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MECHANISM OF FORMATION OF BORIDE LAYERS ON POWDER METALLURGY MATERRIALS FROM THE SYSTEM FE-C-CU

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Abstract

In this study the mechanism of formation of boride diffusion layers of semi-permeable saturating environments in semi-permeable construction materials from the system Fe-C-Cu is traced. The main iron matrix of iron powders type NC 100.24, to which is added 2,0% Cu and 0,4% C. After sintering at 1150ºC density of the samples vary between 5,80÷7,00g/cm^3. In diffusive enrichment was conducted at 950ºC for 10÷100min. Formation mechanism of the diffusion coatings is studied using X-ray diffraction analysis of resulting diffusion coatings. X-rays from were filmed X-ray diffractometer in unfiltered Kα radiation from iron anode at a critical voltage 7,1kV and $K\alpha_{av}$ = 1,93728Å. It has been shown that the seeds of low boride phase Fe_2B and their growth were fixed after the first 20÷40min saturation at a temperature of 950ºC, regardless of the density of the test samples. The nucleation of high boride phase is formed after the first 20min of saturation at 950ºC on samples having a density of 7,00g/cm^3 and 60min at samples having a density of 5,80g/cm^3.

Keywords: powder metallurgy; iron powder NC 100.24; thermochemical treatment; boride layers; X-ray diffraction analysis.

INTRODUCTION

Powder metallurgy currently develop sufficient intensity, which is a consequence primarily of its high cost effectiveness and also by the possibility to obtain materials with unique properties that are impossible to obtain by conventional technologies [3,5,8,9,10, 13,14,15]. This is a technological process in which the powders are used to produce high-quality details by minimal loss of material. Upon proper selection of the powders and their technological properties can provide a wide range of mechanical and physical characteristics of the final product, which can be both metal and ceramic, or a combination of metal with non-metallic components [5,10,14].

Over 80% of its products in powder metallurgy are details with construction purpose. This most often are inexpensive and well available low and medium alloy alloys, technological processing, but often with lows operating characteristics.

It is well known practice for increasing operating characteristics of structural steel products molded to be used different methods of thermochemical treatment. Through them achieved good wear resistance, corrosion resistance, high hardness, and heat resistance of the surface layers of detail. These methods are sufficiently well studied in the technical literature are devoted numerous articles and monographs [1].

Regularities of forming diffusion layers on solid materials is impossible to be transferred directly to the powder metallurgy such as these characterized by several features, the most important of which is the presence of residual porosity. This change significantly the conduct of diffusion processes that are essential in the formation of layers in the application of different methods for thermochemical treatment.

This publication has studied the mechanism of formation of diffusion coatings in one-component diffusion enrichment with boron in semi-permeable powder metallurgical samples of the system Fe-C-Cu in semi-permeable saturating environments [11].

EXPOSITION

It is known that the resistance of boride coatings at different abrasive media is dependent on their phase composition formed in the process of saturation [1,2]. In a series of preliminary studies, we have shown that to achieve good results when working in abrasive environments need received high boride phase – FeB, not to form a dense layer on the surface of the saturation product. This requires in each case at boration of construction materials to study the formation and growth of boride diffusion layers.

Morphology mechanisms of the kinetics of growth of boride diffusion layers by saturation of the powder metallurgical structural material depends on several technological factors such as:

- temperature and duration of saturation;
- composition of saturating environment;
- concentration of elements in the tripartite system and others.

Them by adding the presence of pores - open and closed, it is clear that the emergence and growth of

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diffusion layers in powder metallurgy semi-permeable material depends on many external factors. To issue triple system additional factor is the presence of copper in iron-carbon matrix. Copper, along with all its advantages as an alloying element in this type of construction materials has some shortcomings, which in turn transmit specifics of diffusion processes occurring in boronizing of samples of surveyed triple system.

Based on the above considerations traced the mechanism of formation of diffusion coatings in boration sampling system Fe-C-Cu in semi-permeable saturating environments. For this purpose, we have used the methods of X-ray [4,6,7]. X-rays from were filmed X-ray diffractometer in unfiltered Kα radiation from iron anode at a critical voltage 7,1kV and $K\alpha_{av}$=1,93728Å. The characteristics of the power generator are U=24kV and I=14mA. Interval shooting X-rays from an angle 2θ is 40 ÷ 120º, the scan is every degree.

At study were subjected boride coatings formed after saturation for 10÷100min at 950ºC in a semi-permeable composition with a saturating medium – 1 [12].

$84\%Na_2B_4O_7 + 12\%SiC + 4\%K_2Cr_2O_7$ (1)

Studied models are developed based iron powders NC100.24, such as iron matrix - alloyed with 2,0% copper and 0,4% carbon. After pressing the sample with force 200÷800MPa and sintering at 1150ºC for 1 hour the measured density of the samples varied in the range of 5,80÷7,00g/cm^3.

The formation of the boride coating is followed by X-ray diffraction analysis by changing an intensity of line (211) of Feα - fig.1.

From the start in the process of saturation in the contact surface between the workpiece and the melt establishes a high concentration of boron atoms, which diffuse into the lattice of the solid solution. This leads to a change in intensity of the interference maxima of Feα after cooling.

According to references [4,7], the relative intensity of this line (211) of Feα is 38% - fig.1.a but after saturation for 10÷20min showed a decrease in the amount, and it is of the order 18÷21% - fig.1.b,c. After saturation for 80min it virtually merges with the background of the X-ray diffraction, which shows that it is already 5÷10% - fig.1.e, f.

From the results of Fig.1, it is seen that with an increase in the retention time is recorded only decrease the intensity of the interference maxima of the line (211) of Feα without evidencing a significant deviation of the peak towards a larger Breg's angles, which is characteristic in the boronizing of samples not containing copper [1].

With increasing time of saturation is reached maximum solubility of boron in Feγ resulting in formation of embryos began to lower boride phase Fe_2B. From these embryos after the first 20÷40min saturation begin to grow crystals of Fe_2B - Fig.2.

After saturation for 60min on the sample surface is formed a layer of Fe_2B which hinders the diffusion of

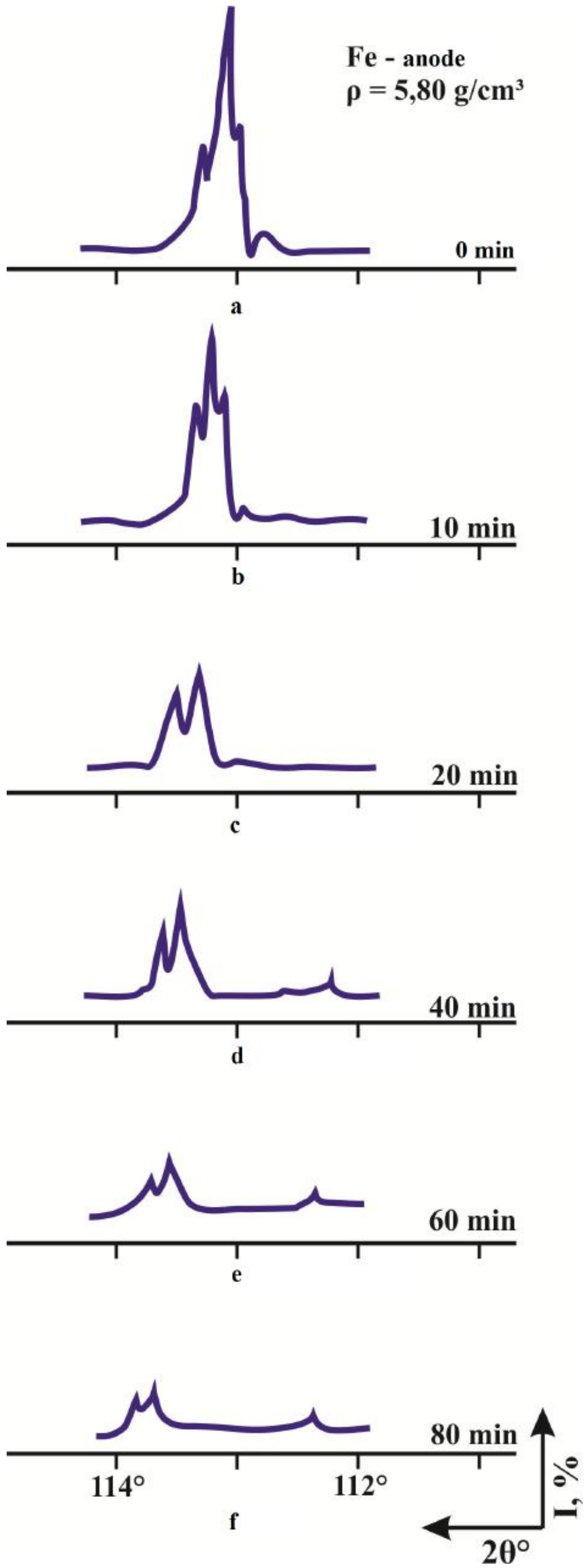

Fig.1. A change in the interference maximum line (211) of Feα alloyed with 0,4% C and 2,0% Cu after boronizing for 0÷80min at 950°C

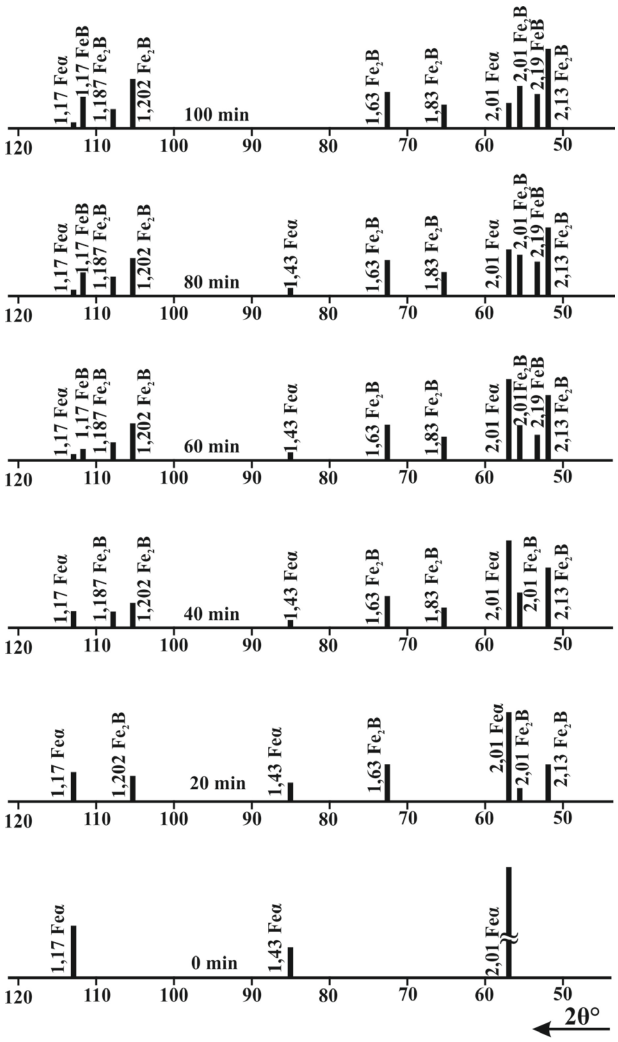

Fig.2.Shtrih diagram of boronizing workpiece with a density of 5,80g /cm^3 after saturation for 100min at 950℃

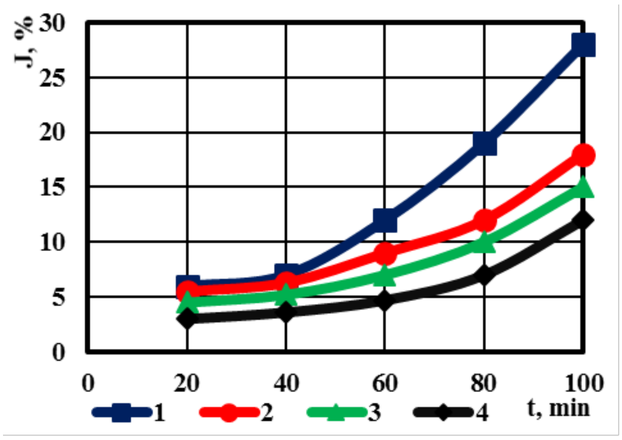

Fig. 3. Change the intensity of the line (211) Fe_2B in different density of the samples: 1 - 5,80 g/cm^3; 2 - 6,20 g/cm^3; 3 - 6,60 g/cm^3 and 4 - 7,00 g/cm^3.

boron atoms from the surface to the core of the specimens. Their concentration on the surface rises to a level allowing the formation of embryos from high boride phase FeB, which is presented in Fig.2 of the strongest lines (111) and (211) situated respectively between planar distance d/n – 2,19 and 1,60.

In the initial stage of saturation - the first 20min, density of the output samples did not substantially affect the formation phase Fe_2B – Fig.3.

By increasing the retention time to 100min, in samples with higher density - 6,60÷7,00g/cm^3, the growth phase Fe_2B is difficult. If the intensity of the line (211) phase Fe_2B in samples with density 5,80g/cm^3 nearly 30%, the samples for density 6,60÷7,00g/cm^3 is within 12÷15%. This demonstrates a slower penetration of boron atoms inside a denser samples and increase the concentration of boron in the surface, This favors the creation of nucleation of high boron-containing phase - FeB, after the first 20min of saturation, while the samples with a lower density - 5,80g/cm^3, nucleus FeB register after saturation for 60min. - Fig.2.

CONCLUSIONS

Of the examination and received at these results can be formulated following important conclusions:

- It has been shown that the seeds of low boride phase Fe_2B and their growth were fixed after the first 20÷40min saturation at a temperature of 950ºC, regardless of the density of the test samples
- It has been shown that the nucleation of high boride phase is formed after the first 20min of saturation at 950ºC on samples having a density of 7,00g/cm^3 and 60min at samples having a density of 5,80g/cm^3.
- It has been shown that reducing the density of samples of 7,00 to 5,80g/cm^3 increases the thickness of the diffusion layer, but reduces the amount of FeB phase in the layer.

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