EFFECTS OF BORAX ON THE WEAR BEHAVIOR OF ORGANIC BRAKE LINING MATERIALS

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ABSTRACT

Industrial brake lining materials are composites which consisting many different components. The expected properties of a brake lining material are high stable friction coefficient and good wear resistance. Borax ($Na_2B_4O_7.10\ H_2O$), the most common compound of boron, was used in the brake lining composition because it is oxidized easily at high temperatures and creates an oxide layer that modifies the surface characteristics**.** In this study borax was added 1%, 3% and 5% in organic and inorganic fiber based brake lining materials. The mixtures were initially stirred for three minutes, then hot pressed at pressure of 80 bar and finally sintered at 800 ºC in a conveyor type furnace. Produced samples were tested with Chase type friction test machine according to SAE-J661 test procedure. Test results indicate that, friction coefficient increases and the wear behavior improves with the increasing amount of borax addition.

Keywords: Borax, Brake lining material, Powder metallurgy, Wear resistance

ORGANİK FREN BALATA MALZEMELERİNİN AŞINMA DAVRANIŞINA BORAKSIN ETKİSİ

ÖZET

Endüstriyel fren balataları birbirinden farklı bileşenler içeren kompozit malzemelerdir. Yüksek ve kararlı sürtünme katsayısı ve iyi aşınma direnci, fren balatalarından beklenen özelliklerin başında gelmektedir. Bor elementinin en bilinen bileşiklerinden olan Boraks ($Na_2B_4O_7.10H_2O$), yüksek sıcaklıklarda kolayca oksitlenerek arayüzeylerde oksit tabakası oluşturmakta ve bu oksit tabakası yüzey özelliklerini değiştirmektedir. Bu çalışmada, organik ve inorganik fiber içeren ticari kullanımdaki fren balatası kompozisyona farklı oranlarda (% 1, %3 and % 5) boraks ilave edilmiştir. Karışımlar üçer dakika özel mikserde karıştırıldıktan sonra 80bar basınçla sıcak preslenmiştir ve ardından konveyör tipi fırında 800 ºC' de sinterlenmiştir. Üretilen numuneler Chase tipi sürtünme test cihazında SAE-J661 standartına göre test edilmiştir. Test sonuçları incelendiğinde, boraks miktarının artmasıyla birlikte balatanın sürtünme katsayısının artarak aşınma davranışında iyileşme olduğu görülmüştür.

Anahtar Kelimeler: Boraks, Fren Balata Malzemeleri, Toz Metalurjisi, Aşınma Direnci

1. INTRODUCTION

Friction materials are composed of many different components and these components are grouped according to their functions under four main headings: (I) reinforcements and binder materials, (II) friction modifiers, (III) fillers and (IV) abrasives. While the reinforcement and binder materials are dispersed on the each side of matrix and provide resistance, rigidity and integrity; friction modifiers change friction coefficient [1,2]. Usually metal, carbon, glass, and kevlar are used as reinforcement materials and are classified as organic or metallic pads according to type of reinforcement material. When examined of temperature, friction and wear relationships, organic-based brake linings are more advantage is observed. Nowadays, use of organic fiber increased since organic fibers are lighter than the other fibers, their raw materials are findable and specific strength are low [3].

Friction modifiers are two types: solid lubricants and abrasives. They largely affect the friction behavior of brake pad. While the powdered abrasive material such as alumina increases the friction coefficient, solid lubricant such as graphite decreases [4,5]. In recent studies, boron and boron compounds are added in brake lining composition to modify the friction coefficient. In metallurgy, boron compounds such as borax and boric acid are used as protective slag-forming substance due to the ability to create sticky, protective and burr-free liquid. For example, due to property of solvation in metal oxides and prevent surface oxidation, the iron surfaces are coated with borax [8]. As a result of studies, use of borax and boric acid is creating resistance against wear and provide to improvement of friction coefficient has been observed [6].

In the present study borax was added in different proportions (1%, 3% and 5%) in organic and inorganic fiber based brake lining materials. The samples were produced by powder metallurgy technique and afterward were sintered. The aim of this study is to show that the effect of borax in brake lining materials. Generally in friction materials, friction coefficient decreases with increasing temperature and this condition is defined as “fade” means elongation of the braking distance. This unwanted event reduces the safety of the brake system [7]. However, the present test results show that while the temperature is risen the friction coefficient increased with increasing borax addition and also wear rate increase partially.

2. EXPERIMENTAL PROCEDURE

2.1. Sample Preparation

Borax was added in Eren Brake Company’s commercial drum-organic-brake lining composition with different proportions (1%, 3% and 5%) and three different compositions were stirred in an industrial type mixer for three minutes. The ingredients of the composition are given in Table 1. All samples are hot pressed at pressure of 80 bar and finally sintered at 800 ºC in a conveyor type furnace.

Table 1. The ingredients in organic-based brake lining composition

Ingredients	Materials
Binder	phenolic resin
Fillers	barite, calcium carbonate
Reinforcements	glass fiber, steel fiber, PAN, aramid fiber
Abrasives	aluminum oxide, iron oxide
Friction Modifiers	metal oxide, metal sulfide, ceramic, borax
Lubricants	graphite

2.2. Friction Test and SEM Analysis

Samples were measured as 25mm x 25mm x 7mm then wear and friction tests were conducted with Chase type friction test machine (Model GM x 11.3 Pyramid Precision Engineering) according to SAE-J661 test procedure (Fig. 1).



Figure 1. Chase type friction machine

After friction and wear tests, the distribution of components on the wear surface was examined with EDS and mapping analysis using scanning electron microscopy (JEOL 6060 model).

3. RESULTS AND DISCUSSION

Fig. 2 shows the average friction coefficients for four samples with different contents. Accordingly Fig. 2, the sample was added 1% borax has the highest friction coefficient value at 93º C, 149 º C and 205 º C and friction coefficient increased with increasing temperature up to 205 º C for all samples.

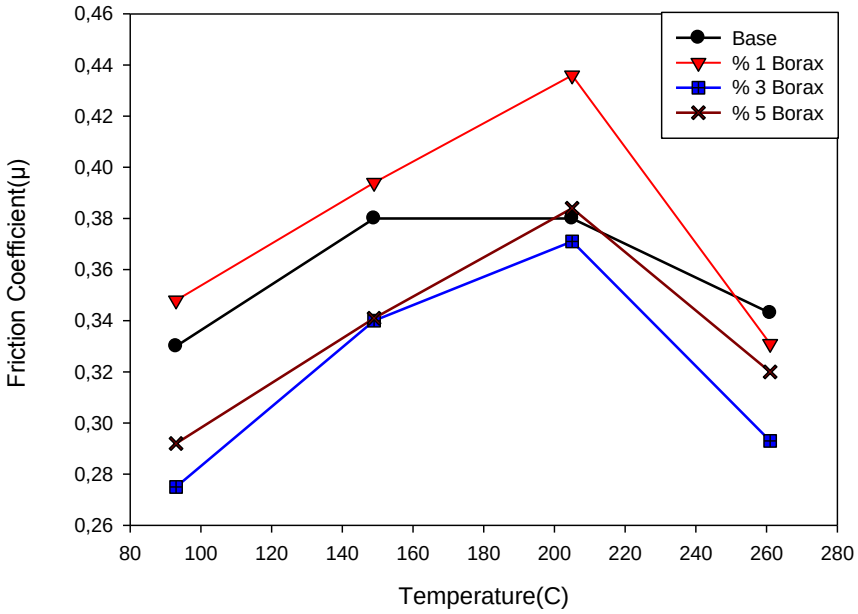


Figure 2. The average friction coefficients for different temperatures

The wear rates of the brake linings manufactured with different borax additions are given in Fig. 3. According the Fig. 3, the highest wear rate was measured in base brake lining composition and the lowest in 1% borax added sample. These wear results show that amount of wear decreased partially with the increasing borax rate.

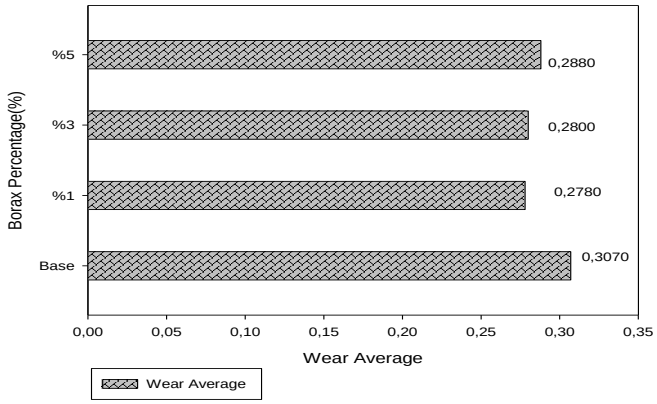


Figure 3. Wear average according to Borax percentage

Fig. 4 is SEM images comparison of samples at 100X magnification and four distinct areas are seen clearly in the each images. EDS analysis image of 3% borax added sample is given

exemplarily in Fig.5 and elementary analysis of four regions show that Table 2**.** According to EDS results, carbon and oxygen ratios in the first region; calcium, oxygen and iron ratios in the second region; iron, boron and oxygen ratios in the third region and oxygen, calcium and silicon ratios in the fourth region are higher than the other elements generally. The other elements are magnesium, titanium, sodium and sulfur in each region.

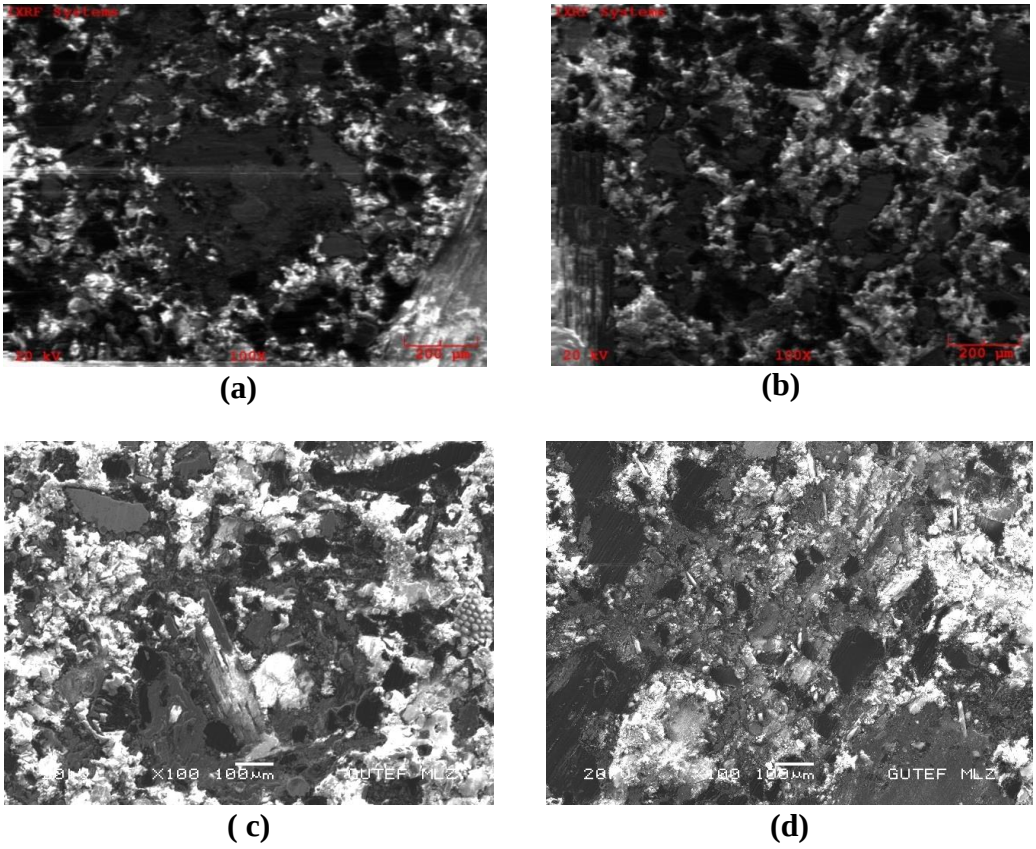


Figure 4. SEM images at 100 magnification of base specimen (a), 1% borax addition (b), 3% addition borax (c), 5% addition borax (d)

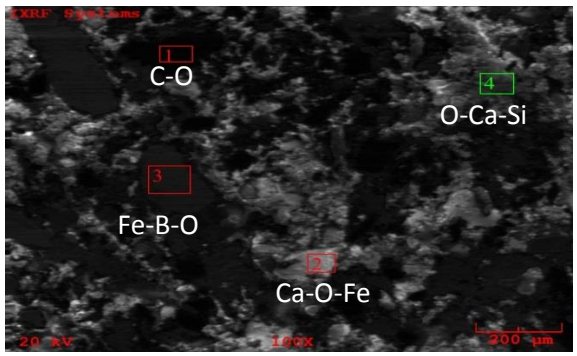


Figure 5. EDS image of 3% borax added sample

Table 2. The elementary analysis of four regions

Different Phases / Samples (%)	Region 1 % C- O	Region 2 % Ca-O-Fe	Region 3 % Fe-B-O	Region 4 % O-Ca-Si
Base	90-5,8	15,3-35,2-7,5	81,4-0-7,7	37,1-15,1-19,3
1 Borax	72,1-5,5	4,9-49,4-2,2	35,1-44-6,8	20-8,4-2,7
3 Borax	76,8-5,8	4,1-21,4-8,8	77,3-9-10,3	30,9-1,5-10,5
5 Borax	78,1-12,8	31,8-45-8,8	0,5-90-8	44,3-27-0,9

As a result of this study, wear rates of the borax containinig brake lining materials are approximately the same value with base material and the friction coefficient increases depending on the addition rate, were seen. Additionally, friction coefficient increases with increasing brake temperature was observed. This is an interesting situation because generally μ value reduces with increasing temperature in brake materials and this undesirable situation means prolongation of the braking distance in vehicles.

μ value of %1 borax addition sample is 0,34 at 93 ºC ; 0,39 at 149 ºC and 0,38 at 205 ºC. It shows that, even if 1% borax addition friction coefficient increases in hot work environments.

As the amount of borax increasing, the wear rate decreases and the μ value increases. This situation is borax easily oxidized at high temperatures and creates the interfacial oxide layer can be explained.

All of these results show that, borax can be used as friction modifiers in composition of brake lining materials.

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