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Tribological Study and Surface Characterization of a Boron Coating Applied to an AISI L6 Steel Used in the Agricultural Area

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Today it is required to increase the surface resistance of the mechanical plow devices used in the agricultural area, these devices present the tribological phenomenon (wear and coefficient of friction (CoF)); It is important to analyze and characterize the surface and the interactions in the initial stages of contact and the changes that the CoF and subsequent wear will have, allowing to predict or establish premature wear [1,2,3,4].

The boriding process that is generated with the dehydrated paste technique can be an alternative to increase the resistance to wear on the surface of steels; It has been determined that the coating with sawn morphology and biphasic FeB/Fe_2B has high lateral surface hardness of between 800 to 2,200 HV, adequate adherence, resistance to compressive stress and tenacious surface scratching [5,6,7].

In the experimental study, AISI L6 steel discs are used (used for plow mechanisms) with a chemical composition of 0.55%-C, 0.70%-Mn, 0.25%-Si, 0.10%-V, 0.75%-Cr, 0.50% -Mo and 1.70%-Ni [6]; the dimensions of the specimens are 2.54 cm in diameter with 1 cm in width; the thermochemical treatment is carried out at 900 °C with a residence time of 0.5, 2 and 3 h; JEOL 6360 LV scanning electron microscope is used to characterize the surface morphology; the CoF study is under dry conditions and with a CETR-UMT-2 reciprocating tribometer, the displacement was 20 mm with a frequency of 1 Hz (30 minutes duration), load of 10 N and counter-body of WC with 1 cm in diameter; ZYGO brand optical profilometer model nexview 3D optical surface profiler is used to determine the surface morphology and roughness.

In the topographic study of the sample with 0.5 h of incubation (figure 1a), clusters of asperities are observed and evidenced by the green/red color morphologies, the clusters of asperities have a height of 1.88 µm; valleys of roughness are observed and identified with the blue color, also, it is detected that the clusters of roughness tend to grow sideways (red) and the valleys of roughness (blue) decrease as the incubation time increases to 3h (figure 1 B) ; Figure 1c obtained by SEM shows the denticular/amorphous morphology of the roughness, also, the areas of clusters of asperities (white arrow) and valleys of asperities (black arrow) are detected. The growth of asperity clusters and asperity valleys is influenced by the dehydrated paste technique, boron diffusion and nucleation of asperity clusters are a function of the dehydrated paste grains and when the grain is in contact with the surface (figure 1d) of the base material, the growth of the asperity clusters in its side view is a function of the incubation time, the widening of the asperity clusters is obtained by the growth of new asperity clusters and subsequent adhesion to existing asperity clusters, figure 1e.

In the roughness studies it is observed that the base material has a roughness of Sa = 0.13±0.02 μm, Sq = 0.17±0.02 μm and Sz = 1.28±0.26 μm, for the thermochemical treatments it is observed that the roughness Sa, Sq and Sz they increase as the incubation time increases, obtaining the maximum roughness for the treatment with 3 h of incubation, showing that the roughness for the boriding process is not homogeneous and increases for each treatment [8], figure 2a; Likewise, research by different authors has shown that the thickness and mechanical properties increase as the incubation time and temperature increase [9,10].

In the tribological tests, it is detected that the CoF for the base material is 0.42, the highest CoF (0.49) is for the treatment with 2 h of incubation, figure 2b; at the start of the CoF test, roughness wear occurs (debris) and it is deposited in the asperity valleys (figure 2c) and can be seen in all treatments from 0.5 (figure 2d) to 3 h (figure 2e) of incubation, at each moment of wear there is a different tribosystem that is propitiated by the change in the area of debris clogging with the asperity valley, low CoF are detected in the base material and propitiated by the formation of a tribolayer at the interface of the tribosystem, figure 2f. Concluding that the boriding treatment with dehydrated paste stimulates boron nucleation and clusters of asperities and non-homogeneous surfaces are formed; the surface changes, mechanical properties and the clogging of the debris in the asperity valleys affect the CoF of each boron surface, obtaining a different tribosystem in each wear until the roughness is eliminated; the best coating is for the sample with 3 h of incubation and it is a suitable alternative to be used in mechanical devices for agriculture as it has the lowest CoF (0.47) and higher wear resistance (width of wear track); the base material presents a tribolayer that decreases the CoF and changes the tribosystem, evidencing that before the tribolayer is formed there is a maximum CoF of 0.51; many researchers decide to remove the roughness of boron coatings [11] but it is not recommended because in some cases they cannot remove all the roughness or they remove part of the coating and affect the tribosystem [12].

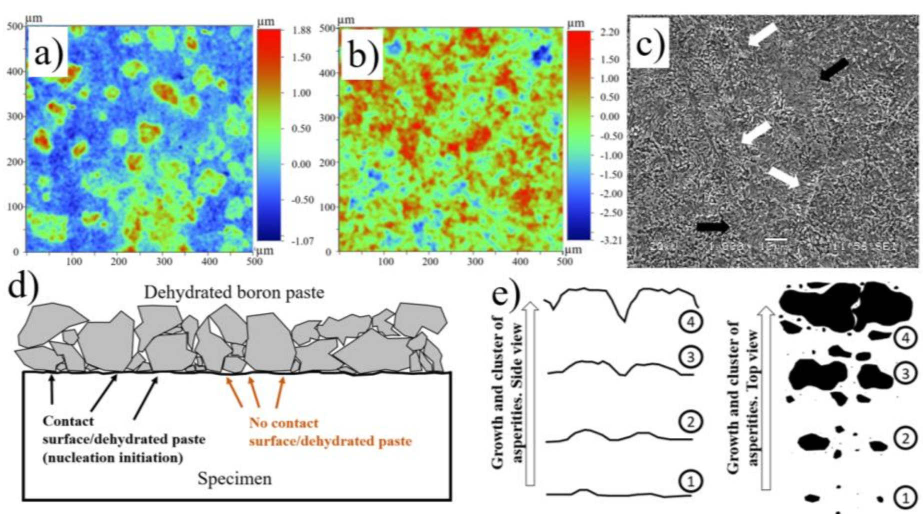

Figure 1. Form in which the asperity clusters and asperity valleys are generated, topographies of the samples at 900 °C with a) 0.5 and b) 3 h, c) morphology of the sample surface at 900 °C with 0.5 h , d) start of boron nucleation during the thermochemical treatment and e) growth shape of the asperity clusters and valleys in side view and top view.

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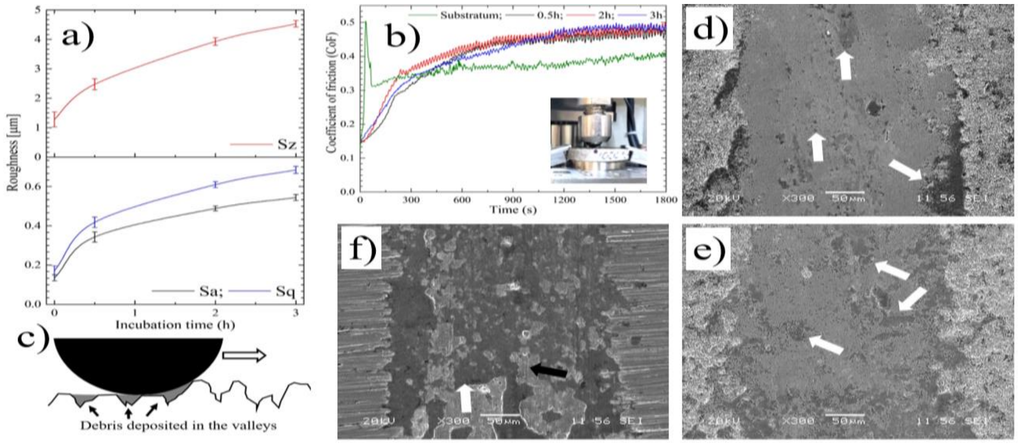

Figure 2. a) roughness of the specimens, b) behavior of the CoF and the initial tribosystem, c) clogging of the debris during the wear process, wear tracks on the surfaces at 900°C with d) 0.5 and e) 3h (white arrow indicates clogging of debris) and f) tribolayer (white arrow) with wear of two bodies (plow marks-black arrow)

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