MODIFICATION AND OPTIMIZATION OF EXISTING SOLID DISC BRAKE ROTOR

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Abstract : Disc Brake is an important component of a vehicle which is used to retard, control and stop speed of vehicle at the will of driver according to road and traffic conditions. Brakes works on the principle of friction as set of stationary pads are pressed against a rotating disc. Heat is generated at disc-pad interface due to friction which results in rise of surface temperature within short time period. These causes wear of solid disc brake rotors and brake pads which probably the most prevalent, disturbing and expensive to brake and automotive manufacturers in terms warranty costs. The efficiency and effectiveness of disk brake rotor can be considerably improved by suggesting better material replacement which going to enhance better life. Motivation of project is to reduce the weight of disc rotor by replacing existing Gray Cast Iron material (GCI) with aluminium metal matrix composites (AMMC). As industry observes composites as a better substitution to metals.
The optimum material made by stir casting process is tested with the help of different experimental setup for different important properties of disc rotor like compressive strength, hardness and wear resistance.
Reading so obtained for optimum material AMMC are compared with the properties of parent material (GCI).These results shows that AMMC is a suitable material with proper reinforcement as properties obtained by experimentations are closer to the parent material. Thus, AMMC can be the substitution for parent material of disc brake rotor.

IndexTerms - **disc brakes; compressive strength; friction; hardness; wear.**

I. INTRODUCTION

Disc Brake is an important component of a vehicle which is used to retard, control and stop speed of vehicle at the will of driver according to road and traffic conditions. Brakes works on the principle of friction as set of stationary pads are pressed against a rotating disc. Heat is generated at disc-pad interface due to friction which results in rise of surface temperature within short time period. These causes wear of solid disc brake rotor and brake pads. This is most prevalent, disturbing and expensive to brake and automotive manufacturers in terms warranty costs. The efficiency and effectiveness of disc brake rotor can be considerably improved by suggesting better material replacement which is going to enhance better life and properties as that of parent material(GCI). Motivation of this project is to reduce the weight of disc rotor by replacing existing Gray Cast Iron material (GCI) with aluminium composites which will result in less fuel consumption.

II. PROBLEM STATEMENTS

Frictional heat generated during braking may cause –

Premature Wear, High stress zone, Decrease in coefficient of friction, thermally excited vibration etc. All above undesirable effects can be eliminated or decreased by changing existing disc brake material with aluminium metal matrix composite material (AMMC).

The major advantages of AMMCs compared to unreinforced materials are as follows –

Greater strength, Improved stiffness, Reduced density (weight) up to 45 percentage, Improved high temperature properties, Controlled thermal expansion coefficient, Thermal/ heat management, Enhanced and tailored electrical performance, Improved abrasion and wear resistance, Improved damping capabilities and no evolution of CO_2 during recycling are different competitive factors which can make AMMC as a substitution to existing material.

III. METHODOLOGY

3.1 SELECTION OF ALTERNATIVE MATERIAL

Different properties of different candidate materials are studied. By comparative study we can judge that Aluminium Metal Matrix Composite material (AMMC) can be a material for alteration. Thus, selecting alternating material for disc brake rotor as AMMC by varying percentage of constituent elements.

3.2 PROCESSING OF AMMC

Silicon Carbide is the only chemical compound of carbon and silicon. This is a very hard and strong material. Mechanically, silicon carbide has low density, high strength, high hardness as well as high elastic modulus. Thermal properties of silicon carbide are also excellent as it has low thermal expansion, high thermal conductivity and excellent thermal shock resistance. Also it has superior chemical inertness. As silicon carbide is added in the aluminium metal matrix as reinforcement, it alters the overall properties of the aluminium based metal matrix.

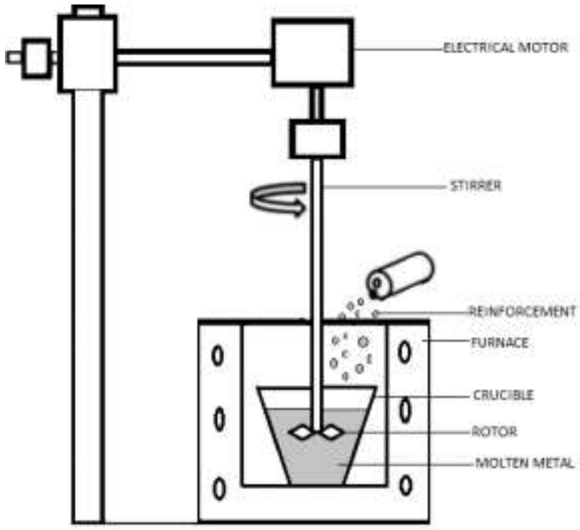

Fig.1: Schematic Setup for Stir Casting Process

The aluminium was melted into a graphite crucible inside a Bituminous Coal Furnace at 750°C. No wetting agent to bind molten metal and reinforcement powder was used. The furnace temperature was kept, above melting point of aluminium, at 715°C, for 10 minutes. After two hours, it get melted completely. Aluminium dross formed is then removed from the surface of the molten metal. Stirrer was then lowered down into the molten metal and allowed to rotate at 120 rpm for 10 minutes. When the vortex appears, the hot powder of Si-C, preheated to 1000°C, was uniformly added to the molten matrix.

The angular velocity of stirrer during adding process is then raised to 150rpm to achieve high integrity and homogeneity of the molecules. The powder is added at a rate of 7g/min. The crucible containing the melt mixture was then carefully taken out of furnace and poured into a specially designed permanent mould. The mould was left to cool and castings were ejected.

Material obtained is tested with different experimental setup to study different mechanical and tribological properties.

IV WEAR TESTING

Wear is a process of removal of material from one or both material surfaces in solid state contact Optimum material should be wear resistant so that it can withstand braking load and serve purpose for longer duration.
In the present experiment the parameters such as speed, time and track radius are kept constant throughout for all the experiments.

4.1 EXPERIMENTAL SET UP

In this study, Pin-on-Disc testing method was used for tribological characterization.
Entire setup is divided in to three units as shown in Fig 4.1.

- Pin on Disc Apparatus
- Computer Aided Data Acquisition System
- Display Unit

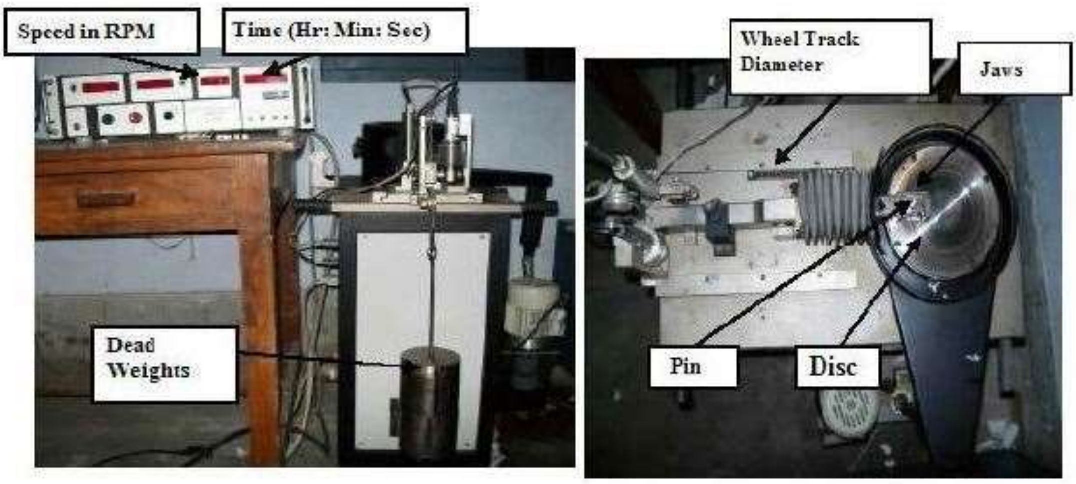

Fig. 4.1 Wear Testing (Pin on Disc Apparatus)

These parameters are given in Table 4.1.

Table 4.1: CONSTANT PARAMERERS

PARAMETER	GCI	AMMC
TRACK RADIUS (mm)	80	80
SPEED (RPM)	900	900
TIME (Sec)	60	60

Pin Sample Specimens:


Fig. 4.2 Specimens of GCI (left) and AMMC (right)

The pin samples were 30 mm in length and 10 mm in diameter for AMMC and GCI both as shown in Fig. 5.2.

V COMPRESSION TESTING

During hard braking, high compressive stresses are generated in the circumferential direction on the disc surface which causes plastic yielding. But when the disc cools down, these compressive stresses transform to tensile stresses. When this kind of stress-strain behaviour is repeated due to frequent braking actions, stress cycles with high amplitudes are developed which might generate low cycle fatigue cracks after repeated braking cycles.

Keeping this in mind compression testing gives credit points for replacement of disc material from GCI to AMMC.

5.1. SAMPLE SPECIMENS:

For compression testing precise cubes of both materials having 2.5mm (one inch) side are manufactured on milling machine. These specimens are kept in between flat plates.

Flat surfaces area of 625mm^2 are sufficient enough for holding specimens and for accurate results.


GCI Cube AMMC Cube

Fig. 5.1 Specimens For Testing Compressive Strength (Cubes-Size One Inch)

5.2 SPECIMENS AFTER COMPRESSION TEST


GCI AMMC

Fig. 5.2: Specimens After compression Test

Original pictures of both the specimen after test are shown in Fig.5.2.

5.3 RESULTS

Results of Compressive strength of Both the materials are tabulated in Table 5.1.

Table 5.1: Compressive Strength of both Specimens

SPECIMEN	GCI	AMMC
COMPRESSIVE STRENGTH (MPa)	566.768	542

VI HARDNESS TESTING

Hardness is a characteristic of a material, not a fundamental physical property. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation. Brinell hardness test is most commonly used to test materials that have a structure that is too rough or too coarse to be tested using other test methods. e.g. castings and forgings.

6.1 SPECIMENS AFTER HARDNESS TEST

Same specimens which are used for compression testing are used for hardness testing.
Original pictures of both the specimen after test are shown in Fig.6.1

Fig. 6.1: Specimens After hardness Test (AMMC)

6.2 RESULTS

Table 6.1: Compressive Strength of both Specimens

SPECIMEN	GCI	AMMC
HARDNESS STRENGTH (HBW)	187	143

Therefore, AMMC can be a substitution for existing GCI rotor on the basis of Hardness Tests results.

VII CONCLUSIONS

Wear analysis shows that –

- AMMC can be a better substitution for existing GCI rotor on the basis of wear, frictional force and coefficient of friction.

Compression Test shows that –

- Compression strength of AMMC material is much greater than Existing material of brake disc i.e. GCI.

Hardness Test results conclude that-

- Hardness of AMMC material is comparatively less than Existing material of brake disc i.e. GCI but it will be within acceptable range.

Therefore, AMMC can be a substitution for existing GCI rotor on the basis of above results.

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