Wet and Dry Abrasion behavior of AISI 8620 Steel Boriding.

I. Hilerio C.[1], M.A. Barron M.[2], R.T. Hernandez L[3], A. Altamirano T[4].
Universidad Autónoma Metropolitana Unidad Azcapotzalco Departamento de Materiales.
Av. San Pablo 180 Col. Reynosa-Tamaulipas 02200 México, D.F.
Tel. 55 53 18 90 00 ext. 2131. Email[1] ihc@correo.azc.uam.mx E. Mail[2] bmma@correo.azc.uam.mx
E. Mail[3] hlrt@correo.azc.uam.mx, E. mail[4]aat@correo.azc.uam.mx

ABSTRACT

Wear tests were developed in two different equipments, designed by Tribology group UAM A in Mexico under the standards ASTM G-65 to dry conditions and ASTM G-105 to wet conditions. Because the standards use different parameters, it was necessary to equal these for both tests, as: load, sliding distance, lineal velocity in the contact point, particle size and hardness of the wheel. Steel used in this paper is employed in machine's components. With the objective of observing the benefit of boriding process on the AISI 8620 steel, was carried out the comparison of this steel with the basic material and the same with the boriding process. The wear rate is significantly less in wet condition than in dry condition; this for the reason that the water acts as a lubricant or refrigerant and hide the abrasion mechanisms. The surface of the boriding sample is very hard and consequently with little loss of the mass; to both tests presented a good behavior to abrasion.

Key words: Abrasive wear, dry abrasion, wet abrasion, boriding.

INTRODUCTION

Abrasive wear is the result of three mechanisms; ploughing, cutting or wedge forming; this phenomenon occurs when hard asperities or abrasive particles, presents an sliding process and interacts with a surface.[1-2]. Wear by abrasion is approximately 50% of all wear in industry; due to the interaction at least by two bodies and in many occasions also the presence of a fluid. For this reason, the tests has been evaluated in dry and wet conditions. The standard ASTM G-65 with the title "Standard test method for measuring abrasion using the dry sand/rubber wheel apparatus"; where it describes the configuration and establishes the operation parameters of the tribometer in dry condition. On other hand, with respect to the test under wet condition is described by the standard ASTM G-105, with the title "Standard test method for conducting wet sand/rubber wheel abrasion test". When the operation parameters have been similars, is possible to make a comparison between both tribosystems.

AISI 8620 steel is a hardenable nickel-chromium-molybdenum low alloy steel; used widely in machine's components. Admit different surface treatment and forming process; such as, carburizing, tempering, forming, welding, boriding, etc.[3]. Thermal hardening is produced by heating a material, followed by a rapid quenching in oil or water. With this operation, the surface of the sample has been hardened. There are five used methods to heating the steel; by electrical induction, resistance, flame, laser and electron beam. [4,5]. The boriding process is a thermochemical treatment, when the boron is diffused in a metallic surface, but this process can also be applied to nonferrous metals such as nickel, cobalt alloys and -refractory metals. This can carried out in pack, liquid, or gas; with a temperature between 900 and 1100°C; The boriding steel exhibit extremely high hardness, commonly from 1500 to 2300HV, obtaining a thin layer between 50 to 150µm. The morphology of boriding layer formed on iron has two types: a superior layer FeB and an inferior layer Fe_2B. The second layer is distributed principally in the grain boundary. Both present similar orientation and they have structural characteristics in columns towards to surface [4,6].

EXPERIMENTAL PROCESS

Material preparation

There were three groups of test specimens in AISI 8620 steel; base, thermal hardening and boriding. The first group didn't have any process; there were cut from a bar into rectangular shape, 25.4mm wide by 57.2mm long by 12.5mm thick. The dimensions are equal to all specimens.

Thermal hardening was processed by induction at 900°C, during 30 minutes with a nitrogen flow at $10ft^3/hr$ and quenching in oil. After this, was realized a tempered treatment at 200°C, during 2 hours.

Boriding process was made by a salt bath, where the specimens were placed into a pot and covered by boron salt; this complex was heat up to 950°C, during four hours. Hardness after this process is 850 HV with a load 100gf, during 10s.

Abrasive wear tests

The tribometers have been developed by group in UAM A, by agreement to standards. Figure 1 shows both type of the machines in schematic form. This equipment was used to study the abrasive wear behavior in dry and wet conditions. The next parameters were used to both tests. The abrasive that was used in this work, is called grain quartz sand with size 230-270µm. Load used 200N between wheel and specimen. Sliding distance of 5586m. With a rotation speed from 250 to 250rpm. Dry test required a flow of abrasive from 0.3 to 0.4 Kg/min; by other hand, wet test used a mixture of 1.5kg. of abrasive and 0.940 Kg. of water. Before having started the tests, the specimens were cleaned and weighed by a analytical balance whit a accuracy of 0.0001g. During the entire test there were 5 times to weigh the difference of the mass.

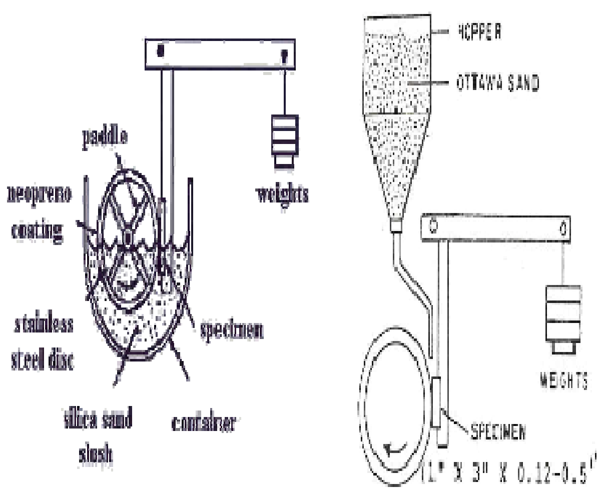

Fig. 1 Schematic of the tribometers. a) under wet condition; b) under dry condition.

Fig. 2: Micrograph of 8620 steel quenched and tempered.

The morphology of boriding layer formed by iron has two layers types: a superior layer made by FeB and an inferior layer made by Fe2B. The second layer is distributed principally in the grain boundary. Both of them, present similar orientation and they have a structural characteristic in columns towards the surface. A metallography in cross section is realised with a chemical reactive (nital 2%) during 6 seconds, it is shown in figure 3.

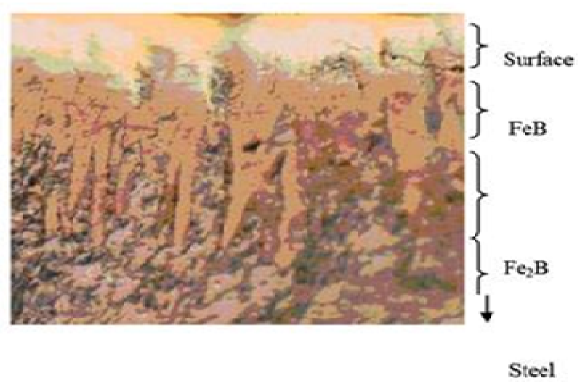

Fig. 3: Micrograph of boriding steel 8620.

RESULTS

The structure of AISI 8620 after hardness, it's shown in figure 2, through a metallurgical preparation for transversal section with a nital reactive (2%) during 6 seconds. Where it has presented a hardness of 400HV; with a load 100gf during 10s.

It is shown the evolution of hardness curve obtained with this process, as shown in figure 4. In comparison with the literature date, this material is very soft, due the sample have had a heat treatment after boriding.

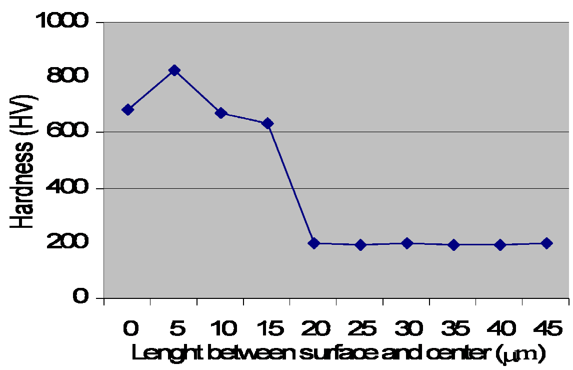

Fig 4. Hardness profile for boriding steel 8620.

Pictures 5 show wear scars obtained with metallic specimen for all steels: base (a), heat treatment (b) and boriding (c).

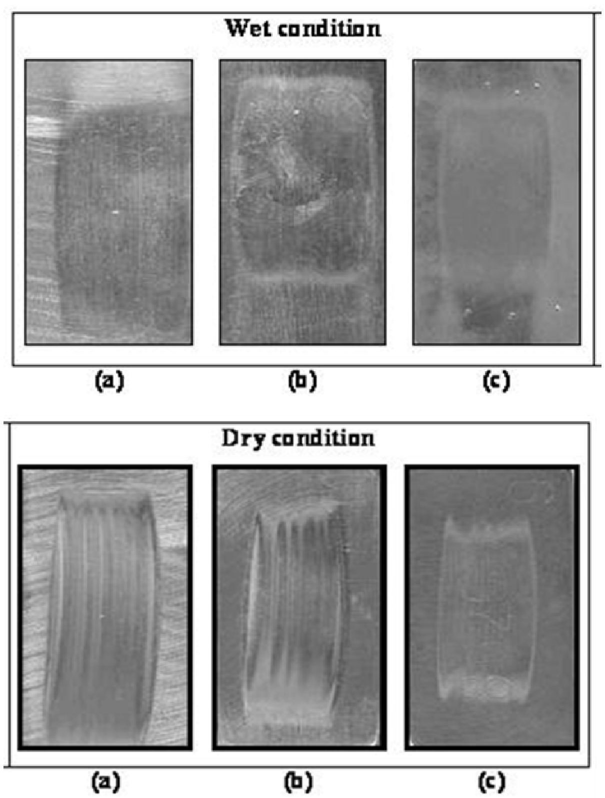

Figure 5: Wear abrasive scars for both conditions.

Abrasion behaviour of boriding steel AISI 8620 for both conditions presents a higher abrasion resistance, as shown in figure 6. It's possible to note a benefit with thermal treatment.

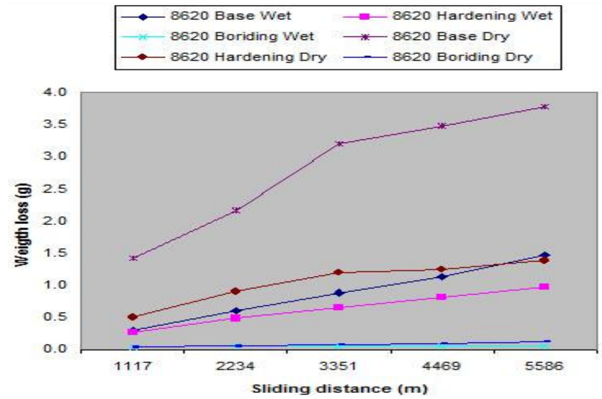

Fig 6. Comparison of behaviour for both wear test condition.

In wet conditions, effect is less severe than those measured for dry condition. This result is explained because in the aqueous tribosystem is formed a water film protection. By consequence, that induce firstly, a difficulty of penetration for abrasive silica sand particles and secondly, an easier slide for sample on metallic surface. For this reason, scars wear are less severe.

CONCLUSIONS

On the basis of the result obtained, it is possible to note that:

- Wear behaviour for a metallic material is modified with a change of its superficial structure. It has been clearly shown this relation in this work. In this study, it has been shown steel behaviours obtained by different surface treatments in function of structure.

- It has been hierarchised the wear resistance property of AISI 8620 steel in this order:
  1) AISI 8620 steel base as the less resistant
  2) AISI 8620 steel hardened by quenched and tempered
  3) AISI 8620 borided as the most resistant treatment

- The borided 8620 steel has excellent properties for both conditions of test, but it obtains better results in wet conditions. So it's possible to establish that borided steel is a useful tool to work in this kind of conditions and resistance against wear.

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