Serbian Tribology Society

SERBIATRIB '19

16th International Conference on Tribology

Faculty of Engineering University of Kragujevac

Kragujevac, Serbia, 15 – 17 May 2019

DETERMINATION OF FRICTION AND WEAR BEHAVIOR OF ORGANIC DUSTS REINFORCED WITH THE BRAKE PADS BY USING TAGUCHI METHOD

Hasan ÖKTEM[1], Ilyas UYGUR[2], Gulsah AKINCIOĞLU[2], Sitki AKINCIOĞLU[2]

[1] Kocaeli University, Kocaeli, Turkey,

[2] Duzce University, Duzce/Turkey,

*Corresponding author:ilyasuygur@duzce.edu.tr

Abstract: *Brake pads play a major role in braking systems controlling the motions of automobiles. There are dozens of different friction materials in the brake pads. The braking performance of the brake pad depends on the content and amount of these powders. In recent years, importance has also been attached to the environmental friendliness of dust. In this study, the brake pad is manufactured with the addition of 3.5 % walnut shell dusts. The walnut shell dusts have been preferred in order to benefit from the local resources of our country. Hardness, density, water and oil absorption tests were applied to the brake pads. A specially designed tester was used for wear friction tests. Friction-wear tests were planned with Taguchi orthogonal L18 test set. Experiments were carried out by applying a pressure of 2 MPa. Variable temperature, speed and braking number are used. Due to the long duration of braking tests and high cost, the Taguchi optimization (Taguchi L18) method has been used to make the tests more efficient. The results obtained were compared with a commercial brake pad sample. The friction coefficient values of the commercial brake pad sample and the walnut added sample are similar. The friction coefficients obtained from the tester are in accordance with SAE J-661 standards.*

Keywords: *Brake pads, walnut shell dust, wear and friction, Taguchi method*

1. INTRODUCTION

The development of the automobile sector has increased studies on the brake pads. One of the most important parts of the braking system of automobiles is the brake pad, which is a composite material containing dozens of different materials. [1]. It is therefore possible to produce brake pads with very different contents. Powder materials in the components affect the braking performance of the brake pads [2]. In recent years, the search for natural dust additives has increased, especially after it has been found that asbestos fibers are harmful to human health [3]. It is also expected to be environmentally friendly as well as a good brake from an ideal brake pad. In their work, researchers examined the performance of brake pads that they produced using natural and environmentally friendly materials. Organic materials such as wollastonite, vermiculite, mica, basalt fiber, chopped glass fiber, ceramic fiber, rock wool, polyester and aramid fibers used in place of asbestos have similar performance characteristics [4]. Furthermore, agricultural, natural remnants and wastes have commenced to be used as new and inexpensive materials in the development of brake pads [5]. There are studies in the literature that are made with agricultural products such as banana shell, rice husk, hazelnut shell. [5-8].

In this study, walnut shell dust, which is harmless to the environment and health, was used as additive material in brake pads (W sample). A specially designed tester was used for wear friction tests. Friction-wear tests were planned with Taguchi orthogonal L18 test set. Experiments were carried out by applying a pressure of 2 MPa. Variable temperature, speed and braking number are used. Due to the long duration of braking tests and high cost, the Taguchi optimization (Taguchi L18) method has been used to make the tests more efficient. The results obtained were compared with a commercial brake pad sample (C sample).

2. MATERIAL AND METHODS

Brake pads are made of walnut shell dust which is added to 3.5% powder in addition to 17 different powder materials. Brake pads are produced by hot pressing. Load and temperature applied during the pressing of the brake pads is important for properly obtaining the pad. The production of the pads was carried out at a pressure of 100 kg / cm² at 180 ° C for 6 minutes. Brake pads are shown in Figure 1.

Figure 1. Brake pad sample

The hardness tests were carried out using a Shore D hardness tester. The water and oil absorption performances were investigated by keeping the brake pads in water and oil for 24 hours. The densities of the brake piercing samples were also measured according to the Archimedes principle. A specially designed device is used for wear and friction performances of the samples. The Taguchi L18 method was used to save time and experiment time. Special design friction wear tester shown in Figure 2.

Figure 2. Special design test device

The factors and levels determined for the Taguchi method are given in Table 1.

Table 1. Factors and levels with Taguchi L_{18} method

Factor Name	Factor	Unit	Values	Levels						
A	Temp.	(C°)	6	30	60	90	125	155	205	
B	Speed	(rev/min)	3	300	600	900	-	-	-	
C	Brake numbers	Num-ber	3	100	200	500	-	-	-	

The experiment sequences designed by Taguchi L_{18} method are given in Table 2.

Table 2. Taguchi orthogonal with L18 experiment sequences

Exp. no	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	1
5	2	2	2
6	2	3	3
7	3	1	2
8	3	2	3
9	3	3	1
10	4	1	3
11	4	2	1
12	4	3	2
13	5	1	2
14	5	2	3
15	5	3	1
16	6	1	3
17	6	2	1
18	6	3	2

3. RESULTS

The measured hardness values and densities of brake pad samples; walnut (W) and Commercial (C) after standing in water adsorption (WA) and in oil adsorption (OA) are given in Table 3.

Table 3. The hardness (Shore D) and density values of samples

Samp-les	Hardness	After WA	After OA	Density (gr/cm^3)
W	88	84	87	2,340
C	86	82	85	2,470

According to the table, the first hardness value of the Walnut-added sample is higher than the hardness of the commercial pad. It can be said that Walnut shell additives increase hardness. After the water and oil absorption, the hardness values of both pad samples decreased. The hardness values of the pads waiting in the water have decreased more than the pads waiting in the oil. This can be explained by the fact that the density of the water is less than the density of the oil. Due to the low density of water, it penetrated more into the samples. Moreover, it can be said that the walnut shell sample absorbs more water because it has less density than the commercial sample. The same situation is observed in the weight changes of the brake pads. Table 4 shows the weight changes of the samples waiting in the water.

Table 4. Weight changes in water

Samp-les	First Weights (gr)	Weight Changes after 24 hours in water (gr.)	Weight Changes (%)
W	250,235	250,727	0,20
C	225,024	225,450	0,19

Table 5 shows the weight changes of the samples waiting in the oil. The weight of the W sample is further increased. Walnut-added sample has more oil absorption. It can be said that it absorbs more oil because its density is less than that of commercial (C) sample.

The results of the friction coefficient obtained according to the Taguchi L18 are given in Table 6.

Table 5. Weight changes in oil

Samp-les	First Weights (gr.)	Weight Changes in oil (gr.)	Weight Changes (%)
W	252,640	253,622	0,39
C	250,677	251,533	0,34

Table 6. The results of the friction coefficient obtained according to the Taguchi L18

Exp.no	Factors			Friction Coef.	S/N Ratio
	A	B	C		
1	1	1	1	0,475	6,466
2	1	2	2	0,469	6,577
3	1	3	3	0,492	6,161
4	2	1	1	0,515	5,764
5	2	2	2	0,488	6,232
6	2	3	3	0,514	5,781
7	3	1	2	0,528	5,547
8	3	2	3	0,530	5,514
9	3	3	1	0,522	5,647
10	4	1	3	0,499	6,038
11	4	2	1	0,505	5,934
12	4	3	2	0,503	5,969
13	5	1	2	0,462	6,707
14	5	2	3	0,480	6,375
15	5	3	1	0,480	6,375
16	6	1	3	0,468	6,595
17	6	2	1	0,480	6,375
18	6	3	2	0,470	6,558

The results in Table 6 were obtained between 0.462 and 0.530 μ. The results of this friction coefficient obtained according to the Taguchi L18 formula comply with the SAE J661 standard. According to 18 different tests applied in different parameters, all values of friction coefficient are suitable for "G" and "H" class. The test results obtained by the Taguchi Method are evaluated by converting them to the signal / noise (S / N) ratio. The Noise Factor is needed to select the optimal values for their variability, by determining these causes or factors, in order to reduce the variability resulting from ordinary or system causes. These factors that create variability are called noise factor [9]. The value with the smallest S / N ratio is calculated and analyzed differently according to the value of the best, the greatest value is best, the nominal value is best, and the quality value is targeted [10]. According to these results, it can be said that it is appropriate to use walnut dust in brake pads because the friction coefficient values are in the appropriate range according to the standards. The graph of the resultant table for the average friction coefficient and S / N ratio for the W-coded brake pad is shown in Figure 3.

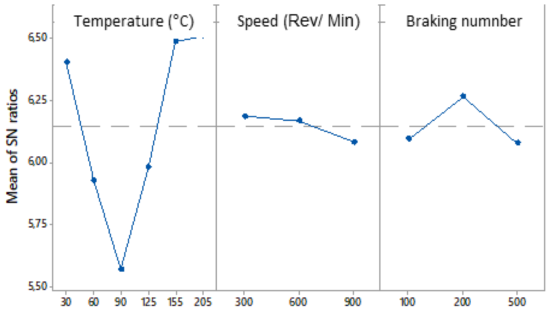

Figure 3. The effect of the factors on the friction coefficient and the S / N ratio for the W sample

The nominal level $A_4B_2C_1$ was determined when the control factors of the friction coefficient results of the W sample were examined. The nominal friction coefficient value was found to be 0.505 µ. Verification test was conducted to determine the accuracy of the results obtained. The friction coefficient verification test results by the Taguchi method of the test specimens are given in Table 7.

Table 7. Nominal friction coefficients and verification test results

Sam-ples	Nominal Levels	Taguchi method Friction coefficient (µ)	
		Experimental result (µ)	Predictions (µ)
W	$A_4B_2C_1$	0,505	0,503

According to the verification test results for the determination of the accuracy of the predicted values by the Taguchi method, the method yielded reliable results. According to the results obtained, friction coefficient results of brake pads can be optimized by Taguchi method.

4. CONCLUSION

As a result of this work, adding the walnut shell dust on brake pads were produced in real dimensions. As a result of friction and wear tests carried out on a specially designed test device, friction coefficient values according to the standards have been obtained. Also, according to the verification test results for the determination of the accuracy of the predicted values by the Taguchi method, the method yielded reliable results. Moreover, friction coefficient results of brake pads can be optimized by Taguchi method.

ACKNOWLEDGEMENT

This study was supported by the Scientific Research Project Unit of Duzce University (DÜBAP-2015/72).

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