STATIC AND MODAL ANALYSIS OF WHEEL CIRCUMFERENCE FOR ALUMINIUM MATERIAL

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Abstract

The purpose of the car wheel rim is to provide a firm base on which to fit the tyre. Its dimensions, shape should be suitable to satisfactorily accommodate the particular tyre required for the vehicle. In this a tyre of a car wheel rim belonging to the disc wheel category is considered. Design is an important industrial activity which influences the quality of the product. The wheel rim is designed by using modeling software CATIAv5R18.In modeling 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 modeling 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 software 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, deflection, 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 two different materials namely Aluminum Alloy and Structural steel and their relative performances have been observed respectively. In addition to this, rim is subjected to vibration analysis, a part of Dynamic Analysis is carried out and its performance is observed.

Keywords:- *Catia, Ansys, Wheel Rim.*

I. INTRODUCTION

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. Early wheels were simple wooden disks with a hole for the axle. Because of the structure of wood a horizontal slice of a trunk is not suitable, as it does not have the structural strength to support weight without collapsing; rounded pieces of longitudinal boards are required. The spoke wheel was invented more recently, and allowed the construction of lighter and swifter vehicles. Alloy wheels are automobile wheels which are made from an alloy of aluminum or magnesium metals. Historically, successful designs was arrived after years of experience well aided worth extensive field -testing. Since the 1970's several innovative methods of testing and experimental stress measurements have been initiated. In more recent years, the procedures have significantly improved by the emergence of a variety of experimental and analytical methods for structural analysis. Durability analysis, that is: fatigue life prediction and reliability methods, for dealing with various inherent in engineering structures has been used for the study of automotive rims. In its basic form a wheel is a transfer element between the tire and the vehicle.The main requirements of an automobile wheel.

Today, there are many kinds of wheels available in the market, and each of them has a every movement and the safety of the vehicle is to be considered as utmost important criteria in a vehicle and is standardized and certified. The first innovative idea to improve a wheel came by wrapping an iron band around the wooden wheels used on carts and wagons. And then, the pneumatic tire was invented, and in some form or another, has

continued to take us to the roads today. The improvements engineered for tires, as well as for rims has continued through the years, with the inventions and enhancements of nylon, cord, rubber, and other materials tried out for different types of tires.

The actual rim or wheel has been experimented with and altered in design and material as the world discovered steel, iron, and aluminum, and variations of these metals, and also different types of plastics. Though for the record, plastics are not yet considered suitable for structure of a rim, but mostly for cosmetic purpose, to cover the rim and improve the appearance. Alloy wheels are wheels that are made from an alloy of aluminum or magnesium. Alloys are mixtures of metal and other elements. They generally provide greater strength over pure metals, which are usually much softer and more ductile. Alloys of aluminum or magnesium are typically lighter for the same strength, provide better heat conduction, and often produce improved cosmetic appearance over steel wheels.

1.2 TYPES OF WHEELS

1.2.1 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 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.

1.2.2 Aluminium alloy wheel:

Aluminium is a metal with features of excellent lightness, thermal conductivity, physical characteristics of casting, low heat, machine processing and reutilizing, etc. This metal main advantage is decreased weight, high precision and design choices of the wheel.

1.2.3 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. It is expansive when compared with aluminium

1.2.4 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 developed stage.

RIM:

The rim is the "outer edge of a wheel, holding the tire."[23] It makes up the outer circular design of the wheel on which the inside edge of the tire is mounted on vehicles such as automobiles. For example, on a bicycle wheel the rim is a large hoop attached to the outer ends of the spokes of the wheel that holds the tire and tube.In the 1st millennium BCE an iron rim was introduced around the wooden wheels of chariots.

FIG 1 ALUMINIUM ALLOY WHEEL

II. STUDY ON WHEEL RIM

2.1 Manufacturing Process

From the very early designs used for pottery purposes to the most advanced contraptions known to mankind the wheel has been continuously driving our civilization like a catalyst in a chemical reaction. We thought it would be a good idea to take a stroll through the many stages of the wheel evolution and see where it's heading now.

Researchers agreed that 3500 BC is the year when the wheel was invented which is more of a ballpark than an exact year .The place is Mesopotamian chariots.

Wheel Manufacturing

The price, strength, weight, and overall performance of the wheel are directly related to the manufacturing technique employed to make it. The most common and least expensive method of wheel manufacturing is gravity casting, where molten metal is simply poured into a mould and allowed to cool and harden. This system works well, but requires the wheel to be heavier and thicker to compensate for porosity in the metal.

Wheel Rim Manufacturing Process

1. Low Carbon Steel Strip
2. Rim band feeding
3. Deburring for both sides
4. Stamping mark
5. Rim band coiling
6. Flatering weld joint
7. AC flash butt welding
8. Trimming welding Slag
9. Panishing
10. End cutting
11. Cooling
12. Re-Rounding
13. Initial flaring
14. 1st roll forming
15. 2nd roll forming
16. 3rd roll forming
17. 4th roll forming for non skid pattern
18. Edge flanging
19. Final Expanding
20. Valve hole punching
21. Press disc into rim
22. Combined welding for rim and disc
23. Bolting rim and disc

III. STRUCTURAL ANALYSIS PROCEDURE

The procedure for a static analysis consists of these tasks:

- Build the model
- Set solution control

- Set additional solution options
- Apply the loads
- Solve the analysis
- Review the results.

IV. MODELLING OF WHEEL RIM

SPECIFICATIONS

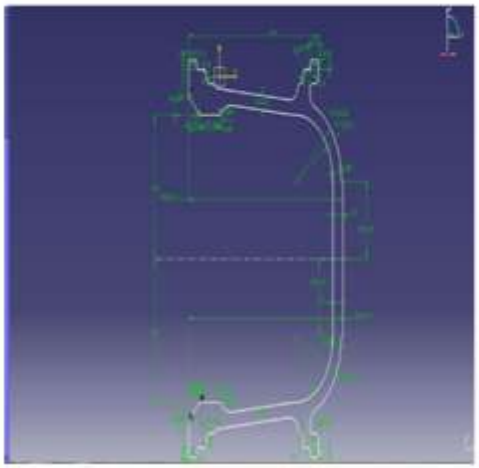
Tyre diameter =560mm, Wheel size=14 inches, Length =260mmFlange shape=J,Rim width=5 inches, Wheel type= disc wheel, Flange height= 0.68inches,Tyre type = radial Aspect ratio=65,Off set=80.54

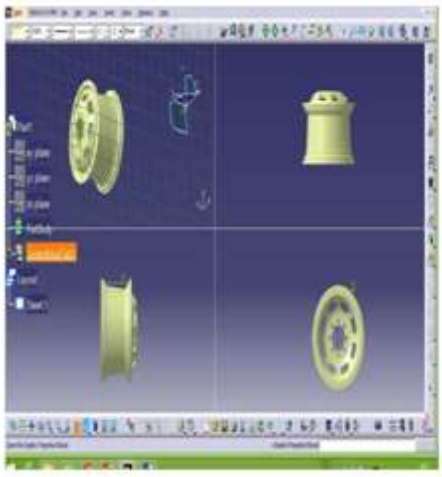
Modules of CATIA:

Sketcher	**Geometric Modelling**
Part	Wire-framing modelling
Assembly	Surface modelling
	Solid modelling

STEPS INVOLVED IN DESIGN

Draw the profile diagram of the wheel rim. Now revolve the profile body with respect to y-axis. Then we obtain the wheel rim body as





BASIC APPROACH TO FEA SOFTWARE:

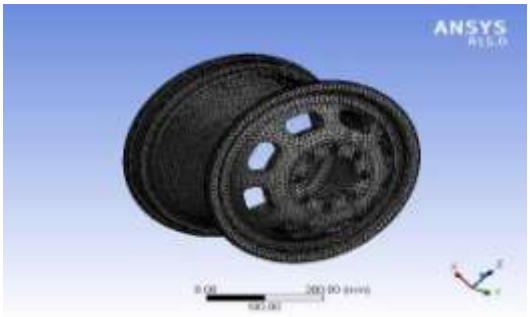
- Pre – processors
- Building of Model,
- Creation of FEA Model for Meshing
- Solver
- Post – Processor

ANALYSIS USING ANSYS

1. After preparing the model in CATIA it is imported to ANSYS. The file

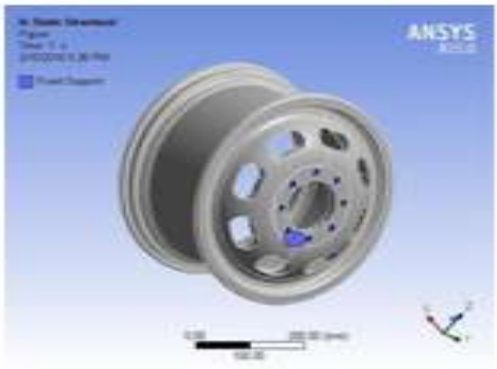
is imported from CATIA by File>Import>IGES

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



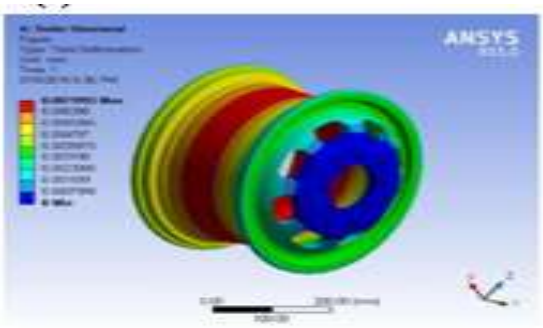
RESULTS FOR ALUMINIUM ALLOY&STRUCTURAL WHEEL RIM

(a) Model - Static Structural - Fixed Support

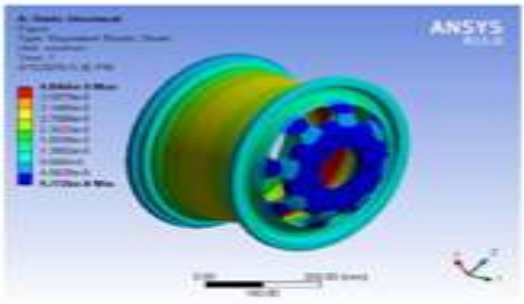


b) Pressure Applied on Aluminum Alloy wheel rim

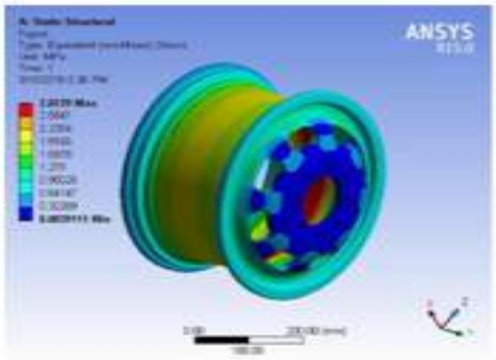
(c)Total Deformation

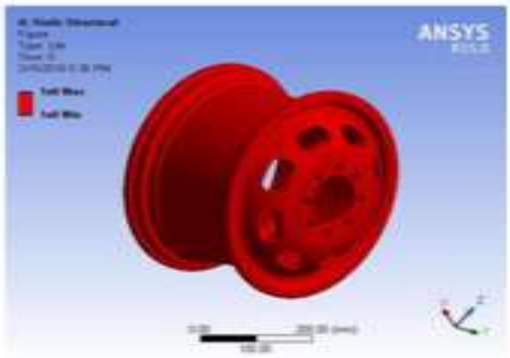


(d) Equivalent Elastic Strain



(e) Von-Mises Stress





(f) Life of Aluminum Alloy Wheel Rim

Test Results

	Structural Steel in (Mpa)	Aluminium Alloy (Mpa)
Total Deformation	0.0025258	0.0071955
Elastic Strain	1.4451e^-5	4.0464e^-5
Vonmises stress	2.8902	2.8729
Structural life	1e^6	1e^8

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 both ALUMINIUM ALLOY & STRUCTURAL STEEL and bolt circle of wheel rims is fixed. Following are the conclusions from the results obtained:

1) Aluminum wheel rim is subjected to more stress compared to Structural Steel.
2) Total deformation is more in case of Aluminum Alloy.
3) Deflections in Aluminum are more when compared to Structural Steel.
4) Since in both the cases Von-misses stresses is less than the Ultimate strength, taking deflections into account , Structural steel is preferred as best material for designed wheel rim.

5) By observing vibrational analysis results frequencies are considered to be safe in both cases

SCOPE FOR FUTURE WORK

1) In this thesis only pressure acting circumferentially on the wheel rim is only considered, this can be extended to other forces that act on the wheel rim.

2) In this thesis, only structural and Vibrational analysis is carried out, this can be extended to transient analysis

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