Effect of Fly Ass on Wear Resistance Property of Brake Material Manufactured by Powder Metallurgy

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ABSTRACT:

In this paper, Effect of fly ass on wear resistance property of brake pad is investigated. Different sample of brake pad with different wt % of fly ash (3,6,9) are manufactured with the help of powder metallurgy. Pin and disc machine is used to find out the specific wear rate of the sample. Load is a dominant factor as increase in load increasing the specific wear rate. Speed was another factor which has a huge impact on determining the wear rate of the specimen. Wear rate first decreased and then increased. It was intermediate at 2 m/s, lowest at 4 m/s and highest deterioration rate was observed at 6 m/s. Fly ash percentage also played an important factor in wear rate of the specimen. Wear. It first decreases than a steep rise was noticed further increasing quantity of fly ash.

KEYWORD: - powder metallurgy, fly ash, specific wear rate, composite material.

1. INTRODUCTION

Powder metallurgy is the field of science in which various types of powders are compressed and treated with heat to make a specific component and to provide specific properties. This involves processes like compaction, mixing or blending, sintering etc. A mixture in different percentage are kept in a die and compressed under specific loading conditions. Different types of powdered material are mixed together whereas mixing is the process of getting a homogeneous mixture by adding powders in various compositions. The mixed powders are kept in a furnace and heated under certain conditions for a specific period of time.

Application of the Powder metallurgy in engineering manufacturing is one of the most important manufacturing mechanism in a vehicle is breaking system and brake pads are the heart of a braking system. Brake pads are mainly made of steel with some frictional materials on the surface that is facing the disk brake rotor or brake drum.

Vermiculite as the filler material as it has high temperature resistance (above 750°C), spreads the heat generated evenly in pads and also absorbs moisture. We are using the Binder Resin Sodium Silicate which can withstand temperatures of above 800°C and Kaolin clay is used as the hardener to achieve the required hardness. Content of fire ash were not taken as constituent of brake pad specimen.

The main objective was to apply the knowledge that we gained about the subject during our degree and gaining practical knowledge of how to apply the concept. Amplifying our practical knowledge and market know how was another point that we took into consideration. The vermiculite and fire ash used together were creating binding problems which resulted in low hardness and tribological properties.

2. MATERIALS AND METHODS:

2.1 Die & Punch Preparation

First we analyzed the various parameters required for die i.e. Die Size, Hardness, Load Carrying Capacity etc. Then, we shortlisted the die materials which had the following properties For e.g. D-2 Die Steel, Hot Die Steel, Tungsten Carbide, HSS etc. As we needed high Compressive strength, very high finishing and very low clearance i.e.(0.02mm) so we opted the Tungsten Carbide Die with and outer chasing of Hot Die Steel and the punch was made of HSS (High Speed Steel). We designed the die and punch assembly on CREO Parametric 2.0. Due to non-availability of proper resources and lack of machining experience we had to outsource the Die and punch assembly to a Die Vender from Ludhiana.

2.2 Sample Preparation

First precisely weighed all the material in chemistry lab using a weighing machine. Then blended the powder mixture in a beaker using a glass rod. After the mixture was uniform we added the resin(sodium silicate) to it and then further blended it to obtain the required green strength of the mixture. This blended mixture was then put in to the die for compression and the load of 100-175 MPa was applied to plunger and die assembly. This high compression resulted into binding the mixture throughout its composition proving very high green strength and filling all the cavities and air holes inside it. When the sufficient amount of load was obtained, we then stopped the hydraulic compression machine and take out the die. The sample inside the die was extracted with long mild steel rod. When the required number of samples were pressed in the die and extracted out, we took them to Material science lab, where we sintered the samples in the muffle furnace at 650°C for 7-8 minutes. The specimens were took out of the furnace very carefully and cooled at room temperature.

Table 1 : Composition of Samples

Name of the Material	Sample 1	Sample 2	Sample 3
Resin (Sodium Silicate)	47.3 gm	44.6 gm	41.3 gm
Kaolin	8.7 gm	8.7 gm	8.7 gm
Vermiculite	30 gm	30 gm	30 gm
Fly Ash	3 gm	6 gm	9 gm
Silicon Carbide	7 gm	7 gm	7 gm
Graphite	4 gm	4 gm	4 gm

Total	**100 gm**	**100 gm**	**100 gm**

2.3 Hardness testing

After the specimens were obtained for all three compositions, we took 2 samples from each composition and tested their hardness on Rockwell hardness testing machine in Material science lab.

Table 2. Hardness values (HRC)

	Sample 1	**Sample 2**	**Sample 3**
HRC (mean value)	**72**	**78**	**74**

Figure 1 Muffle Furnace(A), Compression Machine-1000 kN (B), Rockwell Hardness Tester(C), Die and Punch(D)

3. RESULTS AND DISCUSSION

After the samples were prepared and tested for the Hardness on Rockwell Hardness Tester. Then we took the sample for the Wear Rate testing on Pin on Disk Wear Testing Machine. There we put the sample for various Loading Condition (60kN, 80kN, 100kN) and Speed Variations (2m/s – 6m/s). The Initial Volume of the Samples – 1178.1 mm^3. Following are the results we obtained after the Wear Rate testing:

Table 3: Specific wear rate

S.No	Standard Deviation	Factor 1 A:load (kN)	Factor 2 B:speed (m/s)	Factor 3 C: fly ash (%)	Specific wear rate (mm3/Nm)
1	6	100	2.00	9.00	0.000376209
2	20	80	4.00	6.00	0.000255258
3	14	80	4.00	9.00	0.000267039
4	9	60	4.00	6.00	0.000196383
5	17	80	4.00	6.00	0.000255409
6	7	60	6.00	9.00	0.000251331
7	16	80	4.00	6.00	0.000255681
8	13	80	4.00	3.00	0.000259185
9	11	80	2.00	6.00	0.000282176
10	12	80	6.00	6.00	0.000303167
11	3	60	6.00	3.00	0.000247404
12	19	80	4.00	6.00	0.000255176
13	1	60	2.00	3.00	0.000227769
14	2	100	2.00	3.00	0.00036757
15	10	100	4.00	6.00	0.000333797
16	18	80	4.00	6.00	0.00025519
17	5	60	2.00	9.00	0.000235623
18	4	100	6.00	3.00	0.000387205
19	8	100	6.00	9.00	0.000394273
20	15	80	4.00	6.00	0.000255483

In the above table we have the data of the Specific Wear Rate that we have obtained by testing of the samples on the Pin on Disc Wear Testing Machine. The above results are based on the three factors i.e. different variations of Load, Speed and Wt. % of the Fly Ash.

3.1 Analysis of Specific Wear Rate

After obtaining the Results from the Pin on Disc Testing we put the results in the software where we got the different graphical representation.

Table 4. ANOVA for Response Surface Quadratic Model

Source	Sum of Squares	df	Mean Square	F-value	P-value Prob>F	
Model	6.253E-008	9	6.948E-009	7668.02	< 0.0001	significant
A-load	4.908E-008	1	4.908E-008	54163.34	< 0.0001	
B-speed	8.842E-010	1	8.842E-010	975.88	< 0.0001	
C-fly ash %	1.249E-010	1	1.249E-010	137.85	< 0.0001	
AB	6.938E-013	1	6.938E-013	0.77	0.4021	
AC	1.927E-012	1	1.927E-012	2.13	0.1755	
BC	3.779E-012	1	3.779E-012	4.17	0.0684	
A^2	2.754E-010	1	2.754E-010	304.00	< 0.0001	
B^2	3.886E-009	1	3.886E-009	4288.48	< 0.0001	
C^2	1.773E-010	1	1.773E-010	195.71	< 0.0001	
Residual	9.061E-012	10	9.061E-013			
Lack of Fit	8.867E-012	5	1.773E-012	45.83	0.0004	significant
Pure error	1.935E-013	5	3.870E-014			
Cor total	6.254E-008	19				

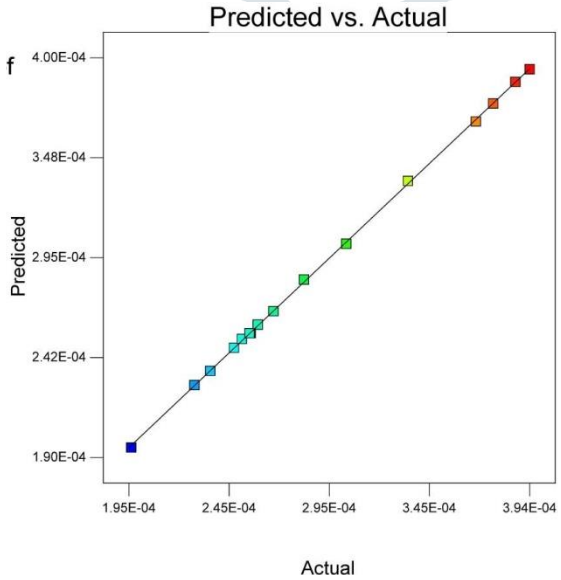

Figure 2 Prediction vs Actual Wear rate

Graphical Representation of the Actual vs Predicted Wear Rate

The above figure depicts the graphical representation of the Actual versus Predicted wear rate of the samples. The actual results we got from the testing of the specimens are approximately same as predicted by the software. There is a possibility of only 0.01% of error due to the noise in the machine and the manual errors. The maximum wear rate is the 0.00394273 mm³/Nm and the Minimum wear rate is 0.000196383 mm³/Nm.

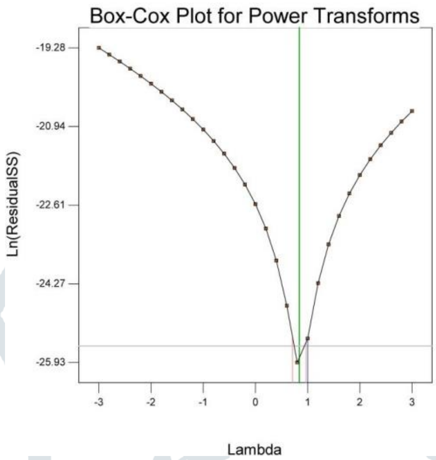

Figure 3: Graphical representation of Box-Cox Plot for Power Transforms

The graph shows the relation between the residual stresses and lambda. The software the default value for the lambda as 1. The lowest acceptable value of 0.71 and the highest being 0.97, the result of our samples came out to be 0.84 which perfectly in line with the required values for lambda between 0.71-0.97. Therefore, we can conclude that the all of the samples were in the acceptable range.

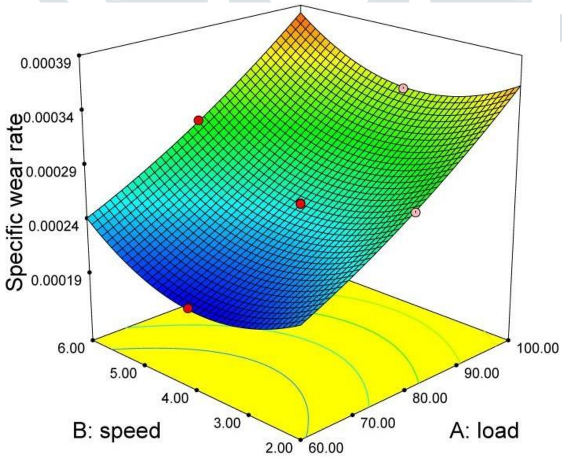

Figure 4: Specific Wear Rate with fly ash as actual factor Speed- Load with respect to Specific Wear Rate

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The graph explains the specific wear rate with respect to the two parameters one of them is speed and other one is load. As it is noticeable that maximum value of specific wear rate is at the values of load at 100kN and speed 6m/s whereas minimum values are obtained at 4m/s and at 75kN of load.

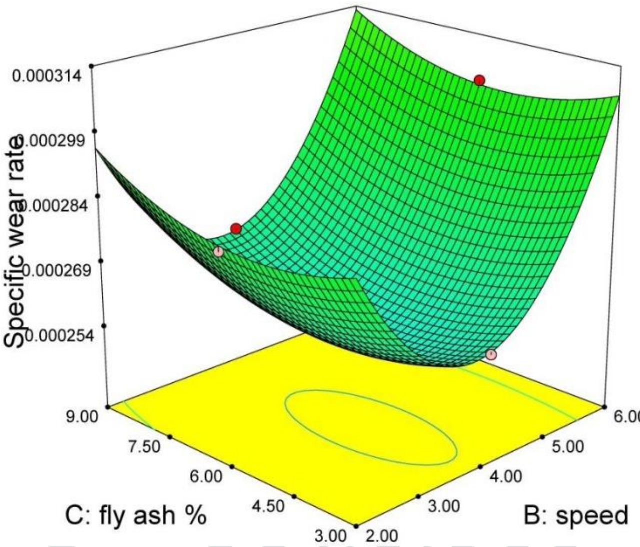

Figure 5: Fly Ash-speed with respect to Specific Wear Rate

This graph depicts the relation of specific wear rate with two important factors (weight percentage of fly ash and speed).In accordance to the graph the minimum value of specific wear rate is obtained at a value of 4m/s speed and range of 3.2 to 6.3 percentage of fly ash. The best value is obtained when load is 80kN.

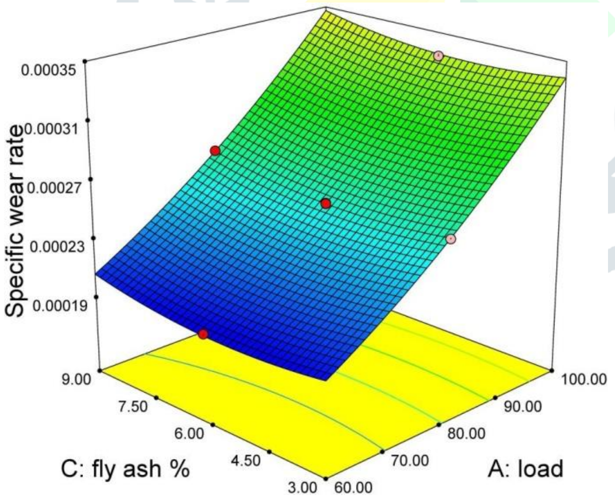

Figure 6: Fly ash- Load with respect to Specific Wear Rate

Here the data shown through the graph is how specific wear rate varies with respect to the factors weight percentage load. The values of specific wear rate increases with increase in load whereas value first decreases then again increases. The recommended value of actual by software is 4.

4. CONCLUSION:

1) Load was a dominant factor as increase in load increasing the wear rate due to the load carrying capacity of specimen.
2) Speed was another factor which has a huge impact on determining the wear rate of the specimen. Wear rate

first decreased and then increased. It was intermediate at 2 m/s, lowest at 4 m/s and highest deterioration rate was observed at 6 m/s.

3) Fly ash percentage also played an important factor in wear rate of the specimen. Wear. It first decrease than a steep rise was noticed further increasing quantity of fly ash.
4) Optimum value of wear rate was observed when a load of 60.05 kN was applied.
5) Optimum deterioration rate was noticed at a speed of 3.98 m/s.
6) Lowest wear rate was seen at fly ash percentage of 6.73.

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