



Boron and Ekabor III coating of AISI 316 stainless steel by PTA surface alloying

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In this study effects of plasma transfer arc-processing (PTA) parameters on the microstructure of boron and ekabor III coatings were studied experimentally. The coatings were manufactured using AISI 316 stainless steel substrate and four different current (160, 165, 170 and 175A) in order to determine coating influence on the microstructure and microhardness. Microstructural changes were examined by optic microscopy (OM), scanning electron microscopy (SEM), energy dispersive spectrometry (EDS) and X-ray diffraction (XRD). Moreover, microhardness test of the coated samples was conducted. The results demonstrate that coatings were successfully produced and different dendritic structures were determined depend on heat input and different coatings. The hardness boron coating and ekabor III of the intermediate zones are in the range 492-715 HV and 608-785HV, respectively.

However, the hardness of the coating structure is in the range 1154-1222HV, respectively.

Keywords: Boron, Ekabor III, AISI 316, PTA.

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1. Introduction

Stainless steels mainly could be classified as ferritic, austenitic and martensitic. The largest group of stainless steels is austenitic stainless steels which is produced in higher tonnages than any others. Because of their excellent corrosion resistance and excellent low-temperature performance they are extensively used in chemical and petrochemical industries [1-5]. Therefore, to improve the surface properties of stainless steels various surface modification techniques have been widely used to improve the wear resistance. Cold spraying, Thermal spraying [5,6], laser cladding [7-9], and plasma cladding [10,11] have been used to improve the surface properties and wear resistance [12]. Plasma transfer arc (PTA) welding coating method has been used for improve the wear, corrosion and heat resistance of the material surface in which provides high precipitation rate and low heat input. In particular, it provides a wide range of materials and a metallurgical bond with low dilution and degradation between the hard-facing layer and the substrate material [13-16]

The powder hard-facing of materials have been conducted by several researches with several method [17-25]. The carburizing, nitriding, boriding and cladding of metals surfaces with the help of the arc can be performed in numerous ways. However, boron and Ekabor III cladding with PTA alloying produced layers which provide high hardness, great tribological properties and good corrosion resistance of the treated surfaces. The goal of this study is to examine AISI 316 stainless steel surface which cladding with boron and Ekabor III powder with PTA technique. For this purpose, boron and Ekabor III powder were placed on a plain AISI 316 stainless steel surface and cladded with PTA.

2. Materials and methods

In this study two coating powders (Boron and Ekabor III) with different properties were used in order to be coated on AISI 316 stainless steel by PTA surface alloying see in Figure 1. The composition of substrate material was given in Table 1 and properties of boron and Ekabor III

powder obtained commercially from Elista san.tic.ltd.sti. are given in Figure 2

Table 1. Chemical composition of test substrate material

Materials	Alloying elements (wt.%)										
	C	C	S	Ni	Si	Mn	Mo	P	Cu	N	Ti
AI	1	0	0	1	0	0	2	0,	0	0,	0,
SI	6,	,	,	0,	,	1,	,	0	,	0	0
316	8	0	0	6	3	5	1	3	3	5	0
	9	2	3	2	9	0	1	3	4	4	8

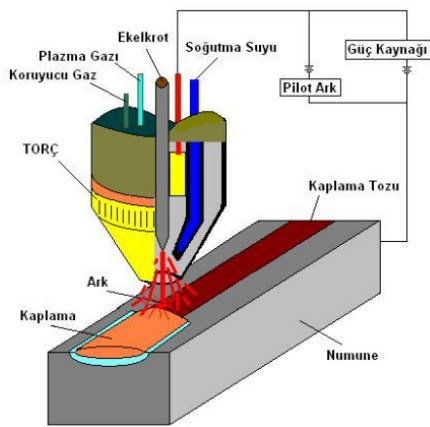


Figure 1: Schematic illustration of the coating method with PTA welding [25].

AISI 316 steel which was selected as substrate material was cut to 100 x 20x10 mm. In order to place the dust on the surface, the groove milling process was carried out at a width of 3.5 mm and a depth of 1.5 mm, followed by cleaning before coating. In order to prevent the boron powder from elementary boron powder from flying away by argon gas, sodium silicate binders were placed in the duct, then pressed and then placed in the oven at 40 °C temperature, and sodium silicate was allowed to fly and such process would not be necessary for Ekabor III. Production parameters of PTA single arc scan coating was illustrated in Table 2. After TIG surface coating was carried out, samples were cut in the cross section of the arc scan for determine morphology of coatings. For examine the microstructure and the distribution of hard phases in the structure, Nikon Eclipse optical microscope with Clemex Software was used. In order to analyze the microstructure of the coating, SEM (Zeiss EVO MA10) and energy dispersive X-ray (EDX) analyzes were performed from the section of the coating. The microhardness of the coating was measured using a Emcotest Durascan20 microhardness tester under a load of 100 gf for.

Table 2. AISI 316 stainless steel PTA coating parameters

Sam No	Setbe setting mm	Nozzle Diameter mm	Speed m/dk	Current A	Shield Gas lt/dk	Plasma Gas lt/dk
S-1	0,8	2,4	0,1	160	25	0,5
S-2	0,8	2,4	0,1	165	25	0,5
S-3	0,8	2,4	0,1	170	25	0,5
S-4	0,8	2,4	0,1	175	25	0,5
S-5	0,8	2,4	0,1	160	25	0,5
S-6	0,8	2,4	0,1	165	25	0,5
S-7	0,8	2,4	0,1	170	25	0,5
S-8	0,8	2,4	0,1	175	25	0,5

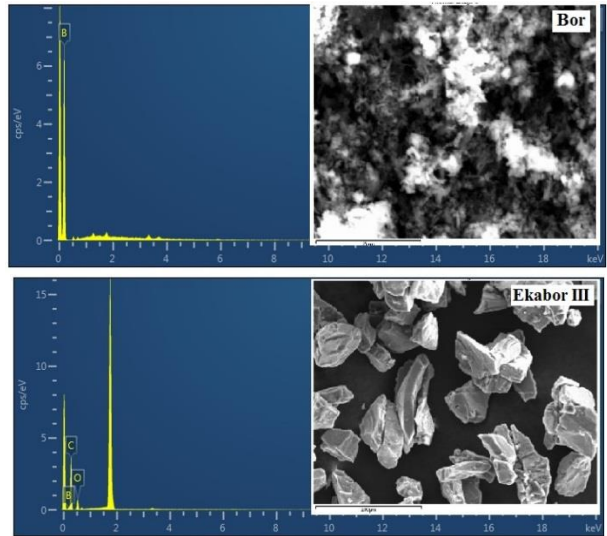


Figure 2: EDS and SEM results of boron and Ekabor III powders

3. Microstructure

In the microstructure studies, it is seen that the dilution between the substrate and the coating layer has been successful. It was determined from the microstructure pictures as seen in Figure 3 that dense dendritic arms were formed especially in the coating layer and the interface region. The dendritic arms formed developed perpendicular to the coating layer.

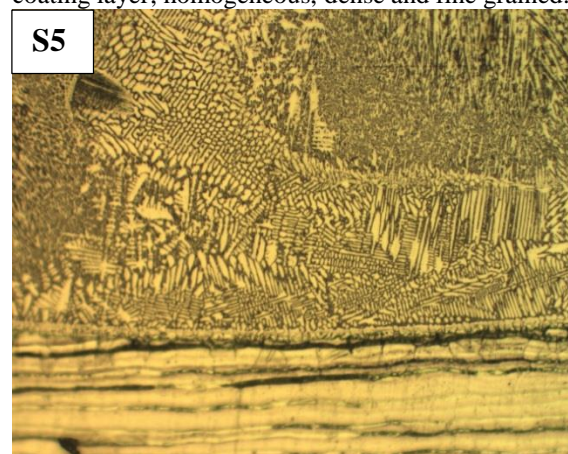
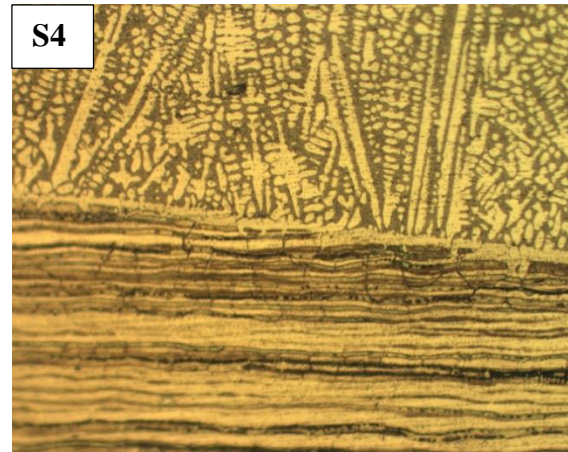
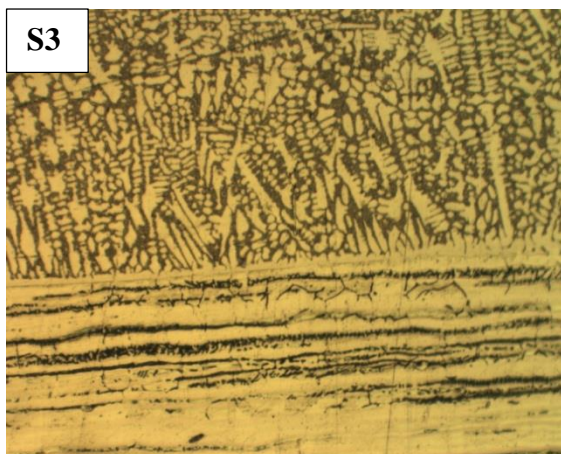
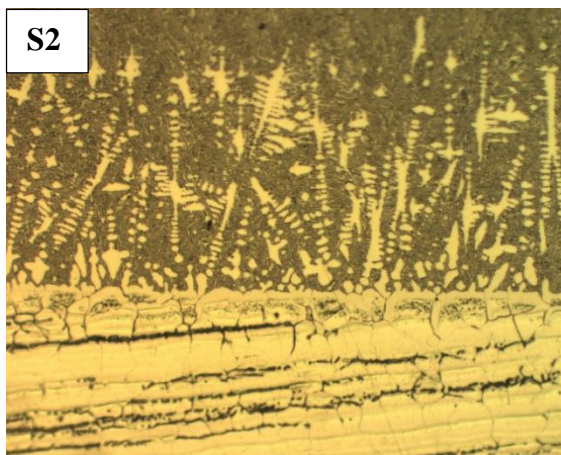
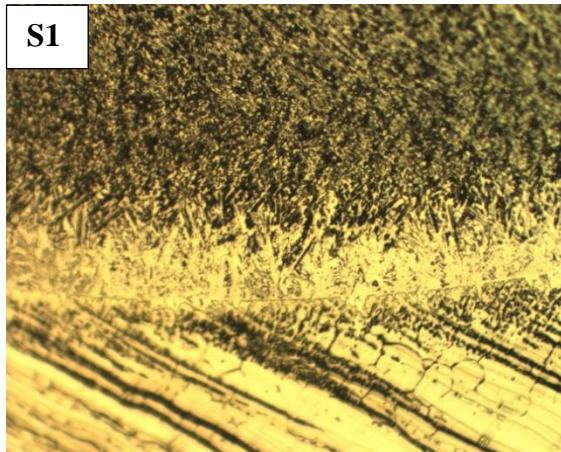


Figure 3. Optical images of boron coated samples. However, it is estimated that the black lines seen in the base material are both carbide precipitations and the formation of rolling marks during etching. The etching process of the samples was achieved by using the electrolytic etching method. As a result of late etching of Ekabor coated samples, light burning, darkening, occurred in the substrate region after etching.

Boron layer formed by boring process made by PTA method in AISI 316L stainless steel containing high proportions of chromium was found to be perpendicular to the substrate and bonded perfectly with the substrate. The surface structure of the coating layer; homogeneous, dense and fine grained.

When the optical images of Ekabor coated samples are examined in Figure 4, it is seen that there is no crack or a problem in the joint. Furthermore, it is seen that dendritization is less in Ekabor coated samples compared to boron coatings.

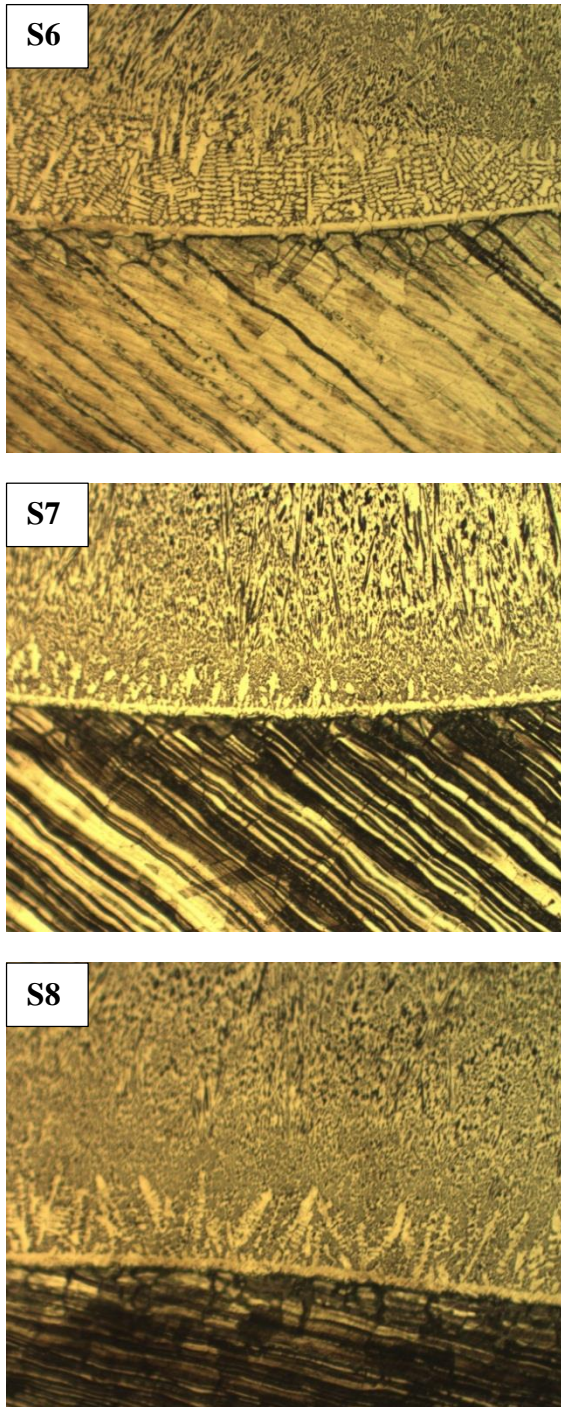


Figure 4. Optical images of Ekabor III coated samples

4. Hardness

The boron layer hardness results of 316L stainless steel lining coated with boron were found to be much higher than the hardness of lining material. Especially when the results of S1 analysis were checked in Figure 5, the hardness of the coating region was 1154 Hv, and the hardness results obtained from the intermediate region were examined, and the highest value of 715 Hv in S4 was obtained. The reason for this is thought to be that the

alloying elements in the coating layer are boron and the substrate is caused by the hard phases formed after melting. Likewise, high hardness values were obtained in the commercial Ekabor coating region. The highest hardness values were found to be 1222 Hv in the S1 coating region in Ekabor coating, and the highest value was reached with 904 Hv in the intermediate region. Hardness analysis results for boron coating and Ekabor coating both values are given separately and these values are given separately graphically.

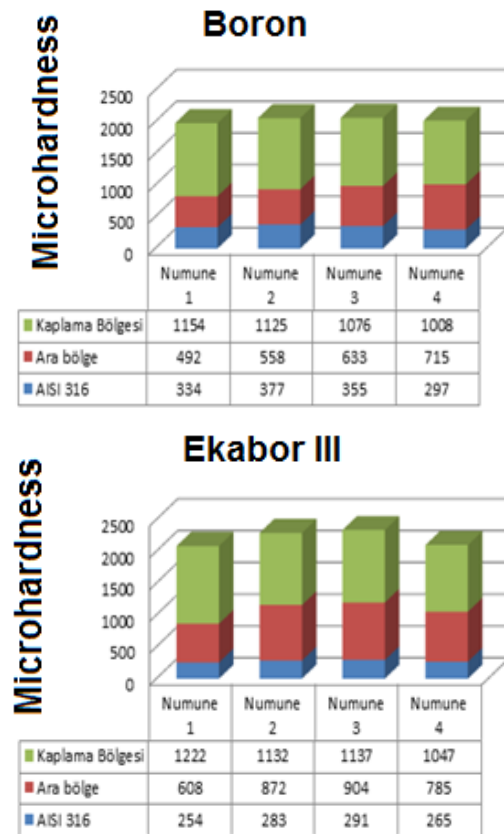


Figure 5. Micro-hardness values of boron and Ekabor III coated samples

Conclusion

In this study, it is aimed to investigate the applicability of BOR and EKABOR III on AISI 316L steel surface by Plasma Arc Welding method and to investigate its usability in industry. For this purpose, the following factors were obtained depending on the factors affecting the coating process, the macrostructure, microstructure and microhardness results of the samples after melting. Boron and Ekabor coating process deposited on AISI 316L steel surface by plasma arc welding method has been successfully melted and coating process has been realized with this method.

As seen in the microstructure pictures after the coating process, it is seen that the coating layers are formed in a smooth direction.

From the microstructure analysis after coating, it is seen from the microstructure pictures that a successful bonding occurs between the coating layer and the coating layer in materials coated with boron and Ekabor.

It has been determined from the microstructure pictures that dense dendritic arms are formed especially in the coating region of the coating samples and are perpendicular to the coating layer. No cracking was observed in the samples as a result of successful solidification. When the results of microhardness analysis are examined, the highest values of boron coating are obtained in the coating region and intermediate region of N1 1154 and N4 715 Hv, respectively. 904. The micro hardness values of the stainless-steel substrate were approximately the same in both coating processes. 316L stainless steel low hardness and weak corrosion resistance is considered to be more efficient results can be achieved as a result of coating work with this kind of materials.

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