Tribological Analysis of Automotive brakepad

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Abstract - *The present investigation describes the tribological behavior of commercial automotive brake pad. As one of the most important components of an automotive vehicle is the brake pad. In this study focused on the tribological behavior of carbon-semi metallic brake pad material, with the help of pin-on-disc tribometer wear analysis was investigated. The experiment was conducted at room temperature at constant load with three different rotating speeds. The effect of some elemental composition material of pad, in particular of carbon and iron, the devlopment of tribological layer and wear particles. The microstructure properties of brake pads were investigated with a scanning electron microscope (SEM) and energy dispersive X-ray spectroscopy (EDS) is used to find the material elemental composition. Investigating the morphology of the pads surface.*

Key Words*: *Brake pad material, Pin-on-disc tribometer, Scanning Electron Microscope (SEM), Energy Dispersive X-ray spectroscopy (EDS).

1. INTRODUCTION

A brake is a mechanical component that prevents a motion by absorbing energy from a moving system. To prevent or to stop the motion of a vehicle the brakes are used. Brake pads are the major components of disc brakes used in automotive applications. The brake pads are the steel backing plates with friction material, which bound to the surface that faces the disc brake rotor. The pads, which converts kinetic energy into thermal energy with, help of friction.

The brakes performance based on mixture of various percentage of materials and microstructure of the brake pad material. In order to achieve good frictional properties more number of ingredients were used, such as fibers, friction modifiers, binder, fillers, solid lubricants, etc. which all bound by phenolic resin [3-7,11]. Actually, the brake pad material should maintain a high coefficient of friction, low temperature and humidity [11,28]. Metals, such as copper, aluminum, steel, brass, and iron are utilized so as to influence the wear behavior and frictional properties [8]. Composite material like banana peel powder, palm kernel shell, [9,10] egg shells[13] eco-friendly materials like bagasse, rice husk, sawdust, lemon peel powder[31-33,35] can be used as asbestos-free brake pads. The copper metal matrix plays a major role in excellent braking [21]. Addition of aluminum clay particles acts as load bearing and solid lubricants [18], the presence of carbon improves in wear resistance [24,25].

These days, brake pad material manufacturers are taking measures to check the quality of the materials regularly to meet the end user needs steady coefficient of friction [3], low wear rates [2], long life of contact plateau [1], minimum temperature at high sliding velocity[7], particle size [4,30,33] noise affecting the COF and particulate matter affecting the environment[10,12-14]. Many investigations carried out so far and friction layers shown by the wear. Typically, smaller size particles composites give better results than the larger. Due to the tiny particle size, there will not be any gap between the various materials in a composite [15]. The contact of disc and pad, the primary and secondary plateaus are formed. Due to tangential forces, plastic deformation seen in primary plateau corresponds to copper, brass fiber metals, which are worn resistant ingredients. The secondary plateau was found with good elastic properties [16, 17].The microstructural transformation takes place in the friction layer while sliding against the cast iron disc. Addition of aramid fibers shows improvement in tribological performance but the drawback is the disc temperature increases with increase in aramid fiber [18, 19]. Potassium titanate was added with the different crystalline structure for pad material, an increase in crystallinity which shows the moderate and stable coefficient of friction and increase in wear rate [20].

In the present work, Tribological properties and wear rate of carbon semi-metallic investigated on pin-on-disc equipment, the pads frictional material dry sliding against the cast iron disc, under at a constant load and different speeds, the braking gets quick and shorter under dry condition [34]. The main intention of the work is to the comprehension of wear components that lead to producing wear debris. The specific equipment like dyno-test and bench test are available, so no experimental setup has been designed to reproduce real braking [11]. The microstructural and elemental compositions of the worn out pads material investigated with help of scanning electron microscope (SEM), energy dispersive X-ray spectroscopy (EDS) analysis.

2. EXPERIMENTAL PROCESS

2.1 MATERIALS

In the present work, a commercial carbon semi-metallic pad material and a cast iron disc were used for the wear test [11]. Carbon replaced with copper and addition of aramid fibers in NAO pads improves in tribological properties [12,19]. The coefficient of friction and fraction plateaus between SM and NAO revealed by L.Y Barros et al [17] compared with LM by P.D Neis et al [17]. Table 1 shows the elemental composition of the brake pad, as measured by energy dispersive X-ray spectroscopy (EDS). Figure. 1 demonstrates a case of the complex microstructure of the brake pad material. With the assistance of EDS investigation, few parts were recognized and comparing outcomes with literature data [11]. The presence of a large amount of carbon and iron oxides can be clearly noticed. The temperature measured with a digital infrared thermometer while testing on pin-on-disc.

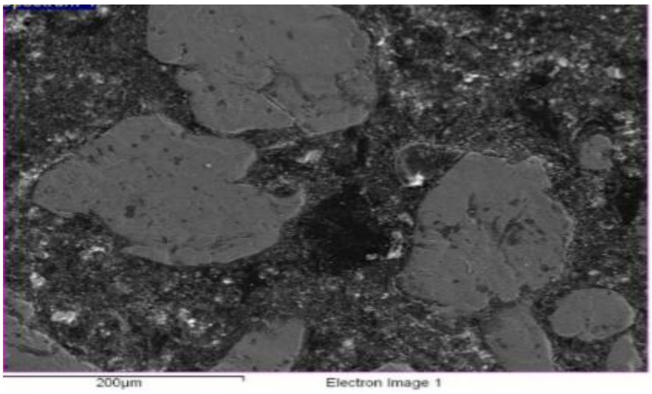


Fig -1: The microstructure of brake pad material. A portion of the material parts are shown.

2.2 Experimental and wear test analysis

At room temperature, the dry sliding test carried out on a pin-on-disc testing device. Cylindrical specimens were machined from brake pad (Figure. 2). They had a pin diameter of 12 mm and a height of 22 mm as per ASTM standards G099. The pins were abraded on the base of the pin with silicon carbide 600,800 grit paper it offers minimal surface damage and stable contact with pin and disc. The wear test carried out at a sliding velocity, v of 3.14 m/s and for 60 minutes, for a distance of 1000 m. The pins were investigated at three different speeds 300,600,900 rpm and at a constant load of 30N. During each test, the wear rate, the coefficient of friction was recorded [11]. The temperature was recorded with a time interval. For this purpose, a digital infrared thermometer is used. The surface morphologies of the worn out pads were investigated in a scanning electron microscope. SEM-EDS is utilized to examine the microstructure and to know the elemental composition

Table -1: Elemental compositional details of the brake pad material measured by EDS.

Element	Weight%
C	37.01
O	14.38
Mg	2.11
Al	0.81
Si	0.59
S	2.45
K	0.28
Ca	0.45
Fe	31.68
Ba	10.24

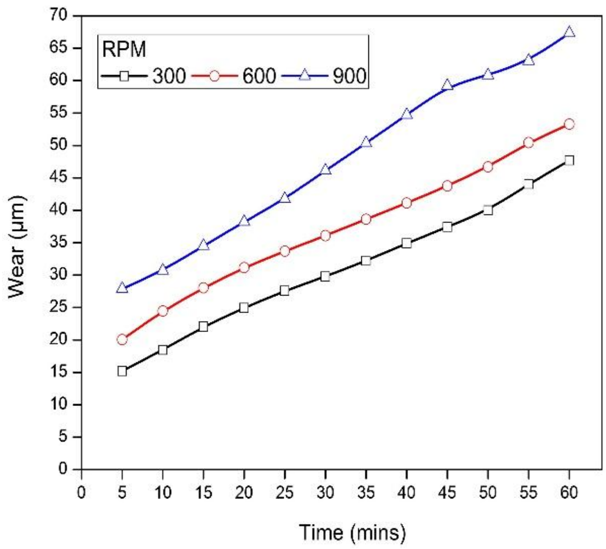
Fig-1 : Samples of brake pad material in cylindrical shape

3. RESULTS AND DISCUSSION

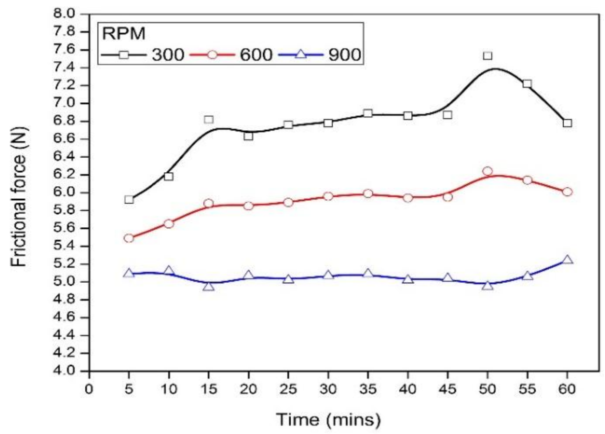
3.1 FRICTION AND WEAR ANALYSIS

Figure. 3. Shows evolution of curves of pin temperature, wear rate and friction coefficient for different speed, i.e., at 300, 600, 900 rpm at a constant load 30N with respect to time. After running a short time, the friction coefficient accomplishes a consistent state value in the 5.02-5.07 N range. On the other hand, the temperature is increasing with sliding distance and time. Due to continuous contact between pin and disc, there is a rise in temperature. The temperature is of the pin unable to cool down to room temperature because of the repeated contact with the disc. The temperature recorded with time interval using a digital infrared thermometer, at the end of each test for three different speeds 300,600,900 was recorded 40.3°c, 45.7°c, 54.4 °c, respectively. Steep temperature rise is seen on the pin contact with a disc with respect to time [26,27,29]. The recorded values of friction coefficient, temperature, and wear rate are listed in Table 2.

The wear rate acquired at the end of each test were 47.69µm, 53.29 µm, 67.31 µm, for the test at 300,600,900 rpm, respectively.



(a)



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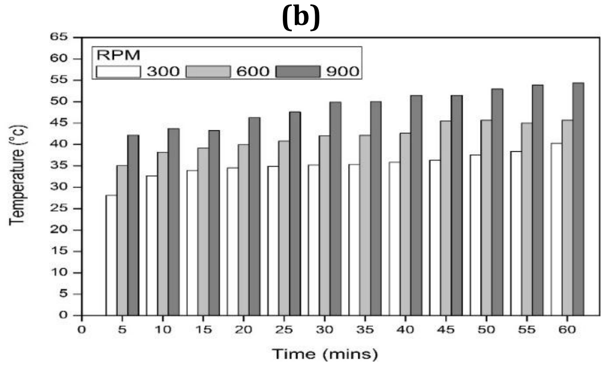


(c)

Fig -3: The variation of (a) wear rate, (b) friction coefficient and (c) temperature for the pin-on-disc test conducted at 300,600,900 rpm, respectively

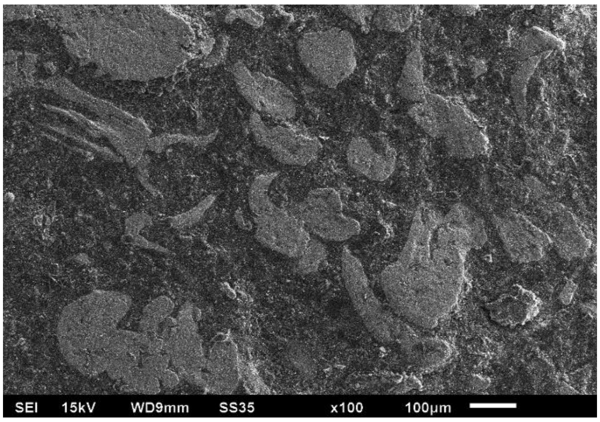
Table -2:

Samples	Speed	Max. Friction coefficient	Max. Wear rate	Max. Temperature
Sample 1	300	7.53	47.69	40.3
Sample 2	600	6.24	53.29	45.7
Sample 3	900	5.24	67.31	54.4

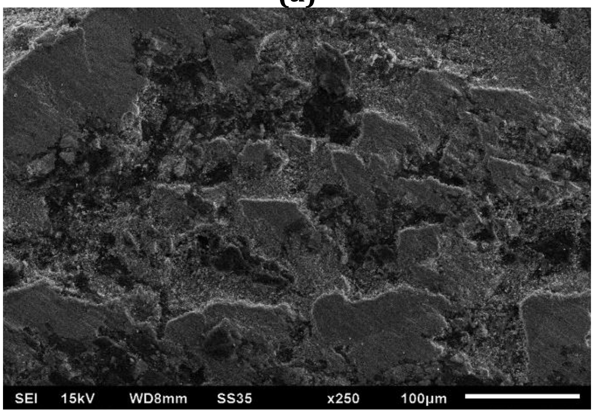
3.2 Analysis of wear tracks

Figure.4 shows SEM viewing of the wear traces on the pin at (a)300,(b)600,(c)900 rpm. The worn out surface is shown. In figure 4, the primary plateaus are made of iron (Fe) with carbon particles. The copper plays a major role in friction are known [5] but, polluting the environment with copper materials. Therefore, copper replaced with steel fibers, semi-metallic, barite gives better results and balanced primary and secondary plateaus were formed [6, 26,29]. EDS investigation featured the presence, majority phases are (C) carbon and (Fe) iron mixed oxides.

The main difference was detected in the test at different speeds are, the frictional force at lower speed shows high friction coefficient with less wear. At a speed of 600 rpm, the formation of cracks found which is shown in Figure. 5(a) [29]. Potassium acts as a reinforcing material which is primary plateau [27]. At a speed of 900 rpm the formation of crack found in the compacted debris shown in Figure. 5(b). Carbon is hard material and Ba is used as filler material, it is a noise absorber and low reactive to binders like Mg, Ca.



(a)



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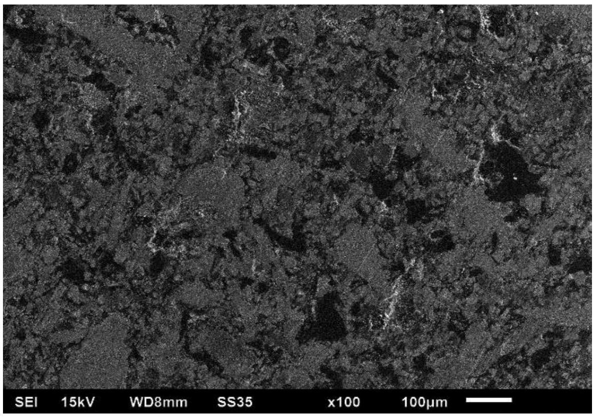
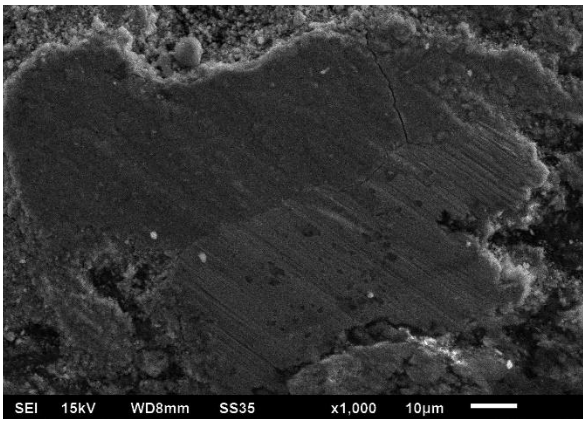
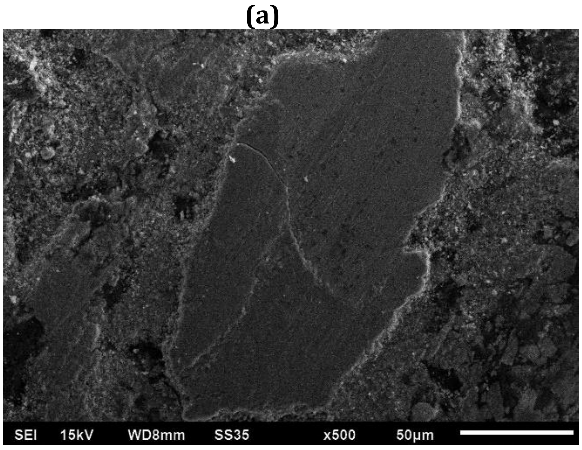


(c)

Fig-4: SEM micrographs showing the wear traces at 300(a), 600(b),900(c) rpm.



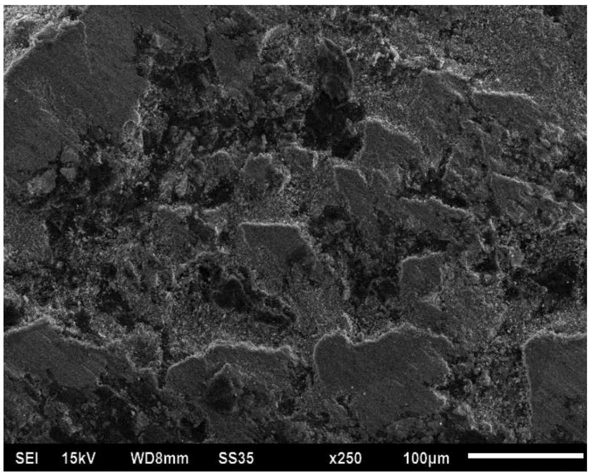
(a)



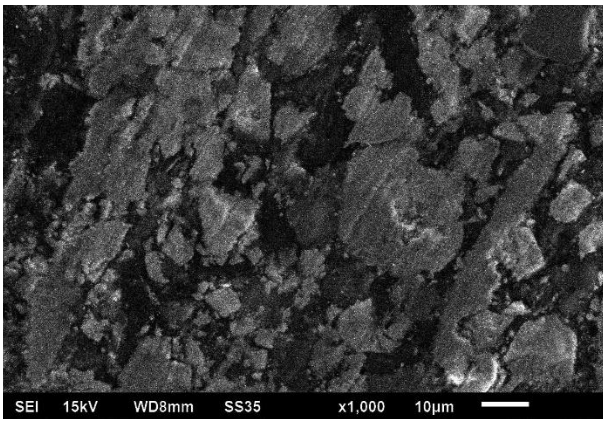
(b)

Fig-5: SEM images of morphological change cracks found wear tested at (a) 600,(b) 900 rpm.

Small cracks were spread to a worn surface when pits are found [21].The secondary plateaus are actually detected with loose particles visible at high rpm, which shows a rough grain size of wear particles. This can be seen in SEM images at higher rpm tested on a pin-on-disc, which is shown in Figure 6(a), 6(b)



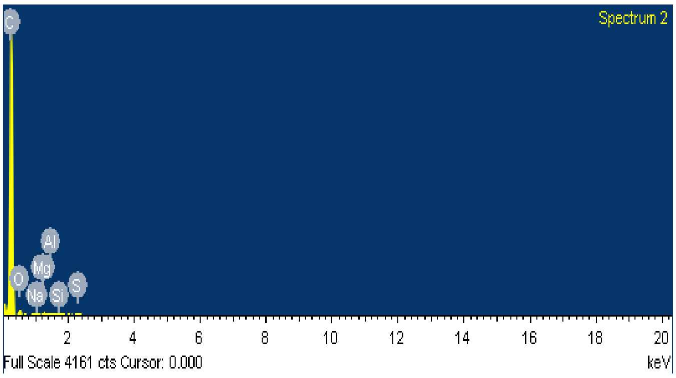
(a)



(b)

Fig-6: SEM images of the morphological attributes of the secondary plateaus samples tested at (a)600, (b)900 rpm, loose particles found in the image.

A particular comment is required for carbon and iron. Various EDS analysis confirmed the finding shown in Figure.7, the fact the carbon content Figure. 7(a) and iron content Figure. 7(b) is higher in the more compacted plateaus and lower in the less compacted plateau [11].



(a)

Fig-7: EDS analysis of spectrum 2 showing carbon content. Shown in Figure 7 (a).

The (C) peak shows worn surface was covered by a certain amount of graphite which gives rise to a generation of subsurface layers [21,23].

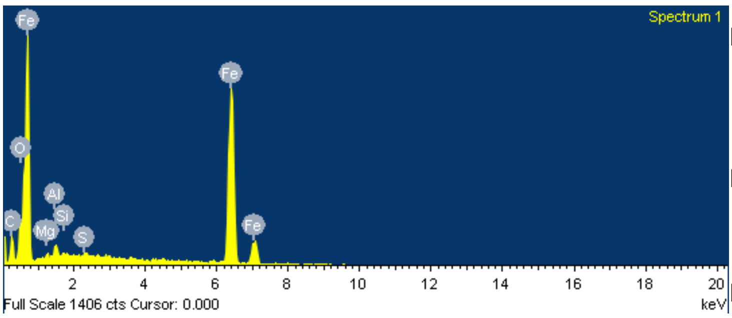


Fig-8: EDS analysis of spectrum 1showing iron content.

4. CONCLUSIONS

Pin on disc has investigated to study the wear analysis of brake pad material while continuous contact with the disc.

- At different speed and at a constant load wear analysis is investigated.
- Wear debris found between pin and disc surface.
- Carbon plays a major role in frictional properties tribological behavior in terms of brake pads.
- The material shows a higher coefficient of friction at lower rpm than higher rpm
- The temperature of the pin increases with increase in speed.
- Wear rate of the pin increases with increase in speed.
- At a speed of 600 and 900 rpm, cracks were found in SEM images, i.e., secondary plateaus were not stable.
- EDS analysis revealed the elemental composition of the material.

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