Development of Asbestos Free Brake Pad

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Brakes are most important safety devices in the machines. Friction lining is an essential part of braking system. Different types of friction materials are used in brake lining of different machines. The brake linings generally consist of asbestos fibres embedded in polymeric matrix along with several other ingredients. The use of asbestos fibre is being avoided due to its carcinogenic nature. A new asbestos free friction material (lining) and brake pad for heavy machines, such as, hydrogenerator has been developed. Physical properties of this new material along with wear properties have been determined and reported in this paper. Non-asbestos composition shows the wear properties comparable to conventional asbestos brake pads.

Keywords: Non-asbestos friction material; Wear properties

INTRODUCTION

The brake is an important safety device in machines. The friction material is an essential part in brake and clutch devices. Different types of brake materials are used in different machines. Light weight materials, such as, aluminium matrix composites cost more than traditionally used gray cast iron due to their high raw material cost[1]. The manufacturing cost involved in the component development using aluminium matrix composites is high. Asbestos is a cheap and easily available raw material[2-7]. It is used extensively as lagging material, insulation material, raw material for making corrugated sheet and as lining material. It is also used as reinforcement in the form of fibre, for making composite material. Due to its good thermal stability and high L/D ratio, it is the most prominent candidate for use as friction material where thermal stability is important criteria.

In hydrogenerators, brake pads are used as friction material. However, during maintenance these also serve as load bearing pads. The brake pads (friction material) presently used are generally made from asbestos fibre. In spite of its good properties asbestos is being withdrawn from all those applications where there is a possibility of man consuming or inhaling its dust, because of its carcinogenic nature. It is necessary to use alternate material for making non-carcinogenic brake pad. Friction materials have evolved from simple formulations containing eight ingredients to complex composites with as many as 20 components. Several formulations have been developed for higher performing products.

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In this study, a new type of asbestos-free composite and its brake pad has been made and characterized for the use in heavy machines and in hydrogenerators.

Several samples having asbestos-free compositions were prepared and their physical and wear properties were evaluated. Apart from these properties sliding wear and abrasive wear properties were evaluated and studied.

MATERIALS AND METHODS

Development of Brake Pad

The new friction material has been developed jointly by RRL, Bhopal and BHEL, Bhopal and a patent application has been filed[8]. This essentially contains binder polymer material, reinforcement fibres, friction modifier, fillers, and few more chemical additives to achieve the desired properties of material. This proprietary process and composition of friction material is given elsewhere[9]. Glass fibres, mineral fillers, metal chips, phenolic resin, graphite and additives were dry mixed in a mixer and then transferred to a mould kept in a hot platen press at 140°C at 1000 kgf/cm^2 pressure for 10 min. After removal from hot press, the material was cured at 120°C in an oven for 24 h. Test pieces were cut to determine various properties as described.

Testing of Brake Pad

Coefficient of friction, density, wear resistance, compressive strength, rivet holding capacity etc were evaluated, Sliding wear measurements were taken on the samples on a pin-on-disc machine model SI-412 C Ducom (India) and two body abrasive wear test were carried out using a Suga abrasion tester (Japan) model NUS-1 at different loads, such as, 1N, 3N, 5N and 7N. Scanning electron microscope (SEM) studies of worn surfaces of the samples were carried out using JSM-5600 JEOL (Japan) model, after gold polishing on samples.

Actual desired size 250 mm × 250 mm × 38 mm brake pad was made by pressing the weighted amount of mixed ingredients in a hot compression press under specified conditions.

RESULTS AND DISCUSSIONS

The composition of material is complex as several ingredients are used in formulation of frictional material. Two different reinforcing fibres and two different phenolic resins were used to observe their effect on desired properties. In composition A, weight ratio of mineral filler to glass fibre was 1.50 which was changed to 0.66 in composition B, whereas in composition C, this ratio was 0.66 with a change in resin type. Modified phenolic resin was used in compositions A and B and unmodified phenolic resin were used in composition C.

Figures 1 to 3 show the variation in abrasive wear volume with sliding distance at different applied forces for three different types of materials A, B and C, respectively. These figures show that increase in load increases the wear volume. Wear volume also increases with sliding distance in all the cases. The increase in wear volume with applied load is attributed to deep penetration of abrasive silicon carbide particles in the sample, cutting and removal of material there from.

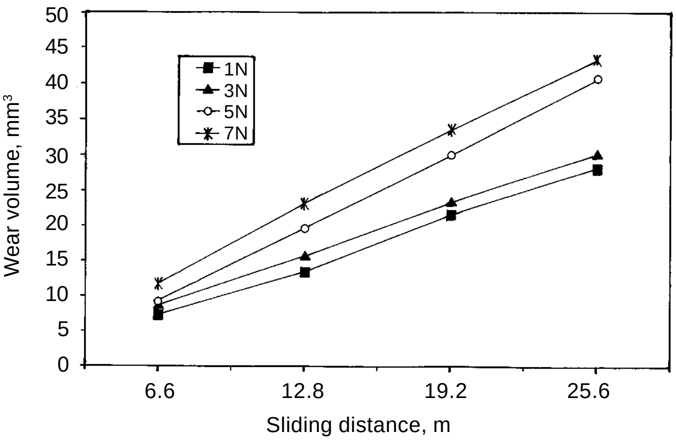


Figure 1 Plot between wear volume and sliding distance of sample A at different applied loads

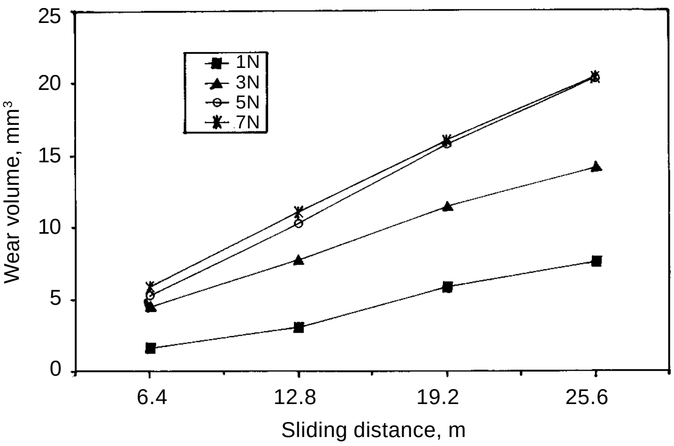


Figure 2 Plot between wear volume and sliding distance of sample B at different applied loads

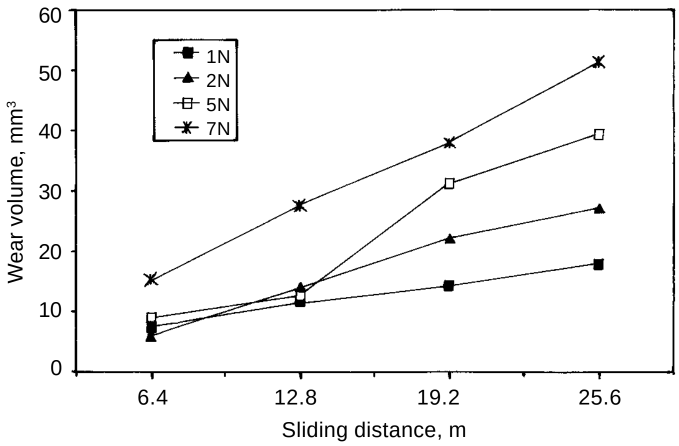


Figure 3 Plot between wear volume and sliding distance of sample C at different applied loads

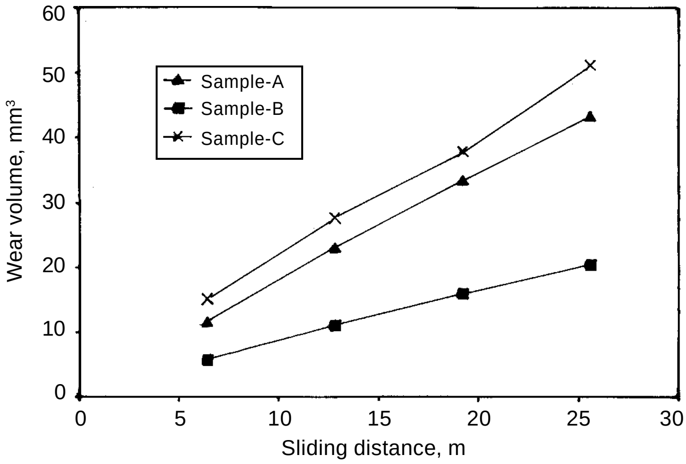
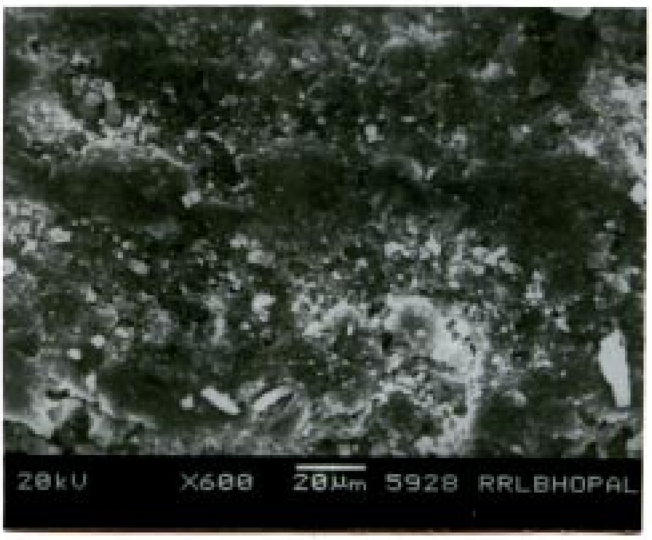


Figure 4 Effect of sliding distance on wear volume of different brake pad samples at 7N load

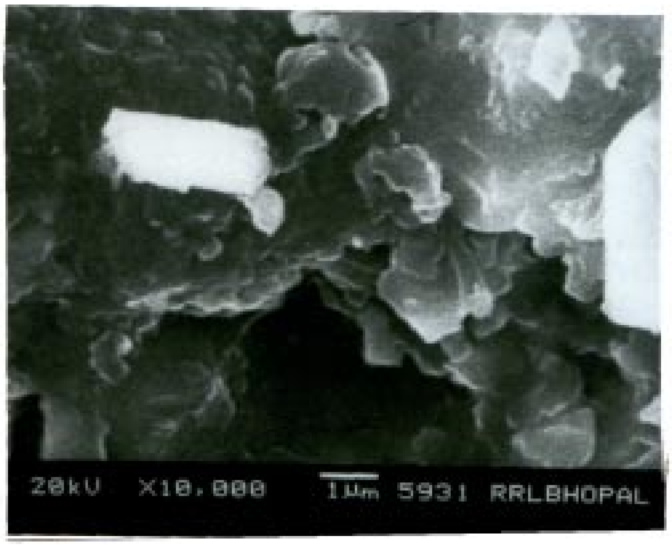
Figure 4 shows the effect of sliding distance on abrasive wear volume of these developed brake pad samples at 7N applied load. Wear losses in these samples are different. Sample B is more wear resistant as compared to sample A and sample C. This difference is due to the change in composition of two friction materials. The glass fibre content is higher in sample B as compared to sample A in which mineral filler to glass fibre ratio is 1.5. On reducing the ratio, wear resistance increases. This improvement is attributed to higher volume fraction of high strength, long glass fibres. On comparing wear results of samples B and C, it is obvious that in spite of low ratio of mineral filler to glass fibre ratio, the wear losses are high in sample C. This sample was made using unmodified phenolic resin. It is, therefore, obvious that modified phenolic resin provides better bonding and wear characteristics as compared to unmodified resin.

Existing brake pads are manufactured by proprietary processes using asbestos fibre along with some other ingredients for binding, thermal conduction and wear resistance. Asbestos based brake pad presently used has density of 2.22 g/cc.

Figure 5 shows the SEM photographs of worn surface of brake pad sample B at 600 and 10 000 magnifications. These samples



(a)



(b)

Figure 5 Microstructure of abraded brake pad sample B at (a) 600; and (b) 10 000 magnifications

were subjected to abrasion test. Deep grooves or wear tracks were formed on the surface as observed in the micrographs shown in Figure 5(a) as dark parallel regions. Large number of broken particles, matrix etc are also observed. In magnified view [Figure 5(b)] it is observed that the matrix is fractured due to abrasive action. Mineral filler was also observed in these micrographs as white cylindrical parts. The sliding wear properties of these samples were also evaluated.

Weight loss was measured after 1000 m of sliding distance and volume loss due to sliding wear was calculated. The data so obtained is given in Table 1. It is observed that newly developed non-asbestos friction materials and conventional asbestos based friction material possess the wear properties of same order and hence could be used as an alternative material. Table 2 provides few other important physical properties of newly developed asbestos-free brake pad composition. Figure 6 is a photograph of actual size brake pad for using in hydrogenerators made by BHEL Bhopal. These brake pads were made using the patented process[8] and desired size dies. The brake pads have been installed in a hydrogenerator installed by BHEL in Hydro Electric Generation Plant, Tawa, Itarsi.

Table 1 Wear behaviour of brake pad materials under sliding wear conditions

Sample	Density, g/cc	Sliding wear test results after 1 km sliding distance against EN-32 steel at 0.50 MPa pressure		
		Wear volume, $cm^3 \times 10^{-4}$	Wear rate, $m^3/m \times 10^{-13}$	Wear resistance, $m/m^3 \times 10^{12}$
Asbestos brake pad	2.22	7.16	7.16	1.397
Asbestos-free brake pad				
Sample A	1.97	6.60	6.60	1.510
Sample B	2.13	7.98	7.98	1.270
Sample C	2.07	2.42	2.42	4.130

Table 2 Physical properties of non-asbestos brake pad material

Properties	Values
Coefficient of friction (dry)	0.30-0.45
Density, g/cc	1.97-2.13
Wear rate, $\times 10^{-13}$ m^3/m	2.42 – 7.98 at 0.5 MPa
Compressive strength, MPa	36-60
Izod impact strength (un-notched), kJ/m^2	11.5-15.4
Rivet holding capacity	Excellent
Maximum operating temperature, °C	175
Maximum working pressure, MPa	1

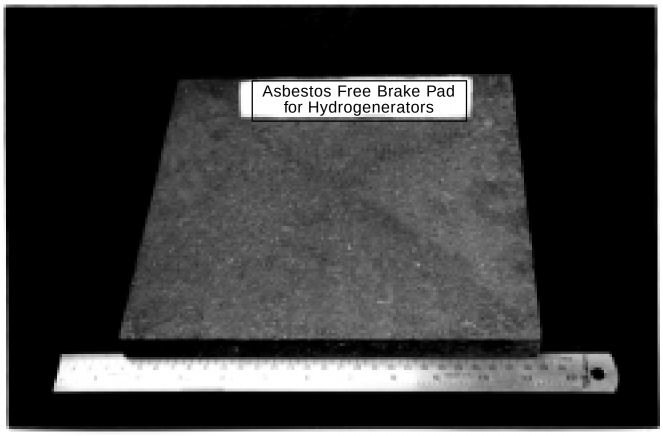


Figure 6 Shows the photograph of actual asbestos free brake pad for hydrogenerator

CONCLUSIONS

1. Non-asbestos friction materials can be developed by replacing asbestos fibres with other suitable reinforcement and suitable formulation.

2. Abrasive wear volume decreases with the decrease in ratio of mineral filler and glass fibre in the non-asbestos formulation.

3. This asbestos-free friction lining material can be used for brake as well as other friction lining applications.

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