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Friction and Wear Properties of a New Semi-Metallic Brake Pad According to SAE J 661: A Case Study in PARSLENT Complex (Iran)

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***Abstract* — Semi-metallic brake pads comprising different friction materials with determined proportions were designed. SAE J 661 was selected to evaluate friction and wear behavior of these brake pads. The average friction coefficient of seven wear stages i.e. first baseline, first fade, first recovery, wear, second baseline, second fade and second recovery were 0.371, 0.363, 0.352, 0.374, 0.390, 0.362 and 0.353 respectively. All friction coefficients of these stages were in the range of 0.35-0.45, which were accordance to standard. Moreover normal and hot friction coefficients of brake pads were 0.364 and 0.352 respectively. As a result new semi-metallic brake pads gained F class category of friction coefficient classification. Finally the percentage of wear rate after seven wear stages was 1.67% which satisfied wear rate principle of SAE J 661.**

***Index Terms* — Friction Coefficient, Wear, Brake pad, Composite.**

I. INTRODUCTION

One of the important parts of an automobile is brake system due to its vital role [1, 2]. Friction between brake pad and disk converts the kinetic energy of automobile to thermal energy. So the friction coefficient between pad and disk and wear behavior of pad must satisfy standard requirements [2]. Society of Automotive Engineer has defined a new version of evaluation of wear and friction coefficient properties of brake pads (SAE J 661) [3]. According to SAE J 661, seven steps are defined for wear test: first baseline, first fade, first recovery, wear, second baseline, second fade and second recovery. Based on these stages, normal and hot friction coefficient of brake pad is reported. These values must be in range of 0.35 – 0.45 for passenger vehicles to satisfy F classification standard. Achieving to this requirements and classification needs to select proper materials for composite pad formulation. There are several categories of brake pads based on materials constituted such as metallic, semi – metallic and ceramic brake pads [1, 4]. Semi - Metallic brake pads is made of metallic and non metallic materials. Metallic materials such as copper helps to transfer heat and non metallic materials such as barite have filler role [5, 6]. The most chemical composition of brake pads are unknown because: 1) brake pads are trading and formulation of a brake pad is belonged to its company 2) a brake pad must satisfy several desirable properties such as wear rate, thermal stability and low noise, so selection of a proper formulation needs many experimental tries [7, 8]. There are many studies about friction materials of brake pads [1-15]. Some studies focused on the optimization of brake pads performance. Xin et al. [9] optimized the amounts of sisal fiber in a brake pad which was made of resin, copper, barite, feldspar, ZnO, antimony trisulfide, clay and sisal fiber. By fixing the amounts of all constituted, the optimum point of friction and wear properties of composite was reported with the proportion of 3:4 between resin and sisal fiber. Moreover they realized that sisal fiber is a good candidate for substitution of asbestos in trading brake pads. Some studies defined asbestos free brake pads which utilized new or waste materials [9, 10]. Ademoh and Olabisi [10] developed maize husks (asbestos free) based brake pad. The results of their work showed that coefficient of friction, abrasion resistance, water absorption, oil absorption, density, hardness, tensile strength, compressive strength, and thermal conductivity of maize husk filler based brake pads compared favorably with commercial brake pads and those produced in past related research works on asbestos free brake pads. Some studies focused on the environment issues related to diffraction of hazardous constituted materials of brake pads such as copper [11, 12]. Straffelini et al. [11] presented a review article in this field. They mentioned that similar to other heavy metal emissions, even the release of copper into the atmosphere may have important environmental and health effects. So they introduced some replacements for copper in brake pads such as graphite. In this study, a new semi – metallic brake pad has been developed and friction and wear properties of it have been evaluated according to SAE J 661.

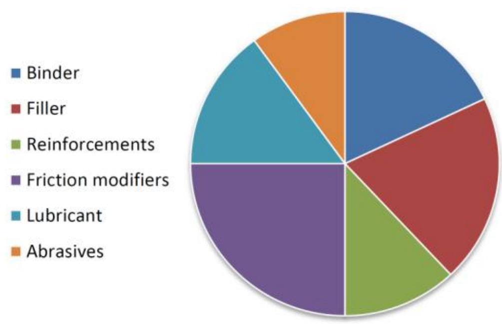

Fig. 1: The portions of different categories of friction materials in the new semi – metallic brake pad.

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Fig.2: The new semi – metallic brake pad.

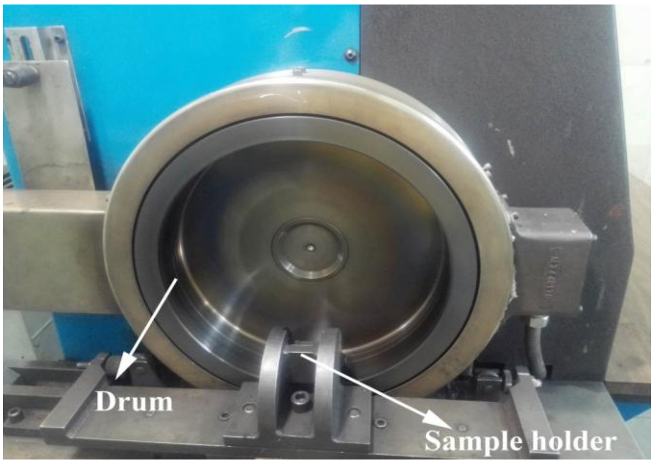

Fig. 3: Drum of wear test machine: A sample with dimensions of 1 in × 1 in × 0.25 was fixed in sample holder for wear testing of CHASE dynamometer machine.

II. Experimental procedure

According to Fig.1, the friction materials were mixed for 20 min in a mixer machine and then poured to Mercedes -Benz-E250 mold brake pad for hot pressing to back plate. Finally all samples were hot pressed and subsequently annealed. The annealed sample was shown in Fig. 2. A sample with dimensions of 1 in × 1 in × 0.25 was prepared from product for wear testing of CHASE dynamometer machine (Fig. 3) and the mass of it was measured (10170 mg).

III. Results and discussions

Fig. 4 shows seven steps of wear test. In the first baseline, friction coefficient of brake pad was evaluated during 20 cycles of pedaling. In the first fade stage, friction coefficient of brake pad is measured automatically and the effect of temperature on the friction coefficient value is determined. Decreasing of friction coefficient in this stage is due to decomposition of binder [8]. As can be seen, the friction coefficient of brake pad in the first baseline and first fade are in the range of standard (0.35 – 0.45). In the first recovery stage, rising of temperature is stopped and friction of coefficient is evaluated during decreasing of temperature. This is a very important stage for brake pad because it must recover previous frictional behavior. Fortunately, the brake pad recovered previous friction coefficient in this stage and its value is in accordance of standard. In addition, the friction coefficient was increased slightly. After first three stages, the wear behavior is measured for 100 pedaling numbers at a constant temperature approximately. According to fig. 4, similar to other stages, the friction coefficient of wear stage is in the range of standard definition. For insurance of friction and wear properties of brake pad, three first stages were repeated: second base line, second fade and second recovery. Finally the sample was weighted secondly (10000 mg) and its loss of weight was calculated (170 mg). According to SAE J 661, the loss of weight of a brake pad after seven wear stages must be lower than of 1.230 gr. As a result, the new semi – metallic brake pad passed this remark too. The normal and hot friction classification of brake pad is F because the normal and hot friction coefficient values were 0.364 and 0.352 respectively. These values are recorded automatically by the friction machine. In the driving test, this new brake pad has not any damage effect on the drum of automobile.

There are several studies about wear analysis of brake pads. Ma et al. [4] investigated the effect of zirconium silicate as an abrasive on the brake friction performance. They reported that by increasing weight percent of zirconium silicate, the friction coefficient of brake pad is enhanced but the wear rate is depressed. Singh et al. [13] used lapinus – wollastonite fibers in the friction composite materials and carried out wear test of samples which were different in the amount of both fibers. They concluded that the increased lapinus fiber content was observed to enhance the friction performance, friction stability and friction fade performance; whereas, increased wollastonite fiber was observed to enhance the wear performance, recovery performance and friction variability of the friction composite. Bijwe et al. [14] studied the influence of modified phenolic resin on the fade and recovery behavior of friction materials. As a result alkyl benzene modified resin showed best wear performance among cashew nut shell liquid modified, alkylbenzene modified, NBR modified and linseed oil modified resin. Jaffar et al. [2] applied SAE J 661 to evaluate 10 formulations (15 types of materials) and select best formulation according to wear test results. The most important result of their study was dependency of wear results to materials constituted brake pads. That mean achieving to a proper wear properties needs several experiments with different chemical compositions to select best formulation. New semi – metallic brake pad of this study was manufactured by several experiments and trials and errors too. Some studies investigated the thermal characterization of brake pads [15]. Thermal analysis is important due to fade phenomenon in brake pad during rising of temperature. By applying this technique, Ramousse et al. [15] discovered the decomposition of the binder system takes place between 250 and 475°C in a trading brake pad.

It must to be said, some studies have evaluated wear properties of brake pads by variation of sliding speed and nominal contact pressure of wear test machine (out of standard authorization) [7]. The aim of these studies is investigation of wear test parameters on the friction behavior of materials pad. Kchaou et al. [7] carried out wear test of brake pads in three conditions: Sliding speed (m/s) / Nominal contact pressure (MPa); 3/0.6,6/1.2 and 9/1.8. They reported that in the high contact pressure, the friction coefficient is degraded relative to low contact pressure. The reason of this phenomenon is agglomeration. A higher contact pressure augments particulate bonding within the wear particle agglomerates.

IV. CONCLUSIONS

Overall, All friction coefficients of seven stages of SAE J 661 were in the range of 0.35-0.45, which were accordance to standard. Moreover normal and hot friction coefficients of brake pad were 0.364 and 0.352 respectively. That means new semi-metallic brake pads gained F class category of friction coefficient classification. Moreover the percentage of wear rate after seven wear stages was 1.67% which satisfied wear rate principle of SAE j 661. In the driving test, this new brake pad has not any damage effect on the drum of automobile.

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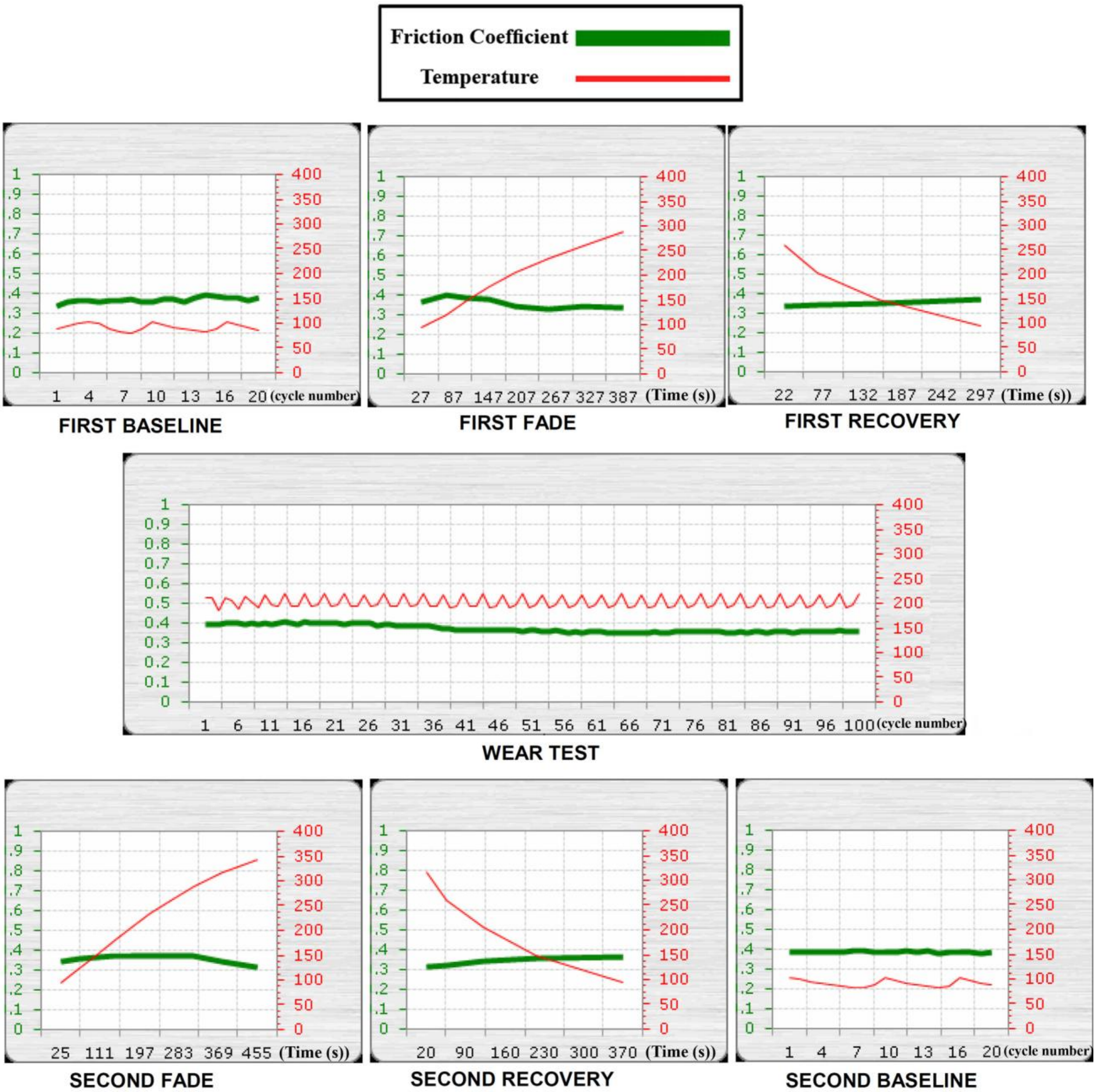

Fig. 4: Seven wear test stages of semi-metallic brake pad according to SAE J 661: first baseline, first fade, first recovery, wear, second baseline, second fade and second recovery.

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