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DESIGN OPTIMIZATION OF CAR WHEEL RIM USING FEA TECHNIQUE

[1]MEKA GANGADHAR REDDY, [2]Mr. A. MAHABOOB BASHA
(gangadharreddym7@gmail.com)
[1]M.Tech Student, Department Of MECHANICAL Engineering
[2]Assistant Professor, Department of MECHANICAL
Chirannjeevi Reddy Institute of engineering and technology Anantapur

ABSTRACT:
Archaeologies and historians of today see the introduction of the wheel as the real genesis of any old civilisation. 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. 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. 3D modelling of the Volkswagen wheel which is different shape of rim (y-shape, u-shape and triangle shape) done in parametric software CREO. Static, fatigue and modal analysis is done ANSYS. In static analysis calculates the stress and displacement by using two different materials namely aluminium alloy and forged steel. In modal analysis, to determine the deflections and frequencies
Keywords: **Car rim, *ANSYS, CREO.***

1. INTRODUCTION:

Automotive wheels have evolved over the decades from early spoke designs of wood and steel, carryovers 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 (strain gauge and finite element methods).Within the past 10 years, durability analysis (fatigue life predication) and reliability methods for dealing with the variations inherent in engineering structure have been applied to the automotive wheel. Archaeologies and historians of today see the introduction of the wheel as the real genesis of any old civilisation. 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.

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 affects 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.

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.

1.4.1 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.

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This is to make the mounting and dismounting of the tire easy. In most circumstances there is a tape of 5 degrees in the bead seat area.

5 WHEEL/RIM (MATERIAL)

The development of wheel is traced from a material viewpoint beginning with wood, the first documented wheel material and ending with new materials under development such as composites and titanium. While it is impossible to imagine what civilization would like without a wheel, many early civilizations has numerous other tools but did not posses wheels. Undocumented legend has it that Chinese philosopher was inspired while watching a flower rolled by wind over the grass. In the period from 1900 to 1935 there were many different types of wheel materials and methods of construction in use. These include wood spoke, cast and forged steel, disc steel, cast Aluminum and wire wheels. Of all the material used in early 1900's only one is not still in use today-wood 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.

LITERATURE REVIEW

Changgu Lee [1] et.al conducted experiments on monolayer graphene and measured the intrinsic breaking strength and elastic properties using nano indentation. Researchers performed a series of simulations to determine the relationship between elastic constant and indentation breaking force. The obtained results were compared with measured values from other experiments. They concluded that grapheme as the strongest material ever measured and deformations of atomic nano materials may be beyond linear regime.

Guoxin Cao [2] reviewed on the mechanical behavior of Graphene at atomic level under free standing indentation and in-plane tension due to its 2D geometric properties. He focused mainly on the linear elastic properties and nonlinear elastic properties while the former properties are studied under small deformation and later under large deformation and concluded that graphene because of its atomic features and stated that atomistic simulation have significant influence in the advancement of technology.

Xin Wang et.al [3] studied about the mechanical properties of graphene in flame retarded epoxy resin and stated that the mechanical properties had decreased due to inclusion of flammable retardants and due to less interfacial interactions of additive.

Sung-Chiun Shiu et.al [4]studied mechanical and thermal properties of graphene in different formats an concluded graphene nano composites have higher elastic modulus and low thermal expansion coefficient and high glass transition temperature. In intercalated graphene, thermal and mechanical properties are improved due to greater amount of high density polymers in graphene nano composite. Oxidation on the surface of graphene proved relatively high reinforcing efficiency due to improved interaction energy.

Rasheed Atif [5] studied about epoxy based graphene nano composites for different weight % reinforcements for improvement in thermal conductivity, electrical conductivity and fracture toughness values for various dispersion techniques and itts. uded ated anymers forcements level of uniformity in dispersion. They stated that influence of graphene on mechanical properties is

depended on the weight fraction, topological features, surface modifications, morphology.

S Chaitanya [6] et.al studied about reducing the rim weight and stated that fuel economy and performance will be improved as the overall wright and inertial loads are reduced by minimizing the unsprung mass. The analysis showed that stresses developed are below yield stress after optimization.

M.Rezal [7] et.al studied about the deformation in car wheel rim and conducted an analysis at different loadings. Researchers suggested that Alloy Wheel Rim is safer, reliable and can withstand higher loads than Steel Wheel Rim as the later had developed high amount of stresses above the yield point, also higher displacement and deformed twice than the former. The

Maximum stress of alloy rim is about 80% less than the maximum stress developed in Steel Wheel Rim.

Gaurav Machave [8] A potentially viable technique for finite element modelling of wheel, subjected to loading, is highlighted. Inflation pressure does have a direct effect on the state of stress in an automobile rim under the influence of a load of the maximum tire rating. Under a radial load, the rim tends to valise about the point of contact, with a maximum displacement occurring at location of the bead seat. The inside bead seat deflects the highest and is prone to loss of air pressure as a result of dislodgement of the tire on the rim. The stresses are much higher in the rim than in the disk. The critical design areas of the wheel are the inboard bead seat and the well.

P. Meghashyam, S. Girivardhan Naidu and N. Sayed Baba[9] observed the results of both static and modal analysis obtained forged steel is suggested as best material and came to a conclusion that Aluminium wheel rim is subjected to more stress compared to Forged steel. In both cases von-mises stresses are less than ultimate strength. Deflections in aluminium are more when compared to forged steel. Since in both the cases von-mises stresses is less than the ultimate strength, talking deflections into account, forged steel is preferred as best material for designed wheel rim.

OBJECTIVE

The objective of this present work

- To examine the effects of tyre air pressure, radial load in conjunction with the centrifugal load on the stress and displacement in rims under static condition, through finite element analysis.
- Optimization of wheel rim to reduce Weight with considering the loads acting on a wheel through finite element analysis.
- Determination of frequency and mode shapes of wheel rim through

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modal analysis using finite element analysis.

- ➢ Life Prediction using finite element analysis considering Stress-life approach Prefer the best material among three lighter alloys such as aluminum 7475, forged steel and Kevlar composite wheel rim considering static structural and modal analysis.

PROBLEM DEFINITION

- ➢ The wheel rim bents due to very high radial load.

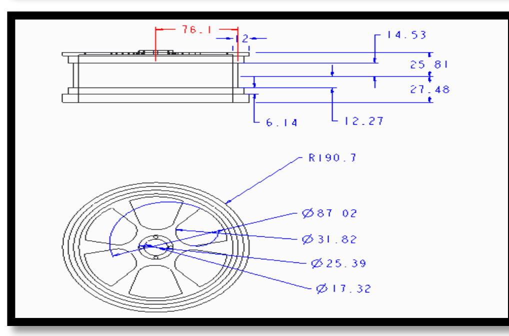
- ➢ Damage such as rust, cracks, dents, etc. could result in excessive vibration, loss of air pressure, instability, and even complete structural failure.

- ➢ The current trend is to provide weight/cost effective products which meet the stringent safety requirements .To reduce the problems and gain the requirements, proper material selection is important in rim design.

- ➢ So analysis for different materials is performed using FEA for Stress, Displacement, Fatigue life and Natural frequency. By analyzing these results we can select an optimum wheel considering strength and durability.

WHEEL SPECIFICATIONS:

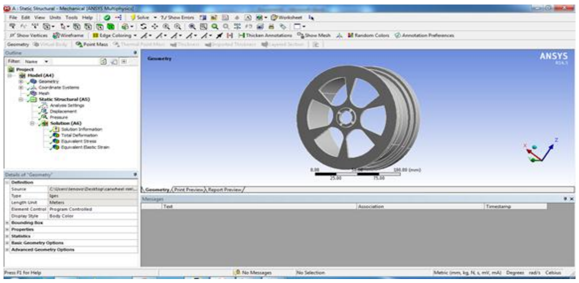
- Model: Volkswagen polo 1.0 TSI
- Rim Dia: 15 in (381mm)
- Rim Width: 6 in (152.40mm)
- Tire pressure: 35psi (0.241N/mm2)
- Aspect ratio: 35-70
- Max power: 81KW
- Centre bore: 57.1mm
- Offset: ET+41 ET- "Einpress Tieffe"(german means offset)
- Max Torque: 160 N-m
- **Models**
- **4.5.1 3d model of U-shape spoke wheel**



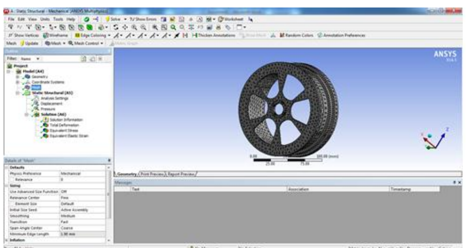
STATIC ANALYSIS OF CAR WHEEL RIM

Case: 1 U-shape spokes

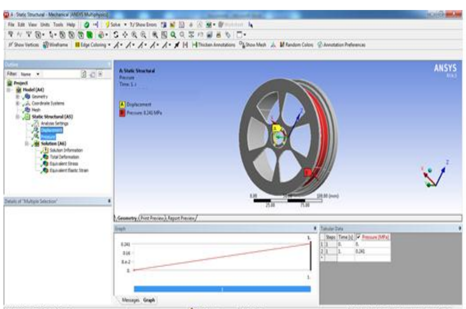
Material: steel



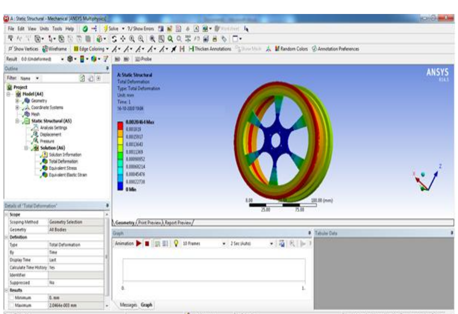
Meshed model



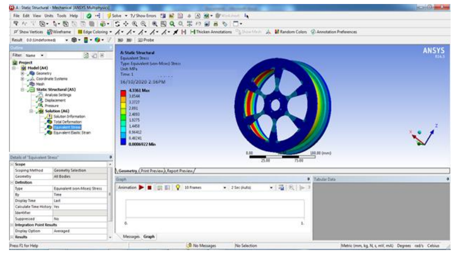
Boundary conditions



Total deformation



VON-MISES STRESS

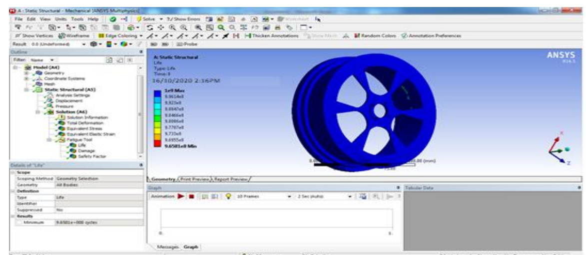


FATIGUE ANALYSIS OF CAR WHEEL RIM

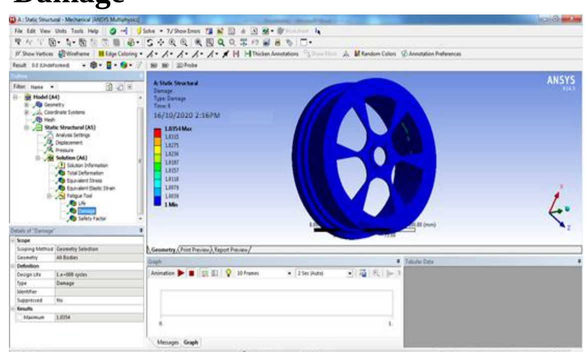
Case: 1 U-shape spokes

Material: steel

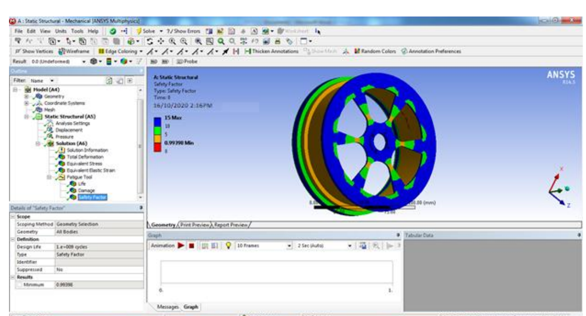
Life



Damage



Safety factor



Results table

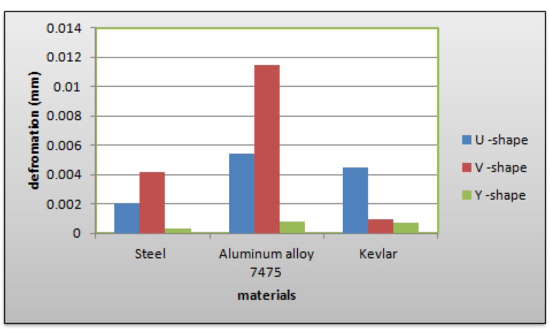
Static analysis results

Spoke shape	Materials	Total deformation(mm)	Stress (N/mm^2)	Strain
U -shape	Steel	0.0020464	4.3361	2.168e-5
	Aluminum alloy 7475	0.0054271	3.9871	5.788e-5
	Kevlar	0.0044671	3.581	4.7175e-5
V -shape	Steel	0.0041876	1.5741	8.0867e-5
	Aluminum alloy 7475	0.011506	1.4793	2.169e-5
	Kevlar	0.00093764	1.3095	1.8147e-5
Y -shape	Steel	0.00029764	0.97119	4.7376e-6
	Aluminum alloy 7475	0.00081123	0.89823	1.3037e-5
	Kevlar	0.0007026	0.84598	1.1131e-5

Fatigue analysis

Spoke shape	Materials	Life	Damage	Safety factor	
				Min	Max
U -shape	Steel	1e9	1.0354	0.9938	15
	Aluminum alloy 7475	1e9	358.02	0.2214	15
	Kevlar	1e9	263.63	0.24044	15
V -shape	Steel	1e9	16.206	0.54761	15
	Aluminum alloy 7475	1e9	11.086	0.60733	15
	Kevlar	1e9	8.2668	0.65828	15
Y -shape	Steel	1e9	1.9872	0.887511	15
	Aluminum alloy 7475	1e9	1.2675	0.959671	15
	Kevlar	1e9	1.011	1.0189	15

graphs



CONCLUSION

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. 3D modelling of the car rim done by parametric software CREO Static and modal analysis done by ANSYS The weight of the rim is optimized by reducing the weight of 7%, and the optimization process is based on the defined loads act by the wheel rim. Since the maximum stress generated at inboard bead seat and flange area are less than the yield strength, hence design is safe for all the three materials If we consider only Deflection and Fatigue life into account the steel can be preferred. As we know the benefits of performance and fuel efficiency from low weight wheels, hence considering the strength to weight ratio and dynamic behaviour, Kevlar Composite material is considered as more feasible to be used in wheel rim than other materials.

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