PREPARATION, TESTING AND COMPARISON OF FRICTION COMPOSITES

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Abstract

The article describes the preparation of the resin-based friction composite samples for the standard passenger car type, its mechanical testing and comparison with commercial brake pads. The composition with low content of metallic particles was designed. Using a matrix-heated laboratory press were prepared several samples of our composite. One of the components is also graphite with nanometrical particle size range. The matrix shape has been chosen considering the real brake pad shape for Skoda Octavia passenger car. Manufactured samples were subjected to brake dynamometer testing measurement using SAE J2522 testing procedure. Further, a comparison focused on efficiency and wear was made.

Keywords: Low-metallic friction composites, automotive brake pads, full-scale dynamometer, phenolic resin

1. INTRODUCTION

Friction composites represent an essential part of the automotive braking systems, where they are being utilized for brake pads. There are several different types formulation of friction composites for different types of industrial application. For automotive brake systems friction composites with low content of metallic components or non-asbestos organic formulations are currently being used [1].

In research nowadays, nanomaterials are also used in friction composite mixtures. They are usually used as a filler compound in case of metallic filler. Their purpose in the composite is to fill the space, rather than affecting the mechanical properties of the friction composite. The subject of this paper is to compare two types of friction composites. First type was laboratory-manufactured friction composite. This friction composite was prepared by using matrix-heated hydraulic press. As for the second type, commercially available standard friction composite was used.

2. EXPERIMENTAL

A composition with low content of metallic compounds was designed, mixed, homogenized and pressed. After the preparation, the prepared brake pads were tested and compared with standard commercially available low-metallic brake pads.

Samples A (laboratory-prepared) and B (commercial) were compared due to their mechanical properties, especially efficiency and wear. To determine the efficiency of the friction composites, a brake dynamometer is used. This brake dynamometer is in courtesy of VSB-TU Ostrava. Brake dynamometer is able to perform several different types of tests, which vary in testing conditions. These tests can simulate the actual load, which is placed on the brakes on the standard automobile. To secure the constant conditions, the load, temperature and the torque are controlled. One of the most used standards in brake pads testing is SAE J2522 (AK Master).

AK Master standard consists of 15 test sections with various speed, pressure and temperature restrictions. The most important sections are 9 (FADE 1) and 14 (FADE 2). These sections are used for measurement of the dependence between friction coefficient and temperature. Friction coefficient is decreasing with increasing temperature. The decrease of friction effect has primary influence on road safety. The wear was determined the knowledge of the thickness and weight values before and after the testing procedure.

2.1 Brake pads preparation

Process of brake pads manufacturing comprises several procedures. At first, it is very important to compact the estimated amount of a friction mixture, thus decrease the porosity of the material. This operation is usually performed on a hot pressing device in a specially formed matrix. As the critical pressure is exceeded, the composite particles start to deform and form connections with other particles. This can be called as the “cold welding” effect. The thickness of the friction composite depends on the amount of the prepared friction mixture and on the pressure, which is applied on the mixture [1]. Mixture used for the laboratory-prepared friction composite contained very low amount of metallic components. In case of using metallic compounds as a filler compound, graphite with nanometer particle size was used.

After a thorough homogenization, the mixture was placed into the matrix of the press, as can be seen in Fig. 1. A standard adhesive used for connecting brake pad and back plate was applied. There are two available matrices. The first matrix (Fig. 1a – left) is used for square 55 x 55 mm samples pressing and the second matrix (Fig. 1a – right) is used for standard brake pad shape samples pressing. For the pressing an uniaxial laboratory press (Fig. 1b) with heated matrix in the shape of brake pad was used.

Fig. 1 Brake pad pressing matrix (1a) and Compact Thermo 300 kN hot press (1b)

The preparation starts with the matrix lubrication with silicon oil lubricant. After lubrication, the mixture is inserted into the matrix, which is brake pad-shaped. The matrix is then placed into a uniaxial unilateral laboratory hot press Compact Thermo 300 kN with pre heated matrix. After the pressing process is done and the pressed brake pad is removed from the matrix, a further hardening is required. Hence, the brake pad is inserted into a pre–heated furnace until the hardening process is finished.

2.2 Brake pads testing

At first, the thickness and weight of the prepared brake pads was estimated. The thickness was measured on four different spots to maximize the accuracy of the measurement. Also, the weight was measured, so the wear rate can be characterized as well. It is also essential to provide the brake disc with a type K thermocouple before the testing starts. Measured temperature of the brake disc is then used as a control parameter for the testing procedure.

Fig. 2 LINK M2800 compact full-scale brake dynamometer

The manufactured brake pads and the commercial brake pads were tested on brake dynamometer LINK M2800 (Fig. 2) with AK Master testing procedure, which meets the SAE J2522 standard. AK Master is a test programme for friction-wear measurements and used for brake pad development by manufacturers and for certification of brake pads. The main purpose of SAE J2522 standard is to compare friction materials under the most equal conditions possible.

The comparison was mainly focused on the FADE mode. This is one of the most important test sections. It mainly shows the stability of friction when high temperature is applied. The fade mode consists of 15 braking cycles with increasing rotor temperature. In each braking cycle the velocity drops from 100 to 5 km/h with deceleration of 5.89 m/s^2. After series of pressure, temperature and recovery tests, second FADE mode was performed. Its purpose is to show how the friction properties differ after another bedding process. The test conditions were the same as in the first FADE [2, 3].

After the brake pad preparation process the testing and comparison with the commercial brake pads was performed. The prepared friction composite was marked as sample A and the commercial friction composite was marked as sample B.

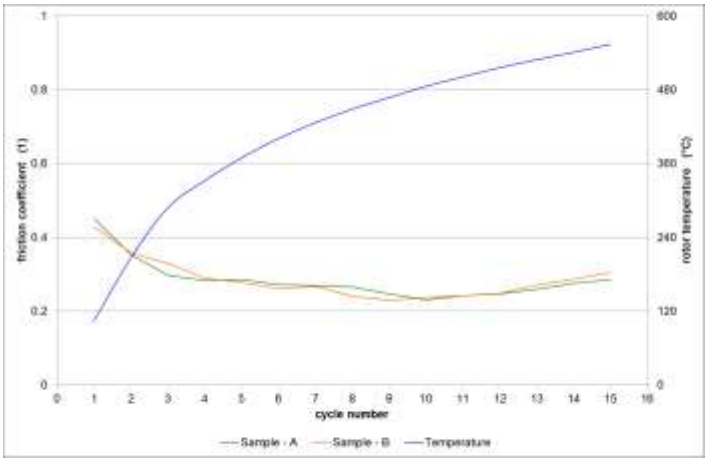

Fig. 3 FADE 1 measurement of sample A and B

The FADE 1 (Fig. 3) test chart shows that the middle effectiveness is decreasing in both cases. The laboratory manufactured friction composite (Sample – A) shows friction coefficient drop from 0.45 to 0.29, so the relative decrease is 37%. It can be seen in the effectiveness line B that the drop is smaller, specifically from 0.43 to 0.31, which means the relative drop is 28%. In the FADE 1 testing procedure are the values of the friction coefficient, of our prepared friction composite, very similar to the values of the tested commercial composite.

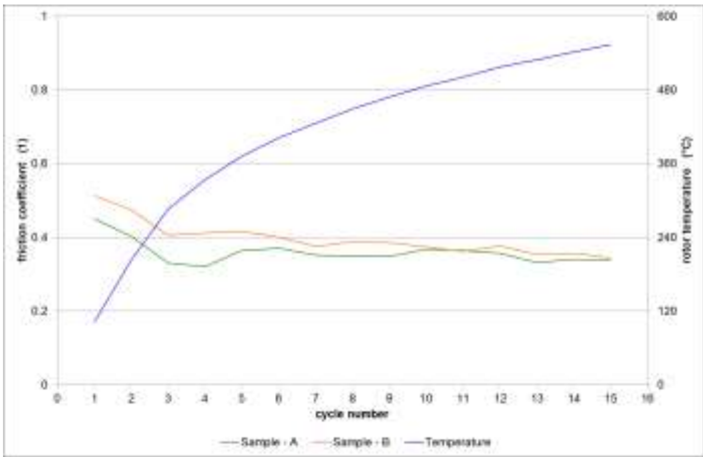

Fig 4 FADE 2 measurement of sample A and B

After several pressure, temperature and recovery tests, the second fade test was performed. The FADE 2 (Fig. 4) test chart shows the comparison between laboratory manufactured brake pads and commercial brake pads, during the second fade test section. It can be seen that the in the beginning of the test, sample B is more effective, but in the final stage of the FADE 2 test section are the friction properties also very similar. The higher efficiency of sample B in the low temperature field could be caused by better contact between the pads and the rotor. The effectiveness drop is from 0.45 to 0.34, that means the relative drop is 24%. The commercial brake pad line B shows that the effectiveness drop is more even than line A. The effectiveness B line decreases from 0.51 to 0.34, which means the relative drop is 33%.

Another critical property of the brake pads was wear. Each brake pad thickness was measured on four different spots before and after the AK Master testing procedure and also the weight was measured before and after the test. Table 1 shows the thickness loss and weight loss of the sample A and B before and after the AK Master procedure.

Table 1 Thickness and weight loss of sample A and B

	Thickness/(mm)	Weight/(g)
Sample A	0.991	11.1
Sample B	0.727	10.0

In comparison to the sample A, the sample B was more effective in term of friction performance. As it can be seen in Table 1, the average wear of the sample A was greater than of the sample B. The weight loss was also higher for sample A than for sample B. This may be caused by different structure of the tested friction composites and different ratio of the components of the composites.

3. CONCLUSIONS

The goal of this paper was to prove that it is possible to prepare brake pads with comparable friction performance and wear with commercial pads in laboratory conditions. The performed tests show that the laboratory-manufactured brake pads are approx. equally effective to selected commercial brake pads. This is obvious from FADE 2 test, where the commercial brake pads have higher friction coefficient in the low-temperature. However, the results also show that the laboratory-manufactured friction composite has greater wear. This means that these laboratory-prepared brake pads are less economical and maybe also less environmentally friendly than tested commercially used brake pads.

Nevertheless, the tests show that it is possible to prepare functioning brake pads in laboratory conditions and further studies are going to be carried out.

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