Structural Analysis of Bike Alloy Wheel

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Abstract— **In this project we are doing the material optimization of two wheeler alloy wheel. This project we are designed the 3D model of the alloy wheel by using pro-e software and the analysis taken by different materials of the alloy wheel and the analysis taken by the ansys software. This project we are analysed the rotational velocity and force acting on the alloy wheel by the three materials. Presently the alloy wheels are made by the material of aluminium alloy and magnesium alloy, this project we are testing the same load under the three materials. The materials are thermoplastic polymer (PEEK), carbon fiber and E glass epoxy. Then the model is analysed for the deflection, max stress induced and strain for all the above materials under same load.**

Keywords— **Bike, Alloy wheel , 3D model,FEA,Ansys**

INTRODUCTION

A wheel is a circular device that is capable of rotating on its axis, facilitating movement or transportation while supporting a load (mass), or performing labor in machines. Common examples are found in transport applications. A wheel, together with an axle overcomes friction by facilitating motion by rolling. In order for wheels to rotate, a moment needs to be applied to the wheel about its axis, either by way of gravity, or by application of another external force. More generally the term is also used for other circular objects that rotate or turn, such as a ship's wheel, steering wheel and flywheel.

Alloy wheels are automobile wheels which are made from an alloy of aluminum. Alloy wheels differ from normal steel wheels because of their lighter weight, which improves the steering and the speed of the vehicle, however some alloy wheels are heavier than the equivalent size steel wheel. Alloy wheels are also better heat conductors than steel wheels, improving heat dissipation from the brakes, which reduces the chance of brake failure in more demanding driving conditions. Over the years, achieving success in mechanical design has been made possible only after years of experience coupled with rigorous field-testing. Recently the procedures have significantly improved with the emergence of innovative method on experimental and analytical analysis.

Lighter wheels can improve handling by reducing unsprung mass , allowing suspension to follow the terrain more closely and thus improve grip, however not all alloy wheels are lighter than their steel equivalents. Reduction in overall vehicle mass can also help to reduce fuel consumption.

1.1Types Of Wheels

There are so many types of wheels still in use in the automobile industry today. They vary significantly in size, shape, and materials used, but all follow the same basic principles.

1.2Wire Spoke Wheel

Wire spoke wheel is a structural where the outside edge part of the wheel (rim) and the axle mounting part are connected by numerous wires called spokes. Today's vehicles with their high horsepower have made this type of wheel construction obsolete. This type of wheel is still used on classic vehicles. Light alloy wheels have developed in recent years, a design to emphasize this spoke effect to satisfy users fashion requirements.

1.3Steel Disc Wheel

This is a rim which processes the steel-made rim and the wheel into one by welding, and it is used mainly for mopeds vehicle especially.

1.4 Light Alloy Wheel

These wheels based on the use of light metals such as aluminium and magnesium has become popular in the market. These wheels rapidly become popular for the original equipment vehicle in Europe in 1960's and for the replacement tire in United States in 1970's.

1.5 Aluminium Alloy Wheel

Aluminium is a metal with features of excellent lightness, thermal conductivity, corrosion resistance, characteristics of casting, low temperature, machine processing and recycling, etc. This metals main advantage is reduced weight, high accuracy and design choices of the wheel. This metal is useful for energy conservation because it is possible to re-cycle aluminum easily.

1.6 Composite Material Wheel

The composite materials wheel, is different from the light alloy wheel, and it (Generally, it is thermoplastic resin which contains the glass fiber reinforcement material) is developed mainly for low weight. Again the second composite material, i.e., Carbon fiber which is been used now a days. This material is also having similar properties of thermoplastic resin. The use of this material is restricted to only sports vehicles because of their high cost of manufacturing process.

1.7 LITERATURE SURVEY

A wheel is a highly stressed component in an automobile that is subjected to loads. Because of the long life and high stresses, as well as the need for weight reduction, material and manufacturing process selection is important in wheel design. There are competitions among materials and manufacturing processes, due to cost performance, and weight. This is a direct result of industry demand for components that are lighter, to increase efficiency, and cheaper to produce, while at the same time maintaining fatigue strength and other functional requirements.

A paper published in the year 2014,which is about the replacement of composite instead of aluminum wheel by Priya Udasi, Sanjay Kumbhare, International Journal of Recent Technology and Engineering. To improve the quality of wheels, aluminum is replaced with composite material and the deformation, stress and strain values of the composite wheel is low compared to aluminium wheel. Wheel design of two wheeler is made by using NX 7.5, andAnalysis has been done by Ansys 13.0 software to determine thevarious stresses, strain. Saurabh M Paropate and Sameer J Deshmukh (2013): In this project presents motor cycle wheel rim is analyzed with different materials. In this project existing aluminium alloy is replaced with magnesium alloy, carbon fiber and thermoplastic resin. By using pro e, a 3-dimensional model of new automotive wheel design is developed. Then, the finite element model of the wheel is built and solved by using ANSYS 11.

1.8 Aim And Scope Of Study

To create simulations of different material alloy wheels that focus on reducing the deformation of the current alloy wheel and selecting better material.

2.METHODOLOGY:

2.1 Modelling

The bike alloy wheel model has been entirely modeled by PRO E software. First of all sketch command of the pro e is opened. Then by using 2d commands sketch is created. Then the 3D model of bike alloy wheel plates is created by extrude, revolve command in pro e.

2.2 Transformation Of Model

Then the model is converted in to the IGES format which is most suitable and easy access for any other software's. Using the IGES format we can import the bike alloy wheel model from pro e to ANSYS. Now we can make static structural analysis.

3.Meshing

After the complete structure is modeled, bike alloy wheel is meshed. This has been done by using ansys workbench software. The last step to be completed before meshing the model is to set the meshing controls, i.e. the element shape, size, the number of divisions per line, etc. Selecting the various parts of the model, one by one finite element mesh is generated. The critical portions are plates with sharp corners, curvature etc. These areas can be remeshed with advance mesh control options. "Smart element sizing" is a meshing feature that creates initial element sizes for free meshing operation. Proper care has to be taken to have the control over the number of elements and hence the number of degrees of freedom associated with the structure. This is done to have a control over the solution time. However, no compromise is made on the accuracy of the results.

3.1 Loading

The types of loading that can be applied in a structural analysis include:

1.Externally applied forces and pressures

2.Steady-state inertial forces (such as gravity or rotational velocity)

3.Imposed (nonzero) displacements

3.2 Analysis

A static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time.

3.3 Generative design

Pro/engineer is a parametric, integrated 3d cad/ cam/ cae solution created by parametric technology corporation (ptc). It was the first to market with parametric, feature-based, associativesolid modeling software. the application runs on Microsoft windows platforms, and provides solid modeling, assembly modeling and drafting, finite element analysis, and tooling functionality for mechanical engineers. the pro/engineer name was changed to creo elements/pro on October 28, 2010, coinciding with ptc's announcement of creo, a new design software solution. Creo Elements/Pro (formerly 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. Geisberg in the mid-1980s, Pro/ENGINEER was the industry's first successful rule-based constraint (sometimes called "parametric" or "variational") 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 design approach is used by companies whose product strategy is family-based or platform-driven, where a prescriptive design strategy is fundamental 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. Creo Elements/Pro provides a complete set of design, analysis and manufacturing capabilities on one, integral, scalable platform. These required capabilities include Solid Modeling, Surfacing, Rendering, Data Interoperability, Routed Systems Design, Simulation, Tolerance Analysis, and NC and Tooling Design.Companies use Creo Elements/Pro 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 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 associativity functionality in Creo Elements/Pro 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.

4.Design Concepts For Creating Alloy Wheel

You can design many different types of models in Pro/ENGINEER. However, before you begin your design project, you need to understand a few basic design concepts:

4.1 pro/engineer wildfire 5.0 compatibility

The release of Pro/ENGINEER Wildfire 5.0 and its compatibility with Windchill 9.1 provides productivity improvements beneficial to the Pro/ENGINEER user working in an integral environment, including embedded browser options on the Windows platform, tabbed browsing, accessible Windchill table views, and support for attributes with units.

4.2 Benefits and Description of Pro/ENGINEER Wildfire 5.0

Starting with Windchill 9.1 M020, Pro/ENGINEER Wildfire 5.0’s integration introduces the following productivity improvements related to CAD data management:

4.3 Optional Browser Configurations – Allows the Microsoft Windows user to choose the embedded browser to run with Pro/ENGINEER, providing the choice between the following:

1.(Default) Internet Explorer and Pro/ENGINEER running under a single process

2.Internet Explorer and Pro/ENGINEER each running as separate processes

3.Mozilla based browser and Pro/ENGINEER each running as separate processes

The default option allows users to continue to run the embedded browser in the same configuration as they have done with previous releases of Pro/ENGINEER, whereas the additional two options allow running the browser in a separate process. Running the browser as a separate process will free up the full application memory limit for Pro/ENGINEER when running 32-bit Windows, which may be advantageous when working with larger assemblies. In addition, the option to configure Mozilla as the embedded browser has been shown to provide additional performance benefits over Internet Explorer, particularly when working with a larger workspace. Setting this option is controlled by a new **config.pro 1,2**

figure 1.1 3d model of alloy wheel created by using pro e

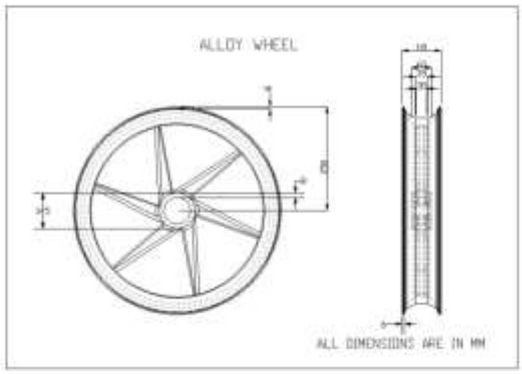

Figure 1.2 Dimensions Of Alloy Wheel

1) 5. STATIC STRUCTURAL ANALYSIS

A static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time.

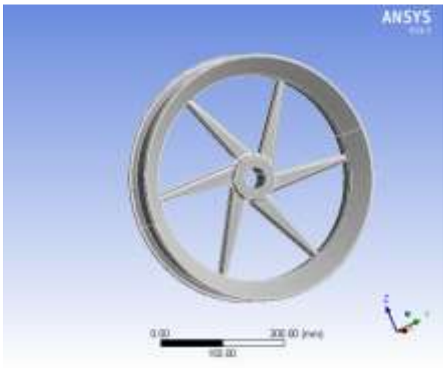

Figure 1.2 Geometry Of Alloy Wheel In Ansys Workbench

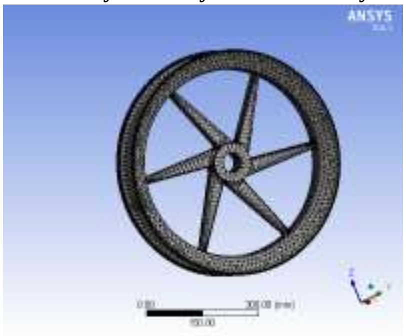

Figure 1.3 Mesh Of Mesh In Ansys Workbench

Figure 1.4 Loads On Alloy Wheel In Ansys Workbench

6.SELECTION OF MATERIALS

6.1Aluminum alloy

Aluminium alloys are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese and silicon. The Aluminum alloy material composition i.e. LM 13 Material composition of LM13 is Al-Si (BS: LM13) alloy was used as the matrix material. The alloy contains 11.00 wt.% Si, 1.00 wt.% Mg, 1.50 wt.%.Ni, 1.00 wt.% Cu, 0.80 wt.% Fe, 0.50 wt.% Mn and balance was Al. LM13–10 wt.% SiCp composite.

6.1.1MECHANICAL PROPERTIES

Young's modulus	71000 MPa
Poisson's ratio	0.33
Density	2770 kg/m^3
Shear modulus	26692 MPa
Bulk modulus	69608 MPa

6.2 Magnesium Alloy

Magnesium alloys are very attractive in such applications as automotive, railway and aerospace technologies. However, their low ignition temperatures have restricted their use. For example, the FAA prohibits the use of magnesium alloys for airplanes. The ignition temperature has been improved to approximately 800 deg C by developing Ca-added, CaO-added and (Ca and Y)-added alloys; however, their mechanical properties are inferior to those of aluminum alloys. Recently, we have developed a non-flammable magnesium alloy with high strength. This alloy contains no rare metals and is produced through plastic working of cast ingots. Its ignition temperature is above 1,117 deg C, which is higher than the boiling point of pure magnesium (1,091 deg C), and the tensile yield strength was 460 MPa, which is similar to super-duralumin. This alloy enables us to expand the application field, to reduce the production costs, and to improve the safety of materials production and working.

6.2.1 Mechanical Properties

Young's modulus	46000MPa
Poisson's ratio	0.29
Density	1800 kg/m^3
Shear modulus	17829 MPa
Bulk modulus	36508 MPa

6.3 Composite

Composite A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fibers, particles, or flakes. The matrix phase materials are generally continuous. Examples of composite systems include concrete reinforced with steel and epoxy reinforced with graphite fibers, etc.

6.3.1 CLASSIFICATION

6.3.2 MATRIX BASED

Polymer Matrix Composites (PMC's) – These are the most common and will be discussed here. Also known as FRP - Fiber Reinforced Polymers (or Plastics) – these materials use a polymer-based resin as the matrix, and a variety of fibers such as glass, carbon and aramid as the reinforcement. Metal Matrix Composites (MMC's) - Increasingly found in the automotive industry, these materials use a metal such as aluminium as the matrix, and reinforce it with fibers such as silicon carbide. Ceramic Matrix Composites (CMC's) - Used in very high temperature environments, these materials use a ceramic as the matrix and reinforce it with short fibers, or whiskers such as those made from silicon carbide and boron nitride.

6.4 E Glass/ Epoxy

The most common types of glass fiber used in fiberglass is E-glass, which is alumino-borosilicate glass with less than 1% w/w alkali oxides, mainly used for glass-reinforced plastics like epoxy. Fiberglass is a type of fiber reinforced plasticwhere the reinforcement fiber is specifically glass fiber. The glass fiber may be randomly arranged but is commonly woven into a mat. The plastic matrix may be a thermosetting plastic- most often epoxy.

6.4.1 MECHANICAL PROPERTIES

Young's modulus	73000 MPa
Poisson's ratio	0.259
Density	1900 kg/m^3
Shear modulus	28991 MPa
Bulk modulus	50484 MPa

6.5 Thermoplastic Resin (Peek)

Polyether ether ketone (PEEK) is a colourless organicthermoplasticpolymer in the polyaryletherketone (PAEK) family, used in engineering applications. PEEK polymers are obtained by step-growth polymerization by the dialkylation of bisphenolate salts. Typical is the reaction of 4,4'-difluorobenzophenone with the disodium salt of hydroquinone, which is generated in situ by deprotonation with sodium carbonate. The reaction is conducted around 300 °C in polar aprotic solvents - such as diphenyl sulphone.

6.5.1 Mechanical Properties

Young's modulus	3950 MPa
Poisson's ratio	0.3931
Density	1320 kg/m^3
Shear modulus	1417.7 MPa
bulk modulus	6158.4 mpa

6.6 Carbon fiber

Carbon fiber, alternatively graphite fiber or CF, is a material consisting of fibers about 5–10 µm in diameter and composed mostly of carbon atoms. To produce carbon fiber, the carbon atoms are bonded together in crystals that are more or less aligned parallel to the long axis of the fiber as the crystal alignment gives the fiber high strength-to-volume ratio (making it strong for its size). Several thousand carbon fibers are bundled together to form a tow, which may be used by itself or woven into a fabric.

6.6.1 Mechanical Properties

Young's modulus	2.1e+5 MPa
Poisson's ratio	0.36
Density	1800 kg/m^3
Shear modulus	1.4706e+5 MPa
Bulk modulus	4.7619e+5 MPa

7.Result And Discussion

7.1 Total Deformation

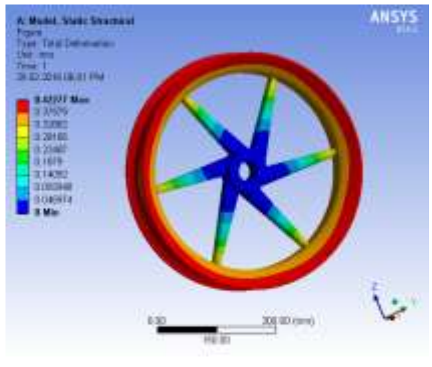

Figure 1.1 Aluminium Alloy

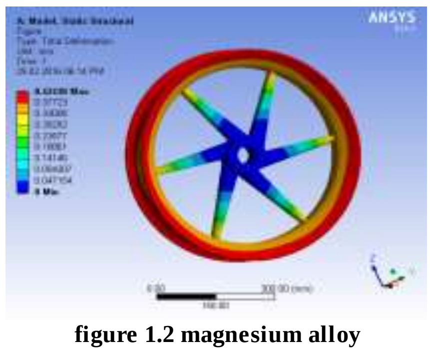

figure 1.2 magnesium alloy

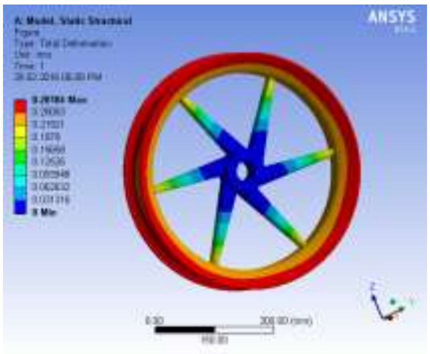

Figure 1.3 E Glass/ Epoxy

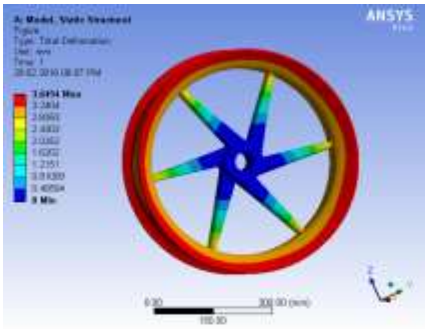

Figure 1.4 Thermoplastic Resin (Peek)

8.CONCLUSION

Analysis results from testing the alloy wheel under static load containing the stresses and deflection are listed in the Table. The materials we analyze are Aluminium alloy, magnesium alloy, E glass epoxy, Thermoplastic resin and carbon fiber.

The analysis of alloy wheel we found that the carbon fiber alloy wheel have a good strength and it have a less deformation under the fixed support and force, than the other three material which are used for alloy wheels. So the existing aluminium alloy material can be replaced with optimized carbon fiber material because of its low deformation and elastic strain values. Compared to other optimized materials like E glass epoxy and thermoplastic resin the carbon fiber has low deformation value. So the suitable material for alloy wheel is carbon fiber.

Doing this project we are study about the 3Dmodeling software (PRO-E) and Study about the analyzing software (ansys) to develop our basic knowledge to know about the industrial design.

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