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Surface Characterization on Agriculture Steel Boriding

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The agricultural industry needs innovative coatings to solve the main problems caused by the extreme conditions to which tillage implements are exposed [1, 2, 3]. Another important factor is the change of geometries and loss of mass on agricultural tools causing a reduction in service life; for this reason, boriding can significantly contribute to reducing the wear and abrasion on these tools [4].Boriding by dehydrated paste is a thermochemical hardening process that can be used on tools or workpieces to prolong the life of the tool [5, 6]. Research shows that the FeB/Fe_2B or Fe_2B coatings generated can be used in sectors for agricultural, marine and aerospace [7, 8, 9].

This study uses a plow disc with chemical composition (weight) of C-0.62% Mn-0.90% Si-0.17%, S-0.035 %, P-0.25%, Ni-0.25%, Cr-0.025%, Cu 0.025%. The specimens obtained were 1.5 cm x 1.5 cm x 0.5 cm. The boriding process of the specimens using boron dehydrated paste at temperatures of 1223 K with an exposure time of 8 hours (BDP-8) using a conventional furnace without inert gas. The surface microstructure was examined by Optical Microscopy (OM) using ZEISS Axio Vert.A1. Also identify the phases obtained by X-Ray Diffraction (XRD) with Bruker D8 Advance equipment, Cu Kα λ=1.5406 Å radiation. The adhesion of the coating formed on the surface was determined by means of the Daimler-Benz Rockwell-C test, VDI 3198 standard, using the Jeol JSM-6010LA (SEM). The hardness measurements are obtained with a Mitutoyo Ultra Micro Hardness Tester, using an indentation load of 100 mN.

Figure 1(a) shows the surface microstructure obtained by BDP-8 treatment. The formation of iron boride FeB dark color and Fe_2B clear color is observed. Furthermore, saw-tooth type iron boride coating morphology is observed on this agriculture grade steel and similar to the researches by Chernoivanov et. al [2] and Sidorov, S.A. et. al [6]. The thicknesses obtained for FeB are 12.13 µm ± 5.6 and Fe_2B are 66.60 ± 4.6 µm. The result of the XRD pattern evidences the peaks of FeB and Fe_2B iron borides in Figure 1(b). Table 1 shows the structure, planes and phases generated by the BDP-8 treatment. Figure 2(a-b) evidences adhesion results showing the HF 3 classification according to the quality evaluation of the adhesion force by the VDI 3198 standard. Therefore, it is deduced that the thickness and morphology of the obtained iron borides have an influence on the adhesion caused by the presence of cracks without desquamation in the indentation marks. The microhardness results shows the values for FeB 1810.31 ± 27.10 and Fe_2B 1716.69 ± 16.09 is due to the distribution of the alloying elements on the iron borides obtained, as shown by Cihangir Tevfik Sezgin et. al. [11] and Marco Antonio Doñu Ruiz et. al. [12]. In conclusion, the surface of the agriculture steel with BDP-8 treatment shows a compact FeB/Fe_2B coating confirmed by XRD. The adhesion is acceptable with the BDP-8 treatment. The surface microhardness obtained shows the change in hardness for FeB and Fe_2B, by BDP-8 treatment. The surface microhardness obtained evidences the hardness for FeB and Fe_2B by the BDP-8 treatment.

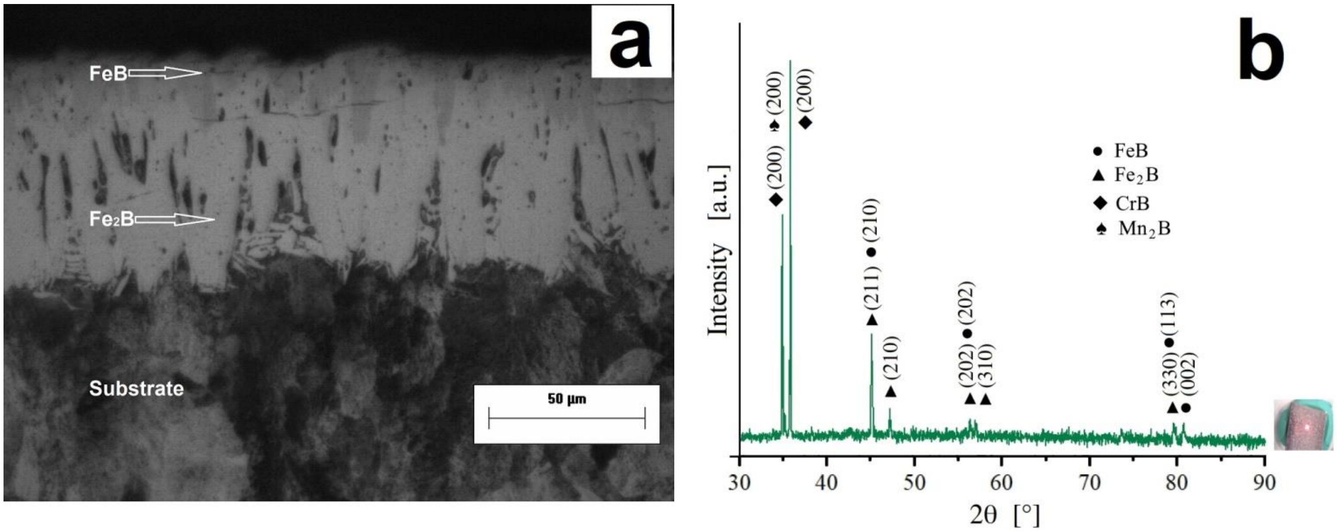

Figure 1. Images of agriculture steel with BDP-8 treatment at; (a) Surface microstructure and (b) XRD patterns.

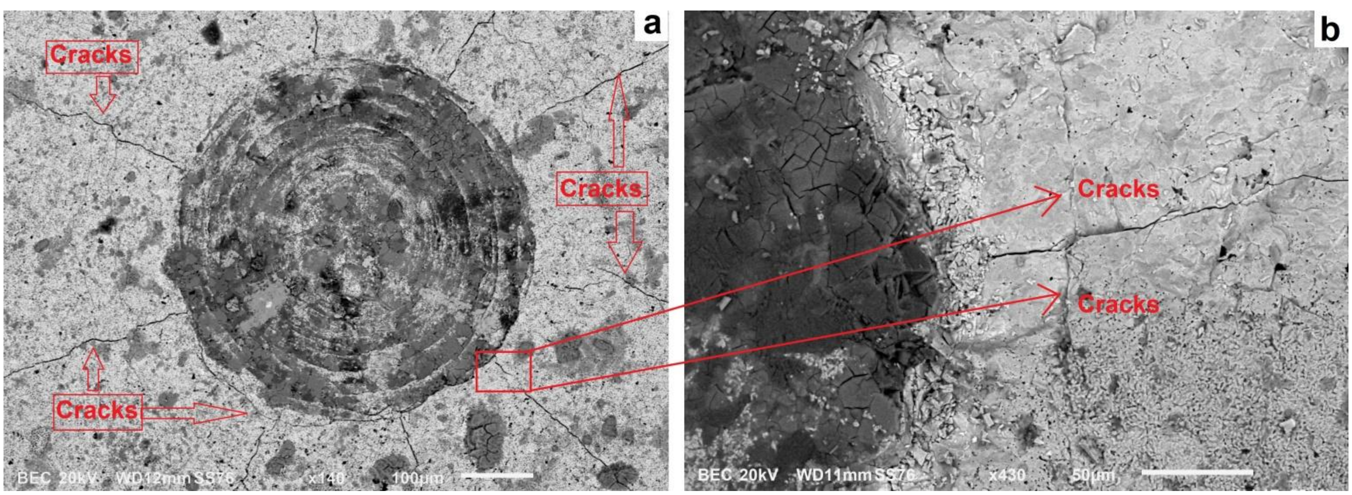

Figure 2. Indentation micrographs on agriculture steel with BDP-8 treatment at; (a) 140x and (b) 430x.

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Peak	2θ [°]	Phase, Structure, Plane		Observations
1	34.8523	CrB, Body-centered tetragonal, (200)	Mn_2B, Body-centered tetragonal, (200)	
2	35.7666	Fe_2B, Body-centered tetragonal, (200)		Highest intensity
3	45.0722	Fe_2B, Body-centered tetragonal, (211)	FeB, Orthorhombic, (210)	
4	47.1446	Fe_2B, Body-centered tetragonal, (210)		
5	56.2470	Fe_2B, Body-centered tetragonal, (202)	FeB, Orthorhombic, (202)	
6	56.9174	Fe_2B, Body-centered tetragonal, (310)		
7	79.5515	Fe_2B, Body-centered tetragonal, (330)	FeB, Orthorhombic, (113)	
8	80.6486		FeB, Orthorhombic, (022)	

Table 1. Peaks and phases in agriculture steel with BDP-8 treatment

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