EXPERIMENTAL INVESTIGATION OF ORGANIC BRAKE PAD

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ABSTRACT

The main requirement of a brake pad is to slow down the car speed by transforming the kinetic energy into heat through friction work at the interface between brake pad and rotor disc. Blames always go to brake pads when a brake-related problem arises. The standard methods to evaluate the performance under sliding condition required the huge infrastructure, manpower and time. Therefore it is necessary to test the brake pad material on reduced scale type tester. In this paper, organic pad material is investigated using pin in disc tribometer. Pin on disc testing the material in simulate condition which is similar to real life conditions. In this paper load, sliding velocity and sliding distance selected as factor. Sliding test is carried at three level of factor and wear frictional force main interest of research. The result concluded that load and sliding distance is main factor which effect on response. As the load and sliding distance increase wear rate of organic pad increased.

Keywords: - *Brake pad, Organic material, Pin on disc, ANOVA*

1. INTRODUCTION

The main purpose of a brake system is to slow down the vehicle or to stop it completely within a reasonable amount of time. A brake system must therefore be reliable in order to provide the operator with a better control. Any moving vehicle contains kinetic energy by virtue of its motion. The faster the vehicle moves the higher is its momentum or kinetic energy. This energy is proportional to the square of the vehicle's speed. Most brakes use the principle of friction to convert this kinetic energy into heat energy. The brakes must therefore store and dissipate all this heat into the surroundings. Over the past centuries, as the technology of transportation has increased, the brake systems have also started becoming more reliable and at the same time more complex. Disc brake system has a higher wear resistance and easier maintenance as compared to other brake system but due to long repetitive braking leads to brake failure & cause severe wear of brake pad. Due to heavy braking there is formation of hot spots on brake disc and formation of grooves on brake pads and excessive wear leading to failure of brake system. Due to excessive braking the wear particles of brake pad get entrapped in between the brake pad & disc which lead to wear of brake pad. Materials used for brake systems should have stable and reliable frictional and wear properties under varying conditions of load, sliding velocity and sliding distance. With development of new materials have the necessity of investigate the brake pad under varying conditions for evolving the performance. In this paper for investigation of organic type brake pad pin on disc tribometer is used.

The pin-on-disc tribometer serves for the investigation and simulation of friction and wear processes under variety of test conditions and wide range of test parameters. Lower sample is disc which is mounted on rotating disc holder. Upper sample can be a ball or pin. Unique feature of this machine is the ability to perform unidirectional as well as bidirectional sliding test without any cumbersome changeover attachment. Test load, rotational speed of disc and wear track diameter are PC controlled. They can be held constant or changed during a test. Frictional force, wear and co-efficient of friction are measured and recorded continuously.

2. LITERATURE SURVEY

Investigated performance of clutch facings material using a Pin-on-disk apparatus by considering normal pressure load, temperature and relative sliding velocity [1] the friction coefficient decreases with increasing temperature and with increasing sliding velocity. Characterized the newly developed brake materials and characterize the effects of metal additives on temperature and friction [2] Increased thermal conductivity of the composites due to metallic fillers. Investigated the influence of humidity and corrosion in high-salinity environment on the friction and wear behavior [3] The friction coefficient increased up to 40% relative humidity while in the interval between 40% and 90% it decreased.

N.S.M. EL-Tayeb et al. [7] investigated sliding performances of newly developed four different noncommercial frictional brake pad materials and compared with other two chosen commercial brake pad materials under dry and lubricated conditions with the help of using a small-scale tribo-tester of pad-on-disc type. Experiment carried out at low and moderate pressure (up to 2.22MPa) and speed (up to 2.1m/s) which is simulate the original braking condition. Result showed that increase in the friction coefficients (5–19%) with increasing pressure or speed meanwhile the wear rates were dependent on the type or ingredient of brake pad materials and the pressure. All non-commercial materials showed higher friction coefficient than a commercial brake pad material. In case of wet condition there was a significant reduction in the friction coefficient but reduction within the safe range.

Nagesh. S.N et al. [8] Developed and investigated the brake pads by varying constituents of existing composition. The sample S4 have slightly high coefficient of friction as compared to S2 may be due to presence of the higher percentage of abrasive in composition. This abrasive also contributes in increase the wear rate. Scanning electron microscope analysis revealed, mineral fiber and other constituents are equally distributed in the matrix. Newly developed brake pad sample S2 and S4 showed results which are equivalent to current brake pad.

Bezzazi. M et al. [10] Investigated performance of clutch facings material using a Pin-on-disk apparatus by considering pressure load, temperature and relative sliding velocity parameter compared with classical SAE J661 standard test. Concluded that the friction coefficient is essentially stable at a level which depends on both the sliding velocity and temperature and does not suffer from fading phenomenon. The friction coefficient decreases with increasing temperature and with increasing sliding velocity. The comparatively results showed that the usual features regarding the coefficient of friction behaviour are identical if differences of temperature are incorporated.

Senatore. A et al. [12] presented the experimental results and outcomes acquired with a laboratory setup on brake and clutch facing samples in sliding motion for different operating conditions. Explored the influences of normal load and sliding speed on the coefficient of friction. The artificial neural predicted the dry sliding performance could lead to accurate frictional maps for electronic control purpose in automotive environment. The materials exhibited a nearly linear dependence of the friction coefficient on the pressure contact in the studied ranges. The higher the sliding acceleration, the higher the friction coefficient; this influence practically vanishes above 2m/s2. In the case of clutch facing, this parameter has shown to be more influential than the pressure.

U.D. Idris et al. (15) A new brake pad was produced using banana peels waste to replaced asbestos and Phenolic resin (phenol formaldehyde), as a binder was investigated. The resin was varying from 5 to 30 wt% with interval of 5 wt%. Morphology, physical, mechanical and wear properties of the brake pad were studied. The samples, containing 25 wt% in uncarbonized banana peels (BUNCp) and 30 wt% carbonized (BCp) gave the better properties and the flame resistance increased as the weight percentage of the resin increased in the banana peels particles. The result of this research indicates that banana peels particles can be effectively used as a replacement for asbestos in brake pad manufacture.

Andrzej Wojciechowski et al. [13] determined the conditions of interaction between the friction material and a brake disc made of grey cast iron with flake graphite on Pin on disc (micro scale) and Krauss test machine (full size). During the tests, the friction force, temperature, and friction path of the friction pair were continuously recorded. The test program covered four test cycles (bedding-in, cold performance test, fade test, and recovery). Each brake application lasted 5 seconds, which was followed by a brake release for 10 seconds. Result showed that from both testing machine, the coefficient of friction (at the cold performance test) was lower by 10–12 % for the friction pair with copper powder and maximum coefficient of friction was lower by about 10%.Wear result from both KRAUSS and T-11 test machines showed about 30% and about 20% reduction in wear of copper powder.

3. MATERIAL AND SAMPLE PREPARATION

3.1 Material Preparation

Organic Based brake pad material procured from CO-EFF friction bands Pune. The material non-asbestos friction material with extremely high amount of organic and inorganic reinforcing fibres system, fine brass fibres, and non-ferrous, organic binding system by special synthetic rubber modified resins plus NBR rubber. It exhibited high friction, mechanical stability, stable friction at high temperatures, excellent wear resistance and salt and water resistance. This is used for 4-wheeler automobiles and also used for stopped and control the speed of hydro generators and wind turbines. The material is cut on lathe machine in the cylinder form of dimension diameter 8 mm and height 25 mm. The end surfaces of pin finished on grinding wheel to ensure the smooth contact with disc during sliding motion. The finished brake pad material in pin shape as shown in following figure.

Fig-1: Organic pad pin

The properties organic brake pad of described in the following table.

Table-1: Physical properties of organic pad

Sr. No	Technical Data	Measured values	Unit
1.	Density	1.90	g/cm^3
2.	Compressive Strength	190	N/mm^2
3.	Hardness	85	Shore D

3.2 Disc Material

Materials used as disc is of Steel disc (EN-31) of diameter 165 mm × 8 mm was prepared on lathe machine by turning and facing operation. Steel disc having following composition.

Table-2: Chemical composition of disc

Sr. No.	Chemical	Observation (%)
1.	C	1.02
2.	Mn	0.35
3.	Cr	1.47
4.	Ni	0.06
5.	Mo	0.02
6.	S	0.018
7.	P	0.016
8.	Si	0.24

3.3 Pin on Disc Tribometer

Friction and wear tests on organic based brake pad facings material under dry sliding conditions, were performed on a Pin-on-disk tribometer (TR-20LE-PHM-400). The objective to evaluate the behaviour of the brake pad material under the effect of normal load, sliding velocity and sliding distance. The tribometer as shown in figure.

Fig-2: Pin on disc tribometer

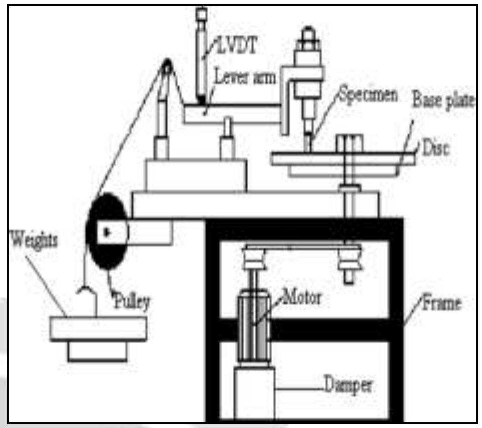

Fig-3: Schematic diagram of pin on disc

The pin on disc machine contains a horizontally rotating disc and a dead-loaded pin. A group of weights connecting the fulcrum through a beam provides the normal force on the pin. The rotation rate and radius of the disc are controllable so that a pure sliding contact is achievable at various speeds between the pin and disc. The fictional force produced between specimen pin and disc is directly measured by load cell at other end. The specimen pin placed at inside the hardened split jaw and clamped to specimen holder. The wear between specimen pin and disc is measured by LVDT and is sensed by a sensor mounted on lever the friction between pin & rotating disc is measured by stain gauge type load cell mounted on a bracket. During the test, friction force is measured by a transducer mounted on the loading arm and a microprocessor controlled data acquisition system is used.

4. EXPERIMENTAL DETAILS

The dry sliding wear test was conducted on a pin-on-disc tester according to standard ASTM G99-05. Wear tested by varying three parameter load, sliding velocity and sliding distance. Number of experiments to performed and decided with the help of full factorial method in Minitab 17 software. According to above input to Minitab software for optimum number of experiments it gives 27 runs for various combinations of the different levels of three factor as follows.

Table-3: Factors and its level

Factor → / Level ↓	Applied Load (Newton)	Sliding Velocity (meter/sec)	Sliding Distance (meter)
High	50	5	2000
Medium	25	2.5	1500
Low	5	1	1000

5. RESULT AND DISCUSSION

Experimental work of organic brake pad is carried on pin on disc tribometer. Continuously recorded wear, coefficient of friction and temperature reading. The experiment carried systematically with the help design of experiment. The output reading of organic pad as follows.

Table-4: Experimental reading of wear

Sr. No	Load (N)	sliding velocity (m/s)	sliding distance (m)	Wear (micron)
1	5	1	1000	10
2	5	1	2000	32
3	25	1	1000	12
4	25	1	2000	38

5	5	2.5	2000	39
6	5	2.5	1000	14
7	25	5	2000	17
8	50	2.5	1000	45
9	50	5	1000	49
10	5	1	1500	19
11	25	2.5	1000	12
12	25	2.5	2000	65
13	50	1	1000	40
14	25	2.5	1500	22
15	5	5	2000	39
16	50	2.5	2000	80
17	25	5	1500	27
18	5	5	1000	12
19	50	5	1500	98
20	25	1	1500	38
21	5	5	1500	24
22	50	2.5	1500	72
23	5	2.5	1500	20
24	50	1	2000	94
25	25	5	1000	24
26	50	1	1500	43
27	50	5	2000	108

Here the three factors load, sliding velocity and sliding distance and response factors wear. For analyzing, for such a particular condition general linear model is used in MINITAB 17. Anova for wear response as follows

Anova			General linear model			
Source	DF	Adj SS	Adj MS	F-Value	P-value	
Load	2	11792.3	5896.1	31.43	0.000	Significant
Sliding velocity	2	291.6	145.8	0.78	0.473	
Sliding distance	2	4802.3	2401.1	12.80	0.000	Significant
Error	20	3752.5	187.6			
Total	26	26	20638.7			
Model summary						
S	R-sq	R-sq(Adj)	R-sq(pred)			
13.6977	81.82%	76.36%	66.86%			

Values of “ Prob > F” 0.0500 indicate model terms are significant. The effect load and sliding distance affect on the wear rate studied with the help of main effect plot with detail description as follows.

Fig-4: Main effect plot

5.1. Load

The applied pressure (Load) is most significant factor among these of three. From interaction plot as the load increased wear rate is also increased but this is very less. After the 25N load, linear relationship will establish between load and wear. As the load increases the wear rate of organic pad also increased. The wear rate up to load 25 N slightly increased and after that there is rapidly increased in wear. Because at heavy load, the deformation is more in pad and this promoted to wear rate. At the deformation is high that means there is chance in split out of particles. For this wear mechanism should understand as given below

5.2. Wear Mechanisms

During wear test, wear can be distinguished into three stages.
First stage: overcoming of roughness of the machine marks on the disc surface.
Second stage: piling up of the tribo-layer.
Third stage: dynamic competition between material transfer processes (transfer of material from pin onto disc and formation of wear debris and their subsequent removal).

6.3. Sliding Distance

The sliding distance is significant factor after load. It have the direct relationship with wear but effect is less as compared to load.

7. REGRESSION EQUATION

This regression equation used to predict the wear value from any random value of load, sliding distance and sliding velocity.

Wear = -42.3 + 1.063 load + 1.93 sliding velocity + 0.03267 sliding distance

6. CONCLUSION

The tribological properties and the effect of different parameter studied with the help of pin on disc tribotester. The load and sliding distance have a significant effect on wear rate. Linear relationship is observed between wear rate and load and sliding distance. This is very helpful for engineers to make the changes in composition which should minimized the wear rate by considering this parameter. Also by taking some precaution during braking wear rate could be minimized in some cases by adopting good practices while driving.

7. REFRENCESS

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