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Research Article/Araştırma Makalesi

Examination of the Tribological Properties of Brake Pads with Different Hardness Characteristics

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Abstract
Brake pads consist of a combination of different materials such as binder, friction adjuster, reinforcement material, lubricant and filler material. Brake pads are produced by using certain proportions of materials containing these components. The tribological properties of the brake pad differ according to the material content of the brake pad composition. The physical properties of the produced brake pads are another factor affecting the tribological properties of the brake pads. In this study, brake pads with different hardness properties were produced. By examining the braking performance of the produced brake pads, its effect on tribological properties has been determined.

1. Introduction

Brake pads in the brake systems of vehicles are composite materials consisting of matrices, fibers and various materials. Researchers are experimenting with a variety of materials that can improve braking performance. The most important factor affecting brake performance is the friction coefficient. In order to obtain a high and stable friction coefficient, it first decides the type of material and then the amount. Most of these studies are carried out experimentally. Especially after the prohibition of asbestos, studies on the search for materials continue with the search for alternative materials to copper these days (Akıncıoğlu et al., 2018:43, Bijwe, 1997: 18, Bijwe and Kumar, 2007: 263, Kumar and Bijwe, 2010: 43, Mahale et al., 2019: 424, Justin et al., 2019: 71, Raj et al., 2018:12, Jeganmohan et al., 2020: 101, Raj et al., 2020: 23). It is not easy to obtain the desired features such as high friction coefficient, high stability, high wear resistance, low amount of wear and environmental friendliness from brake pads. Because brake performance depends on many different parameters such as material type, amount of material, production conditions, braking speed and braking pressure. Therefore, studies on brake pads are complex, and all performance criteria must be examined. In this

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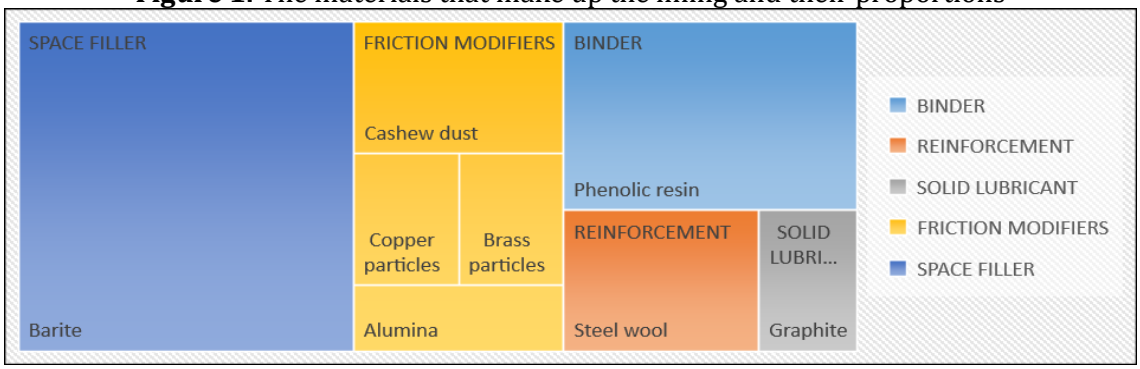
study, the effect of brake pads with different hardness properties on wear and friction properties was investigated experimentally.

2. Material and Experimental

While determining the materials to be used in this study, both scientific studies and commercial pads were taken into consideration, and it was decided to use the most preferred products. Thus, three samples with the same content were obtained by conventional powder mixing, cold molding and hot molding processes. In order to obtain different hardness values in samples with the same content, some changes were made in the production conditions. The materials used in this study and their properties are schematically given in Figure 1.

Figure 1. The materials that make up the lining and their proportions



The powder materials given in Figure 1 were first weighed and mixed on a precision balance. The mixture was subjected to cold molding and hot-pressing processes, respectively. The pressing pressure was different in all of them to obtain different hardness values. Archimedes' principle was used to measure the experimental density of the pads. Rockwell hardness measuring device L scale and 1/4-inch balls were used to measure their hardness. The samples were named H1, H2, and H3. A computer-controlled special design brake tester was used for the brake tests of the samples, and detailed information about the device is available in the previous studies of the authors (Sugözü, 2015: 57, Sugözü, 2018: 70). The masses of the samples before and after the brake test were determined with the help of precision scales and the wear amounts were calculated. The specific wear rate of the samples was calculated according to the formulation in TSE 555 (TSE 555, 2019).

3. Results and Discussion

Graphics related to the data obtained from the brake test of the pads are shown in Figure 2. The friction coefficient value obtained per second from the brake tester is presented as an average. Because at the beginning of the test, the friction coefficient is relatively low during the running-in process of the pad and the disc. The specific wear rate depends on the friction force, density, mass loss, distance from the center of the disc to the center of the pad, and the total number of rotations of the disc.

Figure 2. Tribological properties of pads

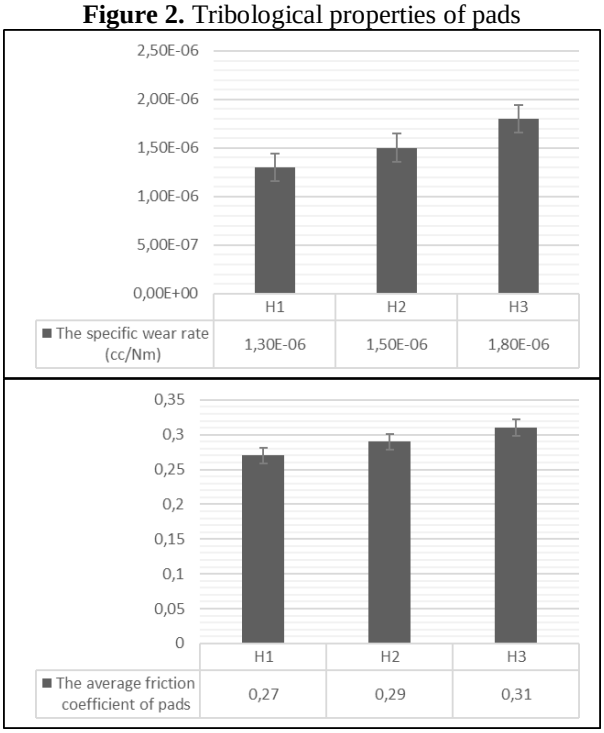
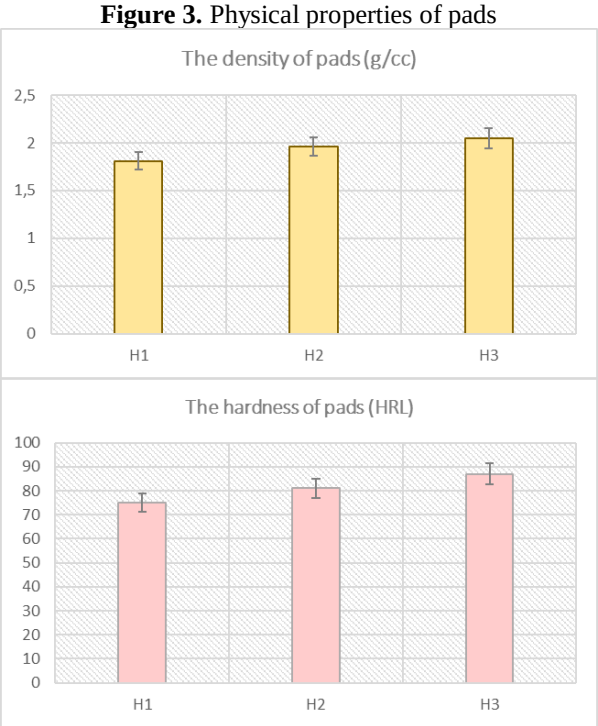


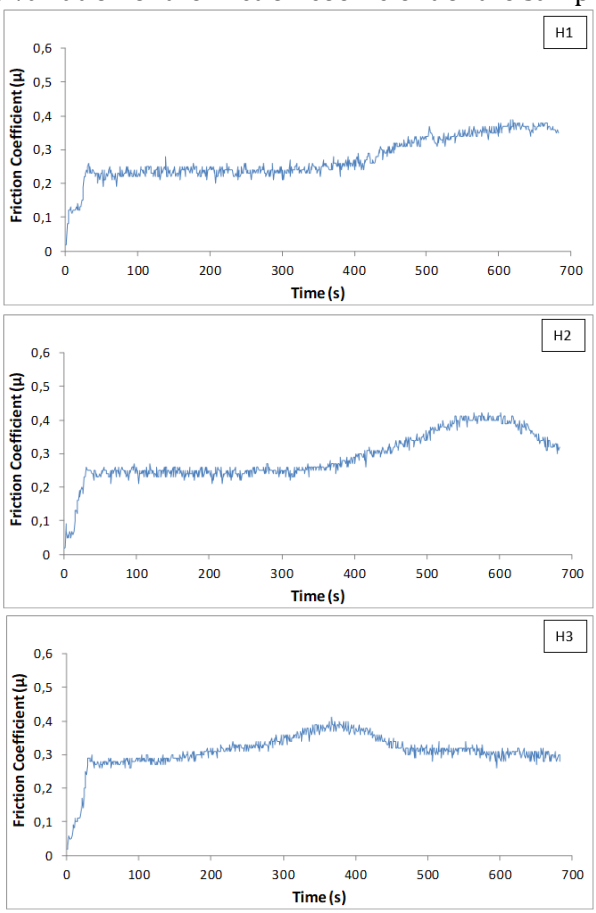
Figure 3. Physical properties of pads



Density and hardness properties of pads are related to both the material and the production conditions. When the density and hardness values of the pads are examined in Figure 3, it can be said that there is a correlation between density and hardness. Likewise, when the hardness and tribological properties of the pads are examined, it is seen that the average friction coefficient and specific wear rate of the pads with high hardness are high. However, if the hardness is too high, the brittleness of the pads increases and the wear resistance decreases. But the

hardness of the H3 coded sample did not adversely affect the tribological properties and is in ideal values.

Figure 4. The variation of the friction coefficient of the samples in seconds



In addition to the average friction coefficient value of the pads, information about the friction stability of the pads can be obtained by examining the data per second in Figure 4. In graphics, the friction coefficient is low first, and it takes the time required for the disc to contact and get used to it. Fluctuations are not preferred in the graphs related to the friction coefficient. In some studies in the literature, a formula for friction stability has been created, and it is calculated by the ratio of the average friction coefficient to the maximum friction coefficient (Bijwe et al., 2012: 296).

4. Conclusions

- The high hardness of the pad increased the friction force and friction coefficient.
- The increase in pressing pressure during the production of pads caused an increase in the hardness.
- It has been observed that the brittleness of the lining with a high hardness ratio has increased, which has led to an increase in the amount of wear.

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