Modeling and Analysis of Car Wheel Rim by using Peek Material

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Abstract— The automobile industry is exploring polymeric material in order to obtain reduction of weight without significant decrease in vehicle quality and reliability. This reduction of weight of a vehicle directly impacts its fuel consumption. In this project, analysis of the Car wheel rim is carried out for weight reduction. The wheel rim is modeled by using standard parameters in Creo Parametric 2.0 software and analyzed to see the variations of deformation and stresses of the rim for different material such as Aluminum Alloy, PEEK (Polyether ether ketone), PEEK with 30% Glass fiber, PEEK-90 HMF 20, PEEK-90 HMF 40 by using the ANSYS 14.0 software.

Key words: Car Rim, Creo Parametric, Finite Element Analysis, Aluminium, PEEK, ANSYS, Static Analysis

I. INTRODUCTION

The wheel is a critical component in the automobile and bears the weight of the car as well as helps the tire to maintain contact between the car and the road. For high and optimal performance, the wheel is designed to meet some safety and engineering criteria. The wheel should be able to withstand the impact of shock and vibrations and be able to bear the weight of the car and the passengers. It should be light in weight but highly durable. The rim of a wheel is the outer circular design of the metal on which the inside edge of the tire is mounted on vehicles such as automobiles. For example, in a four wheeler the rim is a hoop attached to the outer ends of the spokes-arm of the wheel that holds the tire and tube. A standard automotive steel wheel rim is made from a rectangular sheet metal.

The metal plate is bent to produce a cylindrical sleeve with the two free edges of the sleeve welded together. At least one cylindrical flow spinning operation is carried out to obtain a given thickness profile of the sleeve in particular comprising in the zone intended to constitute the outer seat an angle of inclination relative to the axial direction. The sleeve is then shaped to obtain the rims on each side with a radially inner cylindrical wall in the zone of the outer seat and with a radially outer frusto-conical wall inclined at an angle corresponding to the standard inclination of the rim seats. The rim is then calibrated. To support the cylindrical rim structure, a disc is made by stamping a metal plate. It has to have appropriate holes for the center hub and lug nuts. The radial outer surface of the wheel disc has a cylindrical geometry to fit inside the rim. The rim and wheel disc are assembled by fitting together under the outer seat of the rim and the assembly welded together. Wheel rim is the part of automotive where it heavily undergoes both static loads as well as fatigue loads as wheel rim travels different road profile.

II. THEORY OF WHEEL

The tire works as a wheel only after it is set up on the rim and is inflated therefore; the tire and wheel assembly effects the function and performance of the vehicle. The tire is designed and manufactured to suit a usual rim and once installed on the correct rim the tire will perform up to its preferred level. It is needless to say that the life of the tire will be reduced if it is installed on an unsuitable rim. The rim is actually the name for the cylindrical part where the tire is installed. A wheel is the name for grouping between rim and disc plate. Once the disc plate is fixed inside the cylinder this assembly becomes a wheel.

A. Rim Nomenclature:

1) Wheel: Wheel is generally composed 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.

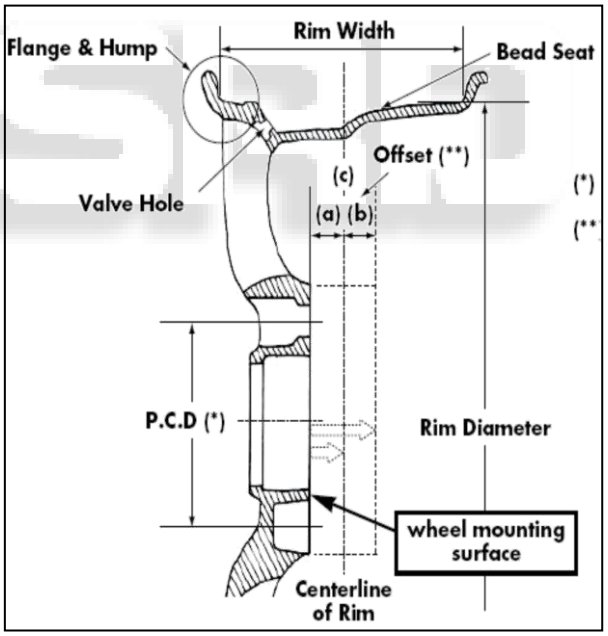

Fig. 1: Rim Nomenclature

4) Offset: This is a space between wheel mounting surface where it is bolted to hub and centre line of rim.
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.

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8) Well: This is a part of rim with depth and width to facilitate tire mounting and removal from the rim.

B. Material used for Rim:

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

1) 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.

2) Light Alloy Wheel:

These wheels are based on the use of light metals, such as aluminium and magnesium has come to be popular in the market. This wheel rapidly become standard for the original equipment vehicle in Europe in 1960's and for the replacement tire in United States in 1970's.

3) Aluminium Alloy Wheel:

Aluminium is a metal with features of excellent lightness, thermal conductivity, rust confrontation, physical characteristics of casting, low heat, machine processing and reutilizing, etc. This metals main advantage is decreased weight, high precision and design choices of the wheel. This metal is useful for energy preservation because it is possible to re-cycle aluminium easily.

4) Magnesium Alloy Wheel:

Magnesium is about 30% lighter than aluminium and also admirable as for size stability and impact resistance. However, its use is mainly restricted to racing, which needs the features of weightlessness and high strength at the expense of weathering resistance and design choice, etc. Compared with aluminium.

5) Titanium Alloy Wheel:

Titanium is an admirable metal for corrosion resistance and strength (about 2.5 times) compared with aluminium, but it is inferior due to machine processing, designing and more cost. It is still in the development stage even though there is some use in the field of racing.

III. ISSUE WITH CURRENT MATERIAL

The wheel rim is mostly manufactured in steel material for passenger cars and Aluminium alloy material for race cars. The steel material offers more strength to wheel and increase weight of the vehicle. Aluminium alloy is lighter than steel. So weight of the vehicle reduced with reduction in life cycle. A vehicle's fuel consumption is based on weight of the vehicle. The weight reduction can be achieved by changing the lighter material with same strength. So the material of wheel rim is changed from aluminium to polymer material.

IV. MODELING OF RIM

The wheel specification is as summarized in Table-1. The mathematical model here refers to the CAD model of the rim. For better analysis, the wheel is modeled using a CAD software, Creo Parametric 2.0, using different features ranging from revolve, sweep, extrude boss base, fillet and surface features. To model the wheel a picture sketch was used. This was to ensure that the actual shape of the rim is used while modeling so as to reduce errors.

S. No.	Specification	Value
1	Rim Width	215.9 mm
2	Wheel Diameter	480 mm
3	Offset	128 mm
4	Pitch Circle Diameter(PCD)	110 mm
5	Centre Base Diameter (CBD)	70 mm
6	Rim thickness	7 mm
7	Bolt diameter	10 mm
8	Number of bolt holes	5

Table 1: Wheel Rim Specification

V. ANALYSIS AND RESULTS

The finite element method is a powerful tool for the numerical procedure to obtain solutions to many of the problems encountered in engineering analysis. Structural, thermal and heat transfer, fluid dynamics, fatigue related problems, electric and magnetic fields, the concepts of finite element methods can be utilized to solve these engineering problems. In this method of analysis, a complex region defining a continuum is discretized into simple geometric shapes called finite elements the domain over which the analysis is studied is divided into a number of finite elements. The material properties and the governing relationship are considered over these elements and expressed in terms of unknown values at element corner .An assembly process, duly considering the loading and constraint, results in set of equation. Solution of these equations gives the approximate behavior of the continuum.

Sl. No.	Parameters	Symbols	Data
1	Velocity of car	V	70 km/hr
2	Radius of Rim	R	240 mm
3	Tire pressure	p_i	303.4 kPa

Table 2: Parameters Used For Static Steady

– Displacements

Translation in x, y, z directions were fixed.
Rotation in x, y, z direction was fixed.

– Angular velocity in X direction is zero,

Y direction is 86.79 rad/s,
Z direction is zero.

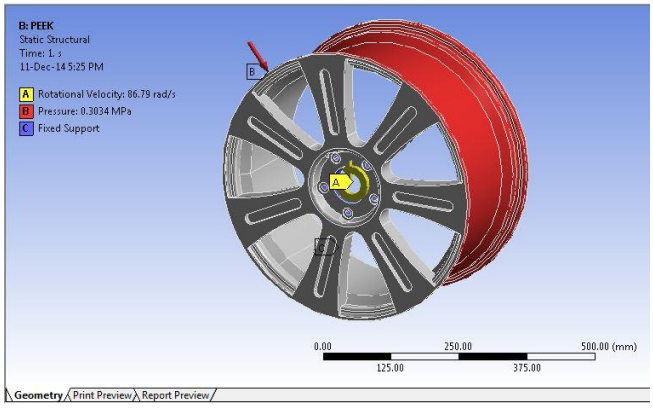

Fig. 2: Boundary Condition Applied

The values obtained from the FEM analysis are tabulated in table 3 as follows

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Sl. No.	Material	Deformation, x (mm)	Stress, σ (N/mm^2)
1	Aluminium Alloy	0.032	19.814
2	PEEK	0.578	21.062
3	PEEK GF 30	0.577	21.293
4	PEEK 90 HMF 20	0.107	21.232
5	PEEK 90 HMF 40	0.524	21.152

Table 4: Results

VI. CONCLUSION

Finite Element analysis of the car wheel rim has been done using ANSYS Workbench. The rim was modeled as per standards and analyzed for different materials such as Aluminum Alloy, PEEK (Polyether ether ketone), PEEK with 30% Glass fiber, PEEK-90 HMF 20, PEEK-90 HMF 40. From obtained results optimization was carried out. The weight of rim is reduced from 15.761 Kg to 7.748 Kg while using PEEK GF 30 material when compare to Aluminium Alloy material. But the deformation and stress of PEEK 90 HMF 20 material is nearly to Aluminium alloy material. And weight of the PEEK 90 HMF 20 material is also 8.041 kg. From the table 4.3 it is clear that PEEK 90HMF20 is best material for the replace of Aluminium Alloy (A356.2) material.

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