Study of Mechanical and Tribological Properties of Automotive Brake Pads

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***Abstract*: In automobile braking system brake pads are the most important component. By friction brake pads convert the vehicle's kinetic energy into thermal energy. In this work due to produce the asbestos free brake pad material for reduce the environmental pollution. The performance of the brake pad depends completely on frictional material used. In the present investigation the brake pad samples were produced by varying constituents (wt %) of the existing composition and new formulation were made with other friction materials. The manufactured brake pad samples were tested for wear, hardness, tensile, impact and micro structural analysis. The various test results were compared with the existing brake pad composition. Generally, MMC has been used in engineering application in broad way because of their mechanical and physical properties. Automobile and aerospace field used because of their high strength to weight ratio, lighter weight, lower cost and good behavior.**

Keywords: **Asbestos, MMC and Brake pad**

I. INTRODUCTION

Brake pads for the most important part of an automobile braking system. The effectiveness of the brakes depends entirely on the quality and proper composition of the brake pads. It offers high coefficient of friction and less wear. Nowadays, most vehicles use disc brakes as they dissipate heat better hence reducing fade when compared to drum brakes. The rotor disc materials of a disc brake system are usually prepared from gray cast iron due to its excellent heat conductivity, good damping capacity and high strength. However, in a disc brake system, there is no single material which has been clever to meet the preferred performance-related criteria such as safety and durability under various brake conditions. The friction materials are essential to give a even coefficient of friction and a low wear rate at various operating speeds, pressures, temperatures, and environmental conditions. Furthermore, these materials must also be compatible with the rotor material in sort to decrease its extensive wear, vibration, and noise during braking. In the earlier period two decades, asbestos was a accepted element used to make brake pads, due to its strength, confrontation to heat and flameproof. Since 1980s, asbestos was known as harmful content and was banned from being used as an element to make brake pads, for the reason that it can root lung cancer and other health problems. Proper selection of frictional materials and required quantities of constituents is mainly based on experience or by trial and error method to make new formulations. Friction materials is a heterogeneous material and is composed of a few elements which are used to develop friction property at low and high temperature, boost strength and rigidity, prolong life, reduce porosity, and reduce noise. The novel formulations are made by varying the elements or weight proportion of the elements to vary the physical, chemical, mechanical and tribological properties of the brake friction materials. Basic elements of frictional materials are classified as additives, fillers, binders and reinforcement fibers. The frictional additives comprise of a mixture of abrasives and lubricants affects the frictional characteristics of the brake pads. Graphite is used to act as a solid lubricant. Barium sulphate imparts heat stability to friction material. Different reinforcement materials such as barium sulphate, groundnut shell powder, graphite and brass fibers are used to enhance friction characteristics and mechanical strength of the friction material. Friction and wear personality of friction material play andvital role in deciding which new formulations developed are suitable for the brake system.

II. LITERATURE REVIEW

The review papers are mainly referred to replacing the asbestos brake pad with composite asbestos free brake pad prepared of the alternate materials. **Raffaele Gilardi,[1]** studied the graphite is commonly used in brake pads. The use of graphite crush has the major goal of solid position lubrication and friction coefficient stabilization. In this article fallout on resin bonded brake pads with hub on noise performance and heat dissipation are presented. Experimental tests are based on replica friction materials with a known formulation and a reduced number of components for a better identification of the role of the graphite type. **Umasankar,[2]** discussed MMC has been used in engineering application in broad way because of their mechanical and physical properties. They are broadly used in the field of automobile and aerospace because of their high strength to weight ratio, lighter weight, lower cost, and good behavior. In present study the mechanical and wear behavior of aluminum metal matrix composite and Sic has been discussed. Brake Pad is manufactured by route of powder metallurgy which is widely preferred because of its low cost, high volume production, ease of operation, sustainability and attractive manufacturing process. Brake pads are developed with light alloy Aluminum 2014 reinforced with SiC to augment the strength and wear resistance and explore the advantage of low density of the matrix. **Omar Maluf, [3]** investigated the end of the 19th century the development of a brake system for the newly invented automobile vehicles was needed. From that moment on, this equipment, which makes use of several components (the brake disc among them), was developed. Historically, the first material used to make brake discs was the gray cast iron, which is a material that fits the requirements it is intended for, such as good thermal conductivity, good corrosion strength, low noise, low weight, long durability, steady friction, low wear rate, and a good price/benefit ratio. **Umar Nirmal,** discussed the tribological properties difference of potentially new designed non-commercial brake pad materials with and without asbestos under various speed and nominal contact pressure. The two fabricated non-commercial asbestos brake pad (ABP) and non-asbestos brake pad (NABP) materials were tested and compared with a selected commercial brake pad (CMBP) material using a pin-on-disc tribo-test-rig under dry contact condition. Results showed that friction coefficients for all materials were insensitive to increasing speed and pressure. NABP maintained stable frictional performance as ABP material when contact temperature elevated. Moreover, NABP proved to have greater wear resistance compared to ABP and CMBP materials. Furthermore, the SEM micrographs of brake pad surfaces showed craters which is due to disintegration of plateaus. Finally, the test results indicated that the NABP has the potential braking characteristic for a brake pad material. **Jayashree bijwe,** discussed the main focus of current research in non-asbestos organic (NAO) friction materials (FMs) is on searching replacement of copper which is a recently proven hazard to the aquatic life. Cu is almost invariably used in the various forms in FMs mainly because it enhances thermal conductivity of a composite which helps to dissipate frictional heat efficiently from the friction surface and thus resists the negative impact on performance especially on fade. Moreover, it also acts as a solid lubricant at high temperature. The replacement is not easy and perhaps will have to be done by a package of ingredients. The search for newer ingredients hence is continuing. In this paper, newly commercialized graphite which is more conducting than the ordinary graphite is explored for possible replacement.

III. PROBLEM DEFINITION

The objective of the present work is to design the composite material of brake pad (Brass, groundnut dust, barium sulphate /graphite) for automobile braking system. This is done to achieve the following. To fabricate a brake pad specimen that has optimum wear and brake noise. To use locally available materials that will not cause environmental pollution as well as health problems.To construct and test the brake pad specimen so as to determine its feasibility for use in motor vehicles.

IV. MATERIALS AND METHODOLOGY

The matrix material used in the present investigation was Brass (with chemical composition presented in Table-I). Brass was purchased from Pandian Metal Mart, Madurai, Tamilnadu, India. Graphite and Barium sulphate was purchased from ayyappa chemicals, sivakasi, Tamilnadu, India. Groundnut shell dust was commercially available. The Photograph of the Groundnut Shell is shown in Fig.3.Conversion of these agricultural wastes to products suitable for use as reinforcements in composites will help extend the frontiers of knowledge of composite materials development and applications, and contribute in agricultural waste management. A key challenge in the processing of composites is to homogeneously distribute the reinforcement phases to achieve a defect-free microstructure. Based on the shape, the reinforcing phases in the composite can be either particles or fibres. The relatively low material cost and suitability for automatic processing has made the particulate-reinforced composite preferable to the fibre-reinforced composite for automotive applications.



Fig.1 Brass alloy bar Fig.2 Barium sulfate Fig.3Groundnut shell and Groundnut shell dust

Fig.4 Graphite powder

Table-I Brass Alloy Chemical Composition

Constituent	% of elements
Copper	56.0-59.0
Lead	2.0-3.5
Iron,	0.35 Max
Total other impurities (excluding iron)	0.7 Max
Zinc	Remainder

Brass is a metal alloy made of copper and zinc the pro-portions of zinc and copper can be varied to create a range of brasses with varying properties.Brass was melted by heating up to 950˚C with use of crucible in the furnace, then the molten state was kept for 30 minutes in the furnace itself. After that we have to stir the alloy and filler materials. So the furnace which was used to stir the mixture heated up to the temperature equal to the molten temperature of alloy. The molten state of alloy was taken into the stirring furnace. Then the molten metal was poured into the molden cavity. After that we get the casting material and machined for required dimension.

Fig.4 casting samples Fig.5 Hardness and impact test specimen

V.EXPERIMENTAL WORK

A. Hardness Test

The hardness of a material is its resistance to penetration under a localized pressure or resistance to abrasion. Hardness tests were carried out on the matrix brass alloy and composite material specimens on a rockwell hardness testing machine. The specimens were metallographically polished for conducting the hardness test.1/16" steel ball indenter was used for this testing and the 100kg of load was applied.

B.Impact Test

An impact test signifies toughness of material that is ability to absorb energy during plastic deformation. The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition. In the impact test, the impact strength i.e., resistance to shock loads and the toughness of material under dynamic load is determined.

VI.RESULT AND DISCUSSION

As discussed in the previous chapters the brass alloys composite materials of 2%. 4% and 6% ash particles have been tested for the hardness values in the Rockwell hardness testing machine. The specification of the ball indenter was same for all type of specimens and the load applied was also same. But the hardness value for the composite of 6% of wt particles is having the higher value of hardness. The variation of the hardness with respect to the samples is shown as the graph in the fig.5.When compared to the pure brass alloy, the brass alloy and filler composited of 6% filler content was having higher value hardness. Brass alloy composite materials of 2%, 4% and 6% filler particles have been tested for the impact strength values in the Charpy testing machine. But the impact strength value for the composite of 6% is having the higher value of impact strength. The variation of the impact strength with respect to the samples is shown as the graph in the fig.6. The load is constant for all wt percentage of samples. Up to 600 seconds the wear will occur for 2% of wt composite material the frictional force and the wear are increasing gradually with respect to time. Up to 600 seconds the wear will occur for 4% of wt composite material. Here also the frictional force and the wear are increasing gradually with respect to time. Again Up to 600 seconds only the wear will occur for 6wt% of composite material. Here the frictional force and the wear are very less when compared to the composite material of 4% and 2% of samples. The wear and the sample for the different wt of 2%, 4% and 6% content is shown in the fig**.**7.

Table-2 Rockwell Hardness

S.No	Specimen		
	2%	**4%**	**6%**
1	69	78	84
2	72	80	90
3	76	84	87
4	73	79	92
5	71	82	95
Average (RHN)	72.2	80.6	89.6

This graph shows the relationship between x-axis is samples and y-axis is RHN. From this graph, the %of filler is increased, the impact strength is also increased.

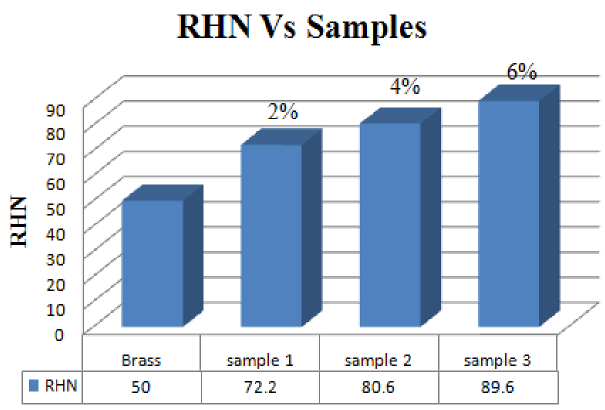


Fig.5 Comparison of hardness value

Table-3 Impact Test

S. No	Specimen	Impact strength (joules)
1	2%	22
2	4%	24
3	6%	26

This graph shows the relationship between x-axis is samples and y-axis is impact strength. From this graph, the %of filler is increased, the impact strength is also increased.

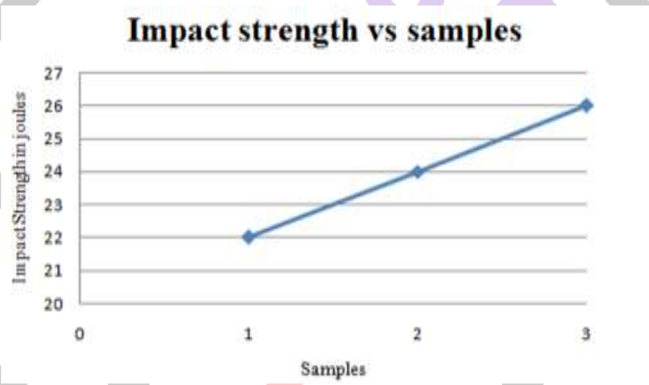


Fig. 6 Variation of impact strength

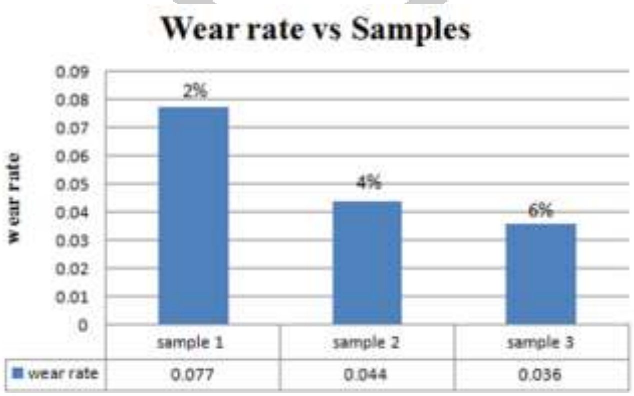


Fig.7 variation of wear rate

This graph shows the relationship between x-axis is samples and y-axis is wear rate. From this graph, the %of filler is increased, the wear rate is decreased. A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the sample's surface topography and composition. The electron beam is generally scanned in a raster scan pattern, and the beam's position is combined with the detected signal to produce an image. The microstructures of the samples,cut from the casting at different locatios ,were obeserved to study the particle distribution.The optical micrographs of metal matrix composite shown in Fig.9.Here,the particles were seggregated at the selected places of plate.But uniform distributions of particles were observed in the micrographs of brass in the presence of GBG mixture at various concentration**.**

SEM can achieve resolution better than 1 nanometer. Specimens can be observed in high vacuum, in low vacuum, in wet conditions (in environmental SEM), and at a wide range of cryogenic or elevated temperatures. Energy Dispersive X-Ray Spectroscopy (EDS or EDX) is a chemical microanalysis technique used in conjunction with scanning electron microscopy (SEM). (See Handbook section on SEM.) The EDS technique detects x-rays emitted from the sample during bombardment by an electron beam to characterize the elemental composition of the analyzed volume. Features or phases as small as 1 µm or less can be analyzed.

Fig.8 Brass with 2wt% GBG (SEM)

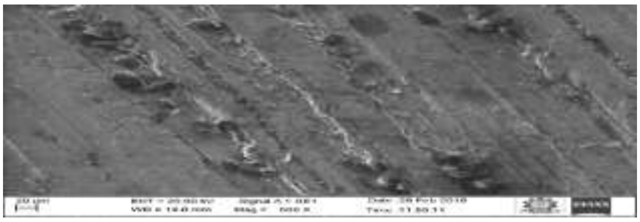


Fig.9 Brass with 2wt% GBG (EDAX)

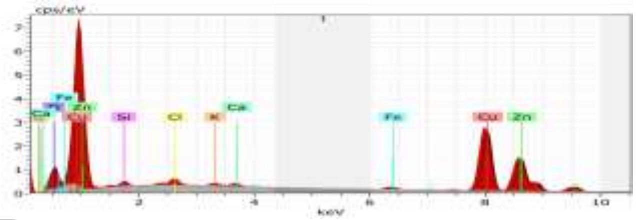


Fig.10 Brass with 4wt% GBG (SEM)

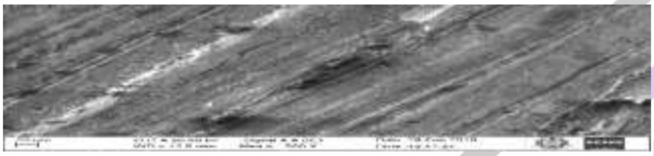
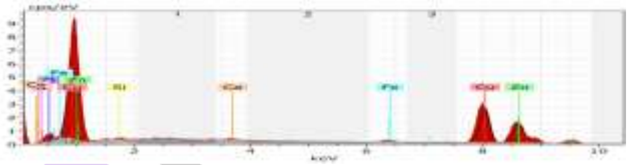


Fig.11 Brass with 4wt% GBG (EDAX)



The microstructure of the Brass alloy and that of the Brass alloy with 2wt% fillers were analysed using Scanning Electron Microscopy/Energy Dispersive Spectrometer. The microstructure of the Brass alloy is shown in Fig.11.The microstructure of the composites reveals small discontinuities and a reasonably uniform distribution of fillers in the Brass matrix.Good retention of reinforced particles was clearly seen in the microstructures of the composites.

CONCLUSION

The fabrication of Brake pad composites containing the mass fraction of 2%, 4%, and 6% reinforcement was carried out and the hardness, impact strength and microstructures were investigated. From the result the impact strength and the hardness values of the composite material having 6wt% are very high when comparing the remaining two types of composite materials

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