EVALUATION OF NON-ASBESTOS HIGH PERFORMANCE BRAKE PADS PRODUCED WITH ORGANIC DUSTS

ÖKTEM Hasan[1], UYGUR İlyas[2], AKINCIOĞLU Gülşah[3], KIR Durmuş[1], KARAKAŞ Hamdi[4]

[1]*University of Kocaeli, Kocaeli, Turkey, hoktem@kocaeli.edu.tr, durmus.kir@kocaeli.edu.tr*
[2]*University of Düzce, Faculty of Engineering, Turkey, ilyasuygur@duzce.edu.tr*
[3]*University of Düzce, Düzce, Turkey, gulsahakincioglu@duzce.edu.tr*
[4]*Form Metal, Kocaeli, Turkey, hamdikarakas2434@gmail.com*

Abstract

Recently, research-development studies conducted for the production of organic brake pads because of the usage of asbestos in brake pads have negative effects on human health and the environment. This study aims to develop to non-asbestos high performance brake pads. Twenty-four types of different dusts in commercial brake pads have utilized as fillers, reinforcements, binders, abrasives and friction modifiers in mixture of organic brake pads produced. In this study, seventeen of these friction dusts were used to develop to organic brake pads. The 3.5 wt.% and 7 wt.% content of hazelnut and walnut as friction modifier materials were replaced with petrocoke dust eco-friendly. The performance of brake pads was determined by microstructural examinations, oil absorption and dimensional stability, and hardness of brake pads. The results indicated that the brake pads produced with organic dusts such as hazelnut and walnut shells can replaced with petrocoke dust. From this, it can be concluded that new type brake pads of non-asbestos organic-based dusts can be effectively used as a replacement for asbestos and performance in brake pad production.

Keywords: Brake pads, hazelnut/walnut dusts, hardness, oil absorption, microstructure

1. INTRODUCTION

The brake pad is one of the most important elements used to provide speed control of the vehicle [1]. Sustainable friction coefficient at high temperature is the most anticipated feature of the brake pads [2]. In the past decade, various researches focused on the use of environmentally friendly for the engineering applications. In this eco-friendly trend also has been used in brake pads friction composite materials industry [3-4]. When it is used to natural composite materials component in the braking pads, released toxic and hazardous chemicals are reduced. People are generally avoided the use of asbestos materials which is located between the brake pads and friction dusts that cause lung cancer [5-7]. For these reasons, different ratios natural additives, with the addition of cheaper and high-performance friction materials used brake pads. Matejka et al. used natural and recycled hazelnut shell powder as the additives in their study. While taking as a basis the Indian hemp fiber and graphite nut shell two different samples were prepared. Specimens were subjected to the friction wear tests. As a result, the sample used nut shell powder (14 wt.%) with natural ingredients, has found the wear resistance and performance [8]. Another natural additives lining material used in the break pad research is palm kernel. Ikpambese et al. [9] evaluated their study, using palm kernel fiber with epoxy resin. According to their results it can be used as a reinforcement material. Bahari et al. [10] produced rice powders as the brake pad additives and they investigated the effect of stiffness and impact resistance of the lining dusts. They concluded that the rice powder reinforced brake pads gives better results than those commercially hardness pads used. Another natural material is used in friction linings sample is a banana peel. Idris et al. [11] used drying banana peel powders in their works. They have also some carbonized some amount of those powders. Carbonized and banana peel powder samples were subjected to some physical, mechanical and corrosion tests for the determination and characterization of the pads. They concluded that banana peel powders can be used in the production of the pads. Ma et al. [12] produced brake pads with bamboo tree dusts and they determine the performance, mechanical properties, friction-wear behavior and microstructure of the pads. Qi et al. [13] produced 7 different brake pads by using walnut shell dusts varying from 0 to 15 wt.%. Researchers produced the friction-wear pads sample tests, hardness measurements and microstructural studies were done. Optimum coefficient of friction lining pads were obtained in the sample containing 5.6 wt.% walnut shell powder. In another study, the friction material, brake linings samples were produced by using petro coke, cashew and Wollastonite. The friction coefficient, density, hardness and roughness and performance of the pads have been identified [14, 15]. In this study, seventeen common dusts and two different dusts are used to produce the samples of the organic brake pads. The hazelnut/walnut dusts as friction modifiers were replaced with petrocoke dusts at two different contents (3.5 wt.% and 7 wt.%). As certain the performance of the produced pads hardness, dimensional changes and weight gain was measured for the different powder addition and obtained results discussed by means of the microstructure.

2. MATERIALS AND METHODS

2.1 Preparation of the raw materials

In this study, seventeen (17) common dusts and two different dusts are used to produce the samples of the organic brake pads. The hazelnut/walnut dusts as friction modifiers were replaced with petrocoke dusts at two different contents (3.5 wt.% and 7 wt.%). The common brake pad dusts given in **Table 1** are fillers (rock wool, vermiculite, rubber scrap, barytes, calcium hydroxide and mica), reinforcements (steel fiber, kevlar pulp), binders (phenolic resin, rubber), abrasives (quartz, zirconium silicate, graphite) and friction modifiers (brass, chalcopyrite, sulphur, petrocoke and walnut/hazelnut). The hazelnut and walnut dusts sieve sizes of 250-400 μm were mixed homogeneously using a mechanical mixer at capacity of 50 kg for a period of twenty minutes before transferring it to a mould. The raw friction materials and mixing process are illustrated in **Figs. 1** and **2**.

Table 1 The common brake pad compositions

Number	Dust Materials	Compositions (wt.%)	Dust grain size (μm)
1	Steel fiber	15-20	125
2	Rock wool	3-6	6-10
3	Kevlar pulp	0.5-2	12
4	Graphite	5-7	45
5	Phenolic Resin	6-8	63
6	Vermiculite	6-8	500
7	Brass	4-6	50-100
8	Calcium hydroxide	7-9	40
9	Zirconium Silicate	3-5	10
10	Metal Sulfide	0.5-1	45
11	Iron oxide (Fe_2O_3)	1-3	0.2
12	Rubber scrap	4-6	50
13	Barytes	6-8	55
14	Rubber (NBR)	2-4	50
15	Petrocoke	3-5	125
16	Chalcopyrite ($CuFeS_2$)	4-7	50
17	Mica+silica	4-5	50-100

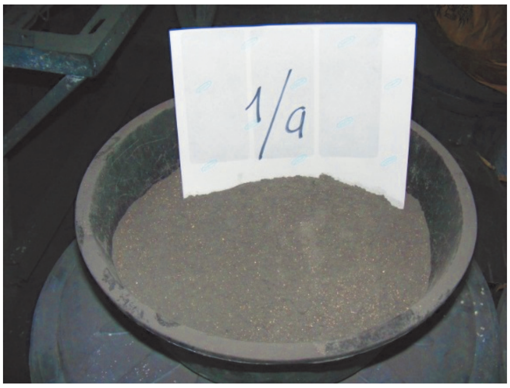


Fig. 1 Preparation of friction dusts

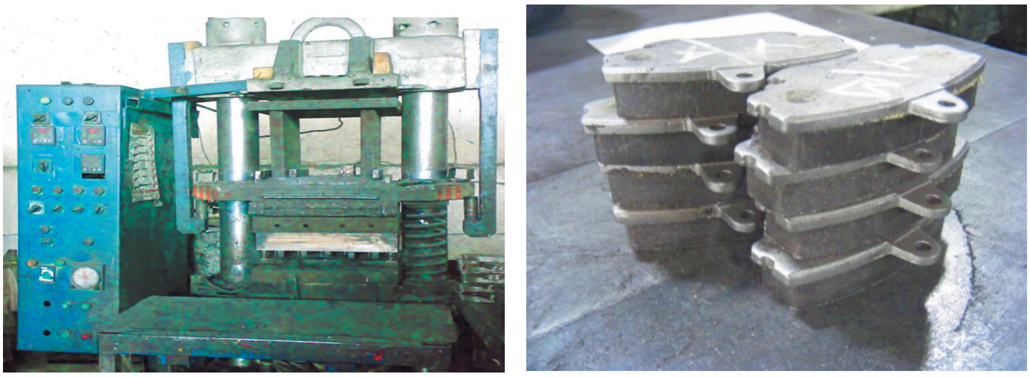
Fig. 2 The mixing of friction dusts for brake pads

The mixtures of brake pad (Renault-Clio automobile) prepared in the appropriate amount (given by **Table1**) were hot-pressed to metal molds. Typical brake pad production parameters are given in **Table 2**.

Table 2 Brake pad production parameters

Mold temperature (°C)	Pressure (MPa)	Time duration (minute)	Holding temperature (°C)	Holding time (h)
180 ± 5	10	6	300	10

After post-curing, the brake pads were finished by polishing them using polisher-grinder with various grinding paper of various sizes to obtain the final products. The previous volume of mixture (weight = 120 g and thickness = 48 mm) is three times bigger than that of the hot-pressed (thickness = 16 mm) products. Typical production procedure of the brake pads is shown in **Fig. 3**.



(a) (b)

Fig. 3 Hot-pressing process (a) and brake pads (b)

3. MECHANICAL PROPERTIES AND MICROSTRUCTURE

3.1. Hardness tests

In order to confirm uniform mixing and proper curing during manufacturing of brake pads with hazelnut and walnut dusts, the hardness of brake pads with and without oil absorption (SEA 20/50 at 26-30 °C) was measured using a Shore D hardness tester (Macrona) according to the ASTM D2240. At least three replications of hardness test for each specimen were made and the average values are reported in **Fig. 7**. Experimental scatter was about ± 2 Shore D.

3.2. Oil absorption and weight change

The oil soak test determines oil absorption behavior of non-asbestos brake pads and the effect of the absorbed oil on its dimensions. After oven drying of the specimens (0-25 °C), its weight was measured. Subsequently, the dimensions (thickness) of the samples were measured using a caliper after twenty-four hours of submersion in engine oil, SEA 20/50 at 26-30 °C. The samples of brake pads were weighed after the excess oil had drained off. **Eq. (1)** was used in determining the weight of brake pads:

$$\text{Absorption } \frac{W_S - W_I}{W_I} 100\,(\%) \qquad (1)$$

Where: W_S - weight after immersion, W_I - weight before immersion

3.1 Microstructure of brake pads

The microstructure of the brake pads as shown in **Figs. 4** and **5** is observed by using a digital metallurgical microscope. In this study, hardness, weight and dimensional change and microstructures of brake pads consisting of seventeen (17) common dusts and two different dusts (3.5 wt.% and 7 wt.%) replaced with petrocoke dusts are investigated. The brake pads with the contents of 3.5 wt.% hazelnut-3.5 wt.% petrocoke and the contents of 7 wt.% hazelnut and 0 wt.% petrocoke are designated as 1A and 1B, respectively. In similar way, the brake pads with the contents of 3.5 wt.% walnut - 3.5 wt.% petrocoke and the contents of walnut wt.% 7 and 0 wt.% petrocoke are designated as 2A and 2B, respectively. After oil absorption at 24 hours, the brake pads with same contents are called as 1AY, 1BY, 2AY, 2BY, respectively.

4. RESULTS AND DISCUSSION

The developed brake pads in this study were composed of fillers, binders, reinforcements, friction modifiers and abrasives. The matrix of the brake pads includes rock wool, vermiculite, rubber scrap, barytes, calcium hydroxide, mica, phenolic resin and rubber. It can be seen that (**Fig. 4** and **5**) the friction dusts consisting brake pads have distributed as homogeneous within the matrix. Also it can be seen from these figures that the gray regions are matrix (fillers and binders), a portion of bright regions likes needle are reinforcement (steel fiber) and the others are friction modifiers and abrasives. Moreover, the microstructures in **Figs. 4** and **5** also exhibit that the content of friction dusts increases with increasing the content of organic dust rate from 3.5 to 7 wt.%.

Fig. 4 The microstructure of brake pads produced with organic dusts

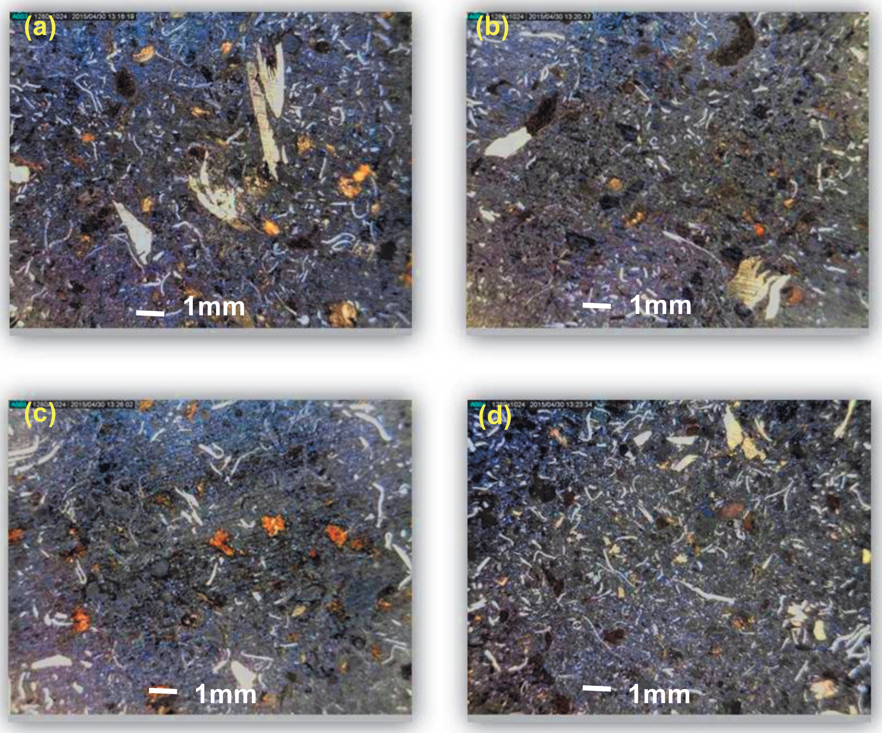


Fig. 5 The microstructure of brake pads with natural dusts: a) 1A b) 1B c) 2A d) 2B

Fig. 6 displays the hardness variations of organic brake pads consisting of hazelnut and walnut dusts at different contents with/without oil absorption (24 hours). In **Fig. 6**, the hardness value of the brake pads (1A) is measured as 92 shore D whereas the hardness value of the brake pads (1B) is determined as 93 shore D. Similarly, the hardness value of the brake pads (2A) is measured as 94 shore D whereas the hardness value of the brake pads (2B) is observed as 95 shore D. The hardness values of the brake pads slightly increases with increasing the contents both hazelnut and walnut dusts. After 24 hours in oil absorption, the hardness values of the brake pads with hazelnut and walnut decrease approximately 2 shore D.

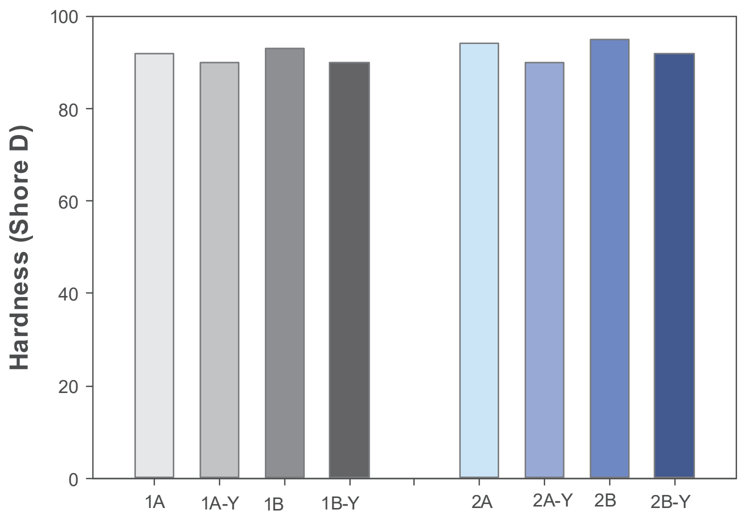


Fig. 6 The hardness variations of brake pads with hazelnut and walnut (3.5 wt.% and 7 wt.%)

Fig. 7 presents the weight variations of organic brake pads consisting of hazelnut and walnut dusts at different contents with/without oil absorption (24 hours). From **Fig. 7**, it can be seen that the weight of the brake pads increased around 1.5 to 2 g. The weight of the brake pad (1A) is 242.1 g while that of brake pads (1AY) is 244.04 g after 24 hours oil absorption. It can also be seen from **Fig. 7**, the weight of the brake pad (2A) is 246.82 g whereas that of brake pads (2AY) is 247.8 g after 24 hours oil absorption. It can be said that significant change on the weight of the brake pads has not been occurred although the contents of hazelnut and walnut increases. Moreover, the dimensions of the brake pads with hazelnut and walnuts are also measured by a digital caliper after oil absorption 24 hours. Any change has not been occurred on dimensions of width, length and thickness.

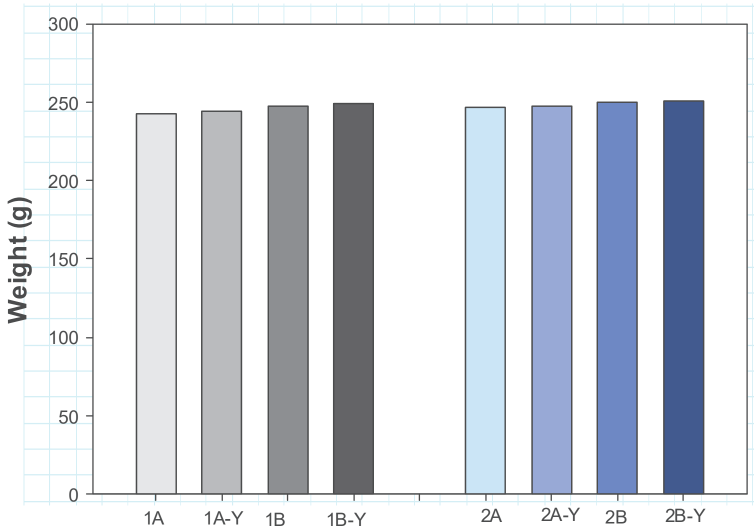


Fig. 7 The weight variations of brake pads with hazelnut and walnut (3.5 wt.% and 7 wt.%)

CONCLUSIONS

- Hazelnut and walnut dusts with the contents of 3.5 wt.% and 7 wt.% have been replaced successfully in the brake pads.
- The friction dusts consisting brake pads have been distributed uniform and homogeneously within the matrix.
- The microstructural observation from brake pads exhibit that the content of friction dusts increases with increasing the content of organic dust rate from 3.5 to 7 wt.%.
- After 24 hours oil absorption, the hardness values of the brake pads with hazelnut and walnut decreased approximately 2 shore D.
- After 24 hours oil absorption, the weight of the brake pads has not been significantly altered although the contents of hazelnut and walnut increased.
- Similar trends have also observed for both the weight and the hardness of the brake pads after oil absorption.
- There has been no dimensional change in the brake pads after oil absorption. This situation can be indicative of the developed brake pads that can be reliably used.
- Finally, the brake pads reinforced hazelnut and walnut dusts can be competed with commercial pads after the friction-wear tests have been performed.

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