Investigation of the Microstructure and Mold Life of Borided AISI 5630 Bims Mold

Doruk A. Alkan[1], Bülent Kurt[2]

[1]Engineering and Architecture Department, Nevşehir Hacı Bektaş Veli University, Nevşehir, TÜRKİYE
[2]Engineering and Architecture Department, Nevşehir Hacı Bektaş Veli University, Nevşehir, TÜRKİYE

Corresponding author: Bülent KURT (e-mail: bkurt@nevsehir.edu.tr).

Submitted on 03.02.2025, Revised on 04.02.2025, Accepted on 04.02.2025, Published online on 31.12.2025

ABSTRACT In this study, boriding was investigated on the surface of 5630 steel bims mold by using pack cementation diffusion method. For this purpose, a mixture of Al_2O_3, B4C and FeW and 10% NaBF4 was used as coating powder, and the AISI 5630 steel surface, which was the substrate material, was coated with the pack cementation diffusion method at 1000 °C for 4 hours and at 950 °C for 4 hours. The successfully obtained coated samples were sectioned and their coating morphologies, thicknesses and microhardness were examined. The phase structures formed on the coating surface were obtained by the X-Ray Diffraction method (XRD) and the Fe_2B layer assessed by optical microscope and micro-hardness testing. As a result of the study, the lowest coating thickness was obtained on the sample coated at 950 °C for 4 hours. Although the highest coating thickness was obtained on the sample coated at 1000 °C for 4 hours. As a result of the microhardness analysis, it was observed that the hardness of the coating layer was approximately 5 times higher (2416 HV) than the substrate material.

KEYWORDS Bims Mold, boriding, pack cementation.

1. INTRODUCTION

Pumice, a spongy rock resistant to chemical and physical factors formed due to volcanic eruptions, has two different characteristics: acid and basic. What separates these two groups from each other is the mineral differences they contain. While pumice with acidic characteristics contains Silicon, Aluminum, Potassium, and Sodium, pumice with essential characteristics consists of aluminum, iron, calcium, and magnesium components [1-5], During the formation, the sudden separation and cooling of the gases in the pumice from the environment creates a porous structure. These pores are not connected, and this causes the permeability of the pumice to be low and the heat and sound insulation to be high [1,2]. Due to these features, pumice is highly preferred in the construction sector. Pumice stones obtained from volcanic formation areas are mixed with cement, water, etc., in production areas and turned into pumice concrete by pressing. This production uses a mold belonging to the pumice concrete to be created in pumice production machines. Each mold has a certain number of presses, which varies depending on the wear coefficient of the pumice mold. Pumice concrete molds are produced from St52 (SJ355J2) metal, and the wear coefficient varies according to the type of steel [1-5].

Different techniques increase metals' resistance to abrasion. The most preferred among these is boron coating. Boron is a mineral found in large quantities in our country and in nature as a compound formed with oxygen due to its high affinity for oxygen [6]. The amount of the compound it makes with oxygen determines the commercial importance of boron. The increase in the amount of boron compound also increases its preferability. The most commonly used boron compounds are Tincal (Borax), Colemanite, Ulexite, Probertite, Boracite, Pandermite, Szaybelite, Hydroboracite and Kernite of these compounds, Tincal has 36.5% B_2O_3, while kernite has 51% B_2O_3 [7]. Colemanite, the most common boron compound, has 50.8% B_2O_3 content, while pandernite has 49.8%, ulexite 43%, probertite 49.6%, and hydroboracite 50.5% [7].

The boron coating process, which uses boron compounds, is a thermochemical process first used by Moissan in 1859. It is based on the enrichment of the steel surface with boron by diffusion [8]. The primary purpose of the process is to form a single-phase iron-boride layer (Fe_2B) on the material's surface, thus providing hardness to the material and increasing the wear resistance of the steel. The boronizing process is carried out at temperatures between 700 and 1100 °C for periods varying between 2 and 12 hours, depending on the properties of the material to be coated [8]. In the boronizing technique, three different layers are formed on the area to be coated. The first layer is the boride layer, while the transition (diffusion) region is below it. The main structure (matrix) is formed just behind the transition region [9]. Boriding can be performed using many different methods, thermochemical or non-thermochemical.

This study aimed to increase the service life of AISI 5630 pumice mold by boriding using the pack cementation method.

2. MATERIALS AND METHODS

After the technical drawing of the pumice mold was drawn, the 1500* 3000* 12 mm AISI 5630 sheet metal was cut with the laser cutting method and smoothed with a press. After the welding mouths were opened in a special welding mouth opening machine, the sheets were assembled, and the material known as mortar pockets (interlacements on the bims) was cut in the same way with a laser using 1500*3000*15 mm AISI 5630 material and processed in a milling machine to form the angles. The tubes (the name of the material used in the places where there is a gap in the material) were laser cut using 1500*3000*4 mm AISI 5630 sheet metal and welded after being bent in an abkant bend. In the last stage, the sheets, mortar pockets, and tubes assembled and welded to each other are welded using the gas welding method (SG2 wire and mixed gas). After the upper mold assembly is completed, the lower and upper molds are adjusted to each other and ready for shipment. The Box Cementation Coating method was used to coat the pumice mold produced in 1263x1206 mm dimensions with boron. In this method, all surfaces were cleaned and placed in an AISI5630 steel box with the coating powder mixture, and the coating process was carried out using the time parameters of 4 hours at 950 and 1000 ^{0}C. For each parameter, the oven was heated gradually to 600 ^{0}C, 800 0C, and the final process temperature. After the process, the box removed from the oven was cooled with water and removed from the mold, and the water cooling process was also applied to the mold (Figure 1).

Figure 1. Coating operations of bimsbeton mold A. Coating oven and ladle B. Bims block mould before coating C. Bims block mould coating photo D. Bims block mould after coating

The coated samples were cut to 15x15x10 mm dimensions for microstructure studies, polished, and the section where the coating section would be examined was etched using nital solution. Coating section optical microstructure and coating layer microhardness studies were carried out.

3. DESIGN AND SIMULATION

In this study, characterization analyses were carried out by coating the pumice blocks with boron using the box cementation process to reduce abrasion and increase the service life of the pumice blocks used in turning volcanic rock pumice into pumice concrete for use in the construction industry. The samples obtained from the mold were examined under an optical microscope.

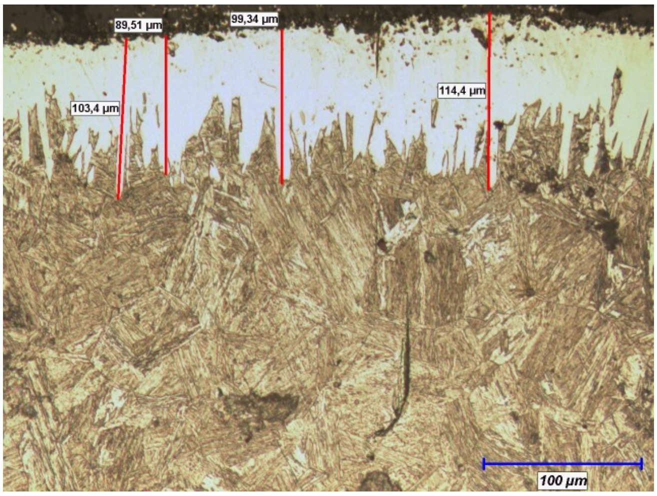

Figure 2. Optical microscope image of the sample.

Optical microstructure photographs show a film-like coating layer on the material's surface (Figure 2). The boron coating thickness on the samples was measured from different areas of the sample, and the maximum and minimum values were obtained. While the maximum value was 114.4 µm, the minimum value was 89.51 µm.

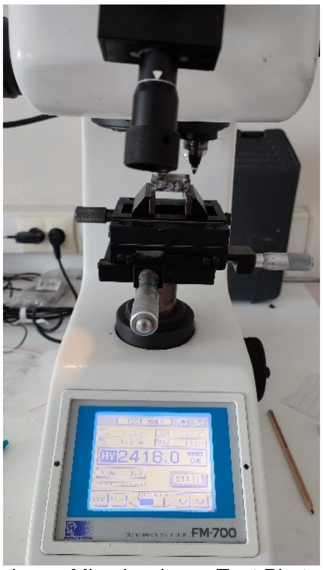

Figure 3. Coating Layer Microhardness Test Photograph.

As a result of microhardness studies on samples taken from the molds where the coating process was performed, a coating layer hardness of 2416 HV were achieved. The main material microhardness value was measured as an average of 750 HV after the process.

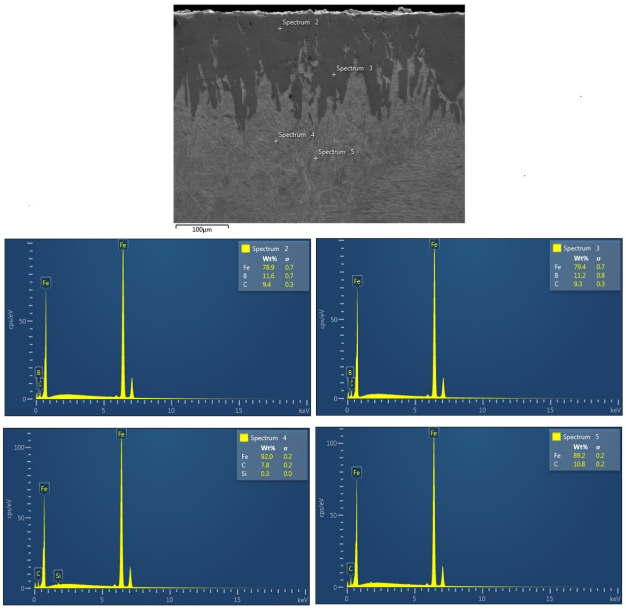

Figure 4. Coating Layer XRD Analysis Graph.

As a result of the point EDS analysis taken from the coating layer on the samples that were coated, 11.6% B, 9.4% C and 78.9% Fe were detected by weight. The obtained result indicates the Fe_2B phase.

4. CONCLUSION

In this study, an attempt was made to obtain a boriding layer on the AISI 5630 steel bims mold surface of using the pack cementation diffusion method and the following results were obtained.

1. Boriding layers were successfully obtained on all bims block surfaces.

2.Coating thicknesses increased with coating temperature.

3.For the sample coated at 1000 °C for 4 hours, the max coating layer thickness was obtained 114,4 micron.

4.It is seen that a layer consisting of Fe_2B phases is formed on the coating surface.

5.Coating layer microhardness value of 2416 HV were obtained.

REFERENCES

[1] Toklu, K., “Pomza taşından üretilen bims blok kalitesinin artırılma olanaklarının araştırılması”, Yüksek Lisans Tezi, İstanbul Üniversitesi, Fen Bilimleri Enstitüsü, İstanbul, 2009.

[2] Ömer A., “Bor Madeninin Stratejil Açıdan İncelenmesi”, Yüksek Lisans, Tezi, Dumlupınar Üniversitesi, Sosyal Bilimler Enstitüsü, Kütahya, 2004.

[3] Gündüz, L., Hafif beton olarak pomza, I. Isparta Pomza, 1998.

[4] Gündüz L., Şapcı N. Ve Davraz M., "Pomza madenciliği, endüstrisi ve türkiye açısından önemi (gelişen yeni bir sektör)", Türkiye 19. Madencilik Kongresi ve Fuarı, IMCET2005, İzmir, Türkiye, 9 - 12 Haziran 2005, ss.397-408

[5] Çevikbaş, A., İlgün,F., "Türkiye pomza yataklarının jeolojisi ve ekonomisi", I. Isparta Pomza Sempozyumu, Isparta: SDÜ,1997, s13-18

[6] Yiğitbaşıoğlu, H., "Türkiye için önemli bir maden: bor." Coğrafi Bilimler Dergisi, 2004, 2(2), 13-25. https://doi.org/10.1501/Cogbil_0000000046

[7] Yücel, A., "Dünyadaki başlıca bor yatakları, üretimi, pazarlaması ve Türkiye'nin önemi", Hacettepe Üniversitesi, 2010.

[8] Arzum ULUKÖY, Ahmet Çetin CAN. Çeliklerin Borlanması. Journal Of Engıneerıng Scıences. 2006 : 12 : 2 : 189-198

[9] Çalık, A., Delikanlı, K., Uzun. A., "Ç1035 Çeliğin Borlama Özelliklerinin İncelenmesi" II.Uluslararası Bor Sempozyumu, Eskişehir, 2004