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WEAR BEHAVIOR OF CARBURIZING ON POWDER METALLURGY ALLOYS

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ABSTRACT

In this paper is studied the influence of wear behavior of carburizing in fluidized-bed on sintered alloys produced by powder metallurgy route. In powder metallurgy, carburization is a thermochemically treatment that occurs in the temperature range of 850-950 ºC and had a great importance to establish the correlation between porosity and carbon diffusion.

KEYWORDS: powder metallurgy, sintering, fluidized bed carburizing, abrasive wear

1. Introduction

Powder metallurgy is an alternative technology of lower cost process. The parts produced by powder metallurgy are of complex shapes and closed to final form, widely used, especially in the automotive industry [1].

The main problem of powder metallurgy products is the presence of pores. The pores acts as potential crack initiation sites, and can also guide and propagate cracks through the material. The properties of sintered powder metallurgy alloys can be improved by increasing the density, reducing pore size, or by adding alloying elements [2-4]. Copper, nickel, molybdenum, manganese and phosphorus are the most common alloying element added in powder form because of its low cost, availability and ability to improve the properties of alloys. Cu increase the toughness and density of the alloys by filling the pores due to melting during the sintering process (copper melts at 1083 °C). Another way to improve the properties of these alloys is by applying heat, thermochemical or mechanical treatments [5-13].

Fluidized bed carburizing is a thermochemical treatment that provides high heat and mass transfer. Due to the acceleration of the chemical reactions and diffusion, the fluidized bed has a rapid heating rate [7-10].

In this paper, the wear behavior of carburized in fluidized bed sintered alloys are analyzed.

2. Experimental procedure

The specimens studied in this paper are represented by atomized iron powder and pre-alloyed iron base powder. The chemical composition of the powders, pure iron and iron-based prealloyed powder with Cu, Ni and Mo is presented in table 1.

After being blended, the powders were uniaxially compacted into specimens, using an universal mechanical testing machine at ambient temperature The samples were pressed in a mold using uniaxial pressing. The applied pressure was 600 MPa and the disc specimens have the dimensions of $\phi\, 8 \times 6$ mm. The samples were mixed with 1% zinc stearate.

***Table 1**. Chemical composition of analyzed powders*

Powder type	Cu	Mo	Ni	C
P_1	0.096	0.008	0.046	<0.01
P_2	1.50	0.50	4.00	<0.01

After compaction, the green samples were subjected to sintering. The sintering temperature was approximately 1.150 °C and the sintering time was 60 minutes. After cooling to room temperature the samples were subjected to gas carburizing treatment. The fluidized bed carburizing conditions were heating at 900 °C during 60 minutes. Specimens were then air-cooled to room temperature. The samples subject to fluidized bed carburizing were tested for abrasion wear test (Fig. 4b). The SiC particles on the abrasive papers were the size of 80 μm and the load applied was 855 g. The distance traversed in each case was limited to 150 cycles corresponding to 76.5 m. The samples were cleaned and weighed using a precision balance before and after each test. Also, after the abrasive wear tests, the worn surfaces were examined by optical microscope, to evaluate the wear mechanism of the material. Also, the microhardness values of the sintered and carburized in fluidized bed alloys were analysed to correlate the wear behavior of this specimens.

3. Results and discussions

Optical micrographs representative of carburized samples are presented in figures 1 and 2. The microstructure of carburized samples was observed by optical microscopy (Olympus BX 50). Due to prolonged time in carburized, the samples were completely enriched in carbon. In sample P_2 with 4%, were evidence the presence of Ni-enrich areas.

Microstructures of specimens subject to carburized in fluidized bed consist in ferrite with pearlitic grains, cementite and Ni-enrich areas.

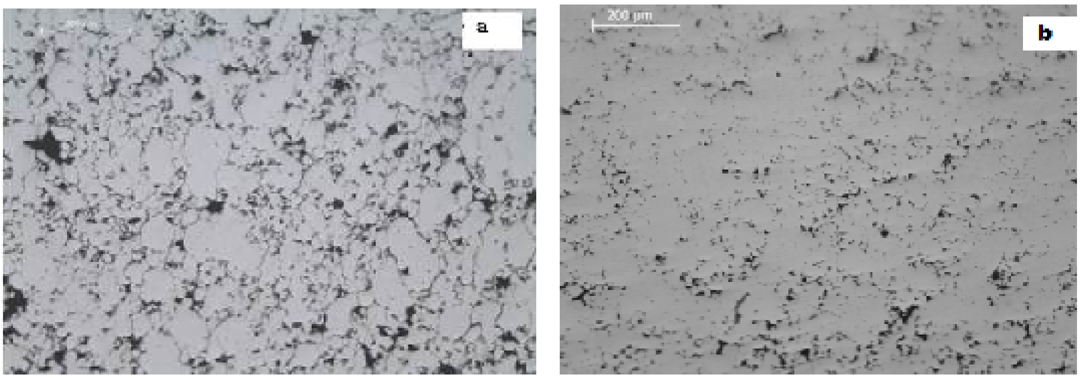

Fig. 1. *Image of the microstructure of carburized samples, unetched, 200x: a) P_1, b) P_2*

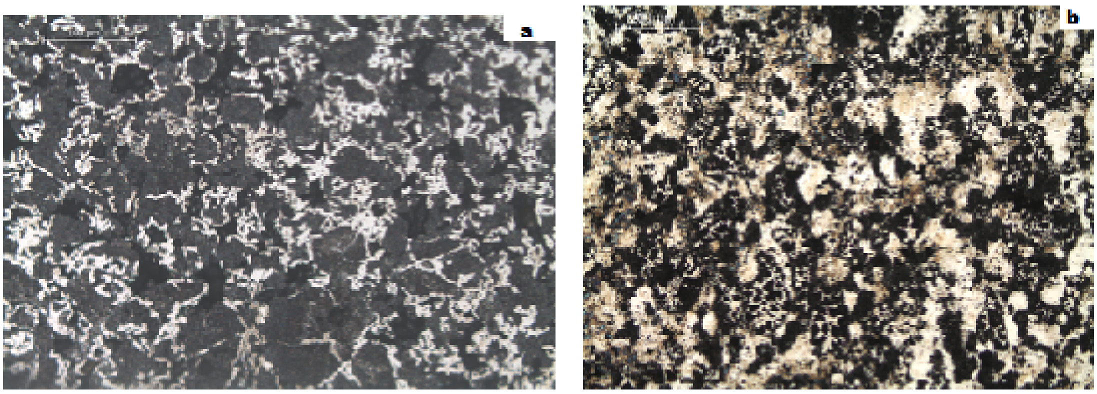

Fig. 2. *Image of the microstructure of carburized samples, etched Nital 2%, 200x: a) P_1, b) P_2*

Microhardness values of the sintered and carburized in fluidized bed alloys were analysed. The microhardness tests were performed by measuring Vickers microhardness, the applied load was 100 and the penetrator was a diamond pyramid. The microhardness was the average of three indentations on the top and anothers three on the bottom surfaces of each samples. Table 2 reports the values of microhardness of studied specimens. It is obvious that the sample P_2 with 4% Ni has the highest microhardness value because the Ni-enriched areas offers local ductility and have a positive influence on hardness and strength of sintered and carburized materials [18]. The worn surfaces of carburized samples after abrasion tests were examined in optical microscope, the typical aspects of abraded surfaces are represented in figure 3. The depth and width of wear grooves of carburized samples P_1 are greater compared to samples P_2.

The wear rate of carburized in fluidized bed specimens was measured as the weight loss, sample P_2 provided the less weight loss.

Table 2. *Microhardness values of sintered and carburized samples*

Sample type	**Microhardness Vickers values for sintered samples** [daN/mm^2]	**Microhardness Vickers values for carburized samples** [daN/mm^2]
P_1	161	403
P_2	178	709

Table 3 presents the weight loss of the carburized samples tested to abrasive wear.

Table 3. *Weight loss of carburized samples*

Sample type	**Weight loss** [g]
P_1	0.16
P_2	0.98

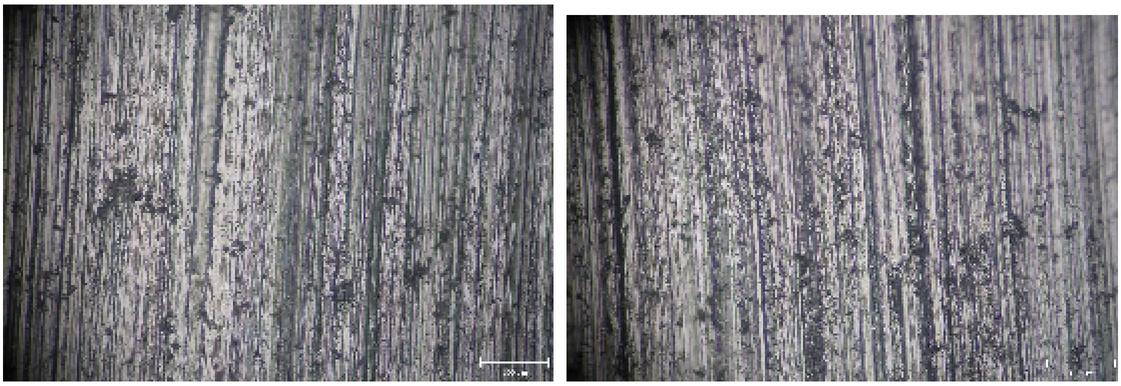

Fig. 3. *Optical photomacrographs of worn surfaces for carburized in fluidized bed samples (x200): a) P_1, b) P_2*

a

b

Fig. 4. *Aspect of initial and worn surface after the abrasion test of carburized in fluidized bed specimens*

4. Conclusions

The following main results were obtained:

- Abrasive wear surfaces for both types of powders presents deeper traces in unalloyed sample and finer trace in samples alloyed P_2, according with the aspects of the surface.

- The carburized sample P_1 presents a depth and width of wear grooves greater, thus there is a possibility of less resistance offered.

- The sample P_2 with 4% Ni has the highest microhardness value because the Ni-enriched areas offers local ductility and have a positive influence on hardness and strength.

- The weight loss is less for the sample P_2 subject to carburized in fluidized bed.

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