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Wear Rate Analysis of Ceramic Coated Brake Lining Material

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ABSTRACT:

Brake lining is a layer of hard material attached to a brake shoe or brake pad to increase friction against the drum or disc. Asbestos, which was the conventional brake material, has an optimal performance in wear rate and thermal resistance but due to serious health-related hazards, asbestos became obsolete. This led to the development of eco-friendly brake materials. Lot of research has been going on with Non-Asbestos Organic materials (NAO) including non-metallic, semi-metallic, fully metallic and ceramic materials. Among that, Ceramic materials are nowadays popularly used as brake friction materials. This is because that the ceramic material possesses high strength and hardness, superior wear and abrasive resistance, withstands high temperature and thermal shock. In this paper the effect of ceramic coating on asbestos brake lining is investigated. The role of ceramic abrasives including Alumina (Al_2O_2) and Zirconium oxide (ZrO_2) as a ceramic coating on the surface of asbestos brake lining has been carried out experimentally. The ceramic material was deposited on the layer of asbestos brake lining by plasma coating process. Several samples were prepared with different thickness (25µ, 35µ and 45µ) and wear characteristic were analyzed using abrasive wheel testing machine which is commonly used to test the abrasive resistance of solid materials. The results were compared with the standard sample (asbestos brake lining) and it was found that the ZrO_2 coating on the surface of the asbestos brake lining of 45 microns thickness coating has shown reduced wear than the other.

KEYWORDS:

Ceramic material; Wear test; Friction properties; Brake lining

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1. Introduction

Ceramic coatings hold significant promise in the reduction of wear and abrasive failure in reciprocating and rotary engines for transportation and stationary power [1]. The experimental analysis for the brake lining material containing potassium titanate significantly improved the friction coefficient and wear resistance [2]. Aluminium matrix composite (AlMC) materials are seems to find wide applications in machine construction. Composite wear resistance can be improved by the addition of reinforcing materials with the matrix. However, the presence of very hard particles like ceramic phase (Al_2O_3 and SiC) increases the wear of the sliding counterpart operating against the composite [3]. Ceramic coatings have great potential for many applications due to their good thermal resistance, high hardness and wear resistance among others. These ceramic based coating can be produced by various method like chemical and physical vapour deposition, atmospheric plasma spraying and electron beam physical vapour deposition. Among these, plasma spray is one of the most effective methods due to its high deposition rate [4-6].

In the past 2 decades, there was a rapid development in the automotive industry, accompanied by increases of speed, loads, and engine power. At various operating speeds, pressures, temperatures and environmental conditions the friction materials are required to provide a stable friction coefficient and a low wear rate. The requirements like reduction of extensive wear, vibration and noise during braking need to be achieved at a reasonable cost and minimum environmental load [7]. Gorjan et al [8] says that various engineering ceramic materials were performed for tribological tests to find a ceramic material with a combination of coefficient, wear resistance and thermal energy dissipation for the car brakes. Al_2O_3-based ceramic showed promising properties, as well as being cost effective. However, the presence of particles of a very hard, ceramic phase (Al_2O_3 and SiC) increases the wear of the sliding counterpart operating against the composite coatings as surface layers reducing wear rate. [10].

In this paper the effect of ceramic coating on asbestos brake lining were investigated. Alumina (Al_2O_3) and Zirconium oxide (ZrO_2) as a ceramic coating was deposited on the layer of asbestos brake lining by plasma coating process. Several samples were prepared with different thickness and wear characteristic were analyzed using abrasive wheel testing machine. The results were compared with the standard sample (asbestos brake lining). The wear rate was comparatively reduced for ceramic coating on asbestos brake lining than the standard sample.

2. Experimental work

An original sample of brake lining was purchased (Autotech Manufacturing & Marketing Co.) from the manufacturer. This brake lining material (Asbestos brake lining) is referred to as sample A and used as standard reference sample to compare with ceramic coated brake lining materials on the surface of abrasive brake lining sample. The ceramic coating sample was prepared by coating the Aluminium oxide and Zirconium oxide on the surface of Asbestos brake lining of various thicknesses. Three different thicknesses of 25µ, 35µ, and 45µ were chosen for the experiment. The coating was done with plasma coating with the addition of epoxy resin as binder. Table 1 gives the detailed structure of the samples prepared for different thickness of coating of Alumina and Zirconium Oxide on the surfaces of asbestos brake lining as base material. Fig. 1 shows the samples of brake lining used for the experiment which is made of purely asbestos material. Figs. 2 and 3 shows the brake lining coated with Aluminium Oxide and Zirconium Oxide respectively on the surface of asbestos brake lining.

Table 1: Experimental test sample details

Sample	Base material	ZrO_2 coating thickness (µ)	Al_2O_3 coating thickness (µ)
Sample A	Asbestos	-	-
Sample B	Asbestos	25	-
Sample C	Asbestos	35	-
Sample D	Asbestos	45	-
Sample E	Asbestos	-	25
Sample F	Asbestos	-	35
Sample G	Asbestos	-	45

Fig. 1: Asbestos Brake lining Samples purchased for experiment

Fig. 2: Aluminium oxide coated samples

Fig. 3: Zirconium oxide coated samples

Coatings can be tested using abrasion testing. Volume loss data obtained from experimental output of coated specimen, whose lives are unknown. However the output data obtained was compared with standard specimen. The comparison data provides a general indication of the worth of the unknown specimen, whether abrasion is the predominant factor causing deterioration of the materials. Wear as a process where bounding of specimen within the working environment results in dimensional loss of one specimen with or without any actual decoupling of material. After the preparation of ceramic coated brake lining specimen of various thicknesses with plasma coating, the specimen was tested for wear rate (cm^3/Nm) and wear volume loss (cm^3) with the help of abrasive testing machine. In this abrasive wear testing machine a constant load of 0.2 N at a sliding distance of 150m of constant speed is used to test the specimen for various thickness of ceramic coated brake lining material.

3. Results and discussions

Tables 2 & 3 give the detailed report of wear rate and wear volume loss for the ceramic material, Alumina & Zirconium Oxide coated on asbestos brake lining specimens. The wear rate difference and wear volume difference of coated brake lining with respect to Asbestos lining are presented in Tables 4 and 5.

Table 2: Test report for coating with zirconium oxide

Sample ID	Asbestos	ZrO_2 of 45µ	ZrO_2 of 35µ	ZrO_2 of 25µ
Abrasive grid size	600	600	600	600
Applied load (N)	0.2	0.2	0.2	0.2
Sliding distance (m)	150	150	150	150
Weight loss (mg)	0.967	0. 483	0. 605	0.937
Wear volume loss (mm^3)	0.385	0.179	0.224	0.347
Wear rate (m^3/Nm)	11.9	5.97	7.47	11.6

Table 3: Test report for coating with aluminium oxide

Sample ID	Asbestos	Al_2O_3 of 45µ	Al_2O_3 of 35µ	Al_2O_3 of 25µ
Abrasive grid size	600	600	600	600
Applied load (N)	0.2	0.2	0.2	0.2
Sliding distance (m)	150	150	150	150
Weight loss (mg)	0.967	0.697	0.878	1.445
Wear volume Loss (mm^3)	0.385	0.258	0.325	0.535
Wear rate (m^3/Nm)	11.9	8.6	10.8	17.8

Table 4: Wear rate difference of coating vs. Asbestos (11.9 m^3/Nm)

Coating thickness vs. Wear rate (m^3/Nm)	2 5μ	35μ	45μ
Al_2O_3	17.8	10.8	8.6
% variation	+49.58%	-9.24%	-27.73%
ZrO_2	11.6	7.47	5.97
% variation	-2.52%	-37.23%	-49.83%

Table 5: Wear volume difference of coating vs. Asbestos (0.385 mm^3)

Coating thickness vs. Wear volume (mm^3)	2 5μ	35μ	45μ
Al_2O_3	0.535	0.325	0.258
% variation	+38.96%	-15.58%	-32.99%
ZrO_2	0.347	0.224	0.179
% variation	-9.87%	-41.82%	-53.51%

4. Conclusion

From the experimental report, it can be concluded that the Zirconium Oxide coating showed better reduction of wear at 45 microns thickness than the asbestos brake lining material. Also the alumina coating brake lining material shows better wear reduction at 45 microns thickness coating. In case of wear volume loss, Zirconium Oxide as well as Alumina coating on the surface of asbestos brake lining material showed better wear volume loss at 45 microns thickness coating.

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