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DESIGN AND ANALYSIS OF DISC BRAKE ROTOR

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Abstract

This paper deals with the analysis of Disc Brake. A Brake is a device by means of which artificial frictional resistance is applied to moving machine member, in order to stop the motion of a machine. Disc brake is usually made of Cast iron, so it is being selected for Investigating. the effect of strength variations on the predicted stress distributions . Aluminium Metal Matrix Composite materials are selected and analysed. The results are compared with existing disc rotor. The model of Disc brake is developed by using Solid modeling software Pro/E (Creo Parametric 1.0).Further Static Analysis is done by using ANSYS Workbench. Structural Analysis is done to determine the Deflection, Normal Stress**,** Vonmises stress**.** Each single system has been studied and developed in order to meet safety requirement. Instead of having air bag, good suspension systems, good handling and safe cornering, there is one most critical system in the vehicle which is brake systems. Without brake system in the vehicle will put a passenger in unsafe position. Therefore, it is must for all vehicles to have proper brake system. In this paper carbon ceramic matrix disc brake material use for calculating normal force, shear force and piston force. And also calculating the brake distance of disc brake. The standard disc breaks two wheelers model using in Ansys and done the Thermal analysis and Modal analysis also calculate the deflection and Heat flux, Temperature of disc brake model. 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.

Key Words*: Disc brake, Pro/E(Creo Parametric1.0), ANSYS Workbench, Finite Element Analysis*

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1. INTRODUCTION

Disc brake consists of a cast iron disc bolted to the wheel hub and a stationary housing called caliper. The caliper is connected to some stationary part of the vehicle like the axle casing or the stub axle as is cast in two parts each part containing a piston. In between each piston and the disc there is a friction pad held in position by retaining pins, spring plates. Each cylinder contains rubber-sealing ring between the cylinder and piston. A schematic diagram is shown in the figure. Due to the application of brakes on the car disc brake rotor, heat generation takes place due to friction and this temperature so generated has to be conducted and dispersed across the disc rotor cross section. An investigation into usage of new materials is required which improve braking efficiency and provide greater stability to vehicle.

2. LITERATURE REVIEW

a. Structural Analysis of Disc Brake Rotor: *K.Sowjanya#1, S.Suresh*2(2013):* Disc brake consists of a cast iron disc bolted to the wheel hub and a stationary housing called caliper.

b. Analysis of Disc Brake : *Swapnil R. Abhang#1, D.P.Bhaskar*2,(2014):* The disc brake is a wheel brake which slows rotation of the wheel by the friction caused by pushing brake pads against a brake disc with a set of callipers.

3. CONCLUSION OF LITERATURE REVIEW

a. The Brake disc design is safe based on the Strength and Rigidity Criteria.

b. Using carbon ceramic matrix disc brake material calculating normal force, shear force and piston force and also calculating the brake distance of disc brake.

4. DESIGN OF DISC BREAK ROTOR

4.1 Disc Brake Rotor

The Disc brake discs are commonly manufactured out of grey cast iron. The SAE maintains a specification for the manufacture of grey iron for various applications. For normal car and light truck applications, the SAE specification is J431 G3000 (superseded to G10). This specification dictates the correct range of hardness, chemical compostion , tensile strength, and other properties necessary for the intended use. Some racing cars and airplanes use brakes with carbon fiber discs and carbon fiber pads to reduce weight. Wear ratestend to be high, and braking may be poor or grabby until the brake is ***hot***. The materials used for rotor disc are explained in detail. It is investigated the temperature distribution, the thermal deformation, and the thermal stress of automotive brake disks have quite close relations with car safety; therefore, much research in this field has been performed.

A] Aluminum Metal Matrix Composites

Aluminum is the most popular matrix for the metal matrix composites (MMCs). The Al alloys are quite attractive due to their low density, their capability to be strengthened by precipitation, their good corrosion resistance, high thermal and electrical conductivity, and their high damping capacity. Aluminum matrix composites (AMCs) refer to the class of light weight high performance aluminum centric material systems. The reinforcement in AMCs could be in the form of continuous or discontinuous fibers, whisker or particulates, in volume fractions ranging from a few percent to 70%. In the last few years, AMCs have been utilized in high-tech structural and functional applications including aerospace, defense, automotive, and thermal management areas, as well as in sports and recreation .There has been interest in using aluminum based metal matrix composites for brake disc and drum materials in recent years. While much lighter than cast iron they are not as resistant to high temperatures and are sometimes only used on rear axles of automobiles because the energy dissipation requirements are not high as compared to front axle. While the friction and wear of almmc were high speeds and loads the behavior could be greatly improved beyond that of iron discs, given the correct match of pad and disc material.

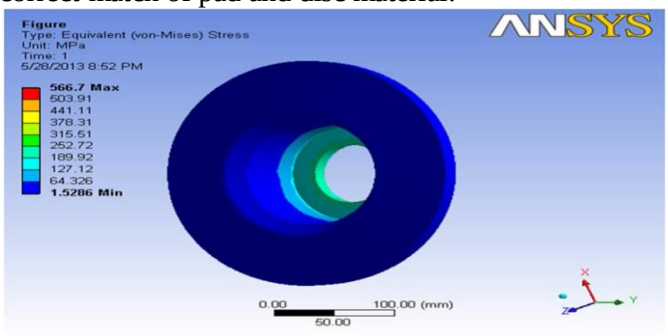

Fig: 1 Results obtained for Al MMC1

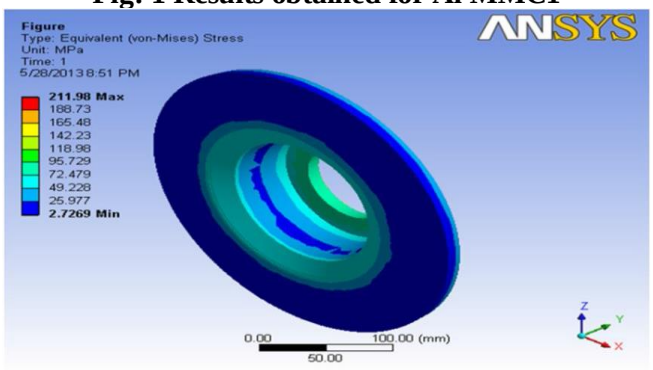

Fig: 2 Results obtained for Al MMC2

B] Cast Iron

Cast iron usually refers to grey cast iron, but identifies a large group of ferrous alloys, which solidify with a eutectic. Iron accounts for more than 95%, while the main alloying elements are carbon and silicon. Here graphite is present in the form of flakes. Disc brake discs. The amount of carbon in cast iron is the range 2.1-4%, as ferrous alloys with less are denoted carbon steel by definition. Cast irons contain appreciable amounts of silicon, normally 1-3%, and consequently these alloy should be considered ternary Fe-C-Si alloys are commonly manufactured out of a material called grey cast iron.

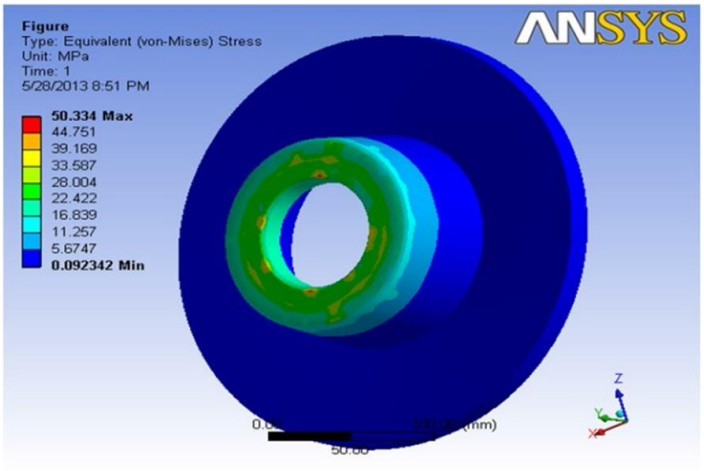

Fig:3 Results obtained from ANSYS Work bench

4.2 Finite Element Analysis

The finite element method is numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in almost every industry. In more and more engineering situations today, we find that it is necessary to obtain approximate solutions to problem rather than exact closed form solution. It is not possible to obtain analytical mathematical solutions for many engineering problems. An analytical solutions is a mathematical expression that gives the values of the desired unknown quantity at any location in the body, as consequence it is valid for infinite number of location in the body. For problems involving complex material properties and boundary conditions, the engineer resorts to numerical methods that provide approximate, but acceptable solutions. The finite element method has become a powerful tool for the numerical solutions of a wide range of engineering problems. It has been developed simultaneously with the increasing use of the high-speed electronic digital computers and with the growing emphasis on numerical methods for engineering analysis. This method started as a generalization of the structural idea to some problems of elastic continuum problem, started in terms of different equations.

A] Structural Analysis

Structural analysis is the most common application of the finite element analysis. The term structural implies civil engineering structure such as bridge and building, but also naval, aeronautical and mechanical structure such as ship hulls, aircraft bodies and machine housing

as well as mechanical components such as piston, machine parts and tools.

B] Types Of Structural Analysis

The seven types of structural analyses in ANSYS. One can perform the following types of structural analysis. Each of these analysis types are discussed as follows:

a. Static analysis
b. Modal analysis
c. Harmonic analysis
d. Transient dynamic analysis
e. Spectrum analysis
f. Buckling analysis

4.3 Modeling Of Disc Brake

It is very difficult to exactly model the brake disk, in which there are still. These assumptions are made, keeping in mind the difficulties involved in the theoretical calculation and the importance of the parameters that are taken and those which are ignored There always a need of some assumptions to model any complex geometry. In modeling we always ignore the things that are of less importance and have little impact on the analysis. The assumptions are always made depending upon the details and accuracy required in modeling. The assumptions which are made while modeling the process are given below:

1. The disk material is considered as homogeneous and Isotropic.
2. The domain is considered as axis-symmetric.
3 Inertia and body force effects are negligible during the analysis.
4. The disk is stress free before the application of brake
5. Brakes are applied on the entire four wheels.
6. The analysis does not determine the life of the disk brake .
7. The disk brake model used is of solid type and it is not ventilated type.

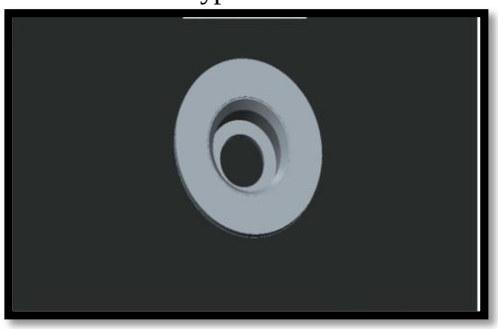

Fig:4 Model of disc brake

5. CALCULATION OF DISC BRAKE

The forces acting on the inner and outer rotor faces due to contact Disc Brake Standard.

Rotor disc dimension = 240 mm. (240×10-3 m)
Rotor disc material = Carbon Ceramic Matrix
Pad brake area = 2000 mm2 (2000×10-6 m)
Pad brake material = Asbestos
Coefficient of friction (Wet) = 0.07-0.13
Coefficient of friction (Dry) = 0.3-0.5
Maximum temperature = 350 ºC
Maximum pressure = 1MPa (106 Pa)

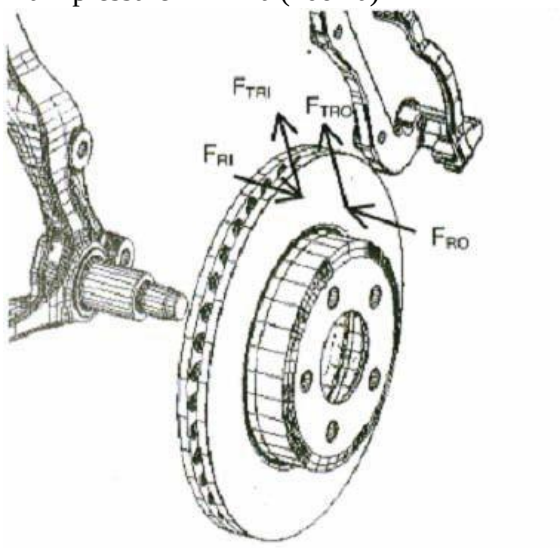

Fig : 5 Disc Break

6 . RESULT AND DISCUSSIONS

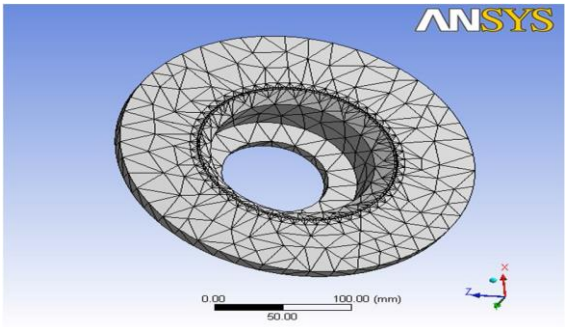

Fig:6 Meshed model of Disc Brake

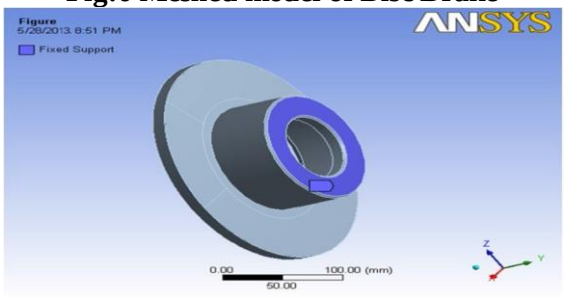

Fig:7 Fixed support

7. CONCLUSION

The following conclusions are drawn from the presentwork.

1. Static structural analysis is carried out by coupling the Thermal solution to the structural analysis and the maximum Von Mises stress was observed to be 50.334 M Pa for CI, 211.98 M Pa for AlMMC1, and 566.7 M Pa for AlMMC2.
2. Comparing the different results obtained from the analysis, it is concluded that Cast Iron is the best possible combination for the present application.
3. The Brake disc design is safe based on the Strength.

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