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Experimental Investigation of Disc Brake using Al- Ni-Cr Composite Materials

Muthusamy. A[1*], Keerthivasan. R[2], Sridharan. P[3], Vimal. R[4], Praveen Kumar.G[5]

[1] Assistant Professor, Department of Mechanical Engineering Anjalai Ammal Mahalingam Engineering College. Kovilvenni, Tamilnadu, India.*
[2,3,4,5] Student, Department of Mechanical Engineering, Anjalai Ammal Mahalingam Engineering College. Kovilvenni, Tamilnadu, India.

[*]Corresponding author
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Abstract

In this work, an effort has been designed to raise the reliability of engine fuel efficiency using Al- Cr –Ni composites with other alternatively materials for the disc brake guides. Aluminium matrix composites have found the most suitable inside automotive, aerospace and aircraft industries and contain the greatest promise for future year's growth. This paper analysis the valve mechanical properties of the Al- Ni-Cr composite material by using composite model plate and evaluate the mechanical properties. In this paper the existing disc brake steel is replaced with composite disc brake.

Keywords: Disk Brake, Composites.

1. Introduction

The need of efficient use of energy & materials is being felt strongly because of diminishing resources in the present times. There has been an important role of materials in the development of civilizations. In the transportation sector when earlier large bulky automobiles are compared with today's light weight, technologically superior vehicles. Man has been using iron, copper & their alloys for thousands of years, but surprisingly until the last century he was oblivious of the bauxite ore (which has aluminium) is the second most abundant ore in earth crust. It became an economic competitor to steel & cast iron in engineering applications because of its excellent combination of properties like lightweight, high specific strength, stiffness & good corrosion resistance, higher ductility etc. However, the poor mechanical and tribological properties of aluminium (yield strength: 30 Mpa, tensile strength: 70 Mpa).

Limits its wider range of usage. Realizing the potential as well as availability of Aluminium, considerable efforts are being made to explore the possibilities of improving the mechanical strength and wear resistance so as to meet the requirements of various applications. More aluminium is being consumed now a days than all other non-ferrous metals/ alloys including Copper. The transformation of the automobiles requiring more fuel, frequent maintenance to the energy efficient automobiles requiring lesser maintenance and which is also environment friendly has resulted from better engineering & materials. With the turn of century material technology in automobiles undertook a shift towards all aluminium cars. In order to improve the mechanical strength & modulus of aluminium, it is alloyed with various alloying elements such as Cu, Zn, Mg, Si, Mn etc. Amongst the various Aluminium alloys AlZn-Mg alloys are found to show tremendous improvement in mechanical strength and finds its application in aerospace and automobile structural components. Al Mg cast alloys show excellent corrosion resistance, good machinability and attractive appearance when anodized. In internal combustion engines, Al-Si alloys are used extensively because of their properties like low coefficient of thermal expansion, bearing properties, good corrosion resistance in association with the strength in automotive industries, to achieve reduced fuel consumption as well as greenhouse gas emission is a current issue of utmost importance. To reduce automobile weight and improve fuel efficiency, the auto industry has dramatically increased the use of aluminium in light vehicles in recent years. Aluminium alloy-based metal matrix composites (MMCs) with ceramic particulate reinforcement have shown great promise for such applications.

These materials having a lower density and higher thermal conductivity as compared to the conventionally used gray cast irons are expected to result in weight reduction of up to 50 – 60 % in brake systems. Moreover, these advanced materials have the potential to perform better under severe service conditions like higher speed, higher load etc. which are increasingly being encountered in modern automobiles. Since brake disc or rotor is a crucial component from safety point of view, materials used for brake systems should have stable and reliable frictional and wear properties under varying conditions of load, velocity, temperature and environment, and high durability. There are several factors to be considered when selecting a brake disc material. The most important consideration is the ability of the brake disc material to withstand high friction and less abrasive wear. Another requirement is to withstand the high temperature that evolved due to friction. Weight, manufacturing process ability and cost are also important factors those are need to be considered during the design phase. In material selection stage, the recyclability of cast iron is advantageous but the evolution of CO2 during re-melting has to be taken in consideration. The brake disc must have enough thermal storage capacity to prevent distortion or cracking from thermal stress until the heat can be dissipated. This is not particularly important in a single stop but it is crucial in the case of repeated stops from high speed.

1.1.Introduction of Composites

Composite is a combination of two or more chemically distinct and insoluble phases. Constituent materials or phases must have significantly different properties for it to combine them: thus, metals and plastics are not considered as composites although they have a lot of fillers and impurities The properties and performance of composites are far superior to those of the constituents Composites consist of one or more discontinuous phases (reinforcement) embedded in a continuous phase (matrix).

1.2.Uses of Composites

The biggest advantage of modern composite materials is that they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made that exactly meets the requirements of a particular application. Composites also provide design flexibility because many of them can be molded into complex shapes. The downside is often the cost. Although the resulting product is more efficient, the raw materials are often expensive.

1.3.Applications

Spacecraft: Antenna structures, solar reflectors, Satellite structures, Radar, Rocket engines, etc.

Aircraft: Jet engines, Turbine blades, Turbine shafts, Compressor blades, Air foil surfaces, Wing box structures, Fan blades, Flywheels, Engine Bay doors, Rotor shafts in helicopters, Helicopter transmission structures, etc.

Miscellaneous: Bearing materials, Pressure vessels, Abrasive materials, Electrical machinery, Truss members, Cutting tools, Electrical brushes, etc.

Automobile: Engines, bodies, Piston, cylinder, connecting rod, crankshafts, bearing materials, etc.

2. Disc Brake and the Systems

Disc brake systems generate braking force by clamping brake pads onto a rotor that is mounted to the hub. A schematic view of the brake system is shown in Fig. 2. The high mechanical advantage of hydraulic and mechanical disc brakes allows a small lever input force at the handlebar to be converted into a large clamp force at the wheel. This large clamp force pinches the rotor with friction material pads and generates brake power. The higher the coefficient of friction for the pad, the more brake power will be generated. Coefficient of friction can vary depending on the type of material used for the brake rotor. Typically service brakes are concerned with dynamic coefficient of friction, or the coefficient of friction measured while the vehicle is moving.

All modern disk brakes systems rely on brake pads pressing on both sides of a brake rotor to increase the rolling resistance and slow the car down. The amount of frictional force is found by multiply the force pushing the pad into the rotor by the coefficient of friction of the pad. So, the force slowing the brake disc or rotor is the braking system is a vital safety component of ground-based transportation systems; hence the structural materials used in brakes should have possess some combination of properties such as good compressive strength, higher friction coefficient, wear resistant, light weight, good thermal capacity and economically viable.

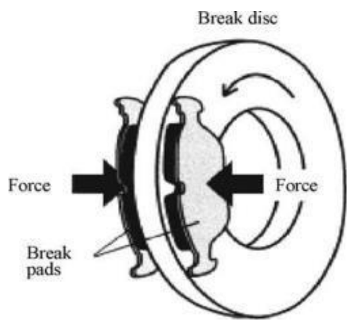

Figure 1: Brake System

2.1.Selection of Materials

This chapter describes the details of processing of the composites and the experimental procedures followed for their mechanical characterization. The materials used in this work are

1. Aluminum alloy
2. Nickel
3. Chromium

2.2.Methods

2.2.1.Stir Casting Process Studies

Fabrication techniques affect the microstructure, the distribution of the reinforcing materials and interfacial bond condition between reinforcing phase and matrix. These techniques have to ensure uniform distribution of the reinforcing material in the matrix and formation of good bond between matrix and reinforcing material, to obtain MMCs with optimum properties. There are several fabrication techniques available to manufacture different MMC. Depending on the choice of matrix and reinforcement material, the fabrication techniques can vary considerably. According to fabrication methods can be divided into three types. These are solid phase process, liquid phase process and semi solid fabrication process. Among the variety of manufacturing processes available for discontinuous metal matrix composite, stir casting is generally accepted as a particularly promising route, because of low cost. lie in its simplicity, flexibility and applicability to the large quantity production. This semi solid metallurgy technique is the most economical of all available routes for MMC Production. It allows very large sized components to be fabricated, and is able to sustain high productivity rates. Has shown that the cost of preparing composite materials using a casting method is about one third to one half that of competing methods.

2.3.Mixing Ratios

Table 1: Mixing Ratios

MATERIALS	1	2	3
Aluminium	95%	90%	80%
Nickel	2%	5%	10%
Chromium	3%	5%	10%

The composites were prepared by stir casting process. Shows schematic diagram the original setup of the stir casting process. Resistance furnace with a temperature range of 3000 C was used to melt the matrix material. The furnace has a temperature controller with k type thermocouple to control and measure the temperature. An electric motor is fixed at the top of the furnace to provide stirring motion to the stirrer. The speed of the stirrer can be varied as the setup has a speed controller attached to it.

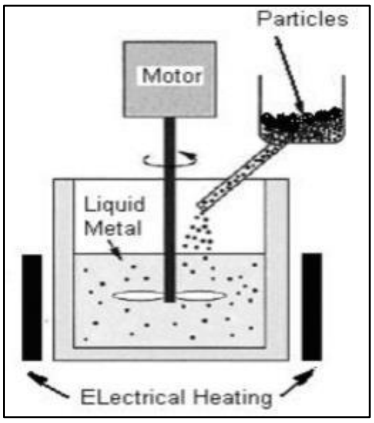

Figure 2: Stir Casting Process

3. Mechanical Property Test

3.1.Wear test:

Surface engineering point of view, wear test is carried out to evaluate the potential of using a certain surface engineering technology to reduce wear for a specific application, and to investigate the effect of treatment conditions (processing parameters) on the wear performance, so that optimized surface treatment conditions can be realized. In a pin-on-disc wear tester, a pin is loaded against a flat rotating disc specimen such that a circular wear path is described by the machine. The machine can be used to evaluate wear and friction properties of materials under pure sliding conditions. This test method describes a laboratory procedure for determining the wear of materials during sliding using a pin-on-disk apparatus. Materials are tested in pairs under nominally non-abrasive conditions. The principal areas of experimental attention in using this type of apparatus to measure wear are described. The coefficient of friction may also be determined.

3.2.Knoop hardness test:

The Knoop hardness test is a micro hardness test - a test for mechanical hardness used particularly for very brittle materials or thin sheets, where only a small indentation may be made for testing purpose. Metallurgists have long used various types of indenters for testing the hardness (defined as resistance to deformation) of metals. Attempts to apply to minerals the Rockwell, Vickers, and other types of machines which measure hardness in terms of deformation of the specimen by penetration of a standard-shaped point applied by a specified machine, have met with little success because of the tendency of minerals to fracture during the penetration of the indenter. Since the fracture represents displacement and deformation of other material than that immediately adjacent to the point of the indenter, greater penetration takes place than is proper for the indenter and its associated machine. Moreover, the displacement due to fracture cannot be measured readily, and therefore introduces an unknown factor into the measurement.

4. Compression Test

A compression test is a mechanical test in which a material or product responds to forces that push, compress, squash, crush and flatten the test specimen. Compression testing is a fundamental mechanical test, similar in nature to tensile and bend tests. Compression tests characterize material and product strength and stiffness under applied crushing loads. These tests are typically conducted by applying compressive pressure to a test specimen using platens or specialized fixtures with a testing machine that produces compressive loads. During a compression test, properties of the material including sample stress and strain are measured and various calculations made. Data is plotted as a stress-strain diagram. Data is used to determine qualities such as compressive strength, elastic limit, proportional limit, yield point, yield strength, and modulus of elasticity. Many samples are placed between two plates or platens that distribute the applied load across the entire surface area of two opposite faces of the test sample. The plates are compressed together by a compression-capable test machine, causing the sample to flatten. The sample's deflection or strain is measured by the machine or bya deflectomer or extensometer.

5. Test Results

5.1.Hardness Test

Table 3: Hardness Test

MATERIALS\ COMPOSITIONS	Hardness number BHN	Hardness value Mpa
Sample 1	4.40	12.35
Sample 2	14.20	45
Sample 3	8.20	27.2

5.2.Surface Wear Test

Table 4: Surface Wear Test

MATERIAL\ COMPOSITION	W0 (g)	W1 (g)	TIME min	Wearrate (g\m)
Sample 1	6.12	6.02	20	0.005
Sample 2	5.192	5.150	20	0.0021
Sample 3	5.377	5.308	20	0.00345

5.3.Compressive Test

Table 4: Compressive Test

MATERIALS\ COMPOSITION	**Compressive stress**
Sample 1	135.23
Sample 2	250.58
Sample 3	173.76

6. Test Specimen

Figure 3: Test Specimen

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