



Applicability of Liquid Areas for Saturation During Boronizing of Construction Powdered Materials of Fe-C-Cu System

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Abstract: In the last few years in some publications are expressed an opinion that liquid areas for saturation are inapplicable during the thermochemical treatment of a powder metallurgy materials. In this publication after numerous of tests for bending strength of saturated in composition of liquid boronizing powder metallurgy models of the system Fe-C-Cu is proved a contention that boronizing in liquid areas is possible, but the composition of melts should not contain any chlorides and fluorides.

Keywords: thermochemical treatment, boration, liquid areas, powder metallurgy

I. Introduction

In some of the publications by thermochemical treatment of the materials are expressed an opinion that methods for saturation in liquid areas are unacceptable during thermochemical treatment of sintered materials. During the process of saturation is assumed that the working area infiltrate through the pores in to the core of the details and cause formation of corrosion processes. They from itself harshly reduces the strength characteristics of the workpieces and in some cases that could cause details demolition. But unfortunately the authors of this publications does not adduce facts nor evidences in confirmation conclusions expressed in this direction.[1,3,4] The liquid areas for saturation inherently could be divided into two main groups: soluble and insoluble into water. Toward first group are assigned for example all of the chloride salts and to the second insoluble crystals. The melts of the first group absorb moisture from the air and in the process of saturation forms solutions which could be too aggressive as regards to the formed diffusion layer during the process of saturation. Therefore is necessitates for developing of areas for liquid saturation of powder metallurgy construction materials to compulsory into consideration the aggressiveness of the melt in regard to the formed diffusion layer. This may be achieved through making a valuation of operating duration to the already formed diffusion layers, which is a measure for passing of corrosion processes into saturated samples. If during the operating duration the formed diffusion layers retain their structure and properties it should not be apprehensive of passing processes related to internal corrosion into saturated workpieces.[2,4] Regarding this the present researches objective is to study the opportunity for boronizing into liquid saturated areas of the powdered metallurgy workpieces from the system Fe-C-Cu.

II. Technical requirements

The subject of this study are workpieces, developed on the basis of iron powders ASC 100.29. Towards them is added 0.4% carbon and 2.5% copper. Obtained compositions are pressed with a different force allowing forming samples with different porosity – 10 to 25%. Its sintering is performed in tunnel furnace at temperature of 1150°C for 1 hour and protective atmosphere of dissociated ammonia. Thus way formed workpieces, are exposed on liquid boronizing into different melts on temperature of 950°C during 4 hours. For establishing the influence of the saturated area onto the strength characteristics of the workpieces is measured the bending strength as well after the thermochemical treatment, as after 120 days of remaining in industrial conditions – table 1.

From the obtained experimental results is seen that during saturation in melts composed from basis of alkaline chlorides and fluorides after a continuance of a 120 days is obtained decreasing of bending strength values. For samples with less porosity – 5%, this decreasing is within 220 to 250MPa, in those samples with porosity of 15% is within 3 to 4 times. This decreasing of the strength characteristics are evidences for passing internal corrosion processes and impose the necessity to developing of a new composition for borating which does not include alkaline chlorides and fluorides.

Table I. Bending strength after boronizing in liquid areas

№ of composition	Composition of saturated area	P, %	R _{mi} , MPa				
			Continuance, days				
			0	30	60	90	120
1	2	3	4	5	6	7	8
1	12%Na ₂ B ₄ O ₇ + 36%B ₂ O ₃ + 10%Al ₂ O ₃ + 24%NaCl + 9%SiC + 9%Na ₂ AlF ₄	10	580	519	450	395	312
		15	340	328	306	300	286
		25	232	214	176	118	87
2	14%Na ₂ B ₄ O ₇ + 40%B ₂ O ₃ + 12%Al ₂ O ₃ + 12%NaF + 10%B ₄ C + 12%Na ₂ AlF ₄	10	584	505	460	310	265
		15	330	314	228	208	155
		25	228	178	133	82	53

After numerous experiments was developed a composition for liquid boronizing of a construction powdered metallurgy materials from the system of Fe-C-Cu which does not include alkaline fluorides and chlorides – 1.

$$(80 \div 85)\% \text{Na}_2\text{B}_4\text{O}_7 + (10 \div 15)\% \text{SiC} + (1 \div 5)\% \text{K}_2\text{Cr}_2\text{O}_7 \quad (1)$$

Composition is based on borax – Na₂B₄O₇, but as a deoxidizer is used SiC.

The samples that were study from us after saturation during 4 hours in temperature of 950°C at composition number 1 was conducted layered phase analysis of formed diffusion layer. The analysis was conducted on a X-ray diffractometer in radiating of iron anode with the wavelength $\lambda = 1.93728\text{\AA}$ and mode I=14mA and U=24kV.

Results from layer by layer analysis are presented as a bar chart on fig.1.

From the bar chart is seen that over the samples surface after saturation is formed low-boride phase Fe₂B, which is spread up to 0,10 mm in depth from the surface of the samples. At a larger distance from the surface are not observed nor lines of the iron-diboride, neither compounds of the other elements with diffusible boride phase. At a depth larger than 0,10 mm are fixing only diffraction maximum of the iron.

Figure 1. Layer by layer X-ray crystal analysis on a sample with porousness 25% after boronizing in 950°C in composition 1 during 4 hours.

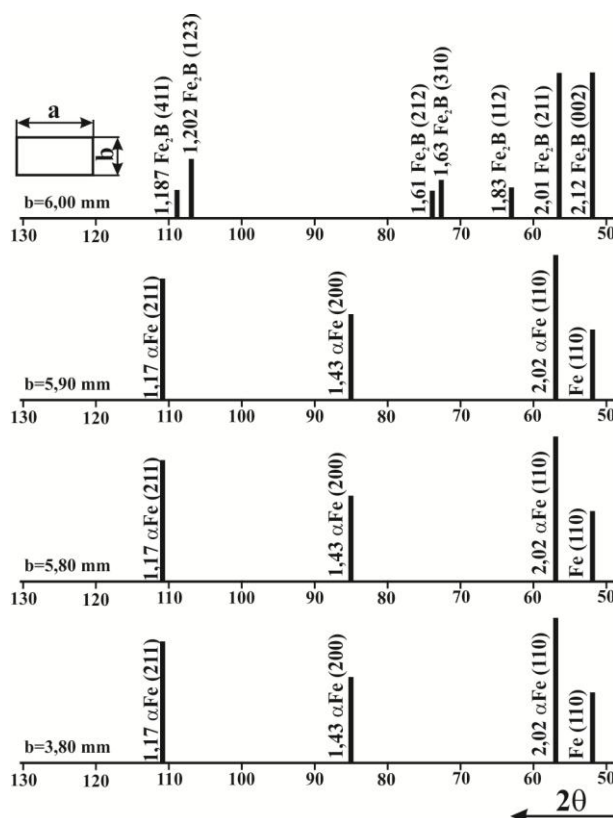


Figure 2. Quantity of the open pores – 1 and closed pores – 2 pores after samples sintering in 1150°C during 1 hour.

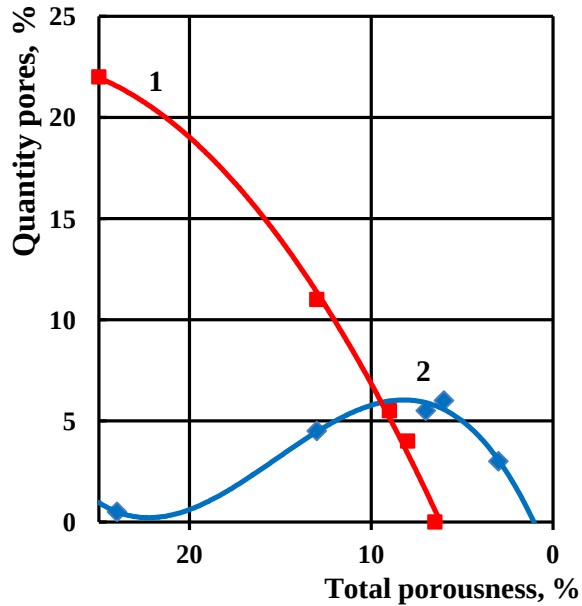
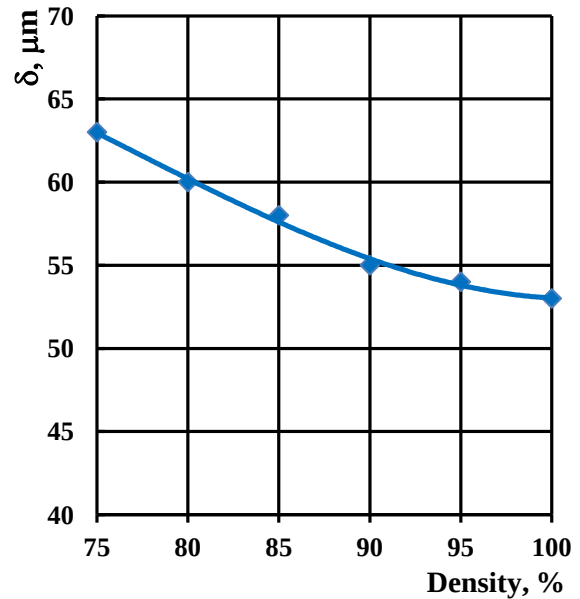


Figure 3. Porosity influence of the samples over the thickness of the formed boride coating



Based on the results of fig.2, should be assume that in samples with porosity lower than 20 to 30% in which the type of the pores is principally through will be seen boride phase all over the structural section of the samples. However, in practice nor during the conducted layer by layer analysis, neither during post-analysing of the microstructure do not indicate that.

From the conducted researches on to samples with different porosity shows that in the area of formed diffusion layer the porosity is effaced and during the constant temperature of saturation and tempering the size of this non-porous area is modify only versus samples density – Fig.3.

Formed in this case non-porous area could be explained by the following reasons:

- ❑ Effacement of the opened porosity in the process of saturation on account of forming boride phases – Fe_2B and FeB which is accompanied with volume increase.
- ❑ Further sintering of the samples due to continuous heating – 4 hours at 950°C.
- ❑ Speed increasing of diffusion in the system Fe-B through forming of eutectic – $\text{Fe} + \text{Fe}_2\text{B}$, which have lower melting temperature – 1149°C than that of the iron

To prove the absence of corrosion processes in the saturated at composition 1 samples, after continuance for about 120 days in air bending strength is observed. Through its determining are used samples with different consistence and sizes of the samples 6x6x100mm². The bending test are conducted as required as EN. Calculation of values for R_{mi} are conducted by using the formula 2.

$$R_{mi} = 1,5 \cdot F_{max} \cdot b/a^3 \quad (2)$$

where: F_{max} – biggest bending load before samples damage;
a, b – sample size – mm.

Reserched samples are borated during 2 hours at temperature of 950°C

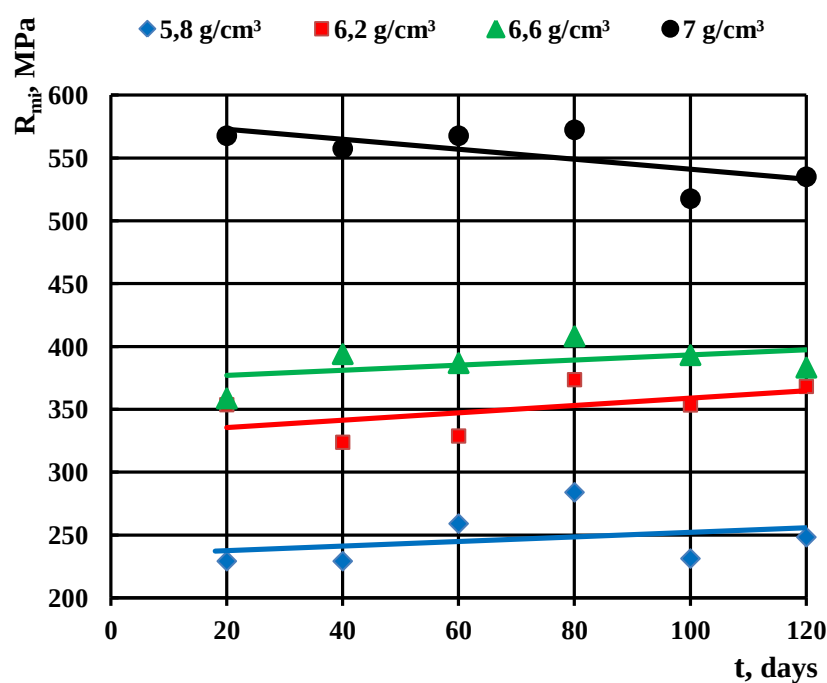
The bending strength tests are observed of 10 samples with the same density at time interval of 20 days – from 0 to 120 days. Averaged values from the observations are presented at table №2, but graphical interpretation in to coordinates continuance of stay – bending strength on Fig.4.

It should follow by interaction of the rest of the melt with the moisture or the water vapourization from the air and the metal surface over the time the bending strength decreasing. From the obtained experimental results is seen that fundamental changes at bending strength values are not registered. For samples with consistence 5,80 g/cm³ the bending strength vary in range of 20MPa, and for samples with consistence 7,00 g/cm³ in range of 55MPa.

Table 2 Bending strenght after boronizing.

№ of test	Continuance time, days	ρ , g/cm ³	Sizes of the samples structural section, mm		F_{max} , N	R_{mi} , MPa
			a	b		
1	2	3	4	5	6	7
1	20	5,80	5,98	5,95	330	229,08
		6,20	5,98	5,98	509	353,58
		6,60	5,96	5,99	516	358,56
		7,00	5,98	5,93	818	567,62
2	40	5,80	6,00	6,00	330	229,08
		6,20	6,01	6,01	466	323,70
		6,60	6,01	6,00	571	393,82
		7,00	6,08	6,01	803	557,36
3	60	5,80	6,01	6,03	373	258,96
		6,20	6,02	6,01	473	328,68
		6,60	6,01	6,02	557	386,65
		7,00	6,02	6,04	818	567,62
4	80	5,80	5,85	6,01	409	283,86
		6,20	6,01	6,02	558	373,50
		6,60	6,00	6,01	587	407,96
		7,00	5,99	5,98	828	572,3
5	100	5,80	5,98	6,01	377	231,17
		6,20	6,04	6,01	508	353,38
		6,60	6,00	6,00	571	393,02
		7,00	6,01	6,01	746	517,52
6	120	5,80	6,01	5,99	345	248,20
		6,20	6,00	6,00	517	368,12
		6,60	6,00	6,01	556	383,06
		7,00	6,03	6,01	764	534,95

Figure 4. Bending strenght of boronizing samples of the system Fe-C-Cu after continuance on air



From the obtained results is seen that after continuance of 120 days on air is not registering any fundamental changes about the bending strenght values. Regardless continuance lasting for a certain consistence of the researched samples the values of the bending strenght vary in range of $\pm 5\%$ from the average values for the certain consistence.

III. Conclusion

From the conducted researches and obtained results could be presented the following conclusions:

❑ After continuance lasting on air – 100 to 120 days, over the borated powder metallurgy samples from the system Fe-C-Cu is not registering decreasing of bending strenght values and could be draw a conclusion that corrosion processes are not at present. From this turn its prove that after saturation in the developed composition for liquid borating in the samples does not remain components that helps forming and ongoing to the corrosion processes

❑ Non-existence of the corrosion processes after continuance natural ageing tretment of the saturated samples could be explained with protective ability of the formed diffusion layer from FeB and Fe₂B.

❑ The achieved experimental results allows us to claim that the developed composition for liquid boronizing which does not include chlorides and fluorides could be used for a diffusive concentration of powder metallurgy construction products from the system Fe-C-Cu with porousness from 10 up to 25%.

IV References

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