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Study of Tribological Performance of Brake Pad for Increasing the Wear Resistance of Disc Brake

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Abstract: *Brake pad & disc are most imperative segment of an automobile braking system. Due to hard or repetitive braking in steep gradient COF & wear rate, effectiveness between brake pad and disc is decreases. The tribological behavior of a coated brake pad material tested under dry sliding conditions by utilizing a pin-on-disc equipment. Abrasive, low metallic material, Non-asbestos organic materials (NAO) are used for pin and steel for disc. The input parameters considered for this test are load, pressure and sliding velocity. Force applied on the brake pad will change according to the speed of the vehicle and the braking distance so, for experimentation we have calculated the actual force applied by the vehicle at different speeds and simulated the same condition on machine. Experimental results will compared in terms of wear rate & coefficient of friction. The wear rates of the coated discs are always negligible, since the contact temperature isn't adequately high to initiate a conditioning or an oxidative harm of the coatings.*
Keywords: *Coatings , COF , Braking System, Friction, Tribological*

I. Introduction

The word Tribology is derived from a Greek word 'Tribos' which means rubbing .The Tribological phenomena that occur in brake systems are interesting even in other respects than just the braking action. One important issue, that is gaining increasing importance over the last years, concerns the environmental impact of wear debris produced by the braking action. The importance of friction and wear control cannot be over emphasized for economic reasons and long term reliability. Tribology is crucial to modern machinery which uses sliding and rolling surfaces.At room temperature and in the selected testing conditions, the friction material sliding against the uncoated disc requires a comparatively long time to reach a steady-state, featuring a constant friction coefficient. In both cases, the wear of the friction material (the pin) was mild and the wear of the coated discs is negligible[1]. The coefficient of friction obtained was within the recommended standard for automobile brake pads. The friction coefficient decreases when the applied loads, sliding speed and temperatures increased. The amplitude of the friction fluctuations was seen at all the stages. Due to sliding surface irregularities, the temperatures, speed and applied load cause a typical stick–slip oscillation as observed in the frictional profiles. This decrease could be explained by the appearance of significant plastic deformation of the pin surface[2].The degradation mechanisms observed in the friction material induced a transition from mild to severe wear during continuous dry sliding conditions. Through this study, it was possible to gain further information on the main wear mechanisms and in this way to identify critical parameters to develop better friction materials, in the context of performance, lifetimes and pollutant emissions[3].they studied and In this study, we have compared the tribological performances of four types of hardfaced/ thermal sprayed coatings. The results showed that hardness was not the only characteristic that affects the wear resistance. In contrast to other coatings, the wear rate of NiFeBSi-WC coating was not in correlation with its hardness. The different wear performance of this coating was attributed to the different type and morphological features of the reinforcing particles.[4]The objective of this study is to define those brake characteristics, within the space bounded by the relationship between brake pedal force and vehicle deceleration, which lead to acceptable driver-vehicle performance.In this context, the present study is focussed on the Tribological behaviour of a commercial friction pad material dry sliding against a steel disc. Pin-on-disc tests were conducted at room temperature under mild wear conditions, as concerns load and rotating speed.

II. Selection Of Parameters

2.1.Selection Of Material:

The two materials selected for testing are:
1.Non Metallic
2. Semi- Metallic

2.2. Selection Of Coating

A coating is a covering that is applied to the surface of an object, usually referred to as the substrate. The purpose of applying the coating may be decorative, functional, or both. The coating itself may be an all-over coating, completely covering the substrate, or it may only cover parts of the substrate. Functional coatings may be applied to change the surface properties of the substrate, such as adhesion, wettability, corrosion resistance, or wear resistance. our aim for providing a coating to the brake pad material is to reduce the wear and friction between meeting surface. for this purpose we are using HVOF coating.

Coating info -

- NiCr Based coatings shows higher wear resistance than any other coatings.
- Coating is applied on brake pad material by HVOF thermal sprayed material.
- WC based coatings shows less wear resistance than NiCr coatings.
- In thermal sprayed method sintered powder is used to coat surfaces.
- Thermal sprayed applied to improve Tribological and mechanical properties and it was observed that the coefficient of friction under dry condition.
- NiCr coatings also shows fine, uniform and layered microstructure and also sliding wear conditions .
- Cr3C3-NiCr cermet is extensively used for wear and corrosion resistance applications.

NiCr Based Coating - Cr3C2-NiCr Composition - 75%Cr3C2 , 25%NiCr Powder size - 10-45 um	Tungsten Based Coating - WC-CoCr Composition - 86% WC , 12% Co , 4% Cr Powder size -10-25 um

2.3.Experimental Setup:

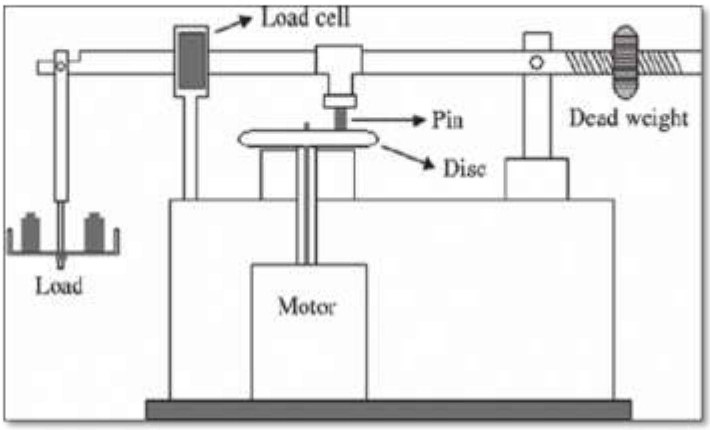


Fig. 1

2.4.Pin-On-Disc Test

In this study, Pin-on-Disc testing method was used for tribological characterization. The test procedure is as follows: Initially, pin surface was made flat such that it will support the load over its entire cross-section called first stage. This was achieved by the surfaces of the pin sample ground using emery paper (80 grit size) prior to testing Run-in-wear was performed in the next stage/ second stage. This stage avoids initial turbulent period associated with friction and wear curves Final stage/ third stage is the actual testing called constant/ steady state wear. This stage is the dynamic competition between material transfer processes (transfer of material from pin onto the disc and formation of wear debris and their subsequent removal). Before the test, both the pin and disc were cleaned with ethanol soaked cotton Before the start of each experiment, precautionary steps were taken to make sure that the load was applied in normal direction.

III. Design Calculations Of Disc Brake

To simulate the experiment we have to calculate the various parameters such as speed and force. As Follow

Model No : Alto 800 (Disc Brake)
Type : Plain Brake
Max Speed : 120 Km/Hr(Vehicle)

Dimensions of vehicle wheel:
The various dimensions of the vehicle are shown in the table 4.1. and table 4.2.

Table 1 Basic parameters of a vehicle

Parameter Name	Parameter Value
Mass Of Vehicle (M)	1140 Kg
Top Speed	120 Km/Hr OR 33.33 m/s
Wheel Diameter	540 mm
Wheel Base	2360 mm
Rim Diameter	304.8 mm
Body Length , Breadth & Height	3495,1475,1460 mm

Table .2 Various parameters of disc rotor

Parameter Name	ParameterValue
Outer diameter of the rotor disc	221 mm
Inner diameter of rotor disc	133 mm
Hole diameter	60 mm
Thickness of rotor disc	10 mm
Calliper piston diameter	44 mm
Mass of disc	2.9 kg

A)Velocity of rotor dependent on speed-

$$V = \frac{(120 \times 1000)}{3600}$$

$$V = 33.33 m/s$$

B)Angular velocity of rotor-

$$v = \frac{(\pi \times D \times N)}{60}$$

$$33.33 = \frac{\pi \times 0.54 \times N}{60}$$

$$N = 1180 rpm$$

C)Kinetic energy of vehicle-

$$K.E. = \frac{1}{2} \times m \times v^2$$

$$= \frac{1}{2} \times 1140 \times 33.33^2$$

$$K.E. = 633206.67\ J$$

D) Tangential breaking force-

$$BF_t = \frac{K.E.}{S.D}$$

$$= \frac{633206.67}{20}$$

$$BF_t = 31660.33 N$$

F)Breaking torque on wheel-

$TW = F_t \times R$

$= 7915.08 \times 0.27$

$TW = 2137.07 Nm$

Radius of wheel dia $= R = \frac{D}{2} = \frac{0.54}{2} = 0.27$ m

G)Breaking torque on disc-

$Tb = TW \times \frac{R}{r}$

$= 2137.07 \times \frac{0.27}{0.1105}$

$Tb = 5221.8 Nm$

H)Effective rotor radius-

$Re = \left(\frac{rotor.dia}{2}\right) - \left(\frac{Caliper.piston.dia}{2}\right)$

$= \left(\frac{221}{2}\right) - \left(\frac{44}{2}\right)$

$Re = 0.0885 m$

I)Clamping.force-

$F = \frac{Tb}{2 \times \mu \times Re}$

$= \frac{5221.77}{2 \times 0.5 \times 0.0885}$

$F = 59003.05 N$

J)Contact area-

A = 2 × Contact area of piston of caliper

$= 2 \times \frac{\pi}{4}\left((dia.of.rotor)^2 - (dia.of.rotor - dia.of.piston)^2\right)$

$= 2 \times \frac{\pi}{4}\left((0.221)^2 - (0.221 - 0.044)^2\right)$

$A = 0.0275 m^2$

K)Contact pressure-

$P = \frac{F}{A}$

$= \frac{42145.03}{0.0275}$

$P = 2145.56 \times 10^3 N/m^2$

L)Force on machine-

$$P = \frac{F}{A}$$

$$2145.56 \times 10^3 = \frac{F}{\frac{\pi}{4} \times 0.010^2}$$

$$F = 170N$$

The value of the pressure generated at different Speeds will be different so the force applied will also be different. The table **3.3** shows that.

Table 3.3 Value of The Pressure Generated At Different Speeds

SR.NO.	SPEED (Km/hr)	RPM	FORCE (N)
1	120	1180	170
2	100	982	117
3	80	785	75
4	70	688	58
5	60	590	42

3.1.Weight Loss

The alloy and composite samples are cleaned thoroughly with acetone. Each sample is then weighed using a digital balance having an accuracy of ± 0.1 mg. After that, the sample is mounted on the pin holder of the tribometer ready for wear test.The specific wear rates of the materials were obtained by W = w where W denotes specific wear rates in mm3 /N- w is the weight loss measured in grams, density of the worn material in g/mm3 and F is the applied load in N.

3.2.Wear Calculation

1. Area

 Cross sectional Area=πr^2

2. Volume loss

 Volume loss = Cross sectional Area x Height loss

3. Wear rate

 Wear rate = Volume loss / Sliding distance

4. Wear resistance

 Wear resistance = 1/ Wear rate

5. Specific wear rate

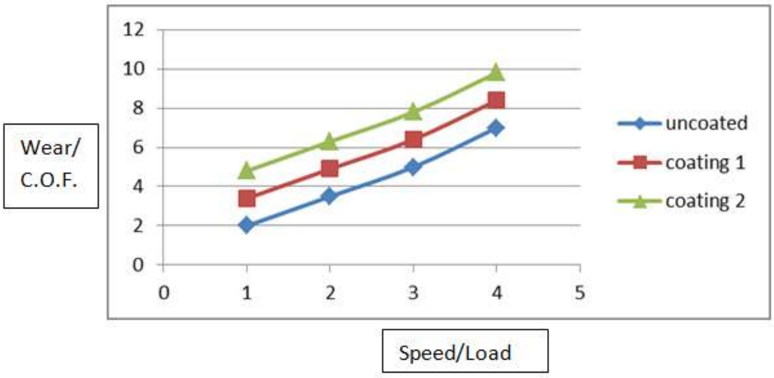
 Specific wear rate = Wear rate/load

3.3.Wear Behaviour

The aim of the experimental plan is to find the important factors and the combination of factors influencing the wear process to achieve the minimum wear rate and COF. The above mentioned pin on disc test apparatus was used to determine the sliding wear characteristics of the composite. Specimens of size 10 mm diameter and 30 mm length were cut from the cast samples, and then machined. The contact surface of the cast sample (pin) was made flat so that it should be in contact with the rotating disk. During the test, the pin was held pressed against a rotating EN31 carbon steel disc by applying load that acts as a counterweight and balances the pin. The track diameter was varied for each batch of experiments in the range of 50 mm to 100 mm and the parameters such as the load, sliding speed and sliding distance was varied in the range given in Table **6.6**. An LVDT (load cell) on the lever arm helps determine the wear at any point of time by monitoring the movement of the arm. Once the surface in contact wears out, the load pushes the arm to remain in contact with the disc. This movement of the arm generates a signal which is used to determine the maximum wear and the COF is monitored continuously as wear occurs and graphs between COF and time was monitored for both of the specimens.

IV. Expected Results & Graphs

The following charts & graphs are expected to get for each material:



V. Conclusion

1. We performed one sample test on Machine to know actual operation of machine.
2. We designed and analyzed of disc brakes.
3. Drerived mathematical model to obtain the test conditions (speed, load etc.) with respect to actual service conditions.

Conflict of interest the authors declare that there is no conflict of interests regarding the publication of this paper.

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