Analysis ofAlternatives for Brake Disc Material using various Aluminium Metal Matrix Composite

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ABSTRACT

The objective is to design and analyse thestructural and thermal stress distribution of brake rotor at the real time condition during braking process. The structural analysis of the Rotor Disc of Disc Brake is aimed at evaluating the performance of disc brake rotor of a bike under severe braking conditions and there by assist in disc rotor, design and analysis. In this project, an attempt has been made to investigate the suitable hybrid composite material which is lighter than cast iron and has thermal strain, Yield strength and density properties. The changes are carried out to reduce the stress concentration and weight of the brake rotor, which keeps the brake disc mass low thereby increasing the stability of the vehicle. With the help of Computer Aided Design (CAD), Catia V5 R20 software the structural model of brake rotor is developed. Furthermore, the finite element analysis performed with using the software ANSYS 18.1. The transient thermo-elastic analysis of Disc brakes in repeated brake applications for various Aluminium MMC has been performed and the results were compared with Conventional Cast iron material.

Keywords:*Disc Brake Rotor, Static Analysis, Cast iron, Aluminium MMC's.*

INTRODUCTION

A brake is a mechanical device that inhibits motion by absorbing energy from a moving system. It is used for slowing or stopping a moving vehicle, wheel, axle, or to prevent its motion, most often accomplished by means of friction.

Disc brake is a veryimportant component of our automobiles. It is employed to halt the vehicle or to slow the vehicle to a required velocity from a given initial velocity. Disc brake is a device which is used to convert kinetic energy into thermal energy by means of friction. The primary duty of a brake rotor is to act as a friction surface, generating an opposing torque to a shaft. A disc brake system consists of several components like brake disc, a brake calliper and brake pads. When the brake pedal is applied, pressurized hydraulic fluid squeezes the brake pad friction material against the surface of the rotating brake disc, i.e. rotor. On the result of it, there produces a friction which enables the vehicle to slow down or stop. During the time of braking, energy is transferred to the rotor in the form of heat.

LITERATURE SURVEY

Braking system is one of the most fundamental safety critical components in the modern vehicles. Brake absorbs kinetic energy of the rotating parts (Wheels) and the energy is dissipated in the form of heat energy to the surrounding atmosphere. It decelerates or stops the vehicle. When brake is applied, the disc brake is subjected to high stress, thus it may suffer structural and wear issues. Hence for the better performance, structural, stress and the thermal analysis is preferred to choose suitable material. The objective is to model and analyses stress concentration, structural deformation and thermal gradient of disc brake. Here the disc brake is designed by using any design software and analysis is done by ANSYS workbench14.1 .

PROBLEM STATEMENT

Brakes are often described according to several characteristics. The peak force is the maximum decelerating effect obtained during the braking. The peak force is sometimes greater than the traction limit of the tires.In those case, the brake can cause a wheel skid. Brakes typically get hot in use, and will fail when the temperature gets too high. Cast iron is higher in density and also oxidizes faster.

METHODOLOGY

The study of different research papers should be made and problems in the earlier design should be identified. The design should be completed with all the specifications of the Brake Disc. The finalised design is created into the 3D model by using CATIA V5 R20. The design is then converted into IGES/STEP file in order to import into the ANSYS 18.1. The imported design is then meshed and the various analysis is made using ANSYS 18.1. The comparison between the various alternatives is made and the material for the Brake Disc is selected.

COMPOSITION

- CONVENTIONAL CAST IRON
- 85%Al + 15%SiC
- 90%Al + 5%SiC + 5%Fly Ash
- Al-TiB_2

PROPERTIES

MATERIALS	CAST IRON	85%Al+15 %SiC	90%Al + 5%SiC + 5%Fly Ash	Al-TiB_2
Density (kg/m^3)	7200	2775	3552	4865
Young's Modulus (N/mm^2)	125000	106475	99660	86030
Poisson's Ratio	0.25	0.28	0.285	0.27
Co-efficient of Friction	0.41	0.51	0.55	0.47
Co-efficient of Thermal Expansion(C^-1)	1.37E-5	1.47E-5	1.42E-5	1.41E-5
Thermal Conductivity(Wm^-1C^-1)	52	140	110	130

DESIGN-> CATIA

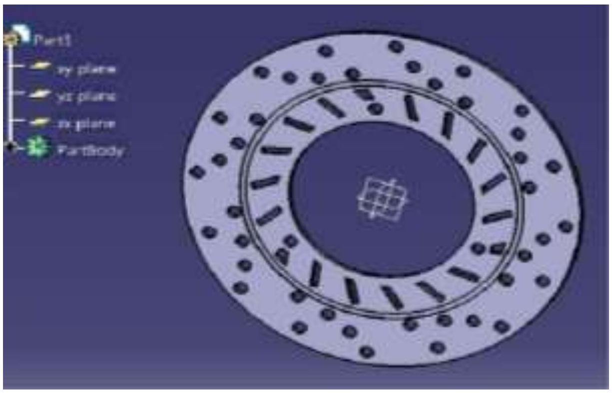

Fig 1. Design of Disc Brake

STRUCTURAL ANALYSIS-> ANSYS

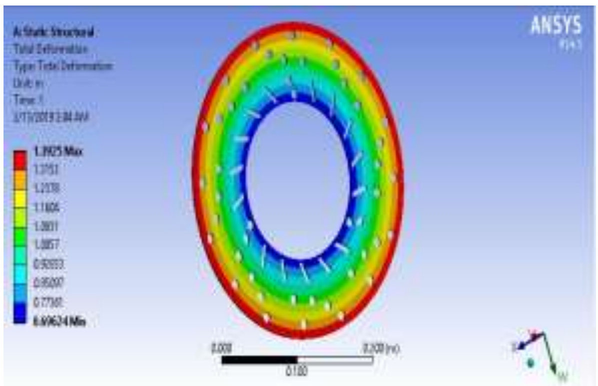

Fig 2. Cast Iron

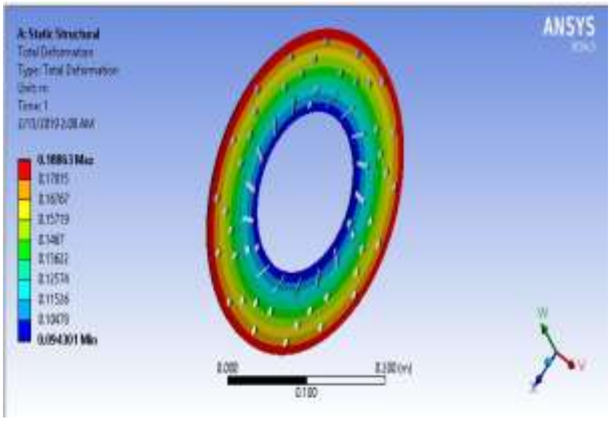

Fig 3. 85%Al + 15%SiC

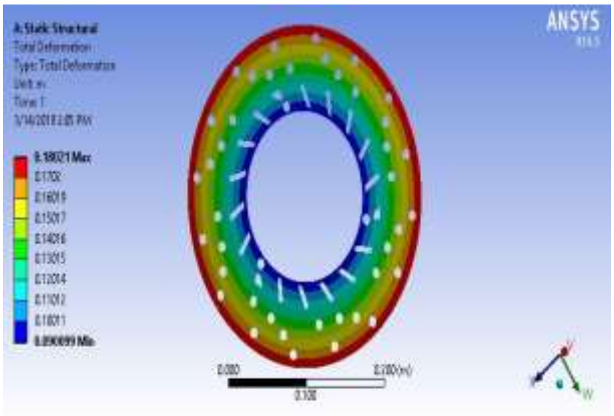

Fig 4. 90%Al+5%SiC+5%Fly Ash

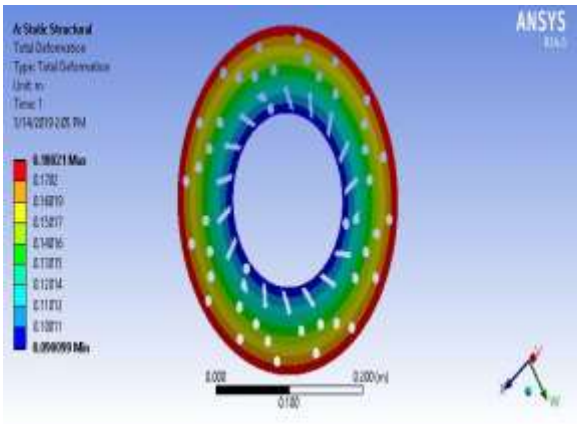

Fig 5. Al-TiB_2

RESULT FOR STRUCTURAL ANALYSIS:

MATERIAL	CAST IRON	85%Al+ 15%SiC	90%Al + 5%SiC + 5%FlyAsh	Al-TiB_2
Minimum Deformation(mm)	0.692	0.094	0.090	0.096
Maximum Deformation(mm)	1.362	0.183	0.180	0.188

THERMAL ANALYSIS->ANSYS:

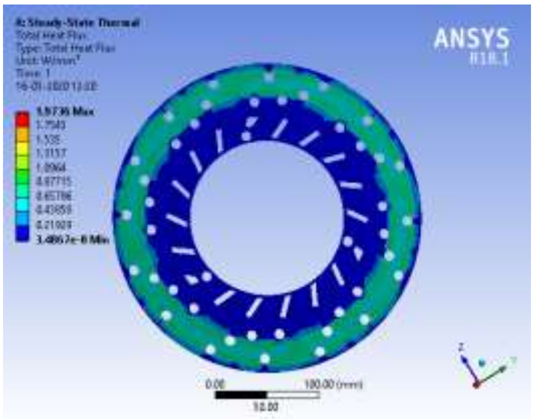

Fig 6. Cast Iron

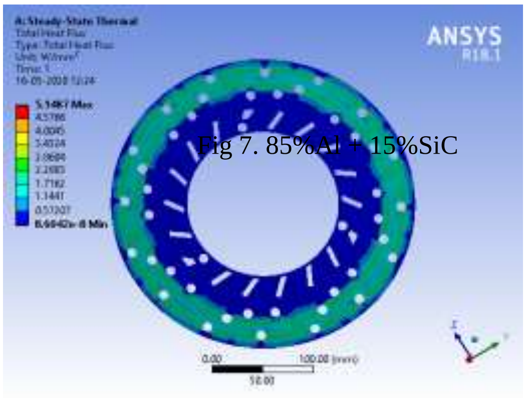

Fig 7. 85%Al + 15%SiC

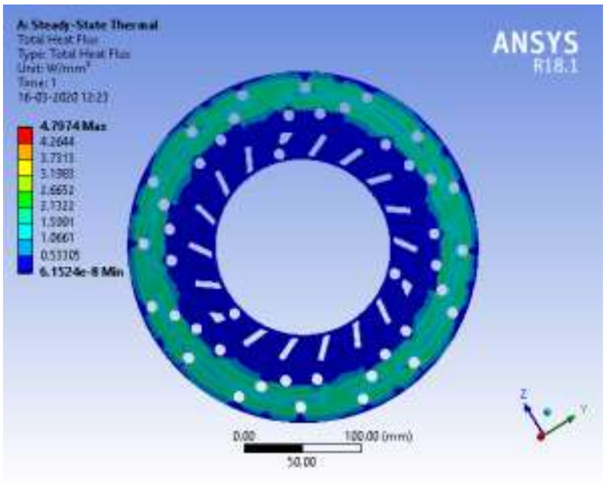

Fig 8. 90%Al + 5%SiC + 5%Fly Ash

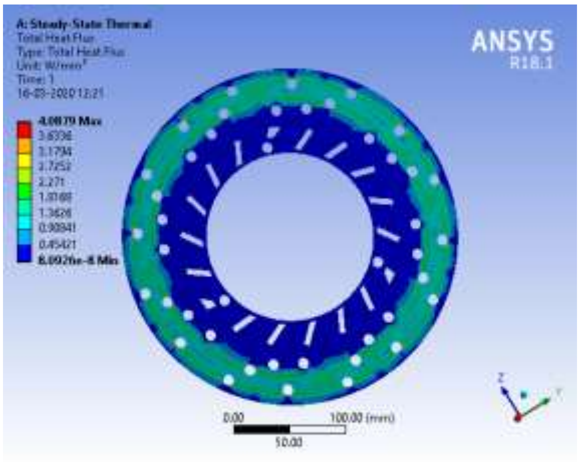

Fig 9.Al-TiB_2

RESULT FOR THERMAL ANALYSIS:

MATERIAL	CAST IRON	85%Al+ 15%SiC	90%Al + 5%SiC + 5%FlyAsh	Al-TiB_2
Minimum Heat Flux(W/mm^2)	3.4867 e-8	8.6042 e-8	6.1524 e-8	8.0926 e-8
Maximum Heat Flux(W/mm^2)	1.9736	5.1487	4.7974	4.8079

CONCLUSION

This project gives a numerical simulation of the thermal and structural behaviour of brake disc for two different materials by means of the computer software ANSYS 18.1. In order to improve the efficiency of braking and provide greater stability to vehicle, an investigation was carried out and the suitable hybrid composite material which is lighter than traditional materials used for brake disc and has preferably good Modulus of Elasticity, Yield strength and density properties. Though it has higher hardness, greater stable characteristics which can withstand high pressure, temperature and resistance to thermal shock.

The Structural and Thermal analysis for the various alternatives of the Brake Disc is made by using various types of Aluminium Metal Matrix Composites. From the observation of the various result obtained and the comparison made, it is found the Aluminium Metal Matrix Composite more advantages over the Conventional Cast iron Brake Disc material.

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