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EFFECT OF FLUIDIZED- BED CARBURIZING ON MECHANICAL PROPERTIES AND ABRASIVE WEAR BEHAVIOR OF SINTERED STEELS

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ABSTRACT

In this paper is studied the influence of fluidized bed carburizing of sintered steels, for three different types of powder. Carburization is one of the most popular variety of temochemical treatment. Usually, carburization occurs in the temperature range of 850-950 ºC. In powder metallurgy, the carburization had a great importance to establish the dependencies between porosity and their ability to take carbon.

KEYWORDS: powder metallurgy, fluidized bed carburizing, abrasive wear

1. Introduction

The growth of ferrous powder metallurgy (P/M) over the past three decades has been outstanding as this technology proves to be an alternate lower cost process to machining, casting, stamping, forging, and other similar metal working technologies. Parts manufactured by powder metallurgy (P/M) are widely used, especially in the automotive industry.

Powder metallurgy parts of complex shapes are obtained and close to final form, with precise surface [1]. Also, specific parts made by powder metallurgy processing help to save time, energy, material, labor and money [2, 3].

Compared to classical metallurgy, additional processes (such as machining, forging, etc.) are minimized in powder metallurgy [4, 5].

Sintering is the process of compaction, consolidation by heat treatment. It is a complex process representing a summation of physical and physic-chemical phenomena that follow each other or overlap.

Sintering process can be divided conventionally into three stages which follow each other at high temperature:

• initial stage - is the transformation of point contacts between particles in bridges and their expand to about 25-30% of the particle radius to form "necks" that cause hardening of the specimen. At this stage the particles retain their individuality, and contractions are small (max.4-5%).

• intermediate step is to extend necks between particles to particles, losing their individuality. At this stage occurs 85-90% of total densification and grain growth of the particles.

• the final stage starts at a lower porosity, 10% and consist in transforming the network channels in isolated pores. The mechanisms involved in the transport of material to sintering are surface, intergranular limits and volume diffusion (Fig. 1).

The properties of sintered materials are determined both by the nature of the material's characteristics of powders used, pressing and sintering process parameters and subsequent processing procedures applied [6].

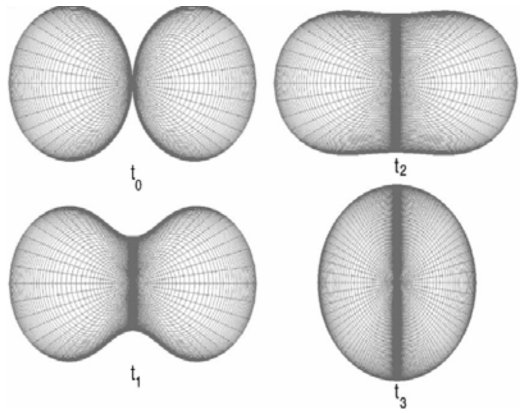

Fig.1. *The schematic of two powder particles during sintering, carried out using finite element method at different sintering times,* $t_0 < t_1 < t_2 < t_3$ *[7].*

Carburizing consists in a surface carbon enrichment, which gradually decreases towards the core [8-14].

In this paper, the mechanical properties and abrasive wear behavior of carburized in fluidized bed sintered steels are analyzed. The abrasion tests were conducted under constant load and speed conditions.

2. Experimental procedure

2.1. Materials

Specimens prepared from atomized iron powder and from pre-alloyed iron base powders were analyzed in this paper. The chemical composition of the powder samples, pure iron and iron-based prealloyed powder with Cu, Ni and Mo is presented in Table 1. To evaluate the mechanical properties, a die for making the samples in the form of a cylinder was produced. The samples were used to evaluate mechanical properties such as Vickers microhardness and abrasive wear.

The powders were mixed with 1% zinc stearate. The samples were compressed in a universal mechanical testing machine to a pressure of 600 MPa, the dimensions of disc specimens are $\phi 8 \times 6$ mm. Uniaxial pressing in the mold is used effectively for mass production of simple components.

In figure 2 is the picture of the sample.

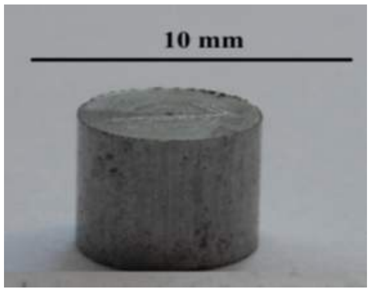

***Fig. 2.** Aspect of sintered sample.*

The green samples were sintered in a laboratory furnace, within a controlled atmosphere. The sintering temperature was approximately 1.150 °C and the sintering time was 60 min with a heating rate of 30-40 °C/min. All the samples were kept in the furnace for slow cooling to room temperature.

The microstructure depends on the amount of sintered carbon and cooling rate. Before the sintering temperature is reached, the parts were maintained during 30 min at 500 °C to burn lubricant, respective zinc stearate.

After cooling to room temperature the samples were carburized-treated.

***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	1.75	<0.01
P_3	1.50	0.50	4.00	<0.01

Treatment conditions for the fluidized bed carburizing process were heating at 900 °C during 60 min. Specimens were then air-cooled to room temperature.

The microstructure of carburized samples was observed by optical microscopy (Olympus BX 50). Photomicrographs were obtained at a magnification of 200X. In Figure 3 is presented the size distribution of the analyzed powders.

2.2. Mechanical properties

The samples, carburized in fluidized bed were analyzed according to their mechanical properties. The microhardness tests were performed by measuring Vickers microhardness, and the test parameters are: the penetrator is a diamond pyramid diameter and load of 100g.

The microhardness was the average of three indentations on the top and another on the bottom surfaces of the samples.

2.3. Abrasion wear tests

Abrasive wear is a process of removal and destruction of surface tested material. It is affected by many factors such as mechanical properties and abrasive materials, microstructure, loading condition, etc.

Samples subject to fluidized bed carburizing were tested for abrasion wear test (Fig. 4). The SiC particles on the emery papers were the size of 80μm and the load applied was 855g. The distance traversed in each case was limited to 150 cycles corresponding to 76,5 m. The samples were subjected to circular motion over the wheel on which the abrasive paper was stuck.

The abrasion wear process in which the abrasion test was carried out included:

- first, fixing the abrasive paper on the wheel;
- the samples of known weight were loaded on the machine and applied the load;

- the specimen surface and the abrasive paper were always in strong contact with each other under the predetermined load, and
- the samples were cleaned and weighed prior to and after each test interval.

Fig. 4. *Aspect of worn surface after the abrasion test.*

The samples were weighed using a precision balance with a sensitivity of 10^{-4} before and after each test, so it was possible to evaluate the wear undergone by the material. After the tribological tests, the worn surfaces were examined by optical microscope, in order to identify the dominant wear mechanisms.

3. Results and discussion

3.1. Microstructure

Optical micrographs representative of carburized samples are presented in Figures. 5 (a, b, c). Microstructural analysis shows uniform structures with specific components of steel depending on difussion carbon content.

Most alloying elements move the S point to the left of the Fe-C diagram, means that powder by increasing the carbon content by applying thermochemical treatment in fluidized bed carburizing can be reached at the surface structures of eutectiod hipereutectoid steel (pearlite and cementite).

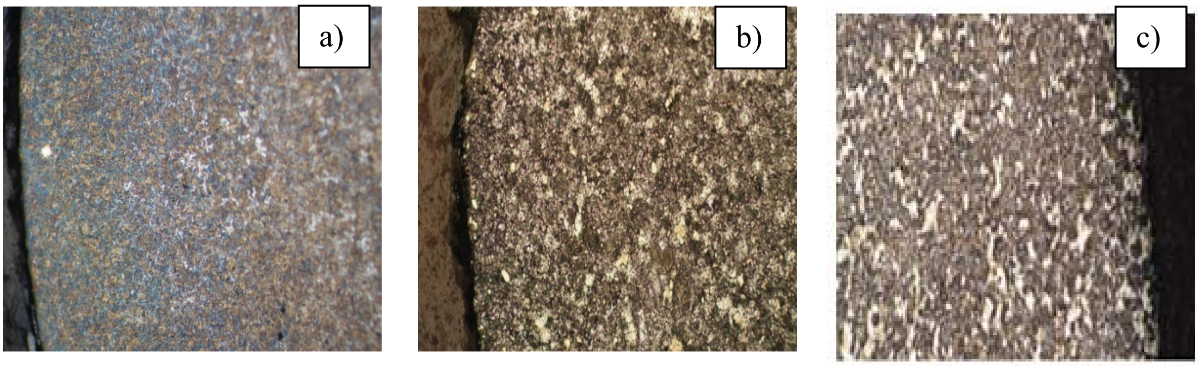

Fig. 5*. Microstructure of sintered steel subject to fluidized bed, etching 2% Nital, 200x.*

This distribution of structures explains the major hardness of carburized superficial layer. Figure 6 shows a microhardness values for carburized treated samples studied.

It is found that all three types of samples have proximate values of Vickers microhardness.

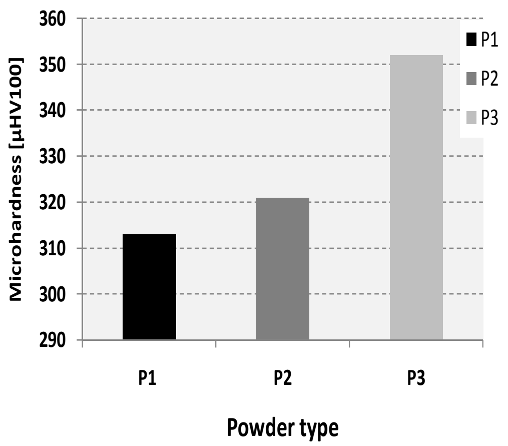

Fig.6. *Vickers microhardness values of the carburized samples.*

3.2. Tribological tests

The worn surfaces of carburized samples after abrasion tests were examined in optical microscope, the typical aspects of abraded surfaces are represented in Figure 8.

The depth and width of wear grooves of carburized samples P_1 are greater compared to samples P_2 and P_3.

Figure 7 presents the weight loss of the sintered samples tested to abrasive wear.

The wear rate was measured as the weight loss, sample P_3 provided the greatest weight loss.

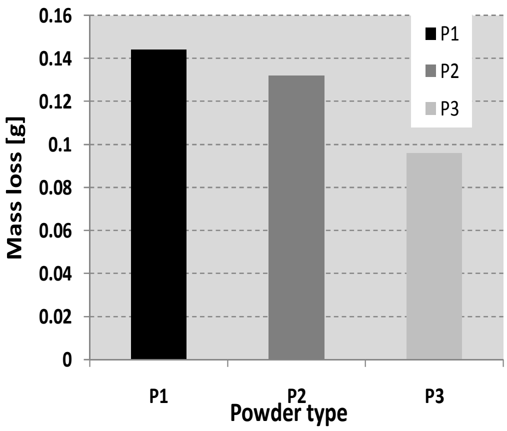

Fig. 7. *Weight loss for carburized treated samples.*

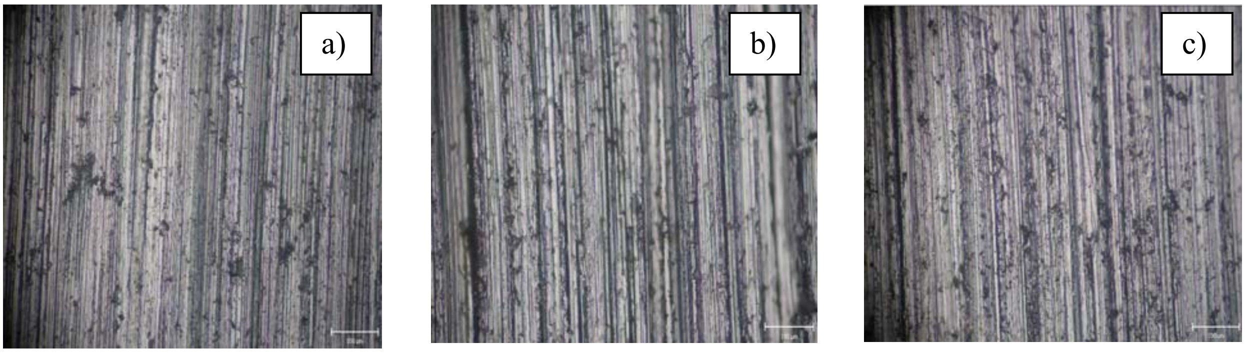

Fig.8. *Optical photomacrographs of worn surfaces for carburized samples (x200): a) P_1, b) P_2, c) P_3*

4. Conclusions

According to the experimental results in this study, the following conclusions may be discussed:

■ Based on the measurements of microhardness, the samples P_2 and P_3 show higher values.

■ Abrasive wear surfaces for all three types of powders presents deeper traces in unalloyed samples and finer trace in samples alloyed P_2 and P_3, as subsequent wear tests give results in conformity with these aspects of the surface.

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

■ The carburized samples P_2 and P_3 present a much smaller wear groove width that can ensure a good resistance.

■ The weight loss is less for the carburized samples P_2 and P_3.

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