

Modelling and Thermal Stress Analysis of Disc Brake Used For Two Wheeler

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ABSTRACT

At the IAA in Frankfurt in 1999, the carbonceramic brake disc had its world premiere. The use of the high-tech material had revolutionized the brake technology: In comparison to the conventional grey cast iron brake disc the carbon-ceramic brake disc weighed round 50 per cent less reducing the unsparing mass by almost 20 kilograms. Further significant advantages are: improved brake response and fading data, high thermal stableness, no hot judder, excellent pedal feel, improved steering behavior, high abrasion resistance and thus longer life time and the advantage of avoiding almost completely brake dust.

At first Porsche AG built the carbon-ceramic brake disc in 2001 into the 911 GT2 as series equipment. Since that time also other premium brands use the advantages of this innovative brake technology for more security and comfort. These are for example sports cars and luxury class limousines from Audi, Bentley, Beatty and Lamborghini. In this paper we will design a disc brake using carbon ceramic composite for high speed two wheelers. The main aim of this paper is to design a composite disk break with least possible production cost and long life, for achieving this goal we will compare different models of structural models of disk brakes with different materials finally we conclude the best model and material based on the thermal behavior and stress concentrations of each model, for designing disc brakes we use Catia V5 R21, and for analysis we use Ansys 14.5And the manufacturing of the disc brake is done using 3 printing for the best model output resulted from the ansys.

1. INTRODUCTION

Brake

Brake is a Mechanical Device used to stop or slowing down the Vehicle or a body in motion. A disc brake is a type of brake that utilizes calipers to

"Drum brake", even if other drums patterns are possible; and pads that touch a rotating disc, clutch pairs of pads alongside a disc in arrange to create friction that retards the rotary motion of a shaft, for instance a vehicle axle, moreover to retard its rotational speed or to seize it stationary. Hydraulic disc brakes are the a large amount universally used form of brake for motor vehicles but the ideology of a disc brake are appropriate to almost any rotating shaft. Brakes generally use friction amid two surfaces hard-pressed together to renovate the kinetic energy of the moving vehicle or body into heat. Brakes may be described as using friction, pumping, or electromagnetic. One brake may use a number of principles: for instance, a pump may pass fluid through an orifice to create friction.

Mechanical brakes are most common and can be divided broadly into shoe or pad brakes, using an open have on surface, and hydrodynamic brakes, such as parachutes, which use friction in a working fluid and do not overtly wear. Classically the term "friction brake" is named to mean shoe brakes and excludes hydrodynamic brakes, still while hydrodynamic brakes usefriction.Friction brakes are frequently revolving devices with a motionless pad and a rotating wear exterior. ordinary configurations comprise shoes that bond to rub on the outside of a rotating throb, such as a band brake; a rotating throb with shoes that expand to rub the inside of a drum, regularly called a "drum brake", even if other drum patterns are possible; and pads that touch a rotating disc, usually termed as "disc". Other brake configurations are used, but less frequently.

A drum brake is a vehicle brake in which the friction is sourced by a set of brake shoes that push against the inner surface of a rotating drum. The drum is associated to the rotating wheel center.

usually termed as "disc". Other brake configurations are used, but less frequently.



Manufacturing Process:-In present-day, the utilization of metal is vast and there are various processes of manufacturing a product from only use of pure molten metal or from any supplementary state of metal as well. When considering the dissimilar methods of



Industrialized, most accepted methods used in large industries. Metal Casting, Metal Cutting, Metal Forming and shaping, Fabrication and welding. The talk about are a small number of that are used by industries to manufacture different products that could build up a machine or other tools. The disc brake system is congress product and these parts are manufactured disjointedly through dissimilar actions to one a further. When the disc ring is isolated, it has a ideal circular form.

sketch of Disk brake

Manufacturing of Composite disc Brakes:-Brake discs can be made directly from the molten fragile ceramic materials but scientists have set up that petite carbon yarns would be an answer for the brittleness of composite materials. The following materials are added to the disc brake to avoid brittleness, short carbon fibers, Carbon powder, Heat molded Resin. After that at the time of when the brake disc shape is obtained by heating the mixture of above materials and cooling down, another ceramic material known as silicon is added to harden the brake disc, forming a new material called silicon carbide. The talk about heat molded resin is a material that combines all additional materials mutually in that mixture of the brake disband on one occasion this material is hardboiled by

Ceramics and their Characteristics:-Ceramic materials are the inorganic compounds of metallic and nonmetallic elements and their atoms are held together by ionic or covalent bonds these are stronger than metallic bonds. These are hard and brittle with high melting points. Resistance to high Temperature Low electrical and Thermal Conductivity Resistance to wear and corrosion Low



ductility some distinguishing Characteristics of ceramics



2. MATERIAL STUDY

The motivation to develop CMCs was to overcome the problems associated with the conventional technical ceramics like alumina, silicon carbide, aluminum nitride, silicon nitride or zirconium – they fracture easily under mechanical or thermo-mechanical loads because of cracks initiated by small defects or scratches. The crack resistance is – like in glass – very low.

To increase the crack resistance or fracture toughness, particles (socalled monocrystalline whiske rs or platelets) were embedded into the matrix. However, the improvement was limited, and the products have found application only in some ceramic cutting tools. So far only the integration of long multi-strand fibers has drastically increased the crack resistance, elongation and thermal shock resistance, and resulted in several new applications. Carbon (C), special silicon carbide (SiC), alumina (Al₂O₃) and mullet (Al₂O₃-SiO₂) fibers are most commonly used for CMCs. The matrix materials are usually the same that is C, SiC, alumina and mullets.

Ceramic matrix composites Advantages:*-a*) Excellent wear and corrosion resistance in a wide range of environments and temperatures) Higher strength to weight ratioc) Higher strength retention at elevated temperature) Higher chemical stability) Non-catastrophic failure) High hardness) Lightweight Carbon Fiber Reinforced Polymers can be expensive to produce but are regularly used anywhere high strength-to-weight ratio and rigidity are compulsory, for example aerospace, automotive



and civil engineering, sports goods and an rising number of other technical claims.

3. INTRODUCTION TO FEA

FINITE ELEMENT ANALYSIS :-(FEA)

Was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variation calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Top established a broader definition of numerical analysis. The paper centered on the "stiffness and deflection of complex structures". By the early 70's, FEA was limited to expensive mainframe computers generally owned by the aeronautics, automotive, defense, and nuclear industries. Since the rapid decline in the cost of computers and the phenomenal increase in computing power, FEA has been developed to an incredible precision. Present day supercomputers are now able to produce accurate results for all kinds of parameters. FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

FEA uses a complex system of points called nodes which make a grid called a mesh. This mesh is programmed to contain the material and structural properties which define how the structure will react to certain loading conditions. Nodes are assigned at a certain density throughout the material depending on the anticipated stress levels of a particular area. Regions which will receive large amounts of stress usually have a higher node density than those which experience little or no stress. Points of interest may consist of: fracture point of previously tested material, fillets, corners, complex detail, and high stress areas. The mesh acts like a spider web in that from each node, there extends a mesh element to each of the adjacent nodes. This web of vectors is what carries the material properties to the object, creating many elements.

Types of Engineering Analysis:-Structural analysis consists of linear and non-linear models. Linear models use simple parameters and assume that the material is not plastically deformed. Nonlinear models consist of stressing the material past its elastic capabilities. The stresses in the material then vary with the amount of deformation as in. **Vibration** analysis is used to test a material against random vibrations, shock, and impact. Each of these incidences may act on the natural vibration frequency of the material which, in turn, may cause resonance and subsequent failure. Fatigue analysis helps designers to predict the life of a material or structure by showing the effects of cyclic loading on the specimen. Such analysis can show the areas where crack propagation is most likely to occur. Failure due to fatigue may also show the damage tolerance of the material.

Results of Finite Element Analysis:-FEA has become a solution to the task of predicting failure due to unknown stresses by showing problem areas in a material and allowing designers to see all of the theoretical stresses within. This method of product design and testing is far superior to the manufacturing costs which would accrue if each sample was actually built and tested. In practice, a finite element analysis usually consists of three principal steps:

Preprocessing: The user constructs a model of the part to be analyzed in which the geometry is divided into a number of discrete sub regions, or elements," connected at discrete points called nodes." Certain of these nodes will have fixed displacements, and others will have prescribed loads. These models can be extremely time consuming to prepare, and commercial codes vie with one another to have the most user-friendly graphical "preprocessor" to assist in this rather tedious chore. Some of these preprocessors can overlay a mesh on a preexisting CAD file, so that finite element analysis can be done conveniently as part of the computerized drafting-and-design process. Analysis: The dataset prepared by the preprocessor is used as input to the finite element code itself, which constructs and solves a system of linear or nonlinear algebraic equations

Kijuj = fi Where u and f are the displacements and externally applied forces at the nodal points. One of FEA's principal advantages is that many problem types can be addressed with the same code, merely by specifying the appropriate element types from the library.



4. INTRODUCTION TO CATIA AND ANSYS

CATIA:-CATIA also known as **Computer Aided Three-dimensional Interactive Application** and it is software suit that developed by the French company call Dassult Systems.

CATIA is a process-centric computer-aided design/computer-assisted manufacturing/computeraided engineering (CAD/CAM/CAE) system that fully uses next generation object technologies and leading edge industry standards. CATIA is integrated with Dassult Systems Product Lifecycle Management (PLM) solutions. It allows the users to simulate their industrial design processes from initial concept to product design, analysis, assembly and also maintenance. In this software, it includes mechanical, and shape design, styling, product synthesis, equipment and systems engineering, NC manufacturing, analysis and simulation, and industrial plant design. It is very user friendly software because CATIA Knowledge ware allows broad communities of user to easily capture and share know-how, rules, and other intellectual property assets.

Engineering Design:-Catia V5 offers a range of tools to enable the generation of a complete digital representation of the product being designed. In addition to the general geometry tools there is also the ability to generate geometry of other integrated design disciplines such as industrial and standard pipe work and complete wiring definitions. Tools are also available to support collaborative development.

ANSYS:-ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of userdesignated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated, or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

Generic Steps to Solving any Problem in ANSYS:-Like solving any problem analytically, you need to define (1) your solution domain, (2) the physical model, (3) boundary conditions and (4) the physical properties. You then solve the problem and present the results. In numerical methods, the main difference is an extra step called mesh generation. This is the step that divides the complex model into small elements that become solvable in an otherwise too complex situation. Below describes the processes in terminology slightly more attune to the software.

Analysis- Used extensively Harmonic by who produce rotating machinery, companies ANSYS Harmonic analysis is used to predict the sustained dynamic behavior of structures to consistent cyclic loading. Examples of rotating machines which produced or are subjected to harmonic loading are: Turbines Gas Turbines for Aircraft and Power Generation Steam Turbines Wind Turbine Water Turbines Turbo pumps Internal Combustion engines Electric motors and generators Gas and fluid pumps Disc drives A harmonic analysis can be used to verify whether or not a machine design will successfully overcome resonance, fatigue, and other harmful effects of forced vibrations.

5. ANALYSIS

THERMAL ANALYSISOF MODEL 1 DISK OFAL203/SIC

IMPORT MODEL



Import model for Model 1 disk of Al2O3/SiC

MESH MODAL



Meshed model for Model 1 disk of Al2O3/SiC

TEMPERATURE



Temperature Input data for Model 1 disk of Al2O3/SiC

CONVECTION



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Convection Input data for Model 1 disk of Al2O3/SiC

RADIATION



Radiation Input data for Model 1 disk of Al2O3/SiC

RESULTS: TEMPERTURE



Temperature results for Model 1 disk of Al2O3/SiC

TOTAL HEAT FLUX



Total heat flux results for Model 1 disk of Al2O3/SiC

DIRECTIONAL HEAT FLUX



Directional heat flux results for Model 1 disk of Al2O3/SiC

THERMAL ANALYSIS OF MODEL 3 DISK OF CARBON CERAMICS:-

IMPORT MODAL



Import model for Model 3 disk of Carbon ceramics

MESH MODAL



Meshed model for Model 3 disk of Carbon ceramics

TEMPERATURE



Temperature Input data for Model 3 disk of Carbon ceramics

CONVECTION



Convection Input data for Model 3 disk of Carbon ceramics

RADIATION



Radiation Input data for Model 3 disk of Carbon ceramics

RESULTS: TEMPERTURE



Temperature results for Model 3 disk of Carbon ceramics

TOTAL HEAT FLUX

Total heat flux results for Model 3 disk of

Carbon ceramics

DIRECTIONAL HEAT FLUX



Directional heat flux results for Model 3 disk of Carbon ceramics

6. REPORT

The Result has been shown in the given table are the Temperature, Total Heat Flux, Directional Heat Fluxes of Disc Brakes with three different models with different Materials.

GRAPHS FOR THERMAL ANALYSIS OF MODEL 1:-

TEMPERETURE:



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Graph1 Graph showing Min Temperature vs Material for Model 1



Graph2 Graph showing Max Temperature vs Material for Model 1

TOTAL HEAT FLUX:



Graph3 Graph showing Min Heat flux vs Material for Model 1





DIRECTIONAL HEAT FLUX:



Graph5 Graph showing Min Directional Heat flux vs Material for Model 1



Graph6 Graph showing Max Directional Heat flux vs Material for Model 1



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GRAPHS FOR THERMAL ANALYSIS OF **MODEL3:-**

TEMPERATURE



Graph 7 Graph showing Min Temperature vs Material for Model 3



Graph 8 Graph showing Max Temperature vs Material for Model 3

TOTAL HEAT FLUX:



Graph 9 Graph showing Min Heat flux vs Material for Model 3



Graph 10 Graph showing Max Heat flux vs Material for Model 3

DIRECTIONAL HEAT FLUX:



Graph 11 Graph showing Min Directional Heat flux vs Material for Model 3



Graph 12 Graph showing Max Directional Heat flux vs Material for Model 3



7. CONCLUSION

In this paper we will designed 3 different models of disk brake using carbon ceramic composite for high speed two wheelers. The main aim of this paper is to design a composite disk brake with least possible production cost and long life, for achieving this goal we will compare different models of structural models of disk brakes with different materials. Here we have designed the disc brake using Catia V5, and thermal analysis is done in Ansys to the different models and the results are verified in a graph and tables.

As we observe in the first model the analysis is done with 2 materials i.e. with CARBON CERAMICS and AL2O3/SIC. As we observe in the results the material with AL2O3/SIC is the best product which increases the life as we compare the results in the heat flux (20244). So we can conclude that the materialAL2O3/SIC is the best output for model 1

As we observe in the second model the analysis is done with 2 materials i.e. with CARBON CERAMICS and AL2O3/SIC As we observe in the results the material with AL2O3/SIC is the best product which increases the life as we compare the results in the heat flux (35927). So we can conclude that the materialAL2O3/SIC is the best output for model 2As we observe in the third model the analysis is done with 2 materials i.e. with CARBON CERAMICS and AL2O3/SIC As we observe in the results the material with CARBON CERAMICS is the best product which increases the life as we compare the results in the heat flux (23813). So we can conclude that the material CARBON CERAMICS is the best output for model As we compare the 3 different models and their results for the best material outputs, here by comparing the obtained results we can conclude that the materialAL2O3/SIC with the model 1 is the better product for the better life.

8. FUTURE SCOPE

Present study deals with disk brakes with composite ceramics for high speed two wheelers. Now a day's Braking system failures in two wheelers becomes increasing this causes to accidents. And manufacturing of this is expensive. And this study extends that to reduce the cost of disk brakes by using the most abundant material Aluminum with the use of composite technology are used to reduce the expenses. Aluminum Composite Ceramics are light weight and strength and thermal resistance also Because of this Characteristics we are used this material. At present time it has become major concern to Automotive Industries are used Gray Cast iron has the Braking material it is brittle material and low thermal conductivity as compared to Composite Ceramic Brakes are very much farther than Cast iron.

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