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STATIC ANALYSIS OF WHEEL RIM USING CATIA AND ANSYS16.0

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Abstract - *The purpose of the car wheel rim 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. In this study a tire of car wheel rim belonging to the disc wheel category is considered. Design in an important industrial activity which influences the quality of the product. The wheel rim is designed by using modelling software catiav5r18. In modelling 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 modelling of the wheel rim is made by using CATIA. Later this CATIA 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. ANSYS static analysis work is carried out by considering different materials namely aluminium and forged steel and titanium their relative performances have been observed respectively. In addition to this rim is subjected to vibration analysis (modal analysis), a part of dynamic analysis is carried out its performance is observed. In this paper by observing the results of both static and modal analysis obtained forged steel is suggested as best material.*

Key Words: **ANSYS, CATIA V5, Stress Analysis, Wheel Rim.**

1. INTRODUCTION

1.1 Introduction:

Archaeologies and historians of today see the introduction of the wheel as the real genesis of any old civilization. The wheel is perhaps the most significant discovery of old times. The wheel has developed from nothing more than an oversized bearing to a fully integral part of any modem transportation vehicle. The modern vehicle is also seen today a fashion item to complement people's individual requirements. Motor vehicles are produced according to very strict rules to ensure the safety of the passengers. Every component is therefore designed according to the criticality of the component. Wheels are classified as a safety critical component and international cods and criteria are used or design a wheel.

Materials to produce these wheels have become has sophisticated as a design and materials can range from steel to non-ferrous alloys like magnesium and aluminium. Automotive wheels have evolved over the decades from early spoke designs of wood and steel. Carry over's from wagon and bicycle technology, to flat steel discs and finally to the stamped metal configurations and modern cast and forged aluminium alloys rims of today's modern vehicles historically successful designs arrived after years of experience and extensive field testing. Since the 1970's several innovative methods of testing well aided with experimental stress measurements have been initiated.

In recent years, the procedures have been improved by a variety of experimental and analytical methods for structural analysis is (strain gauge and finite element methods). Within the past 10 years, durability analysis (fatigue life predication) and reliability method for dealing with variations inherent in engineering structure have been applied to the automotive wheel. Wheel rims affect the braking performance of a vehicle as result of the following for parameters: size, weight, design or ventilation, materials. The size of the wheel rim governs how much space there is between the rim and the brake rotor. By moving up to a higher diameter wheel rim there will be more scope for air flow around the brakes and therefore better cooling. The weight of the wheel rim is an obvious issue. The mass is not only important in terms of the overall weight of the wheel, the rotational inertia of the wheel goes up with more weight as well, causing even more work for the brakes.

The handling of a vehicle is always improved with light weight. As in case of ride, the lighter the unsprung weights are more easily controlled in the motion of the tire wheel and the better the adhesion to the road surface. Another factor in handling has to do with wheel strength and flex. A

more rigid wheel will reduced wheel flex during cohering and improve tire performance. This is especially important with low aspect ratio, high performance tires that can be generate high cornering forces.

Car wheels are divided in to two main groups, steel wheels and alloy wheels. Alloy wheels are frequently fitted typical during the manufacturing of modern vehicles. All steel wheels to be made up of two pressed components, the rim and the wheel disc, which are joined (welded) together.

1.2. Theory of Wheels

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.

2.1 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.
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.
8. **Well:** This is a part of rim with depth and width to facilitate tire mounting and removal from the rim.

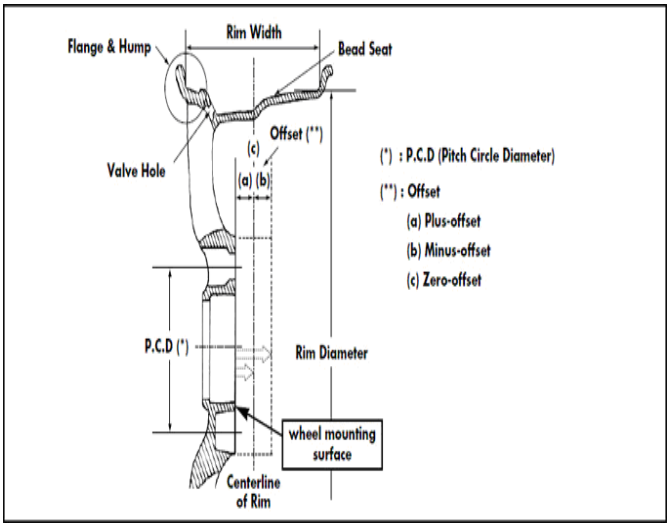

Fig 1: Rim Nomelclature

2.2 Type of Wheel/Rim: (Dimensional)

2.2.1 Shape of Rim

Typical rim shape vehicles are made up of the following.

a) Drop centre rim (DC)

Drop centre rim (DC rim) is shaped so there is fine between the bead seat parts which is placed on both sides of the rim. This is to make the mounting and dismounting of the tire easy. In most circumstances there is a taper of 5 degrees in the bead seat area.

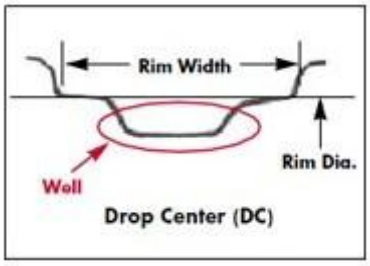

Fig 2: Drop Center

b) Wide drop centre rim (WDC)

Wide drop centre (WDC rim) is mostly the same as DC rim. To expand 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.

c) Wide Drop Centre Rim With Hump

In addition, this design has a bump, on the beginning of the

bead seat area. This hump 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 highspeed.

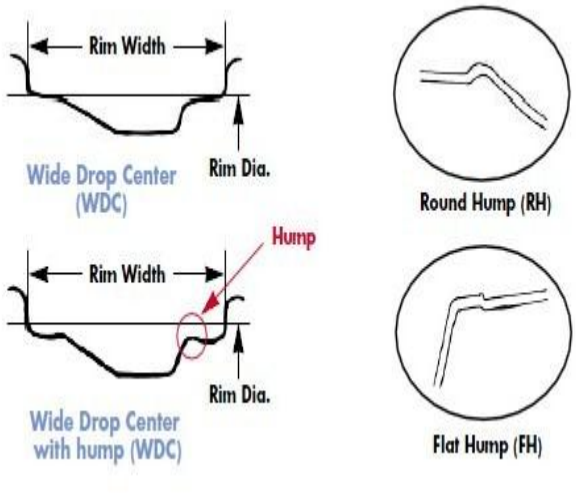

Fig 3: Wide drop center

2.2.2 Types of Wheel/Rim (Material)

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.

a) 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. Today's automobiles with their high horsepower have made this type of wheel manufacture obsolete. This type of wheel is still used on classic vehicles. Light alloy wheels have developing in recent years, a design to give emphasis to this spoke effect to fulfil users fashion requirements.

b) 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.

c) 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. The advantages of each light alloy wheel are explained as below.

i. 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.

ii. 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.

iii. 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.

iv. Composite material wheel

The composite material wheel is different from the light alloy wheel, and it is developed mainly for low weight. However this wheel has inadequate consistency against heat and for best strength. Development is continuing.

Specifications of Model Wheel Rim:

Tire diameter (approx.) = 560 mm

Wheel size = 14 inches

Length = 86 mm

Flange shape = J

Rim width = 15cm

Wheel type = disc wheel

Flange height = 0.68 inches

Tire type = radial

Aspect ratio = 65

Offset = 80.54

3. METHODOLOGY

3.1 Modeling in CATIA:

CATIA software is the standard in the 3D product design, featuring industry-leading productivity tools that promote one of the best practices in design while ensuring compliance regarding industry and company standards. The designing of CATIA solution allow you to design you faster than any other software. The figure shows the solid model of the disc brake by using CATIA. By taking the circular and petal disc brake dimensions we have to draw the disc brake model in CATIA.

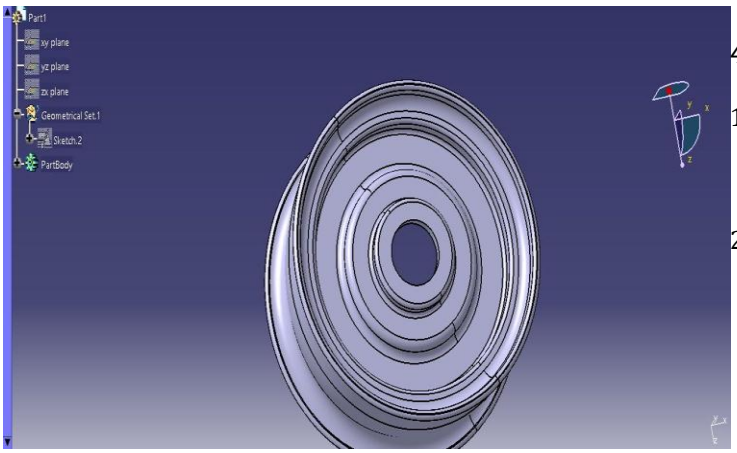

Fig 4: Revolved sketch

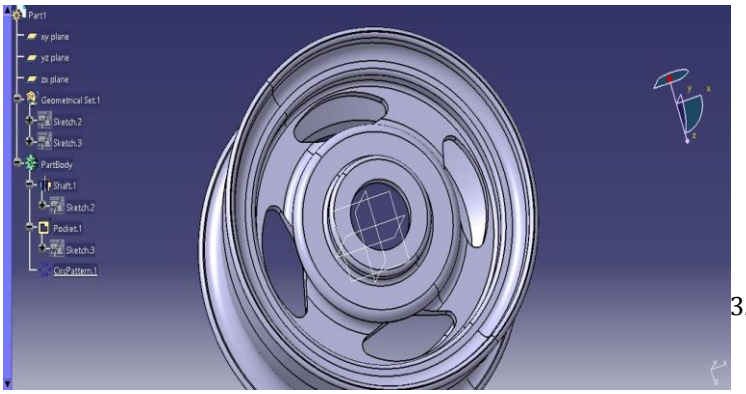

Fig 5: Rim cutting

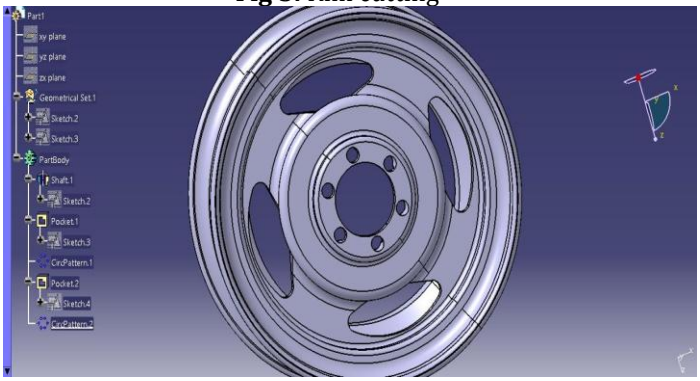

Fig 5: Final shape

The above shown figure is model drawn in the CATIA software are by using the exact Dimensions of the wheel rim with correct thickness and Dimensions.

3.2 Analysis in ANSYS:

Dr. John Swanson founded ANSYS Inc in 1970 with a vision to commercialize the concept of computer simulated engineering, establishing himself as one of the pioneers of Finite Element Analysis (FEM). The software implements the equations that govern the behavior of these elements and solve the problems, by creating comprehensive explanation of how the acts as whole. The results can be obtained in the form of tabular column or graphical forms.

4. RESULTS

1. After preparing the model in CATIA it is improved to ANSYS. the file is imported from CATIA by file>import>IGES

2. The imported model is meshed by using TETRA mesh. the meshed model is as follows:

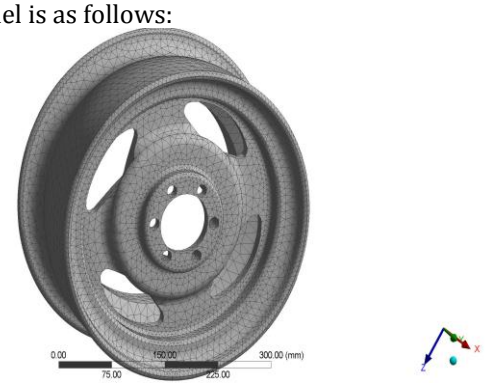

Fig 6: Meshed Model

3. Later this meshed model is defined with three different materials namely ALUMINIUM, FORGED STEEL and TITANIUM and subjected to static analysis.

4.1 AT PREPROCESSOR STAGE:

Input data for ALUMINIUM:

Young's modulus: 0.71e5N/mm^2

Poisson's ratio = 0.33

Density = 2800kg/m^3

Circumferential pressure = 200 kpa

Input data for FORGED STEEL:

Young's modulus: 2.1e5N/mm^2

Poisson's ratio = 0.3

Density = 7600kg/m^3

Circumferential pressure = 200 kpa

Input data for TITANIUM:

Young's modulus: 1.1e5N/mm^2

Poisson's ratio = 0.3

Density = 4500kg/m^3

Circumferential pressure = 200 kpa

1. After this meshed model is constrained at holes by all DOF where the bolts has to be placed.

2. After constraining the meshed model, the model is subjected to a circumferential load of 200 kpa.

3. Later the results were obtained in the SOLVER module.

4. Later in the SOLVER module, analysis type is changed from static command to modal command and solution in done in solution window.

5. Next solution results such as stress, displacement, von mises, ultimate strength etc., it can be observed in GENERALPOST-PROCESSOR

4.1.1 Results for Aluminium Wheel Rim:

(a) Deformation result

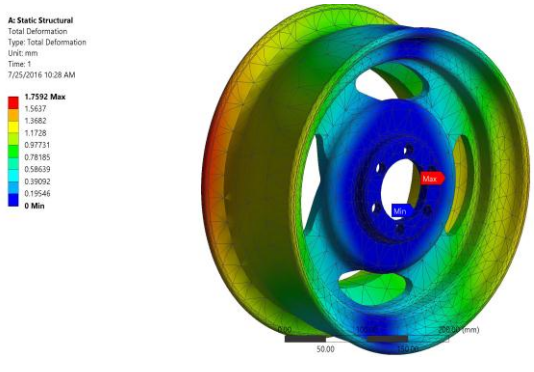

Fig 7: Deformation in aluminum

(b) Von-Mises Stresses

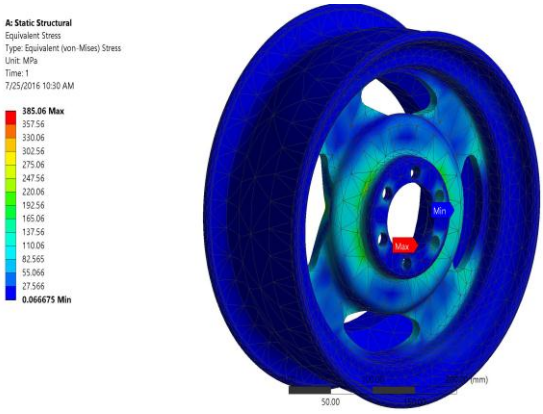

Fig 8: Stress in aluminum

4.1.2 Results for Forged steel Wheel Rim:

(a) Deformation result

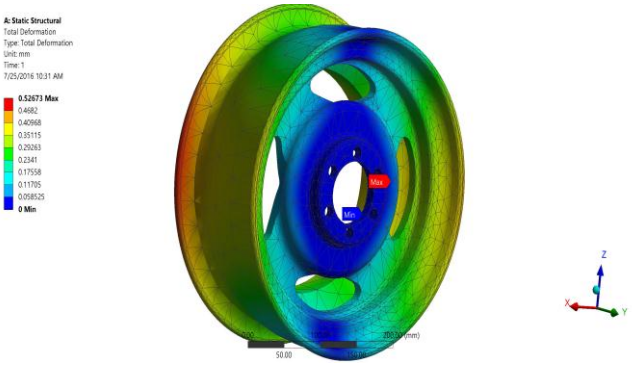

Fig 9: Deformation in forged steel

(b) Von-Mises Stresses

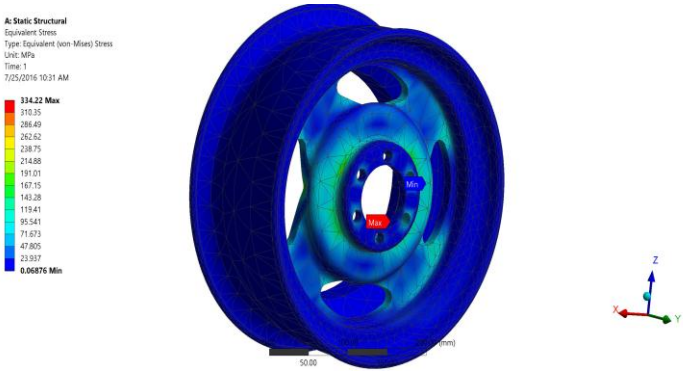

Fig 10: Stress in forged wheel

4.1.3 Results for Titanium Wheel Rim:

(a) Deformation result

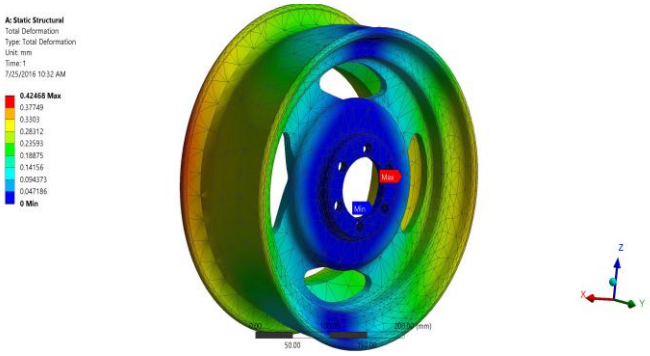

Fig 11: Deformation in titanium wheel

(b) Von-Mises Stresses

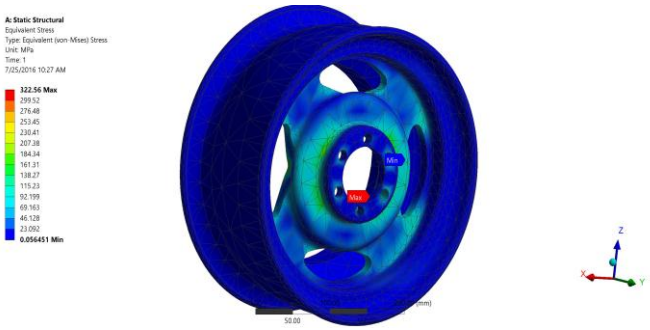

Fig 12: Stress in titanium wheel

4.1.3 STRESS RESULTS:

Table 1: Results Table

Material	Von-Mises Stress Mpa	Total Deformation, mm
Aluminum	385.06	1.7592
Forged Steel	334.22	0.5267
Titanium	322.56	0.4246

5. CONCLUSION

CAD model of the wheel rim is generated in CATIA and this model is imported to ANSYS for processing work. An amount of pressure 200 kpa is applied along the circumference of the wheel rims made of ALUMINIUM, TITANIUM & FORGED STEEL and bolt circle of wheel rim is fixed. Following are the conclusions from the results obtained:

From the above table titanium is the best metal for preparing rim due to consideration of cost we would select forged steel because titanium is high in cost compared to other two materials. Though the high cost of titanium has deterred its use in most applications in the past the fact that titanium is the fourth abundant metal on the planet is now being realized. Although the price may be on the higher side when compared to other metals, it is slowly becoming more readily available and finding more applications.

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