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MECHANICAL PROPERTIES AND ABRASIVE WEAR BEHAVIOR OF FLUIDIZED-BED CARBURIZED SINTERED IRON ALLOYS

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ABSTRACT

This paper is a study of the influence of fluidized bed carburizing of sintered steels on the mechanical properties and the abrasive wear behavior for two different types of powder. Carburizing was carried out at a temperature of 900° C and maintained for 20 minutes and 40 minutes, respectively. It was found that the best values for Vickers microhardness and abrasive wear were recorded when the carburizing time is 40 minutes for powder P_2.

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

1. Introduction

Powder metallurgy (P/M) is a technology providing an alternative lower costs process comparing with other metal technologies.

Powder metallurgy's markets for this parts are varied, the automotive applications are dominated.

Iron powder accounts for around 90% of the total world powder production and is the most common form of powder in manufacturing, mostly in the auto industry [1- 4].

The four basic stages of powder metallurgy are: powder manufacture, powder mixture, pressing and sintering (Fig. 1).

Sintering is the process of compaction, consolidation by heat treatment of a part. It is a complex process, with physical and physicochemical phenomena that success or overlap [4]. The mechanisms involved in the transport of material to sintering are surface, intergranular and volume diffusion.

The properties of sintered materials are determined, in the first step, by the nature of the material characteristics for the powders involved, and ,secondary by pressing and sintering process parameters [5].

Mechanical properties can be improved by increasing the density, reducing the pore size or applying a thermochemical treatment (carburizing, nitriding, boriding) [6-7].

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 fluidized bed carburized sintered steels are analyzed. The abrasion tests were conducted under constant load and speed conditions.

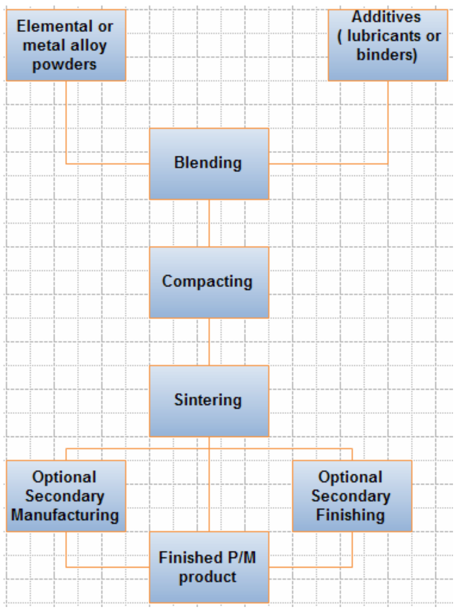


***Fig. 1**. Powder Metallurgy Process*

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.

***Table 1**. Chemical composition of analyzed powders (wt%)*

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

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 the disc specimens are $\phi\, 8 \times 6$mm. In Figure 2 is the picture of the sample.

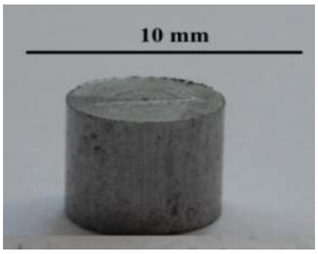


***Fig. 2.** Aspect of sintered sample*

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.

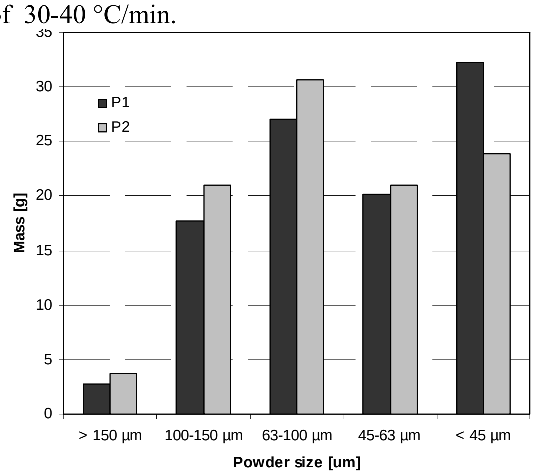


***Fig. 3.** Size distribution of analyzed powders*

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, respectively zinc stearate.

After cooling to room temperature the samples were carburized-treated. Figure 3 presents the size distribution of the analyzed powders. The treatment conditions for the fluidized bed carburizing process were heating at 900°C during 20 and 40 minutes. The specimens were then air-cooled to room temperature.

The carburized layer depth is a function of carburizing time and carbon potential available surface [10]. When the carburizing times are increased, deep carburized layers are obtained, which can lead to a structure consisting of residual austenite in excess or free carbides. These two microstructural elements have adverse effects on residual stress distribution in the layer. Therefore, a high carbon potential may be suitable for short carburizing times, but not for increased carburization. In this study, it appears that only the carburized sample with 40 minutes shows the carburized layer. The microstructure of the carburized samples was observed by optical microscopy (Olympus BX 50). Photomicrographs were obtained at a magnification of 200X.

2.2. Abrasion wear tests

Samples subject to fluidized bed carburizing were tested for abrasion wear test (Fig. 4). The SiC particles on the abrasive 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 76.5m.

The samples were subjected to circular motion over the wheel on which the abrassive paper was stuck.

The abrasion test process included the steps: first, fixing the abrasive paper on the wheel.

Then, the samples of known weight were loaded on the machine and then the load was applied, and, finally, the samples were cleaned and weighed prior to and after each test interval.

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

After the tribological tests, the worn surfaces were examined by optical microscope, in order to identify the dominant wear mechanisms.

2.3. Mechanical properties

The carburized in fluidized bed samples 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.

3. Results and discussion

3.1. Microstructure

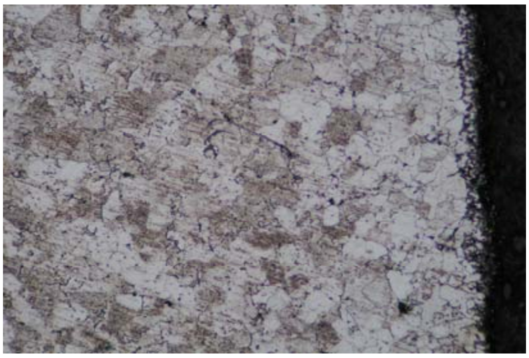
Optical micrographs representative of carburized samples are presented in Figures 5 and 6. Microstructural analysis shows uniform structures with specific components of steel depending on difussion carbon content.

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

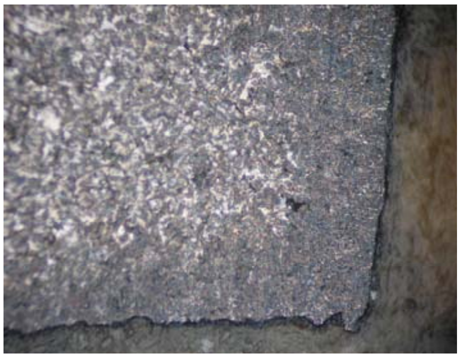
This distribution of structures explains the major hardness of carburized superficial layer.

3.2. Tribological tests

The worn surfaces of carburized samples after abrasion tests were examined under the optical microscope, the typical aspects of abraded surfaces are represented in Figures 7 and 8.



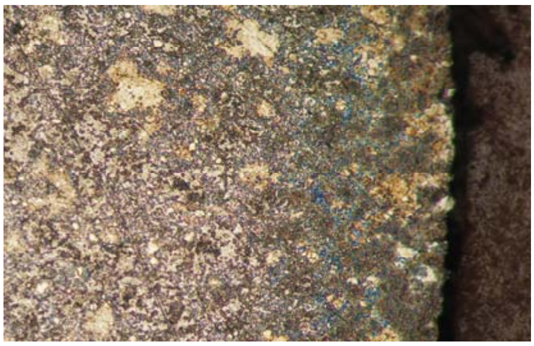
a)



b)

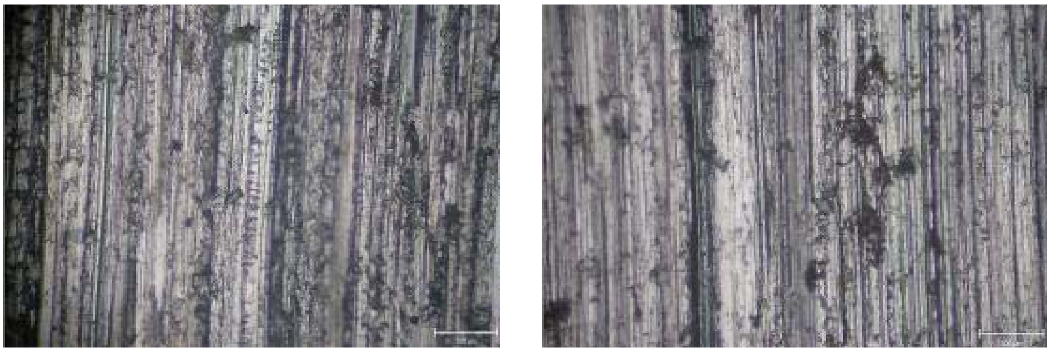
Fig. 5*. Microstructures of sample carburized (powder P_1) at 900° C: a) 20 minutes (200x), b) 40 minutes (200x), etched Nital (2%)*

a)



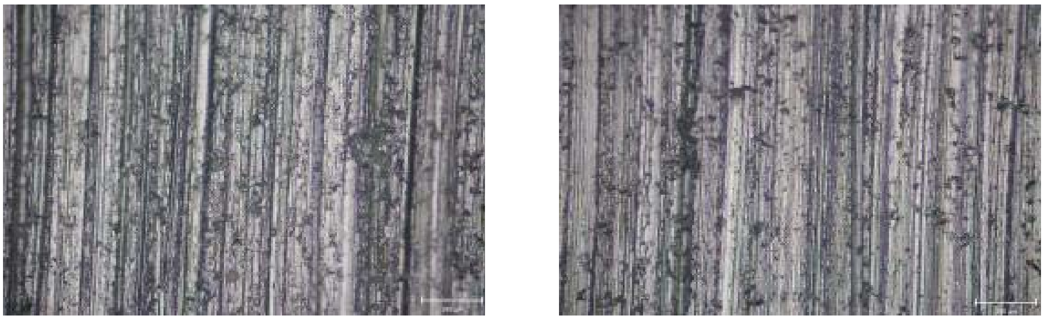
b)

Fig. 6*. Microstructures of sample carburized (powder P_2) at 900° C: a) 20 minutes (200x), b) 40 minutes (200x), etched Nital (2%)*



a) b)

Fig. 7. *Optical photomacrographs of worn surfaces for carburized samples at T= 900°C, 20 minutes. (x200): a) P_1, b) P_2*



a) b)

Fig. 8. *Optical photomacrographs of worn surfaces for carburized samples at T= 900°C, 40 minutes. (x200): a) P_1, b) P_2*

Figures 9 and 10 show microhardness values for the carburized treated samples studied. It is found that samples carburized for 40 minutes have proximate values of Vickers microhardness. The depth and width of wear grooves of carburized samples P_1 are greater compared to samples P_2.

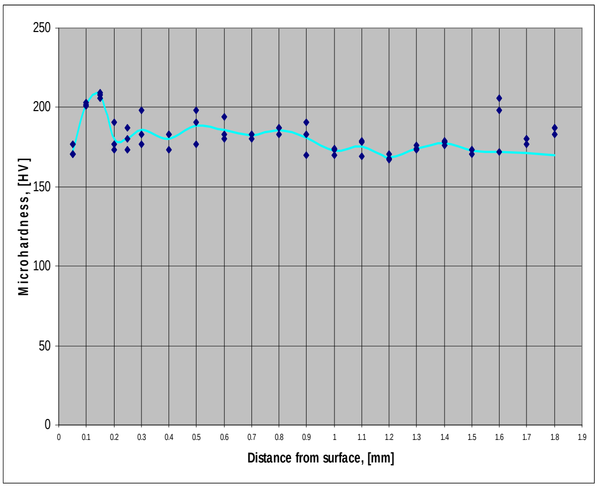


Fig. 9. *Microhardness variation from surface to the center for carburized sample (powder P_1) at T= 900°C, 40 minutes*

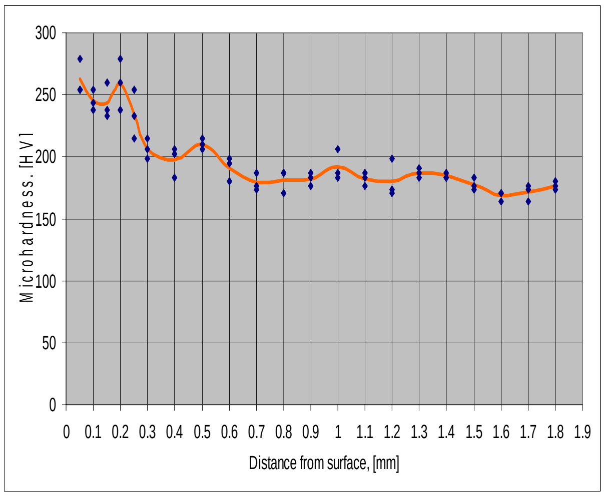


Fig. 10. *Microhardness variation from surface to the center for carburized sample (powder P_2) at T= 900°C, 40 minutes*

4. Conclusions

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

-the best microhardness values were recorded when the sample were carburized at 900°C for 40 minutes, especially for powder P_2;

-the carburized layer depth is a function of carburizing time and carbon potential available surface;

-abrasive wear surfaces for two types of powders present deeper traces in unalloyed samples and finer trace in samples alloyed P_2, as subsequently wear tests giving results in conformity with these 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 carburized samples P_2 present a much smaller wear groove width, that can ensssure a good resistance.

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