A review on Modelling and Structural Analysis of Wheel Rim Using CREO and ANSYS

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Abstract— Rims are critical components of any vehicle. The wheel is a device that enables efficient movement of an object across a surface where there is a force pressing the object to the surface. In the present every vehicle was designed with alloy wheels which are more efficient than spokes wheels. In this project we designed the rim from the existing dimensions by modelling software. The wheel rim is modelled by using modelling software PTC CREO 2.0. By using this software the time spent in producing the complex 3-D models and the risk involved in the design and manufacturing process can be easily minimized. So the modelling of the wheel rim is made by using CREO. Later this CREO model is imported to ANSYS for analysis work. ANSYS is the analysis software used for simulating the different forces, pressure acting on the component and also calculating and viewing the results. By using ANSYS software reduces the time compared with the method of mathematical calculations by a human. ANSYS static analysis work is carried out by considered by aluminium materials and their relative performances have been observed respectively.

Key words: Wheel Rim, CREO, ANSYS, Static analysis

I. 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. Archaeologies and historians of today see the introduction of the wheel as the real genesis of any old civilization. The wheel is the most significant discovery of old times. 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. The importance of wheel and tyres in the automobile cannot be challenged. Without engine, car may tow, but without the wheels, this is not possible. The wheel with tyres takes full load, and reduces friction, and provides cushioning effect to passenger by absorbing vibration due to road surface unevenness and assist in steering control.

The alloy of conventional disc wheel in case of car and wire wheel as in case of motor bike has better aesthetic looks and easy of manufacturing. The main requirements of an automobile wheel are;

1) It should be as light as possible so that unsprung weight is least
2) It should be strong enough to perform the above functions.
3) It should be balanced statically as well as dynamically.
4) It should be possible to remove or mount the wheel easily.
5) It material should not deteriorate with weathering and age. In case, the material is suspected to corrosion, it must be given suitable protective treatment.

II. THEORY OF WHEEL

A wheel is a circular device that is capable of rotating on its axis, facilitating movement or transportation while supporting a load (mass), or performing labour in machines. Safety and economy are particularly of major concerns when designing a mechanical structure so that the people could use them safely and economically. Style, weight, manufacturability and performance are the four major technical issues related to the design of a new wheel. The tire works as a wheel only after it is set up on the rim and is inflated therefore: the tire and wheels assembly affects the function and performance of the vehicle. The tire is designed and manufactured to suit a usual rim and once installed on correct rim the tire will perform up to the preferred level.

A. Rim Nomenclature:

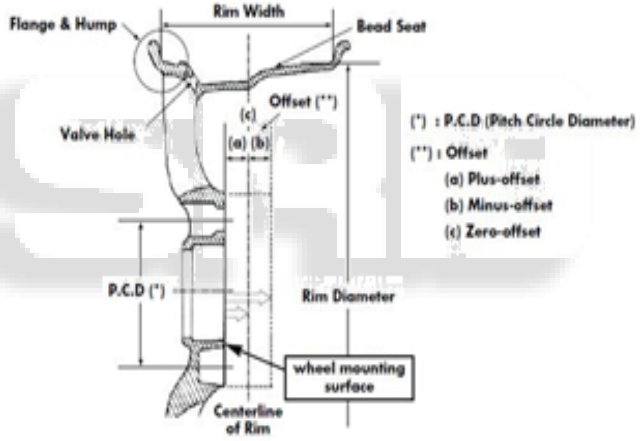

Fig. 1: Nomenclature of rim

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 surface where it is bolted to hub and centre of the line.
5) Flange: The flange is a part of rim which holds the both beds of the tire.
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.
8) Well: This is a part of rim with depth and width to facilitate tire mounting and removal from the rim.

B. Type of Wheel Rim (Based On Dimensions):

Typical rim shape vehicles are made up of the following

1) Drop Centre Rim:

Drop centre (DC) rim is shaped so there is fine between the bead seat parts which are placed on the both sides of the rim. This makes mounting and demounting of the rim easy.

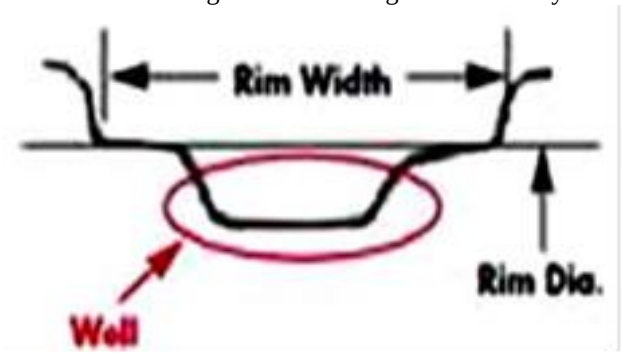

Fig. 2: Drop Centre Rim

2) Wide Drop Centre Rim:

Wide drop centre rim is mostly the same DC rim. To extend the width of the rim, with a slighter well and a lower flange height, this rim is mostly applied to low aspect ratio tires. This design is presently applied to rims for tires of most passenger vehicles.

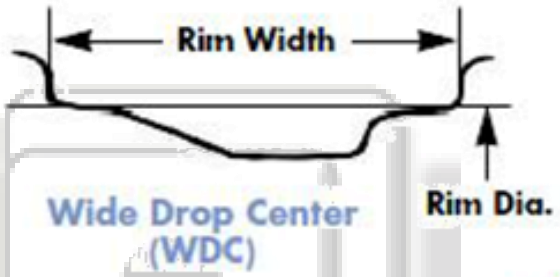

Fig. 3: Wide Drop Centre Rim

3) Wide Drop Centre Rim with Hump:

In addition, this design has a bump, on the beginning of the bead seat area. This bump is to prevent the bead sliding down and air outflow from the rim due to the horizontal force applied to the tire when a vehicle tubeless tires runs at high speed.

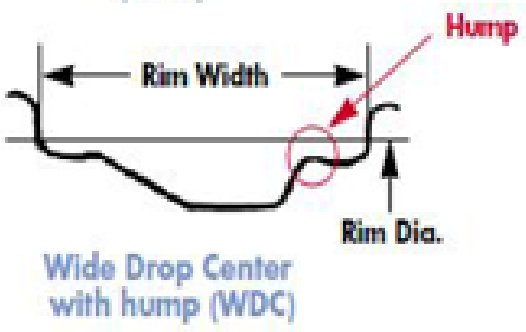

Fig. 4: Wide Drop Centre with Hump Rim

C. Type of Wheel Rim (Based On Material):

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. Steel and light alloy are the foremost materials used in a wheel rim however some composite materials together with glass-fibre are being used for special wheels.

1) Wire Spoke Wheel:

Wire spoke wheel is an essential where the exterior edge part of the wheel rim and the axle mounting part are linked by numerous wires called spokes.

Fig. 5: Wire Spoke Wheel

Today's automobiles with their high horse power have made this type of wheel manufacture obsolete. This type of wheel is still used on classic vehicles.

2) Steel Disc Wheel:

This is a rim which practices the steel made rim and the wheel into one by joining (welding), and it is used mainly for passenger vehicles especially original equipment tires

Fig. 6: Steel Disc Wheel

3) Alloy wheel:

Alloy wheels were first developed in the last sixties to meet the demand of racetrack enthusiasts who were constantly looking for an edge in performance and styling. These wheels are based on the use of light metals, such as aluminium and magnesium has come to be popular in the market.

III. THEORY OF WHEEL

These techniques are cheaper than performing tryouts with actual dies and equipments. Optimization can be achieved quickly and efficiently through the use of simulation software. Modelling provides more information about the process i.e. load requirement and metal flow at different stages of the process.

CREO is modelling software which is used for creation and modification of the objects. In CREO design and modelling features are available. Design means the process of creating a new object or modifying the existing object. Drafting means the representation or idea of the object.

Modelling means create and converting 2D to 3D. By using CREO software create the model of wheel rim.
Specifications of Model Wheel Rim:
Tire diameter (approx.) = 650mm
Wheel size = R18=18 inches
Rim width = 207 mm
Wheel type = Disc wheel
Flange height = 150mm
Tire type = Radial
Aspect ratio = 40
Offset = 31.5mm

Fig. 7: 3D Modelling of Wheel Rim

IV. RESULT ANALYSIS

Structural analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by load that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time.

Diagram of aluminium wheel. 3-diemensional modal of the wheel was created in Creo2.0 and the file was exported in the IGES (international graphics exchange specifications) format into ANSYS16. The mesh was meshed with 10- node tetrahedral structural solid elements. The wheel was meshed using an element edge length is 5mm.

Boundary conditions: To ensure the accuracy and reliability of the analysis result, the structural and mechanical model of the rear wheel is estab-lished.Net weight of the motorcycle is 100kg and the maxi-mum allowable load is 180kg. The tire used is a common version with inner tube filled to gas pressure 0.28mpa, uniformly distributed on the exterior ring surface of wheel. To ensure reliability of the analysis, the sum of motorcycle net weight and maximum allowable load was applied to the rear wheel alone. The sum was considered to be the maximum load, which was distributed on the inner surface of bearing supporting the axle. By calculation, the maximum load is equal to 1500N.
Properties of Materials:
Input data for ALUMINIUM ALLOY:
Young's modulus= 0.71e5 N/mm2
Poisson's ratio = 0.33
Density = 2800 kg/m3
Circumferential pressure = 21.3kpa
Input data for FORGED STEEL:
Young's modulus = 2.3e5 N/mm2
Poisson's ratio = 0.3
Density = 7600 kg/m3
Circumferential pressure = 21.3kpa

V. RESULTS

A. *Total Deformation of Wheel Rim:*

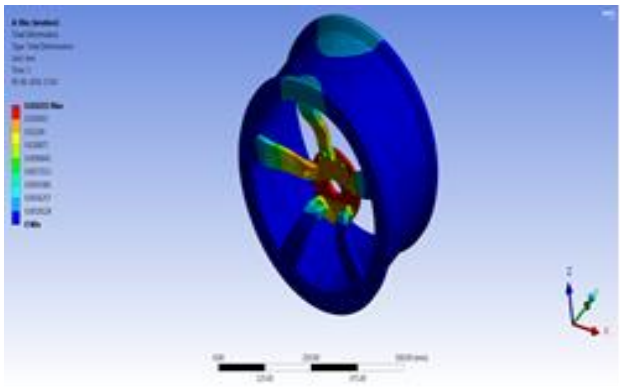

Fig. 8: Total deformation

B. *Equivalent (Von-Misses) Stress:*

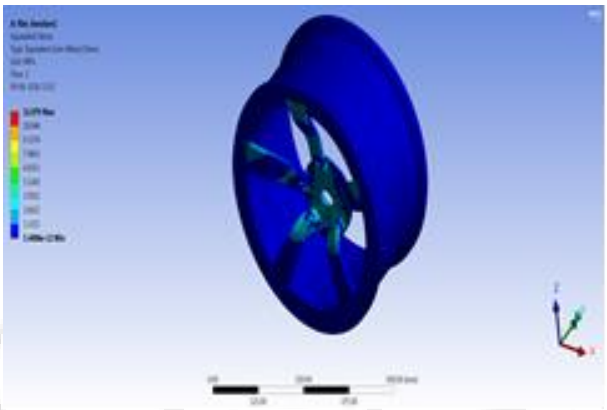

Fig. 9: Von-Misses stresses

C. *Stress Intensity:*

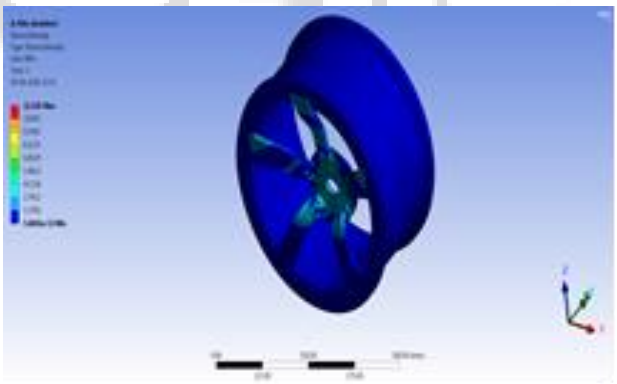

Fig. 10: Stress intensity

D. *Principal Stress:*

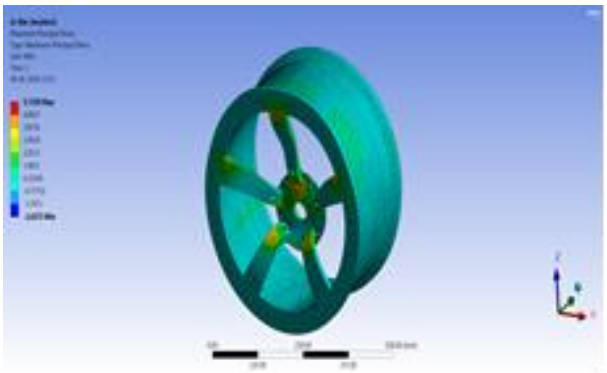

Fig. 11: Principal Stress

VI. CONCLUSION

CAD model of the wheel rim is generated in CREO2.0and this is imported to ANSYS 16.0 for processing work. A force of 1500N is applied along the circumference of the wheel rims made of aluminium alloy and bolt circle of wheel rim is fixed. Following are the conclusions from the results obtained:

1) The total deformation of alloy wheel is maximum 0.0163mm. Maximum deformation was at the circumference of the wheel and minimum at the bolt portion as shown in Figure 11.
2) The equivalent (von-misses) stress of alloy wheel was maximum11.979 MPa. For required loading condition current design is safe.
3) Stress intensity maximum value is 12.335 MPa and max. Principal stress value is 5.773MPa.

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