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Design and Analysis of Motorcycle Disk Brake

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Abstract: *The disc brake is a device for slowing or stopping the rotation of a wheel. A brake disc (or rotor), usually made of cast iron or ceramic composite, is connected to the wheel and/or the axle. Friction causes the disc and attached wheel to slow or stop. Brakes convert friction to heat, but if the brake get too hot, they will cease to work because they cannot dissipate enough heat. This condition of failure is known as brake fade. This paper discusses the phenomenon of heat distribution on the brake disc during braking. Heat distribution on the brake disc is caused by kinetic energy changing into mechanical energy. Energy changes occur during the braking process due to friction between the surface of the disc and a disc pad. The temperature resulting from this friction rises high. Disc brakes are exposed to large thermal stresses during routine braking and extraordinary thermal stresses during hard braking. Structural and Thermal analysis is to be done on the disc brake. The materials used are Cast iron and finding the suitable material and also find the best geometric design. Structural analysis is done to verify the strength of the disc brake for applied loads. This is important to understand action force and friction force on the disc brake new material, how disc brake works more efficiently, which can help to reduce the accident that may happen in each day Thermal analysis is done to verify thermal properties like thermal gradient and thermal flux etc. Comparison can be done for displacement, stresses, thermal gradient etc. for the materials to check which material is best. ANSYS is general purpose finite element analysis (FEA) software package. Analysis of brake rotor includes Structural analysis and Steady state Thermal analysis for each design. A comparison between the existing brake rotors and proposed new design is carried out and based on the results the best design is found out by ANSYS software*

Keywords *-Design, ANSYS, SOLIDWORKS, Disc brake, Friction, Thermal analysis, FEA, Comparison, Heat flux, Structural analysis, strength, Stress*

I. INTRODUCTION

The model of brake disc is designed based on analytical measurements and standard values available from the standard catalog. The brake disc is designed using SOLIDWORKS. The designed model of disc brake is analyzed structurally and thermally to study its properties using ANSYS. The models are individually analyzed for the calculated structural boundary condition and the same as for thermal boundary condition. The alternate models are analyzed both structurally and thermally.

Different materials used to design disc brake in this study first one are cast iron and other composite materias. SOLIDWORK used to design disc brake and ANSYS used to thermal analysis. The practical use of finite element modeling is known as FEA which is best understood during the real problem solving. FEA has been widely used by the automotive industry. It is a very popular tool for design engineers in the product enlargement method. FEA allows design engineers to analyze their designs while the designs are still in the procedure of an adjustable computer aided design (SOLIDWORK) model. This helps and gives flexibility to the design engineers to go back and forth to implement of the FEA analysis results in the whole design process and improve the model. It is important to understand the FEA basics, modeling techniques, the inherent errors and their effects on the quality of the results so as to render FEA as a successful design tool. FEA is also used as a computational tool for carrying out engineering problem analyze.

II. PROJECT DETAIL

Disc brakes are more familiar from automotive applications where they are used extensively for car and motorcycle wheels. These typically consist of a cast iron disc, bolted to the wheel hub. This is sandwiched between two pads actuated by pistons supported in a caliper mounted on the stub shaft. When the brake pedal is pressed, hydraulically pressurized fluid is forced into the cylinders, pushing the opposing pistons and brake pads into frictional contact with the disc. Friction material in the form of a brake pad exerts mechanical, hydraulic, pneumatic or electromagnetic force against both sides of the disc. This friction causes the mounted discs to slow or stop the wheel. Brake friction generates frictional forces as two or more surfaces rub on each other to reduce wheel spin. Based on the design configuration, the friction brakes on the vehicle can be grouped into drum brakes and disc brakes. If the solid-type disc brake disc has a low heat transfer rate, then the time required for cooling the disc is longer. A ventilated disc brake system is widely used in an automobile braking system which serves to increase the cooling time of braking in which the area of contact between the disc rotor and disc brake pad remains the same. The main aim of the work is to investigate the thermal characteristic of the disc brake. The comparison between the solid disc brake is conducted using a finite element method. The advantages of this form of braking are steady braking easy ventilation, balancing thrust loads, and design simplicity. There is no self energizing action, so the braking action is proportional to the applied force.

The main reason of the brake disc overheating is friction. During the working principle of the braking system is based on friction with the aggressive driving style it increases. This tends to an increase in the temperature of the brake about 800°C. The heat produced at the boundary between the brake pad and the disk is dissipated from the disk and pad by convection and radiation. In the model, the rotation is modeled as convection in the disk. The heat dissipation from the disk and pad surfaces to the surroundings is described by both convection and radiation.

2.1 Software Uses

The SOLIDWORKS CAD software is a mechanical design automation application that lets designers quickly sketch out ideas, experiment with features and dimensions, and produce models and detailed drawings 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 user-designated size) called elements. The software implements equations that govern the behavior 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.

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. In practice, a finite element analysis usually consists of three principal steps Pre-processing, Analysis, Post- processing.

2.2 Literature Review

PIOTR GRZEŚ, 2011 [1] the aim of this paper was to investigate the thermal information of the solid disc brake during sudden, emergency braking. In this paper thermal analysis of disc brakes in brake application was done. To obtain the numerical simulation parabolic heat conduction equation for two dimensional model was used. The results show that both rotating speed of disc and contact pressure with specific material properties intensely.

RAJENDRA POHANE, R.G.CHOUDHARI, 2011 [2] FEM model is prepared for contact analysis. A 3D finite element model of the brake pad and the disc is developed to find structural analysis, and transient analysis. The comparison is done between the solid and ventilated disc keeping the equal material properties and constraints and using general purpose finite element analysis. This project discusses how general purpose finite element analysis software can be used to analyze the mechanical stresses & the thermal stresses at disc to pad surface.

CHOI AND LEE, 2004 [3] presented a research on Finite element analysis of transient behaviors in disk brakes. A transient analysis for thermo contact problem of disk brakes with frictional heat generation is performed using the ANSYS. To analyze the thermo elastic condition occurring in disk brakes, the coupled heat conduction and elastic equations are solved with contact problem. Material used is carbon composite and wear is

assumed zero. The numerical simulation for the thermal behavior of disk brake is obtained in the different brake condition.

TALATI AND JALALIFAR, 2009 [4] presented a paper on Analysis of heat conduction in a disk brake system. In this paper, the governing heat equations for the disk and the pad are extracted in the form of transient heat equations with heat generation that is dependant to time and space. In the derivation of the heat equations, parameters such as the duration of braking vehicle velocity, geometries and the dimensions of the brake components, materials of the disk brake have been taken into account.

HARIPAL SINGH AND HARSHDEEP SHERGILL, 2012 [6] presented paper on thermal Analysis of Disc Brake Using COMSOL in these paper Finite element analysis techniques is used to predict the temperature distribution and identify the critical temperature of brake disc. Considering all three modes of heat transfer (conduction, convection and radiation) for three different materials of rotor disc are been used (cast iron, Al and ceramics). It is concluded that cast iron can be used in brake disc which will give moderate cooling at low temperature as compared to other. Ceramics has good cooling characteristics but it is costly, can be used in racing cars where high temperature is produced.

2.3 Problem Definition

2.3.1 Problems associated with disc brakes

Vehicle safety in automobile engineering is a first priority in production of new vehicle. Each component of a vehicle has been studied and analyzed in order to meet safety requirements, instead of having air bag good suspension system good handling and safe cornering there is one most critical system in the vehicle will put a passenger in unsafe position. Therefore it is a must for all vehicles to have proper brake system. Vehicle braking system is the most important component regards to safety of automobile, therefore so many researchers conducted a study on brake system Failure of brake especially in two-wheelers have been one of the major causes for many accidents. The forced stresses acting on the disc brake due to forced braking damages the disc and eventually it breaks. This shows that no proper material has been chosen while analyzing the disc at different conditions.

Friction brakes act by generating frictional forces as two or more surfaces rub against each other. The stopping power or capacity of a friction brake depends on the area in contact and coefficient of friction of the working surfaces as well as on the actuation pressure applied. Wear occurs on the working surfaces, and the durability of a given brake (or service life between maintenance) depends on the type of friction material used. Disc (Rotor) brakes are exposed to large thermal stresses during routine braking and extraordinary thermal stresses during hard braking. The main objective of this project is to propose a new brake disc design which will reduce the total deformation and, increase the maximum heat dissipation. If the temperatures reached in braking become too high, deterioration in braking may result, and in extreme conditions complete failure of the braking system can occur. It can be difficult to attribute thermal brake failure to motor vehicle accidents as normal braking operation may return to the vehicle when the temperatures return to below their critical level.

To minimize the above problems in existing disc brake it is necessary to analyze different types of disc brake, which are commonly used in automobile industry and to propose a new design of brake. Analysis of disc brake includes Structural analysis and Thermal analysis for each design. A comparison between the existing brake rotors and proposed new design is carried out and based on the results the best design is found out by ANSYS software. To design and analyze disc brake made of gray cast iron. Cast Iron materials are used to design the disc brake. The brake will be then be optimized based on some parameters to get the best possible design. The brake was created in Solid Works and imported to ANSYS for analysis. Brakes are of utmost importance in an automobile. Design of brakes, later in this project, is completely based on pure mechanical modeling and calculation. Brakes in commercial or performance vehicles are used depending on the specifications required and the braking force required. To design, model a disc.

Modeling is done using SOLIDWORKS. Structural and Thermal analysis is to be done on the disc brakes using different materials composite. Structural analysis is done on the disc brake to validate the strength of the disc brake and thermal analysis is done to analyze the thermal properties. Comparison can be done for deformation stresses, temperature etc. form the different materials to check which material is best. The main purpose of this project is to study the Thermal analysis of the Materials and the Cast Iron, and. A comparison between the two materials for the Thermal values and material properties obtained from the Thermal analysis low thermal gradient material is preferred. Hence best appropriate design, low thermal gradient material cast iron is chosen for the Disc Brakes for better result. A comparison between the existing brake disc and proposed new design is carried out and based on the results the best design is found out by ANSYS software.

2.4 Objectives of design and analysis of disc brake:

With the help of analysis, we will design an efficient brake disc which will help to dissipate heatmore efficiently, thereby reducing the heat transfer to the vehicle and environment.

In order to overcome brake wear, cracks, etc. we will design the brake disc using lighter or composite materials in order to increase thermal efficiency by a slight margin.

To reduce plastic yielding we will try to use some metal or composite material linings to decrease the maximum temperature a brake disc will reach at the time of braking.

Analysis and structural analysis is carried out on a disc brake, best design shape of disc brake like Cutting pattern in disc and material there by a best combination is suggest.

III. METHODOLOGY

3.1 MATERIAL SELECTION

Material selection is a most important step in the process of designing any physical object. In the context of product design, the main goal of material selection is to minimize cost while meeting good product performance goals. Systematic selection of the best material for a given application begins with properties and costs of candidate materials. Material selection is often benefited by the use of material index or performance index relevant to the desired material properties. The most commonly used brake disc material is cast iron, because it possesses excellent friction properties, has low cost, retains strength at elevated temperature, has relative ease of manufacture and is thermally stable. The material selection process generally involves basic steps which have to be identify before concluding the final material. The material which most meets the objective is selected as main material and the other materials are kept as a substitute if in-case the material fails during manufacturing, the next material in the ranking is selected

3.2 Calculation.

To make the calculation the initial condition are taken from site and the assumptions such as weight of the vehicle, speed of vehicle, weight distribution, coefficient of friction, stopping time, tyre radius, etc. are taken into account. All the basic theoretical calculation related to disk brake also important before the analysis and design. Calculation is done as per the problem statements

3.3 Design and Analysis

In order to obtain a 3D model of the disc brake a 2D sketch was prepared in the part sketch in the modeling software Solid Works. Disc rotors were prepared to compare the results. Two different metals are design, disc brake in this study first one are cast iron and other composite material. SOLIDWORKS uses a 3D design approach as design a part, from the initial sketch to the final result, we create a 3D model. From this model, we can create 2D drawings or mate components consisting of parts or subassemblies to create 3D assemblies. We can also create 2D drawings of 3D assemblies. When designing a model using SOLIDWORKS, we can visualize it in three dimensions, the way the model exists once it is manufactured. The model of brake disc is designed based on analytical measurements and standard values available.

Analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by force. Step in the structural analysis is to apply the boundary conditions. Because the analysis is performed for deformation, displacement, stress and strain, the boundary conditions applied. The boundary conditions are introduced by selecting the simulation mode, and defining the physical properties of the material, and the initial conditions of the simulation

IV. FIGURES AND TABLES

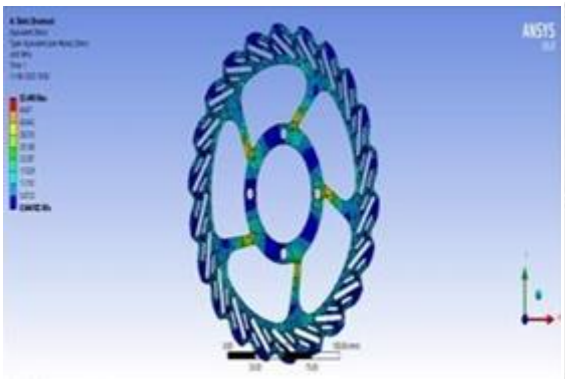

Fig.1. ANSYS model of disk brake

Fig .2. Motorcycle disk brake

V. CONCLUSION

The above study can provide a useful design and help to improve the brake performance of disc brake system. Thus analysis was done on the Disc Brake by comparing cast Iron and Composite material. Analysis has been carried out by cast iron and Composite materials. The results such as deformation, strain, stress, Temperature and total Heat for each material are determined. While carrying out this project we are able to study about the 3D modeling software (SOLIDWORKS) and Study about the analyzing software (ANSYS) to develop our basic knowledge to know about the industrial design. Brakes are of utmost importance in an automobile. Design of brakes, later in this project, is completely based on pure mechanical modeling and calculation. Brakes in commercial or performance vehicles are used depending on the specifications required and the braking force required.

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