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DESIGN OPTIMIZATION OF CAR WHEEL RIM USING FEA TECHNIQUE

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A B S T R A C T

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.

Key words: Car rim, Forged Steel, Aluminium alloy, CREO, Ansys Workbench, etc.

I INTRODUCTION

INTRODUCTION OF CAR RIM

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.

The handling of a vehicle is always improved with light weight. As in case of ride, the lighter the un sprung 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.

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.

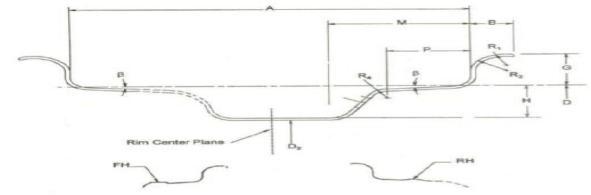
6. Bead Seat: Bead seat approaches in contact with the bead face and it is a part of rim which holds the tire in a radial

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.



Dimensions: A – Rim width
B – Flange width
D – Rim diameter
D_2 – Rim inside diameter
G – Flange height
H – Well depth
M – Well position
P – Bead seat width
R_1 – Flange compound radius
R_2 – Flange radius
R_4 – Well top radius
FH – Flat hump
RH – Round hump
β – Bead seat angle

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.

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 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.

DIFFERENT MODULES IN CREO

- PART DESIGN

- ASSEMBLY
- DRAWING
- SHEETMETAL

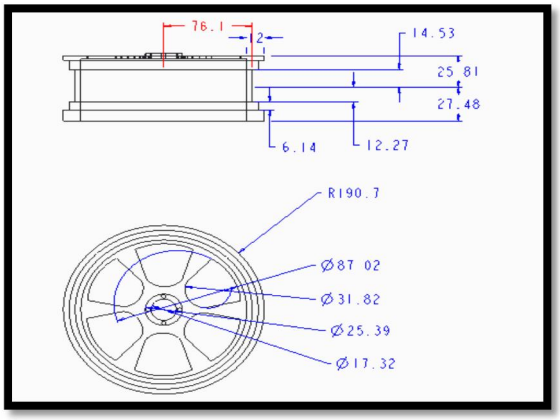
WHEEL SPECIFICATIONS:

- 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- “EinpressTieffe”(german means offset)
- Max Torque: 160 N-m

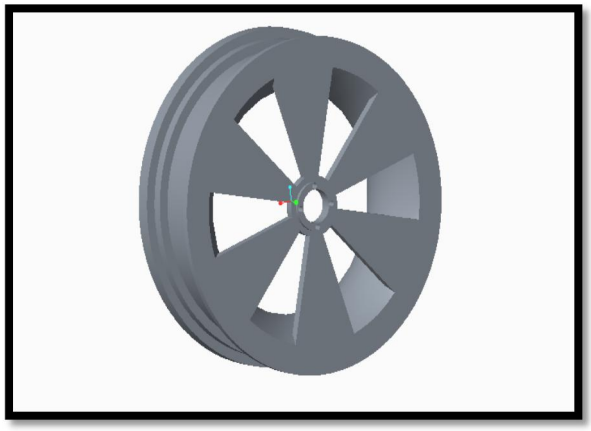
Models

3d model of U-shape spoke wheel

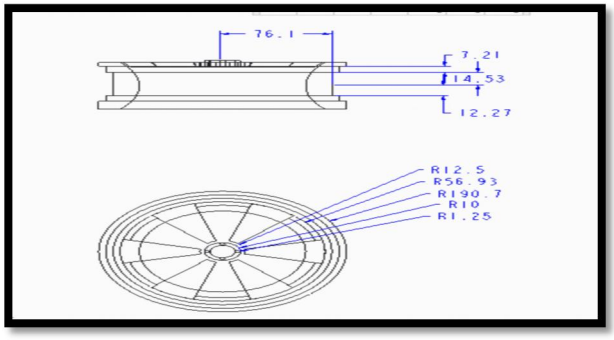
2D model



V shape model



2d model

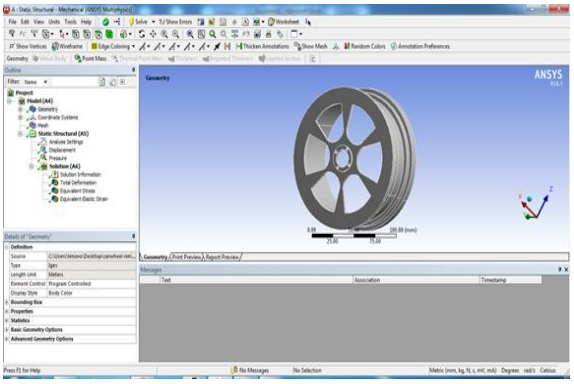


STATIC ANALYSIS OF CAR WHEEL RIM

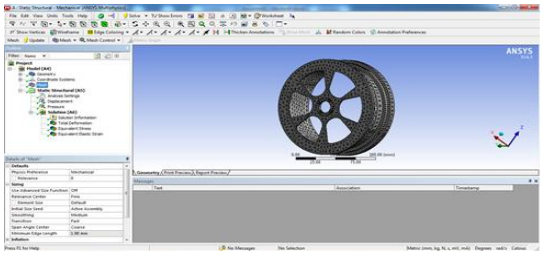
Case: 1 U-shape spokes

Material: steel

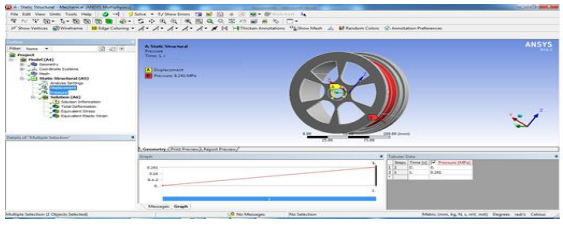
Import geometry



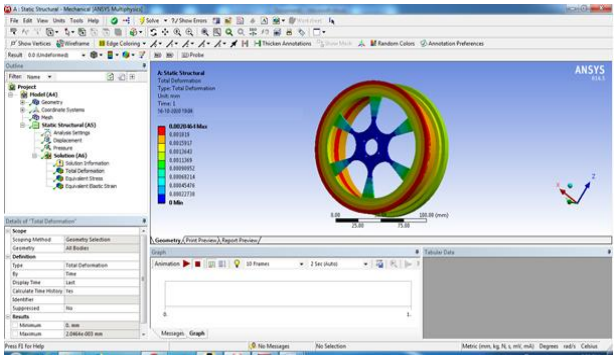
Meshing



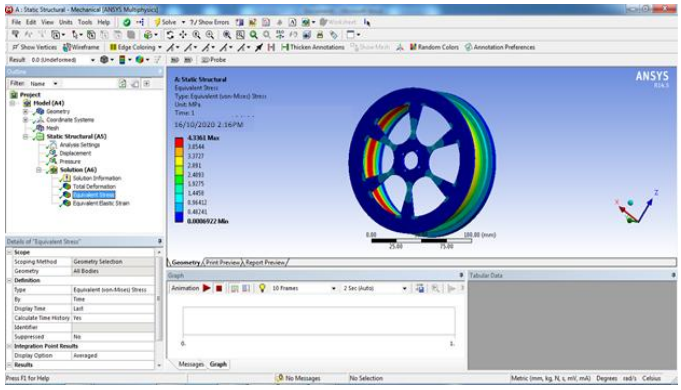
Boundary conditons

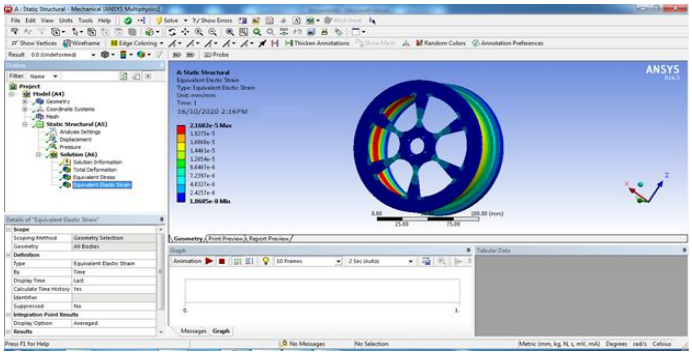


Total deformation



Stress





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**

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 modeling 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 behavior, Kevlar Composite material is considered as more feasible to be used in wheel rim than other materials**.**

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