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Development of friction material by using precast prefired (pcp f) blocks

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Abstract. The braking system used to control and stop automobile system. The braking system converts the kinematic energy into heat energy by friction. The performance of the brake pad depends on composition of friction materials. The asbestos brake pads are carcinogenic nature and it makes so many health problems. The present research work is going to replacement of asbestos by new materials. The new material is made by fused ceramic materials from industrial wastage. In this study the industrial waste are recycled and conducted the suitable test to compare the performance of the new material with existing brake pad material. The wear test was conducted by pin on disc experiment. The non asbestos, nonfused, fused samples are represented by x1, x2 and x3. The new brake pad material is formed by non fused and fused ceramic materials. The brake pads are manufactured by powder compacting process.

Keywords:
Friction, Wear, PCPF Block, Fused PCPF Block, Binder, Pin on Disc.

1. Introduction

The brake pad have been maintain consistent friction coefficient and should not be decompose at high temperatures. Commercially three types of brake pads are available in application such as asbestos, metallic and ceramic brake pads. Asbestos brake pad provided good frictional property and thermal resistance. Asbestos brake pads are carcinogenic nature because of the manufacturer started to find the alternative materials. The ceramic brake pads reduce the vibration, dust and disc or drum wear. The metallic brake pads provide long service life and increased rotor wear [1].the brake pad have been maintain the friction coefficient range from 0.2 to 0.4 under various velocity, friction heat and various operating conditions such as mud and water [2]. The existing brake pads consist of more than 10 elements [3]. Addition of the lubricant increases the stability of friction coefficient and improving the thermal conductivity of brake pad. Although graphite is a important ingredients for maintaining desired hardness level [4]. The binder in the brake pads is used to hold all the particles. Furthermore the addition of filler reduces the cost with increasing productivity of brake pad [5]. The friction materials need the following properties such as fade resistance, wear resistance and corrosion resistance [6]. Sliding velocity is a most important factor for affecting coefficient factor [7]. The wear and friction is plays an important role in development of new material. The wear and friction coefficient is complicated to find because of the following parameters such as particle size, speed, surface temperature [8].the microstructure of the abrasive particles can affect the friction performance of the brake pad [9]. Most of the brake pad materials were conducted wear test with the cast iron disc [10]. Typically 20-30% percentage of solid lubricant required to maintain the coefficient of friction between 0.3-0.4. Commercially various types of metal sulphide used as a solid lubricant in the brake pad [11]. The additions of glass fibre improve the thermal conductivity and diffusivity of brake pad [12]. The friction materials are generally developed by trial and error method or experience helps to

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develop the product. Now a day the following optimization methods are used to develops the composition of friction material [13].

2. Composition of materials

The various types of brake pads are used in automobile system such as asbestos, metallic, ceramic brake pads. The non asbestos, nonfused and fused ceramic samples are represented by x1, x2, and x3. The synthetic resin is used as a binding agent in a fused ceramic brake pad. The synthetic resins are non toxic nature which prevents from health problems. The synthetic resin provides good mechanical strength of fused ceramic sample (X3). The composition of the materials are have been found by EDAX test. The composition of friction materials are shown in the below tables.

Table 1. EDAX result of non asbestos sample

Elements	Weight (Wt %)
C	28.97
O	20.98
Na	0.48
Mg	0.34
Al	0.53
Si	1.29
S	5.88
Cl	0.57
K	0.26
Ca	2.61
Fe	4.25
Ba	33.85
Total	100

Table 2. EDAX result of nonfused sample

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Elements	Weight (Wt %)
C	5.30
O	51.70
Na	0.93
Al	35.85
Si	5.40
Ca	0.35
Fe	0.47
Total	100.00

Table 3. EDAX result of fused sample

Elements	Weight (Wt %)
C	6.97
O	29.29
Na	1.10
Al	4.72
Si	6.24
Ca	2.09
Fe	49.59
Total	100.00

Table 4. The composition of rotor disc

Elements	Weight (Wt %)
C	3.310
Si	1.910
Mn	0.790
S	0.060
P	0.057

3. Properties of friction material and wear test experiment

The wear test was conducted by the pin on disc experimental set up. The non asbestos sample (X1) is prepared from existing commercial brake pad. The new material samples are made by the powder compacting process. The dimensions of the samples are diameter (ϕ) 8 mm and length is 35 mm. The cast iron disc is used as a rotor in the wear test experiment. The samples are manufactured by powder compacting process. The power metallurgy process is economical process which is used increase the productivity. The pin on disc experiment was conducted in dry condition. The properties of the samples are shown in the table 5. The wear test conducted and absorbed result of the samples.

Figure 1. Non asbestos pin.

Figure 2. Nonfused ceramic pin

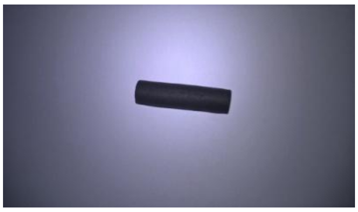

Figure 3. Fused ceramic pin.

Table 5. Physical properties of samples

Properties	X1	X2	X3
Density (g/mm^3))	0.0028	0.0032	0.0036
Hardness (Rockwell)	78	87.5	30.40
Compressive Strength(Mpa)	12.45	31.63	15.41

Figure 4. Pin on disc experiment set up.

4. Result and discussions

4.1 Friction and Wear Property Of The Material

The wear test was conducted on existing and new brake pad materials. The following graphs show the experimental result of the friction materials. The coefficient of friction and wear rate of a material was noted at every hundred meters. The wear tests of the samples are conducted by pin on disc experiment. The experimental set up was shown in the figure 4.

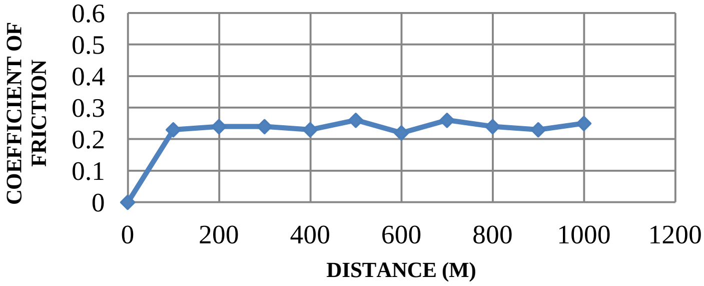

Figure 5a. Coefficient of friction v/s Distance for non asbestos material

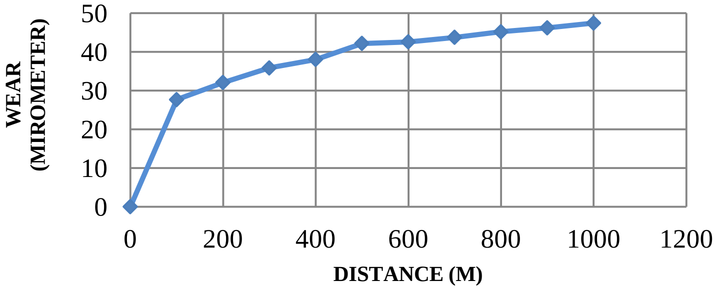

Figure 5b. wear v/s distance for non asbestos material

The non asbestos brake pad material maintains the friction coefficient between 0.2 to 0.3. The presents of graphite maintain consistent friction coefficient. The metallic brake pads are increasing the friction force with increasing applied force on brake pad. After reaching 500 m small fluctuation occurred in frictional force. The cause of fluctuation is adequate amount of graphite presented in the material. The wear rate is gradually increasing above 40 micrometer. The steel fibres increase the wear rate of rotor and increase the fluctuations of friction coefficient.

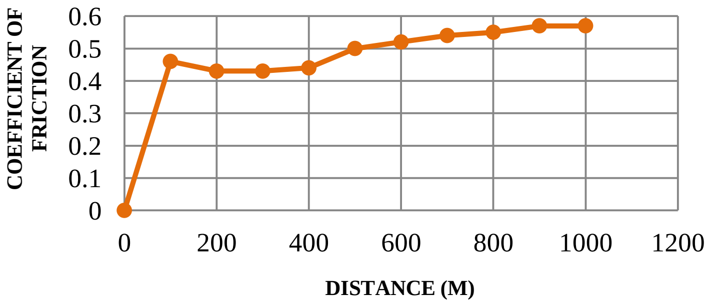

Figure 6a. Coefficient of friction v/s Distance nonfused for ceramic material

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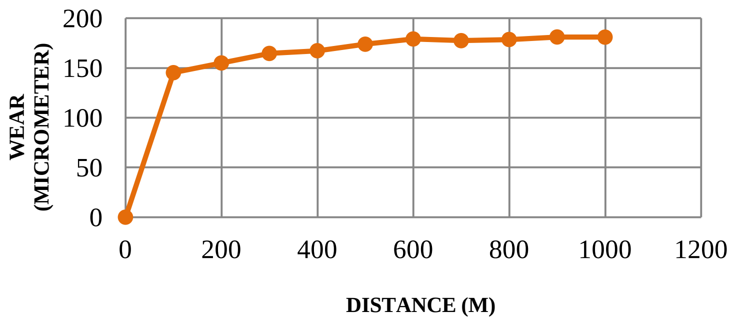

Figure 6b. Wear v/s Distance nonfused for ceramic material

The nonfused ceramic material maintains the friction coefficients between 0.4 to 0.6 shown in figure 6a. The presents of abrasive particle (SiO2) increase the friction force and increase the brittleness of the non fused pin. The amounts of SiO2 particles increase the wear of the rotor disc. The Al2O3 particles are reduced the compressibility of material during sintering process and also decrease the density of non fused ceramic pin. The metal oxides increase the hardness of nonfused friction material. The non fused ceramic sample maintain constant wear rate figure 6b. But the presents of aluminium particles increase the counterpart wear.

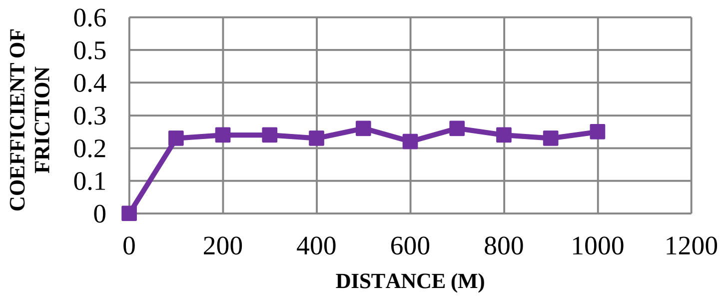

Figure 7a. Coefficient of friction v/s Distance for fused ceramic material

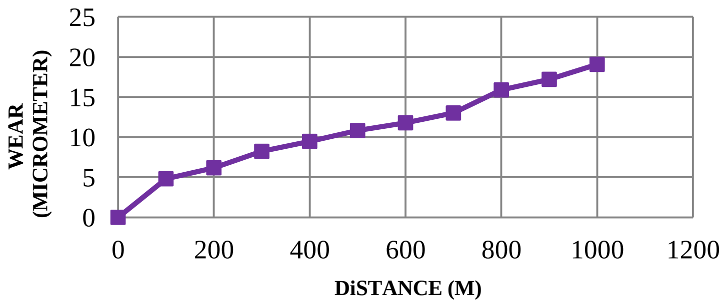

Figure 7b. Wear v/s Distance for fused ceramic material

The fused ceramic materials maintain stable friction coefficient between 0.35 to 0.45 shown in the figure 7a. The steel particles are increasing the mechanical strength of the brake pad. And it is reduce the wear rate of the brake pad. The wear rate of a fused ceramic is less than other materials such as non asbestos and nonfused ceramic materials shown in the figure 8b. The synthetic resin provides good structure rigidity under various operating conditions. The synthetic resins are non toxic nature.

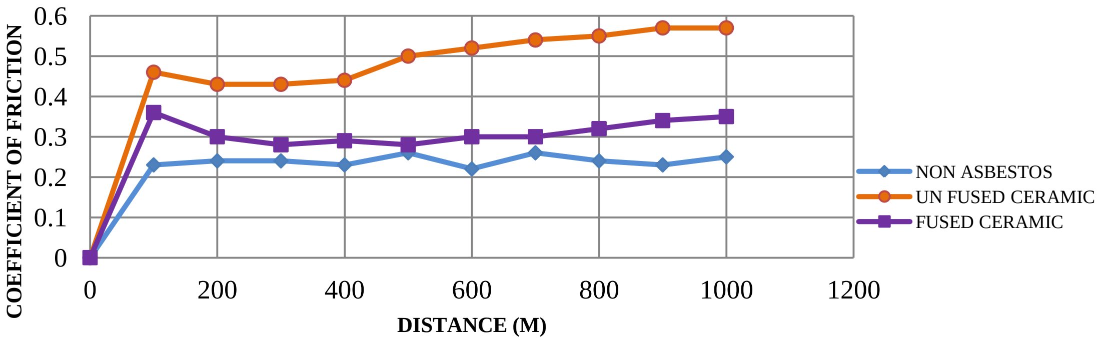

Figure 8a. Coefficient of friction v/s Distance

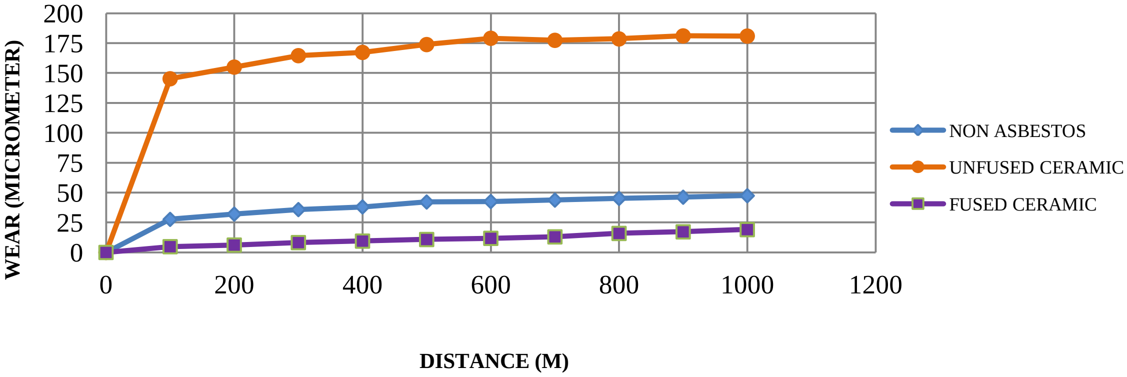

Figure 8b. Wear v/s Distance

The fused ceramic sample gives stable coefficient of friction compared to nonfused and non asbestos samples figure 8a. The SiO2 particles in the nonfused sample increase the friction coefficient and increase the counterpart wear. The commercial brake pad also gives consistent value of friction coefficient. But the wear rate of non asbestos material is more than fused ceramic material. The iron oxide particles reduce the wear rate of the fused ceramic material. The iron oxide particles are acting as an abrasive particle. The consistent friction coefficient shows sufficient amount of graphite and resin are presented in the fused ceramic pin. More amount of abrasive particles increases the inconsistency of friction coefficient and counterpart wear in a nonfused ceramic samples shown in the figure 8b.

The newly developed fused ceramic sample shows better wear resistance figure 8b. The wear of fused ceramic pin gradually increased to 25 micrometer. The non fused ceramic sample wear is increased above 175 micrometer. After reaching 600m the wear of nonfused ceramic pin gradually degreased. The presents of solid lubricant provide the friction stability and reduced the wear of the friction materials. The sufficient graphite content in the friction material maintain stable friction coefficient.

5. Conclusion

The brake pad should be provide consistent friction coefficient under various working condition such as various temperature, water, mud, etc., The fused ceramic material shows better compressive strength. The performance of the brake pad depends on the proper composition of ingredients. The friction coefficient of fused ceramic material is better than other sample. The fused ceramic sample is maintaining constant friction coefficient. The wear rate of fused ceramic pin is less than 25 micrometer. The presents of more SiO2 particles in a nonfused pin increases the coefficient of friction is shown in the figure 6a. The metallic brake pad maintains consistent coefficient of friction. Metallic brake pad material maintains the coefficient between 0.2 to 0.3. Compared other friction materials fused ceramic material (x3) provide better braking performance.

Reference

[1] Chan D and Stachowiak G.W April 2004 Review of automotive brake friction materials, *Proc. Instn Mech. Engrs* Vol. **218** Part D: J. Automobile Engineering, pp 957.
[2] Yuji Enomoto and Takashi Yamamoto 1998 New materials in automotive tribology, *Journal of tribology, Tribology letters* **5**, pp 13-24.
[3] Shin M.W, Cho K.H and Lee W.K 2010 Tribological characteristics of binder resins for brake friction materials at elevated temperatures, *Tribol lett* **38**: pp 161-168.
[4] Bhane A.B, Amira Sellami, Mohamed Kchaou, Riadh Elleuch, Anne-Lise Cristol, Yannick Desplanquesl September 2014 Investigation of tribological properties for brake pad material : a review, *International Journal of Emerging Technology and Advanced Engineering*, Volume **4**, Issue 9.
[5] Amira sellami, Mohamed Kchaou, Riadh Elleuch, Anne-Lise Cristol, Yannick Desplanques 2014 Study of the interaction between microstructure, mechanical and tribo-performance of a commercial brake lining material, *Materials and design* **59**, pp 84-93.
[6] Popa N, Onescu C 2008 About the Tribological behaviour of ceramic materials, *Tribology in industry*, Volume **30**, No. 3&4.
[7] Zhencai Zhu, Guoan Chen, Yilei Li June 2011 Analysis on tribological properties of potentially new friction material with response surface method, *Journal of wuhan university of technology-mater.sci.ed*, Volume **26**, Issue 3, pp 499-503.
[8] Nagesh S.N, Siddarsju C, Prakash S V, Ramesh M R 2014 characterization of brake pads by variation in composition of friction materials, *International conference on advances in manufacturing and materials engineering*, AMME.
[9] Sung Soo Kim, Hee Jung Hwang, Min Wook Shin, Ho Jang 2011 Friction and vibration of automotive brake pads containing different abrasive particles, *Wear* **271**, pp 1194-1202.
[10] Liew K.W, Umar Nirmal 2013 Frictional performance evaluation of newly designed brake pad materials, *Materials and design* **48**, pp 25-33.
[11] Osterle.W, Deutsch.C, Gradt.T, Orts-Gil.G, Schneider.T, Dmitriev.A.I 2014 Tribological screening tests for the selection of raw materials for automotive brake pad formulations, *Tribolgy international* **73**, pp 148-155.
[12] Bakloutia.M, Cristolc.A.L, Desplanquesc.Y, Elleucha.R 2015 Impact of the glass fibers addition on tribological behavior and braking performances of organic matrix composites for brake lining, *Wear* **330-331**, pp 507-514.
[13] Han I, Huang L, Zhang J, Lu Y 2006 Optimization of ceramic friction materials, *Compos Sci Technol:* **66**, pp 2895-2906.