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DESIGN AND ANALYSIS OF CAR RIM

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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 CATIA. 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 wheel rim, load analysis, CATIA software

I. 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.

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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.

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Materials to produce these wheels have become has sophisticated as a design and materials can range from steel to nonferrous 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

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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 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.

II. LITERATURE SURVEY

Changgu Lee [1] et.al conducted experiments on monolayer grapheme and measured the intrinsic breaking strength and elastic properties using nanoindentation. 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 behaviour of Grapheme at atomic level under freestanding indentation and in-plane tension due to its 2Dgeometric 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 grapheme because of its atomic features and stated that atomistic simulation have significant

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influence in the advancement of technology.

Xin Wang et.al [3] studied about the mechanical properties of grapheme 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 grapheme in different formats and concluded grapheme nano composites have higher elastic modulus and low thermal expansion coefficient and high glass transition temperature. In intercalated grapheme, thermal and mechanical properties are improved due to greater amount of high density polymers in grapheme nano composite. Oxidation on the surface of grapheme proved relatively high reinforcing efficiency due to improved interaction energy.

Rasheed Atif [5] studied about epoxy based grapheme nano composites for different weight %reinforcements for improvement in thermal conductivity, electrical conductivity and fracture toughness values for various dispersion techniques and it. Used at edanymers forcements level of uniformity in dispersion. They stated that in fluency of grapheme 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 UN sprung 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 Rims safer, reliable and can withstand higher loads than Steel Wheel Rim as the

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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.

III METHODOLOGY

- 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.
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IV DESIGN

INTRODUCTION TO CAD

Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis,

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or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations.

The term **CADD** (for Computer Aided Design and Drafting) is also used.

Its use in designing electronic systems is known as electronic design automation, or **EDA**. In mechanical design it is known as mechanical design automation (**MDA**) or **computer-aided drafting** (**CAD**), which includes the process of creating a technical drawing with the use of computer software.

CAD software for mechanical design uses either vector-based graphics to depict the objects of traditional drafting, or may also produce raster graphics showing the overall appearance of designed objects. However, it involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application-specific conventions.

CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) space.

CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer animation for special effects in movies, advertising and technical manuals, often called DCC digital content creation. The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are

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designed using techniques unheard of by engineers of the 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry.

INTRODUCTION TO CREO

Pro/ENGINEER, PTC's parametric, integrated **3D CAD/CAM/CAE solution**, is used by discrete manufacturers for mechanical engineering, design and manufacturing.

Created by Dr. Samuel P. Ginsberg in the mid-1980s, Pro/ENGINEER was the industry's first successful parametric, 3D CAD modeling system. The parametric modeling approach uses parameters, dimensions, features, and relationships to capture intended product behavior and create a recipe which enables design automation and the optimization of design and product development processes.

This powerful and rich design approach is used by companies whose product strategy is family-based or platform-driven, where a prescriptive design strategy is critical to the success of the design process by embedding engineering constraints and relationships to quickly optimize the design, or where the resulting geometry may be complex or based upon equations. Pro/ENGINEER provides a complete set of design, analysis and manufacturing capabilities on one, integral, scalable platform. These capabilities include Solid Modeling, Surfacing, Rendering, Data Interoperability, Routed Systems Design, Simulation, Tolerance Analysis, and NC and Tooling Design.

Companies use Pro/ENGINEER to create a complete 3D digital model of their products. The models consist of 2D and 3D solid model data which can also be used downstream in finite element analysis, rapid prototyping, tooling design, and CNC manufacturing. All data is associative and interchangeable between

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the CAD, CAE and CAM modules without conversion. A product and its entire bill of materials (BOM) can be modeled accurately with fully associative engineering drawings, and revision control information. The associatively in Pro/ENGINEER enables users to make changes in the design at any time during the product development process and automatically update downstream deliverables. This capability enables concurrent engineering — design, analysis and manufacturing engineers working in parallel — and streamlines product development processes.

Pro/ENGINEER is an integral part of a broader product development system developed by PTC. It seamlessly connects to PTC's other solutions including Wind-chill, Product View, MathCAD and Arbor text.

DIFFERENT MODULES IN CREO

- PART DESIGN
- ASSEMBLY
- DRAWING
- SHEETMETAL
- MANUFACTURING

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

V ANALYSIS

INTRODUCTION TO FEA

Finite element evaluation is a manner of fixing, typically about, exceptional troubles in engineering and era. It is used mainly for problems for which no actual answer, expressible in some mathematical form, is available. As such, it is a numerical instead of an analytical approach. Methods of this kind are wanted

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because of the truth analytical techniques cannot cope with the real, complicated problems which might be met with in engineering. For instance, engineering electricity of substances or the mathematical concept of elasticity can be used to calculate analytically the stresses and strains in a dishonest beam, but neither can be very a achievement in locating out what's taking region in part of a car suspension device inside the direction of cornering.

One of the number one packages of FEA emerges as, indeed, to find out the stresses and lines in engineering components beneath load. FEA, whilst implemented to any practical model of an engineering element, calls for a massive quantity of computation and the development of the method has depended on the delivery of appropriate digital laptop structures for it to run on. The method is now done to troubles concerning a great type of phenomena, together with vibrations, heat conduction, fluid mechanics and electrostatics, and a large style of fabric residences, which encompass linear-elastic (Hookean) conduct and behaviour concerning deviation from Hooke's law (for example, plasticity or rubber-elasticity).

Many complete famous-reason pc packages within the meanwhile are available that might deal with a considerable range of phenomena, together with more specialised programs for particular applications, for instance, for the study of dynamic phenomena or big-scale plastic float. Depending on the type and complexity of the assessment, such programs may additionally moreover run on a microcomputer or, on the possibility severe, on a supercomputer. FEA is basically a chunk-clever technique. It may be completed to 1-dimensional issues, but extra generally there can be an area or extent inside which the answer is needed. This is split up into some of smaller regions or volumes, which may be known as finite elements. Figure 1 shows a -

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dimensional model of a spanner that has been so divided: the way is referred to as discretisation, and the assembly of factors is referred to as a mesh.

INTRODUCTION TO ANSYS

Structural Analysis

ANSYS Autodyne is pc simulation device for simulating the reaction of materials to quick period immoderate loadings from impact, excessive stress or explosions. ANSYS Mechanical ANSYS Mechanical is a finite detail evaluation tool for structural assessment, together with linear, nonlinear and dynamic studies. This laptop simulation product offers finite factors to version behaviour, and allows fabric fashions and equation solvers for a big style of mechanical design problems. ANSYS Mechanical also includes thermal evaluation and paired-physics capabilities concerning acoustics, piezoelectric, thermal–structural and thermo-electric powered evaluation.

VI RESULTS AND DISCUSSION

Case: 1 U-shape spokes

Material: steel

Save creo Model as .Iges format→→Ansys → Workbench→ Select evaluation device → static structural → double click on

→→Select geometry → proper click on → import geometry → pick out browse →open element → good enough

→→ Select mesh on work bench → proper click on →edit

Double click on geometry → choose MSBR → edit cloth →

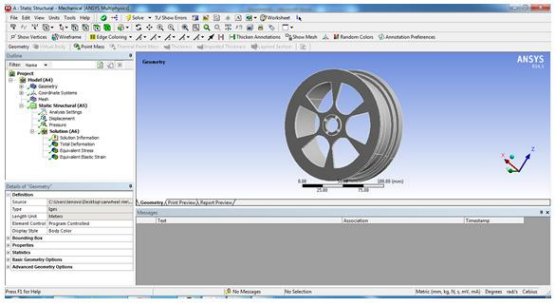

Fig: Imported model

Select mesh on left side part tree → right click → generate mesh →

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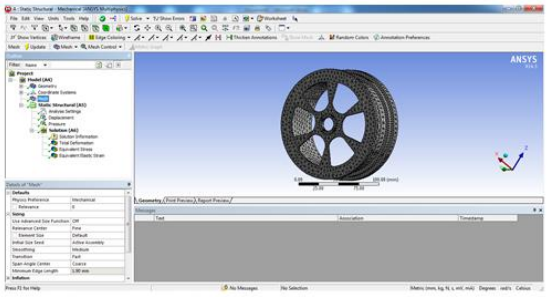


Fig: meshed model

Select static structural right click on → insert → pick rotational velocity and stuck assist → Select displacement → select required area → click on practice → positioned X,Y,Z factor 0 →

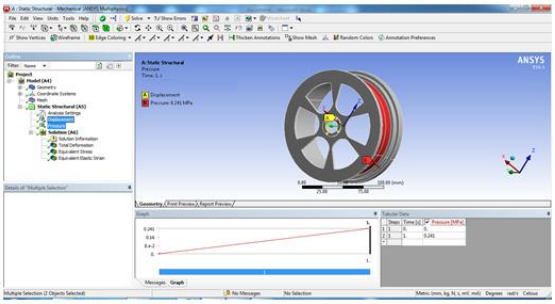
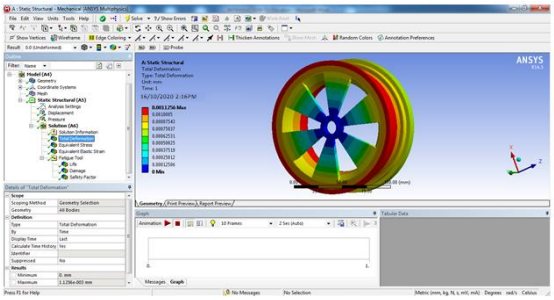
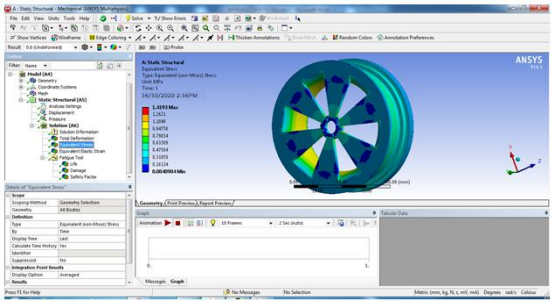


Fig: boundary conditions

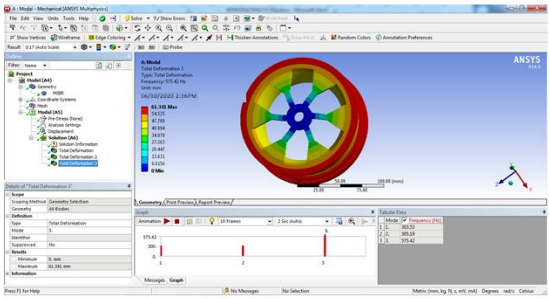
TOTAL DEFORMATION



VON-MISES STRESS



Total deformation 3



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 results

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

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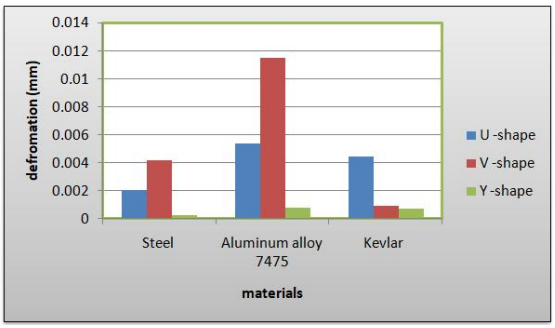
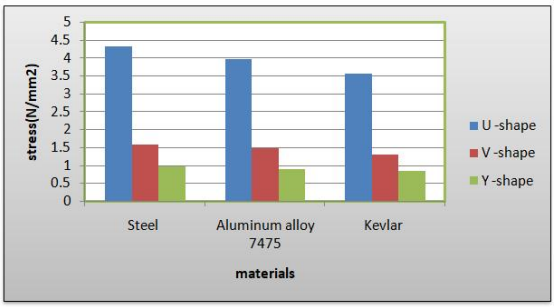


According to the above graph, materials and spoke shapes Vs deformation.

The minimum deformation at Y-shape spoke with material of steel due to weight of material is high compared to other two materials and maximum deformation at V-shape with material of aluminium alloy 7475 due to weight of the material is low when compared to steel.



According to the above graph, materials and spoke shapes Vs stress.

The minimum stress at Y-shape spoke with material of Kevlar composite due to area of cross section increases at Y-shape when compared to other two geometries.

VII 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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