A study on powder-pack boronizing of 316 stainless-steel ball bearing

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ABSTRACT – In this present study, 10 mm diameter of 316 stainless-steel is used in powder-pack boronizing by using solid medium boron, Ekabor 1. The boronizing experiment is carried out in a high temperature furnace at 850, 900 and 950 ºC for 2, 4 and 6 hours. Powder condition and powder-pack surrounding are also featured in this study to analyze the effective powder usage of the treatment. Borided layer surface is characterized using XRD analysis and SEM micrographs. The hardness, wear properties and kinetics atoms of diffusion using Arrhenius equation will be determined in this study. Preliminary results showed hardness of boronized sample is higher than the untreated sample.

1. INTRODUCTION

Boronizing is a thermochemical surface hardening process that involves the diffusion of boron into the base surface at high temperature to produce super hard materials and contributes in better wear strength of a material since hardness is related to wear performance compare to other thermochemical processes [1,2,3]. Powder-pack boronizing treatment is significance to use since it is easy to apply and has low cost compare to other heat treatment processes [4]. The objectives of this study are to investigate the diffusion mechanisms of stainless-steel surfaces using metallurgraphic procedure and to determine the kinetics of the diffusion process using Arrhenius equation with the aim of improving the tribological properties.

2. METHODOLOGY

2.1 *Powder-Pack Boronizing*

For this purpose, boronizing powder is placed in a stainless-steel container and the sample (ball bearing) is immersed in the container. The containers are different in diameters and heights in such a way the samples is surrounded by different thickness of powder. The schematic diagram of powder-pack boronizing is shown in Figure 1.

The variables for boronizing process are selected using Taguchi method in order to determine an effective powder pack boronizing condition. All these parameters are shown in Table 2. The resulted microstructure, surface roughness, hardness, wear and also kinetics diffusions of boron atoms which are subjected to the parameters will be determined.

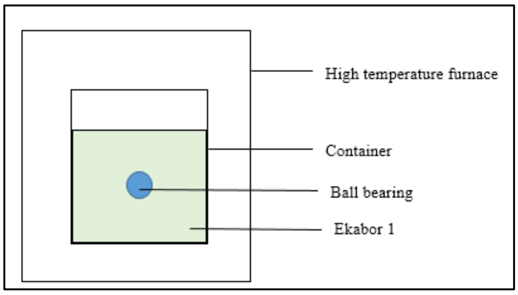

Figure 1 Schematic diagram for powder-pack boronizing process.

Table 2 Parameters for boronizing of 10 mm stainless - steel ball bearing.

No.of experiment	Boronizing Temperature	Boronizing Time	Powder Condition	Powder Pack Surrounding Thickness
1	850 ºC	2 h	100%	5mm
2	900 ºC	2 h	60%	10mm
3	950 ºC	2 h	30%	15mm
4	850 ºC	4 h	60%	15mm
5	900 ºC	4 h	30%	5mm
6	950 ºC	4 h	100%	10mm
7	850 ºC	6 h	30%	10mm
8	900 ºC	6 h	100%	15mm
9	950 ºC	6 h	60%	5mm

3. RESULT AND DISCUSSIONS

3.1 *Microstructure*

Studied on boronizing of stainless steel reported that the cross-sectional surface of borided layer contains iron rich layer [4]. Figure 2 showed boride layer on one of the boronized sample using SEM micrograph.

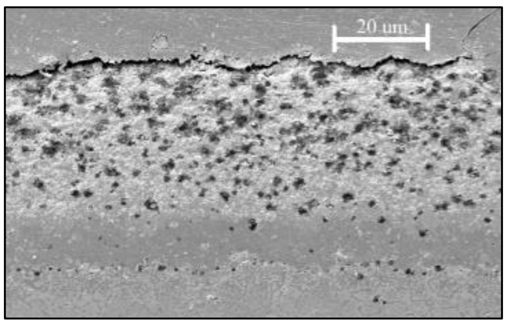

Figure 2 SEM micrographs showed the boride phases formed on the surface after treatment.

3.2 Boride Layer Hardness and Thickness

Table 2 shows the hardness value boride layer thickness from different parameters of boronizing experiments. From this values, it shows the hardness of boronized sample is greater than the unboronized sample.

Table 2 Hardness value and boride layer thickness.

No.of experiment	Hardness Value (HV)	Boride Layer Thickness (µm)
1	354.2	53.77
2	347.2	59.36
3	315.7	55.68
4	351.1	50.43
5	325.7	31.67
6	373.1	163.92
7	339.1	48.22
8	366.9	66.32
9	309.2	25.54

3.3 Wear Properties

Previous studied showed that increase in boronizing time has increased the thickness of the boride layer. This has resulted in a decrease of wear. Therefore, it is claimed that the boronized steels show improved wear performance because of increasing in hardness properties [4], as shown in Figure 4. Similar wear behavior is expected for the current study.

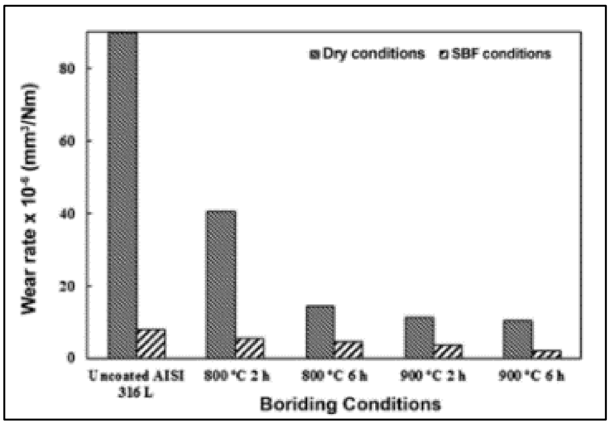

Figure 4 Wear rate variation of the boronized and non-boronized AISI 316L stainless steel according to different wear media [4].

3.5 Kinetics of Atoms Diffusion

The kinetics of layer growth is controlled by perpendicular boron diffusion into the Fe_2B layer [5]. The squared thickness of the boride layer as a function of boronizing time is described as:

$$X^2 = Kt, \qquad (1)$$

Where X is the depth of boride layer (cm), t is the process time (s), while K is the diffusion coefficient (cm^2/s). The relationship between diffusion coefficient D, temperature T, and activation energy Q, can be expressed using an Arrhenius equation [4] as follows:

$$K = K_o \exp(-Q / RT) \qquad (2)$$

Where K is the diffusion coefficient, K_o is called the pre-exponential constant, Q is activation energy (J/mol), T is the absolute temperature (Kelvin), and R is the universal gas constant (J/mol/K) [4]. Such result is shown in Figure 5 [4].

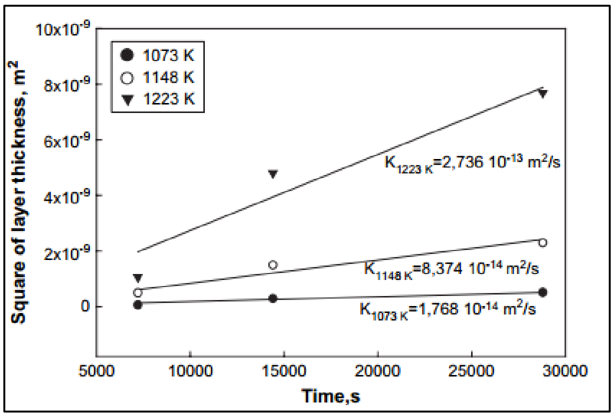

Figure 5 Square of boride layer as a function of boriding time for test temperatures [4].

4. CONCLUSIONS

The investigations on surface properties of borided stainless-steel ball bearing will be done in this study. In comparison with previous studies, there is no further study on boronizing stainless steel ball bearing with different parameters [1,3,4]. Powder utilization in pack boronizing process will be optimized, and it is expected that the relation of the borided hardness with surface diffusion and wear properties of the 316 stainless-steel ball bearing can be elucidated, thus contribute to a development of new potential material for automotive applications.

5. REFERENCES

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