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ASPECTS REGARDIND THE EVOLUTION OF TEMPERATURE IN THE AUTOMOTIVE BRAKE PAD BY USING INFRARED THERMOGRAPHY

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ABSTRACT: The need of reducing weight in automobiles has led to both considerable changes in design and search for lightweight materials. Non-azbestos organic compositesare promising candidate for automobile applications since they offer high specific stiffness and strength, good wear resistance and thermal properties. Non-azbestosorganicfiber reinforced in metallicfrictioncompositesare increasinglybeingused inautomotivebrakedisc pads,shoes,linings,blocks,clutchfacings,and soforth. Different laboratory formulations were prepared with binder, structural materials, filler, frictional additives and varying coconut fibre using powder metallurgy technique. In this paper it has permormed a tribological study to improve the performance characteristics of the new composite material. In order to conduct this study were performed pin composite which plays brake pad in real vehicles braking systems. The aim of this paper is to study the evolution of the temperature field during the process of aging in pins made of new composite material.
Keywords: material, composite, coconut, tribometer, pin, disk

1. INTRODUCTION

The need of reducing weight in automobiles has led to both considerable changes in design and search for lightweight materials. Non-azbestos organic compositesare promising candidate for automobile applications since they offer high specific stiffness and strength, good wear resistance and thermal properties, [1]. The advantages of the composites can be categorized as those related to materials and those concerned with the application parameters, conditions, modes, methodology and application conditions.They include applied load, sliding distance, speed, environment, wear mode, test configuration, [1]. Non-azbestos organic composites has modern automotive disc brake systems experience a wide range of contact scenarios, which continue to remain a perplexing subject for researchers. The primary focus on the interaction of the two main components the disk and brake pad. The wide variety and complex make up of these components along with changing environmental conditions make understanding the exact mechanics beyond the basic idea of friction difficult. In general the tribological contacts present in automotive brakes involve dry sliding contact at varying speeds and contactforces. There is a large amount of published literature suggesting there is an existence of a friction layer that plays a large role in contact interaction of pad and disk brake, [2]. A series of brake stops at a variety of operating condition were performed and the observed values of coefficient of friction were averaged to provide a single value which is referred for analysis, [3]. The automotive braking, for either large or small machines is the most complex and sensitive area of study. Brake performance is influenced by brake disc material brake pad pair, rubbing speed, applied force, [4]. Frictional behavior of the material pairs is very complex due to additional factors like, temperature, prior usage history and the asperities, wear debris, surface contact percentage of drum-liner rubbing surface.[5]. The friction coefficient stability under different operating conditions have been targeted and the performance with aluminium composite brakes have been reported in terms of stability of friction coefficient, surface temperature and wear resistance,[6],[7]. Temperature is thought to have the largest effect on wear and frictional behaviors. Increased temperature affects the mechanical properties as well as acting to more rapidly form oxidation layers, thus greatly reducing contact, [8].

Local high temperature on the pad contact surface can reach flash temperature that is hundreds of degrees higher than that of the bulk of the material. This results in softening of the pad materials leading to a weakened fiber matrix and an overall decrease in the strength of the materials. As temperature increases material shear strength decreases resulting in a decrease in the coefficient of friction. Increased temperatures can also lead to the formation of oxides at the contact interfaces. Certain oxides have lubricating characteristics and may act to aid the lubricating materials already present in the pad. Some disks are prone to large variations due to heat cycles. As previously mentioned the increase in temperature weakens the materials in contact. This leads to increased thermal stress and increased wear. Pad bonding materials are usually suspected of a high rate of degradation under elevated temperatures, [8]. .

The aim of this paper is to study the evolution of the temperature field during the process of aging in pins made of composite material created. In this sense the tribological experiments will be performed on a pin on disc tribometer, under dry friction.

2. MATERIALS AND METHODS

In order to achieve the tribological experiments were performed pin composite. These samples together with iron disk samples will be mounted in the pin on disc tribometer. The composite pin`s mounted in the tribometer take cylindrical form. In the present investigation four identical size brake pins were manufactured of: aluminium, graphite, aluminium oxide, zirconia oxide, phenolic resin and coconut fiber. Table 1 presents the detail formulation of four different types of organic materials for pad disks. In order for making the composite pins was started from a mixture of raw materials shown in Table 1. The raw materials were milled at a speed of 200 rot/min for 5 minutes. After the milling process, the ingredients are mixed and introduced into the mould where it is pressed with a force of 10 N.

Table 1. Formulation of coconut fibre reinforced aluminium brake pad materials

Patern composite	Aluminium [%]	Graphite [%]	Zirconia oxide[%]	Silicon carbide[%]	Aluminium oxide[%]	Phenolic resin [%]	Coconut fiber[%]
CP 1	25	10	2	10	13	40	0
CP 2	20	10	2	10	13	40	5
CP 3	15	10	2	10	13	40	10
CP 4	10	10	2	10	13	40	15

The dimensions of the realised pins are presents in Figure 1 and the product of the pin is shown in Figure 2.

Tribological experiments consists on pressing the composite pin on the surface of a rotating iron disc. In order to determine the tribological characteristics, the iron disc and composite pin were mounted in the assembly of pin on disk tribometer, located in the Laboratory of Machine Parts in the Faculty of Engineering of Hunedoara. In experiment, iron disk play the role of brake disk of all real vehicle braking system and the pin`s play brake pad role. The cinematic scheme of tribometer is shown in Figure 3.

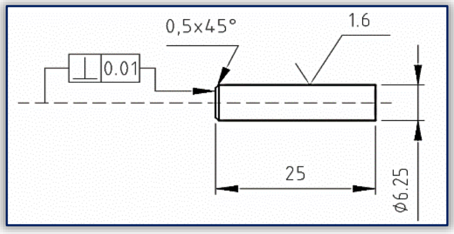


Figure 1. Composite pin size

Figure 2. The finished composite pin

The features of the pin on disctribometer are: electric motor P=1kW, speed n=1500 rot./min, distance between the axis of rotation and specimen d=75 mm, material of the rotating disk is cast iron.The principle of the experiment consists on pressing the composite pin on the surface of a rotating iron disk. The pressing pins surface on the disk was performed with three different forces: 5, 10, and 15 N. This three forces are applied to the lever 4 that allows them to different rays positioning test. Constructive scheme of the lever is presents in figure 4. After the first test was found that lever does not allow a uniform pressure of pin on the disk surface. For this reason was design an arm whose constructive scheme shown in Figure 5. This allows uniform pressing composite pin on the iron disk surface. Figure 6 shown the pin - disc assembly after it was achieved the new arm.

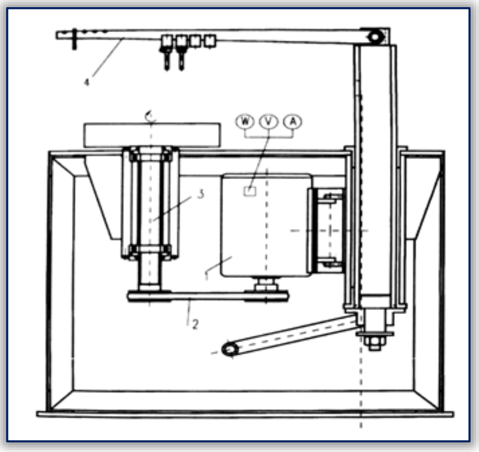


Figure 3. Cinematic scheme
of pin on disc tribometer
1- electric motor; 2- belt drive; 3- vertical shaft rotating disc; 4- lever

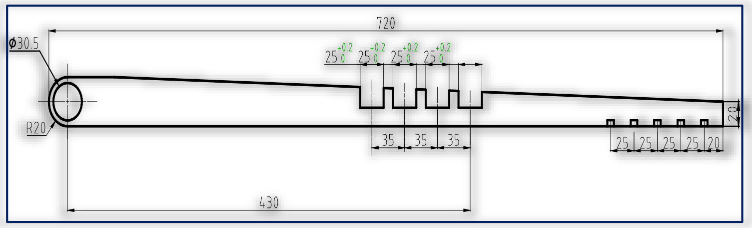


Figure 4. Constructive scheme of the tribometer level

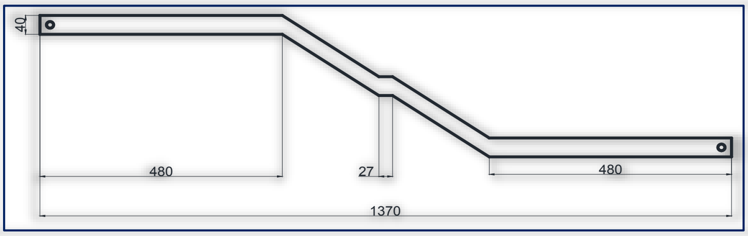


Figure 5. Constructive scheme
of the new tribometer arm designed

Figure 6. Disc-pin assembly

3. RESULTS

Disk speed depends on sliding speed and range of work. The time of each test depends on the sliding speed. Table 2 shows the relationship between parameters used to performe the tribological experiments. The values resulting from the calculation are presented in the Table 2.

Table 2. Testing parameters

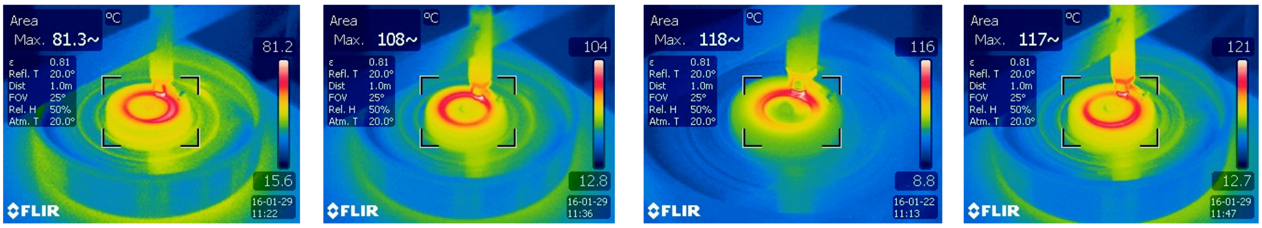
Iron disc speed [rot/min]	Range of work of disc sample [mm]	Sliding speed [m/s] V = ω R	Angular speed [rad/s] ω = π n / 30
1500	25	3,92	157

For each pin composite were performed tests for four different lengths. During the experiments the evolution of friction couplings temperature is determined using a FLIR thermography cameras Thermo CAM Quick View. Captured images can provide information about the evolution of the temperature of the pairs in contact. Highlighting the temperature field by thermography is based onthe relationship between the distribution of the radiation emitted from the composite pin and its material properties.Acquired images showing the distribution of the temperature on the surface analyzed. The advantages of using thermography to determine the temperature distribution is to track changes in real time of accumulated temperature in the brake pad throughout the braking.Temperature distribution can be expressed through color scale units of thermographic images. This images are based on the combination of suggestive colorsand allow thorough investigations on areas of interestor detection of potential high risk areas it is important to know the temperature distribution on the surface of composite pins who plays brake pads role. [9]. Table 3 presents the temperature in the composite pins in friction process using three different forces.

Table 3. The temperature in the composite pins during experiments

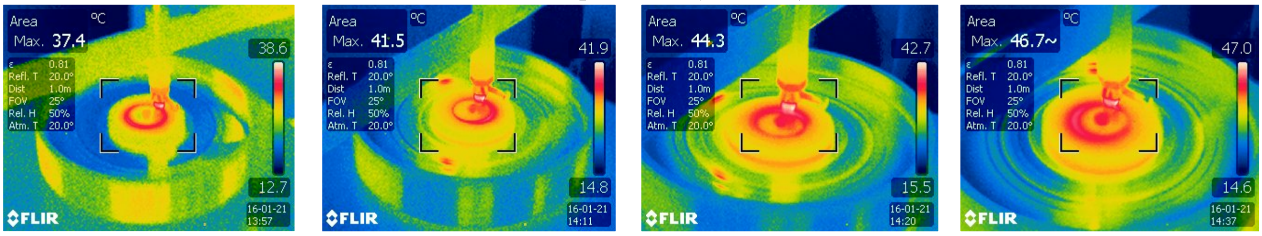
Force [N]	Length of work[m]	Trial time [min]	Temperature[°C]			
			0%	5%	10%	15%
5	500	2,12	66,2	37,4	39	50,1
	1000	4,25	80,8	43,8	41,9	58,3
	1500	6,37	83,9	59,4	42,7	69,0
	2000	8,50	-	59,8	47	70,1
10	500	2,12	-	81,2	85,1	73,9
	1000	4,25	-	104	116	75,5
	1500	6,37	-	116	126	90,2
	2000	8,50	-	121	119	87,8
15	500	2,12	-	115	85,1	89,9
	1000	4,25	-	141	116	91,5
	1500	6,37	-	151	126	92,7
	2000	8,50	-	148	119	91,0

If the pin made without coconut fiber after running between 500-1500 m its destruction occurred. It also notes that temperature in the contact area is greater since the early experiments. This is explained by the fact that, pin structure is not adequate, coconut fiber is use like filler material. For 15% coconut fiber composite, there is a smaller variation of the temperature field than other variants. This requires a lower temperature accumulation in the structure of the pin. Figures 7-9 are presented images showing the evolution of temperature at the point of contact between pin and disk and all temperatures in composite pin`s.



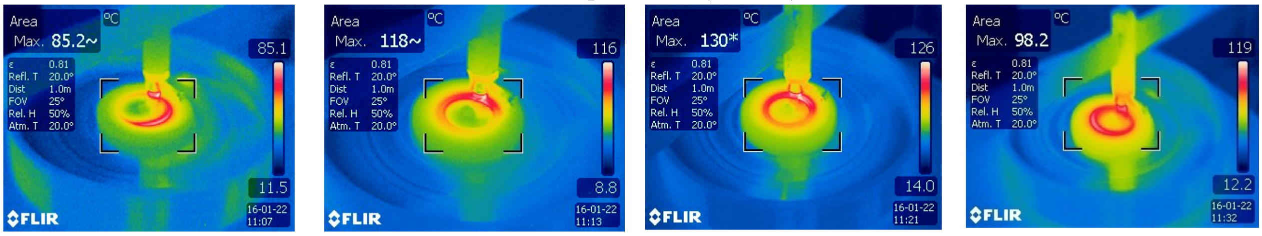
L = 500 m L = 1000 m L = 1500 m L = 2000 m

Figure 7. Evolution of the temperature in the composite for pin with 5% coconut fiber at the end of wear experiments, F=10N, R=25mm



L = 500 m L = 1000 m L = 1500 m L = 2000 m

Figure 8. Evolution of the temperature in the composite for pin with 10% coconut fiber at the end of wear experiments, F=5N, R=25mm



L = 500 m L = 1000 m L = 1500 m L = 2000 m

Figure 9. Evolution of the temperature in the composite pin with 10% coconut fiber at the end of wear experiments, F=15N, R=25mm

5. CONCLUSIONS

The experiments simulates the actual operating condition of the brakes and provides an opportunity to evaluate the operating performance of the pad brakes in similar operating condition at the design stage more accurately before the brakes are put in actual operation.

The facility helps in comparative analysis of the different brakes material in the simulated condition which helps in selection of right material for a wide range of input parameter values.

In the contact zones the temperature rises rapidly in the first part of the test, this period finishing asperities being treated with the composite structure, so as to cover the distance of 500 m in the contact area reaches 115°C at a force of 15 N. Between 500-2000 m, temperature rises less and in the end of the tests, the temperature drops. At the end of the test period, the iron disc has bigger temperature than pin composite which shows a better distribution of temperature on the composite material.Between 1500-2000 m the temperature starts to drop. Most of the heat is dissipated in composite pin which in the real coupling represents the brake pad.

The study led that natural coconut fibre is a potential candidate for the automotive brake pads.

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