile, it may be tubeless or with tube. Whole assembly including rim profile, disc and tube are used while fatigue testing of wheel.

A. Rim Nomenclature

1. *Wheel:* It consists of outer rim and disc [1] [8].
2. *Rim:* Outer circular ring of wheel over which a tyre is mounted [1] [8].
3. *Disc:* It is intermediate part between the rim and axle hub. Cooling holes are provided on it for ventilation [1] [8].

Offset: The distance between the mounting surface and centreline of the wheel [1] [8].

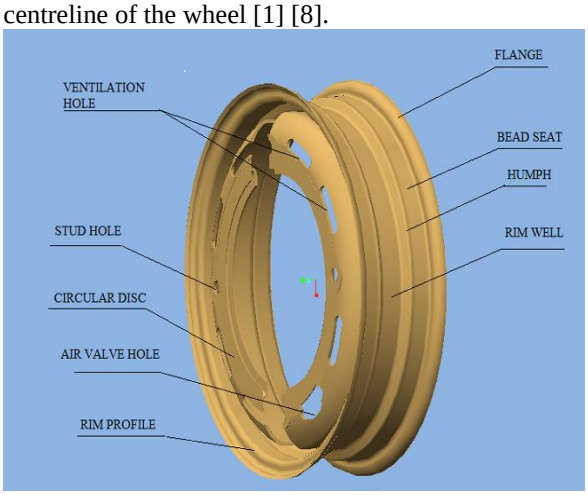

Fig.1 Nomenclature of wheel rim

4. *Flange:* It is the part of wheel rim over which beads of a tyre are mounted [1] [8].
5. *Bead seats:* Bead seat comes in contact with the bead face and is a part of rim which holds the tyre in a radial direction i.e. it is the portion of the wheel rim below the rim flange providing radial support to the bead of the tyre [1] [8] [9**]**.
6. *Ventilation holes:* They are provided for heat dissipation from wheel rim. More holes better heat removal but it decreases strength of wheel.
7. *Well:* This is a part of rim with depth and width to facilitate tyre mounting and removal from the rim [1] [8] [9].

B. Types of wheel rims

a) According to number of pieces:

1) One piece rim (Drop entered): Total numbers of pieces are one.

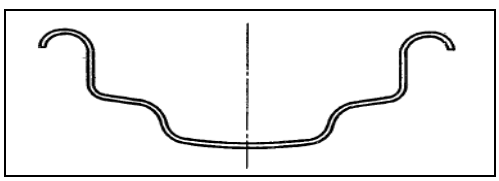

Fig 2 Single piece motorcycle wheel rim [8].

2) Two piece rim: Two parts rim flange and profile.

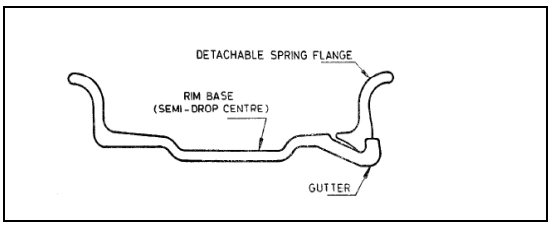

Fig. 3 Two piece wheel rim [8]

3) Three piece rim: It contains three parts namely detachable rim flange, spring lock ring, rim base.

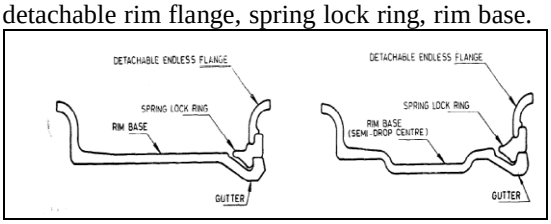

Fig.4 Three Piece Wheel Rim [8]

4) Four piece rim: Contains four pieces.

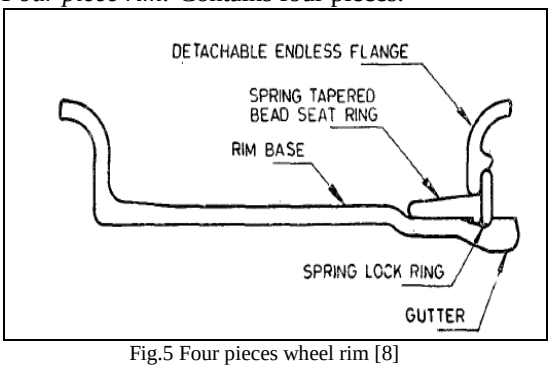

Fig.5 Four pieces wheel rim [8]

5) Five piece rim: Contains five numbers of pieces.

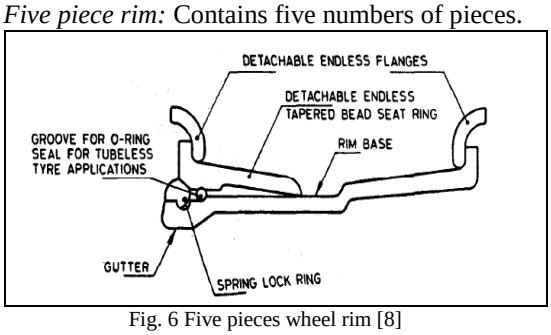

Fig. 6 Five pieces wheel rim [8]

b) According to material used:

1) Light Alloy wheels: Due its light weight they decrease the unsprung weight of the vehicle, good corrosion resistance, stylish. They can be casted easily by low pressure die casting process. Different types of light alloys used for wheel rim are as follows:

i. Aluminium Alloy Wheel:

It is light in weight, casted easily, best thermal conductivity as compared to other materials, good cast ability as well as pressed or rolled in a press shop i.e. manufacturing of aluminium wheel rim is easy [1] [10].

ii. Magnesium alloy Wheel:

Its weight is less than aluminium. Magnesium is good one but it has one disadvantage that it is impossible to remove bends of magnesium materials [1] [10].

iii. Titanium alloy wheel:

It strength is double than the aluminium as well as excellent corrosion resistance. But it is costlier and difficult to machine as well as shaping.

iv. Composite material wheel:

Main purpose of the usage of composite material is to keep low weight of wheel rim assemble as possible as. But composite material has low strength and heat dissipation capacity.

v. Carbon fibre wheel:

Carbon fibre wheel rims now a day's used for racing cars, sport cars. It has very good strength as compared to its weight, good corrosion resistance properties but poor thermal conductivity.

2) Steel Disc wheels: A steel wheel rim was used for cars in the periods of 1910 to 1930. After removal of chromium plating corrosion is main problem of such wheel rims [1] [10].

3) Wire Spoke Wheel: They are used in bikes, bicycles. For bikes such chrome plated wheel rims are used start from its evolution to up till now [1] [10].

C. Manufacturing Processes

In today's world wheel rim is watched as a status of car owner, therefore it must be stylish and attractive without compromising the strength as well as fatigue life. Wide varieties of manufacturing processes are used such casting (low and high pressure die casting, sand casting etc), forging (it may be hot or cold depending on the material), press working etc. Each manufacturing process has certain advantages over the other. For scooter generally pressed or casted wheel rims are used. Low pressure die casting is better manufacturing process because it eliminates defects of ordinary casting such as porosity, scab, blow holes etc.

Forging is employed for manufacturing of wheel rims of heavy vehicles such as truck, trolleys, tractor, harvesters and wood cutting machines. Rim profile of sheet metal wheel rim is generally manufactured by rolling process.

III. MODELLING OF WHEEL RIM

To design and model means study the existing model of rim do the changes in that so its ability to sustain the physical working condition does not change or its behaviour against the loading condition gets improved. CAD model of scooter wheel rim is created in a CATIA. For that purpose commands such as revolve, pattern, trim are used. CAD model of wheel rim is shown in fig.9. CAD model in an IGES format is imported into the ANSYS 14.0.

A. Specification of wheel rim

Rim designation: 3 B X 10
Rim width =76.2 mm (3 inch)
Flange type = B
Rim diameter = 254 mm (10 inch)
Material of rim= C1008

a) Modelling process of Wheel Rim:

1) Rim Disc: First cross sectional profile drafted in a part design mode and revolved we get circular disc without ventilation holes. Then we created ventilation holes and stud holes over disc by pocket command. It is shown in fig.7.

2) Rim Structure: It is nothing but the wheel rim outer ring of B type flange. For modelling of it first we created a cross sectional profile of it then we revolved it and we got this as shown in fig. 8.

3) Assembly of Wheel Rim: In an assembly mode we assembled the above two parts namely rim disc and rim structure (outer ring) is as shown in fig. 9.

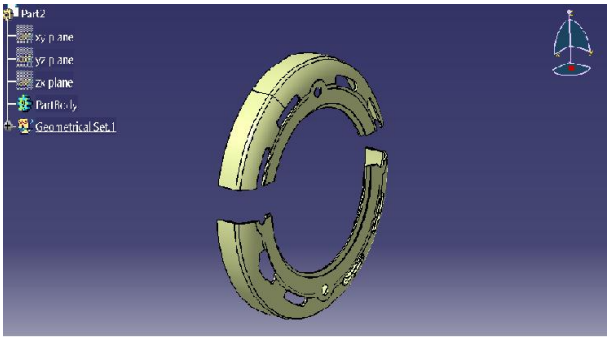

Fig. 7 CAD model rim disc.

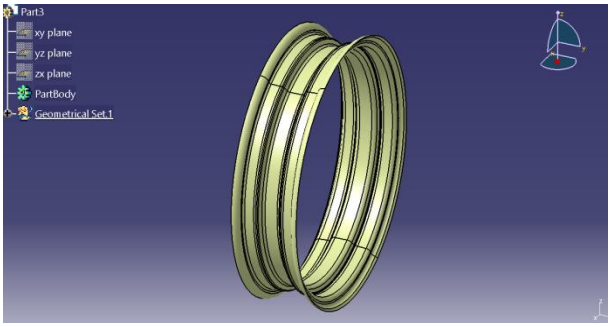

Fig. 8 Rim structure

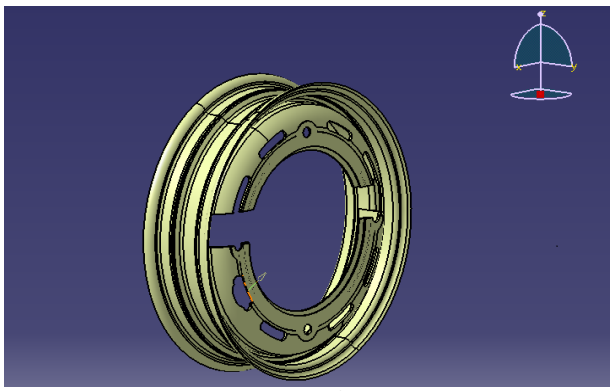
Fig. 9 Assembly of wheel rim parts

IV. FEA ANALYSIS FOR GIVEN LOADING

A) Forces acting on the wheel rim:

Wheel rim subjected to two type's main forces namely tyre inflation pressure and radial load due to gross weight.

a) Tyre inflation pressure:

In order to evaluate the effect of inflation pressure the analysis of rim carried out with tyre inflation pressure of 275.79 kpa being a maximum operating pressure.

b) Constant radial load applied on rim:

Mass of bike-

Dead weight of bike=120kg

Other load=20 kg

Total gross weight= 120+20 kg

Considering worst case of weight on vehicle-

Mass of the vehicle including rider and other three more persons,

M=140 + (65 x 4)

=140 + 260

=400 kg.

Hence maximum average weight on each wheel is 200kg.

B) FEA Analysis:

a) *Welding of rim structure and disc:*

Here outer rim and disc are welded together with the help of 24 spot welds circumferentially. Figure 10 showing the welded assembly in FEA software.

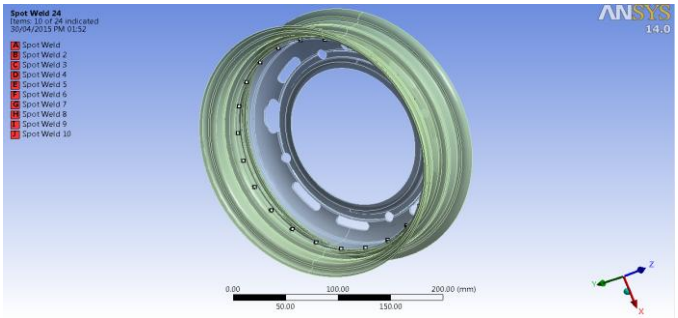

Fig.10 Spot welded assembly of wheel rim

b) Meshing of wheel rim assembly:

Meshing of wheel rim assembly carried out with the help of ANSYS 14.0 and 10 node tetra hydral elements is used for that purpose. Meshing of wheel rim is shown in figure 11 below.

Fig.11 Meshing of wheel rim assembly

c) Boundary conditions:

Wheel rim is attached to the axle hub with the help of stud bolts, that area is kept to be fixed is as shown in figure 11 below.

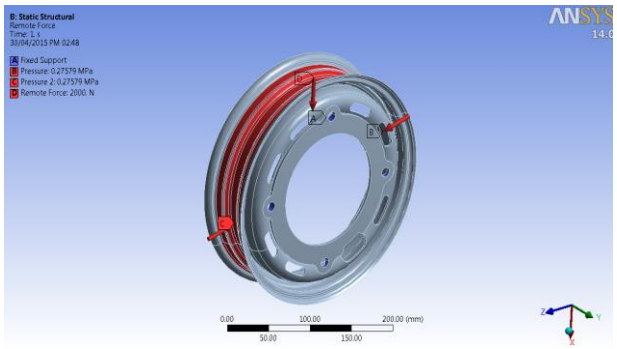

Fig.12 Boundary conditions (force+ Pressure + Fixes support)

V. RESULT ANALYSIS

a) Deformation of wheel rim under radial loading:

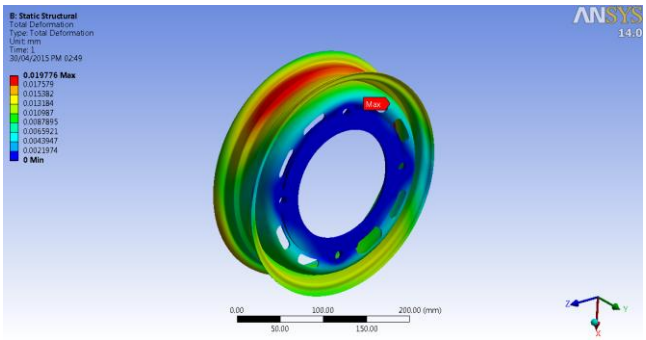

Fig.13 Deformation of wheel rim (max 0.019776 mm)

b) Stress distribution in wheel rim:

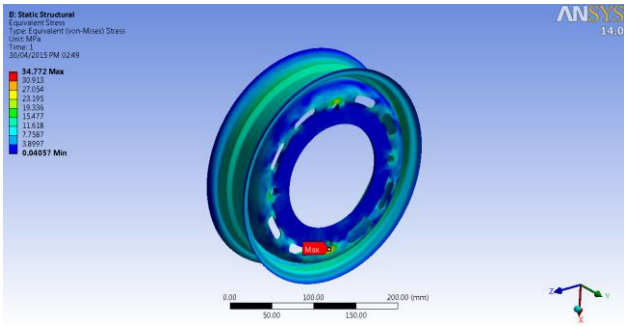

Fig.14 Stress distribution (max 34.772 Mpa)

c) Life of wheel rim:

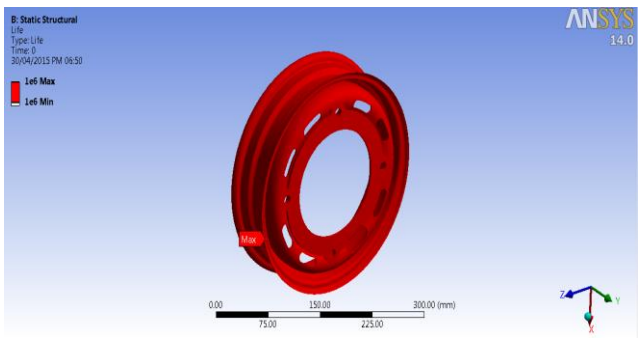

Fig.15 Fatigue life (acceptable 1e10)

VI. Conclusions

CAD model of wheel rim created using CATIA software and meshing, static analysis work completed with the help of ANSYS software. Here conclusions from results are

1. For given material deformation of wheel rim is maximum at outer bead seat areas.
2. Maximum stress distribution occurs at stud holes.
3. Generally required life of wheel rim is 1e6. Here life of wheel rim is acceptable under static fatigue loading.

Future work: we can minimise the number of spot weld of wheel rim i.e optimization is possible. Also by changing the materials of wheel rim we can compare the results obtained for stress distribution, deformation and for life of wheel rim.

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