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Static Structural Analysis of Disc Brake Rotor using Al 6082 (2.5 wt% SiC) Composite Material

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Abstract*: A brake is a mechanical device by means of which frictional resistance is applied to moving vehicle element, in order to stop the motion of a vehicle. The main idea behind the process of performing this function, the brakes absorb kinetic energy of the moving element. The energy absorbed by brakes is dissipated in the form of heat. This heat is dissipated in the surrounding atmosphere to stop the vehicle. During operation of brake system a pressure is applied towards the disc rotor with the calliper and hydraulic assembly. This induces the stresses in disc rotor. So it is the main focus of a designer to minimize these stresses for effective and long term operation of disc brake. In the present study, Al 6082 has been used as a matrix material for analyzing a disc brake rotor. Reinforcement such as silicon carbide for brake rotor is used which improves mechanical properties. Finite element method was used for the simulation of car disc brake rotor using the Ansys workbench 14.0 software. In order to analyze the disc brake rotor, the properties of composites were used. The analysis of brake rotor has been done on basis of static structural analysis. Simulation of disc brake rotor has done using tensile properties of composite material. In the analysis of Composite having 2.5 wt % SiC the maximum principal stress, minimum principal stress, total deformation and von-misses stress have been calculated.*

1. Introduction

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1.2 Braking Requirements

1. The brakes must be strong enough to stop the vehicle with in a minimum Distance in an emergency.[1]
2. The driver must have proper control over the vehicle during braking and the vehicle must not skid.[1]
3. The effectiveness of the brake should not decrease with constant prolonged application.
4. The brakes should have good wear resistance properties.

1.3 Disc Brakes

A disc brake may have a disc made of cast iron or aluminium composite material 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 and 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 etc. [1] passages are drilled in the calliper for the fluid to enter or leave each housing. These passages are also connected to another one for bleeding. Each cylinder contains rubber-sealing ring between the cylinder and piston. A schematic diagram is shown in the figure. [1]

1.4 Principle

The working principle applied on disc brake is that the applied force (pressure) acts on the brake pads, which comes into contact with the rotating disc. At this point of time due to friction the relative motion is constrained.

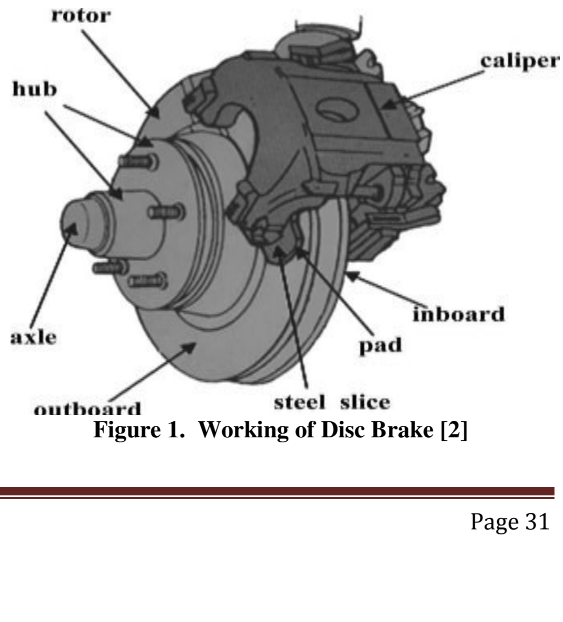

Figure 1. Working of Disc Brake [2]

When the brakes are applied, hydraulically actuated pistons move the friction pads in to contact with the disc, applying equal and opposite forces on the later. On releasing the brakes the rubber-sealing ring acts as return spring and retracts the pistons and the friction pads away from the disc.

2. Metal Matrix Composites

Reinforced metal matrix composites (MMCs), constituted of metallic alloys reinforced with ceramic particulates or whiskers, have emerged from perpetual need of high strength, light weight, higher performance and better wear resistance characteristics. In that scenario, Aluminium metal matrix composites (Al MMCs) assisted automotive engineer and found promising in achieving the vehicle fuel efficiency [3]. Thrust has been given for suitable combinations of matrix, reinforcement and processing routes in developing the composites. Stir casting, a liquid state processing technique was one such route in production of Al MMCs. Several researchers made attempts in developing new grades of composites and studied the intrinsic and extrinsic effects of reinforcements of Al- MMCs. Several attempts have been done for improving the physical, mechanical, thermo- mechanical, tribological properties of these composites. The basic areas of application of theses composites include high-tech machineries, automobile sectors, aerospace etc. Among the advanced engineering materials for aerospace and automotive applications, Al-based metal matrix composites (MMC) having remarkable mechanical properties, including low density, high elastic modulus and strength, and good fatigue and wear resistance creates a high interest towards the application in automotive industry. The main reason behind the evolvement of MMC is the possibility to tailor their properties to meet specific requirements, which makes this type of material unique in comparison with conventional materials.

2.1 Materials and Methods

For present study the Al 6082 has been selected as matrix material. For disc brake rotor application 2.5 %wt SiC has been added by Stir Casting technique. The round cylindrical bars have been found after casting. After that the forging process is applied to get the flat plates because the specimen of tensile testing is required in desired shape and dimensions. The cutting operations have been performed on plates and specimens are prepared by machining process with sophistication. The specimens are tested on UTM machine and mechanical properties like Young's modulus & tensile strength have been found. These properties are used for present study.

2.2 FEA Methodology

The Finite Element Analysis (FEA) or Finite Element Method (FEM) is a numerical technique, which could give near accurate solutions to complex field problems. Basically this method involves dividing the complex structures into known number of smaller structures or elements. This ability of the method is called discretization or meshing, which makes the technique more effective in analysing irregular shaped structures in a variety of engineering problems. Mathematically it is nothing but representing most of physical problems in terms of mathematical models formed by differential and integral equations. Complexities such as irregular shape of the object or boundary conditions involved in the physical problems can make these equations almost impossible to solve directly. In this situation finite element analysis technique is adopted to obtain near accurate solution for the physical problem by approximately solving the governing equations, which could not be solved otherwise.

2.2 Modelling the Geometry and generation of finite element model

A 3D model of the Disc Brake Rotor is built using design modeller in Ansys workbench 14.0. Figure 2 shows the model of disc brake rotor. The brake rotor (Figure 3) is meshed using a linear elastic material law.

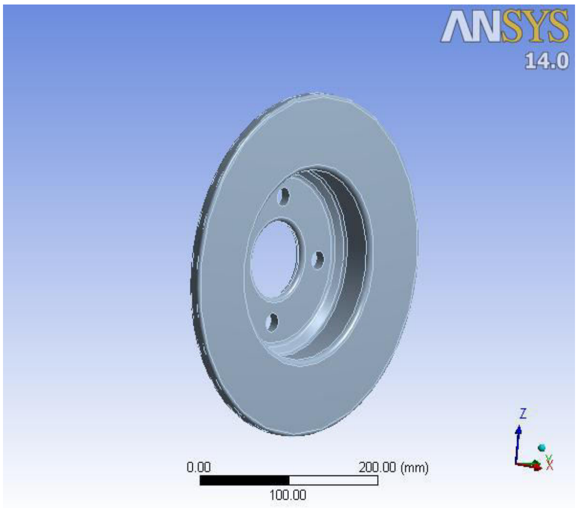

Figure 2. 3D model of disc brake rotor

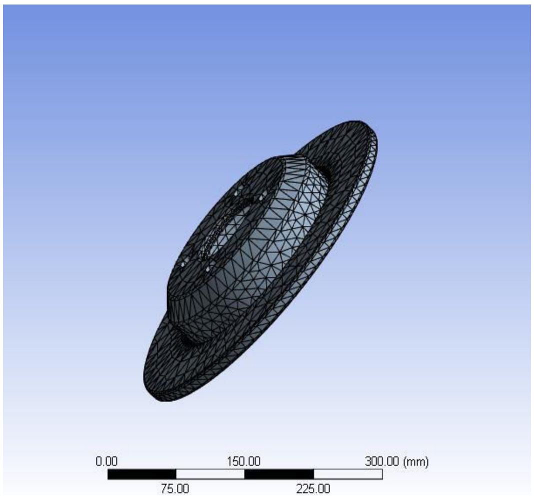

Figure 3. 3D Meshed model of Disc Brake Rotor

3. Static Structural Analysis of Disc Brake Rotor

Static structural analysis is carried out on rotor. All the stresses including Von-misses Principal stress and Total deformation results are displayed below.

3.1 Von Misses Stress

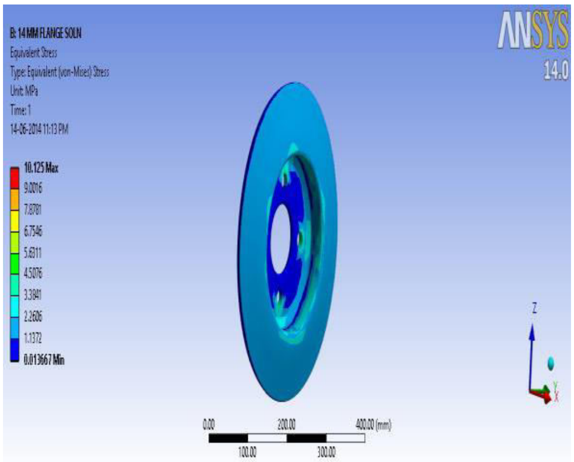

Figure 4. Von-misses Stress in Disc Brake Rotor

3.2 Maximum Principal Stress

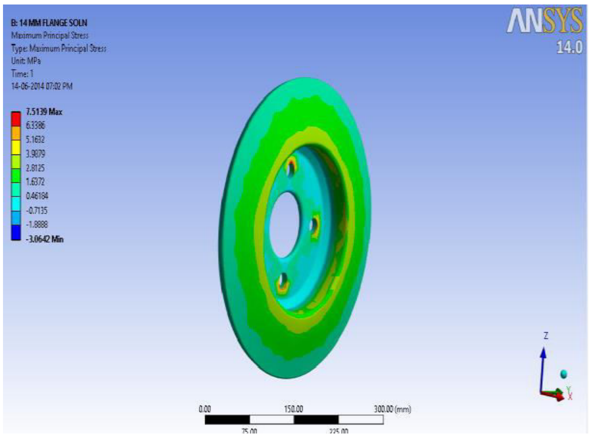

Figure 5. Maximum Principal Stress in Disc Brake Rotor

3.3 Minimum Principal Stress

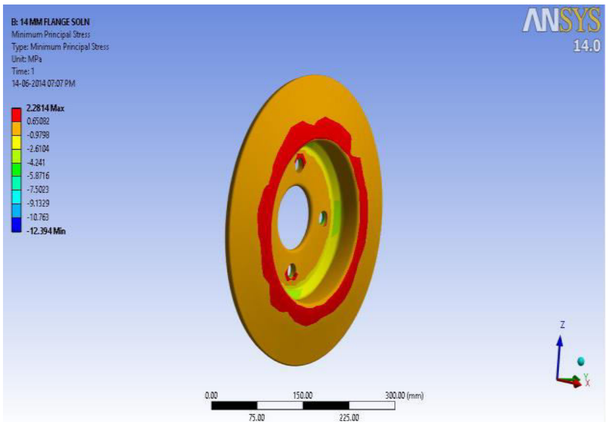

Figure 6. Maximum Principal Stress in Disc Brake Rotor

3.4 Total Deformation

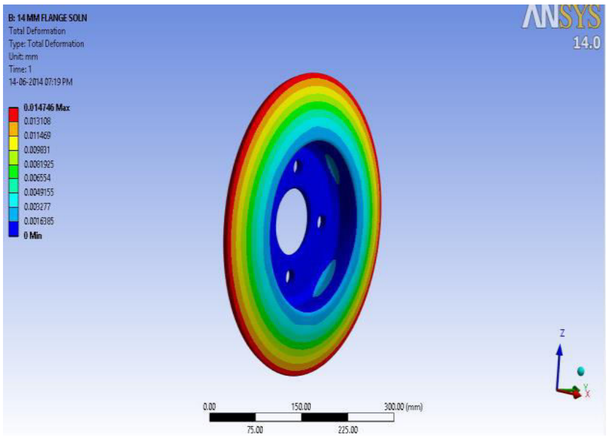

Figure 7. Total Deformation in Disc Brake Rotor

4. Results

The results from Ansys simulation are listed below.

Table 1. Results

Maximum Principal Stress (MPa)	Minimum Principal Stress (MPa)	Total Deformation (mm)	Von-misses Stress (MPa)
7.5139	2.2814	0.014746	10.125

5. Conclusion

The analysis of disc brake rotor shows the results of maximum principal stress of 7.5139 MPa, Minimum principal stress of 2.2814, Total deformation of 0.014746 and Von-misses stress of 10.125.This work is the attempt to reduce the stress level by using metal matrix composite material with SiC particulate by stir casting technique. Clear from above results that the deformation and von-misses stresses are very less as compared with some of previous work by different authors.

6. Acknowledgment

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