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INFLUENCE OF SINTERING TEMPERATURE ON THE STRENGTH PROPERTIES OF THE POWDER STRUCTURAL MATERIAL FROM THE SYSTEM FE-C-P

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Abstract

In the present study the influence of phosphorus over the strength characteristics of the powder construction materials of triple system Fe-C-P is detected. Research samples are subjected to a base iron powder type - ASC 100.29. To the iron matrix 0,2÷1,0%C and 0,3÷0,45%P is added. Pressing is carried out with the effort of 600MPa and sintering is conducted at 950÷1250℃ for 30 min at a protective environment of dissociated ammonia. The density of the samples after sintering is in the range 7,10÷7,12g/cm^3. In tables and graphics are presented experimental results for tensile strength, yield strength and elongation.

Keywords powder materials; yield strength; tensile strength; elongation.

INTRODUCTION

As a result of sintering the powder workpieces large part of the separated free energy leads to increased density of the sintering briquettes. Driving force of the spontaneously flowing process is the difference in free energies of exit and final state [1,3]. Specific ways to lower this difference was significant reduction in the external (surface of the workpieces and open pores) and internal surfaces (closed pores and borders beans), and also the removal of defects in the structure and equilibrium states of the system [2]. In sintering a powder mass moves a large volume of material depending on the nature and state of the system. In that a transfer may be used a plurality of migration mechanisms [1,5].

Final theory about the processes occurring in sintering at this stage there. Many are unknown in physical laws describing the process of sintering as a whole and helps to predict to some extent the final set of mechanical properties of sintered materials. In real conditions of sintering run multiple partial processes that depend on each other many cumulative factors - temperature, time, etc. For example, the combination of surface and boundary diffusion can evolve from kinetic to bulk diffusion [1,5,7]. Along with it in the process of sintering is possible, and the progress of a number of partial phenomena that are not accompanied by a thickening of the parts.

At that time the analysis of processes of kinetic compacting the powder workpieces under the law of the generalized diffusion course not very satisfactory. Various authors believe that the main reasons for the change in the time of voids in sintered bodies are the size of beans and sub-grain, viscosity and a general reduction in the concentration of defects [1,4,6,8]. Displayed on this basis equations for sintering are actually less applicable.

In this connection, the aim of this study was to follow the effect of sintering temperature on the change of the porosity, and through it the strength characteristics in samples of the triple system Fe-C-P.

EXPOSITION

Research subjected samples of iron powder ASC 100.29 type. Iron matrix is alloyed with 0,2÷0,8% carbon, and 0,30÷0,45% phosphorus. Using standard graphite powders mark UF 4 in which the carbon concentration is in the range 96÷97%.

Powders are mixed for 20 minutes in a mixer with intersecting rotary axes type „Turbol“. To improve compressibility of the powder in the mixing process was added 0,8% of a lubricant „Kenolube“.

The compression of the powders was made of hydraulic presses in closed molds with effort 600MPa

Sintering is conducted in conveyor furnaces with a protective atmosphere of dissociated ammonia at a temperature 950÷1250ºC for 30 min.

The density of the samples after sintering is in the range 7,07÷7,12g/cm^3 – Table №1

Table №1 Density of the samples after sintering

№ by order	Press force, **MPa**	**ρ, g/cm^3**	
		$n_{1÷5}$	**average value**
1	2	3	4
1	**600**	7,08	**7,10**
2		7,12	
3		7,07	
4		7,11	
5		7,12	

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Table №2 Experimental results for Rm

T, ºC	Rm, MPa		
	0%P	0,30%P	0,45%P
1	2	3	4
0,2%C			
950	**165**	**297**	**347**
1050	**189**	**339**	**376**
1150	**209**	**371**	**397**
1250	**221**	**405**	**411**
0,5%C			
950	**269**	**384**	**455**
1050	**294**	**407**	**479**
1150	**318**	**449**	**503**
1250	**337**	**485**	**528**
0,8%C			
950	**355**	**515**	**538**
1050	**378**	**539**	**570**
1150	**404**	**578**	**594**
1250	**527**	**611**	**622**

Table №3 Experimental results for Re

T, ºC	Re, MPa		
	0%P	0,30%P	0,45%P
1	2	3	4
0,2%C			
950	**129**	**198**	**207**
1050	**154**	**211**	**233**
1150	**163**	**221**	**253**
1250	**185**	**237**	**281**
0,5%C			
950	**157**	**302**	**319**
1050	**174**	**321**	**338**
1150	**198**	**355**	**367**
1250	**220**	**370**	**401**
0,8%C			
950	**198**	**363**	**377**
1050	**216**	**378**	**396**
1150	**239**	**407**	**424**
1250	**264**	**430**	**453**

Table №4 Experimental results for A

T, ºC	A,%		
	0%P	0,30%P	0,45%P
1	2	3	4
0,2%C			
950	**6,4**	**3,2**	**6,8**
1050	**7,4**	**6,1**	**8,1**
1150	**9,5**	**8,1**	**10,3**
1250	**15,6**	**14,3**	**16,2**
0,5%C			
950	**3,8**	**2,6**	**4,7**
1050	**4,9**	**4,1**	**5,5**
1150	**6,4**	**4,5**	**7,1**
1250	**8,2**	**6,3**	**8,9**
0,8%C			
950	**1,8**	**1,3**	**2,1**
1050	**2,7**	**1,9**	**3,1**
1150	**3,8**	**2,8**	**4,2**
1250	**4,3**	**3,5**	**5,4**

Research on the strength characteristics are carried out under EN 10045-1. Experiments were conducted on a universal-testing machine type ZD 40 PU with a range of applied effort within 100÷1000MPa.

Experimental results of the strength characteristics of the tested materials after sintering at different temperatures are presented in Tables № 2, 3 and 4.

To prevent the influence of porosity on the results obtained for strength characteristics, there have been five experiments. The table shows the average values.

Graphic interpretation of the results is presented in fig. 1, 2 and 3 respectively for the tensile strength, the yield strength and elongation.

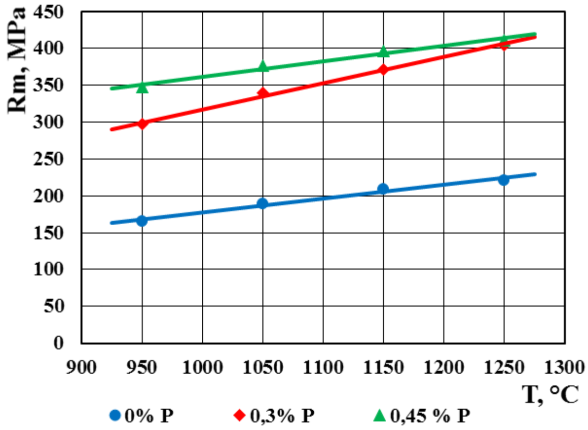
Obtained from experimental results it can be seen that with the increase of the carbon concentration in the samples containing phosphorus tensile strength increases 1,8÷2,0 times. In this growth is not tied to the change in temperature sintering.

Addition of 0,45% of phosphorus in the iron-carbon matrix leads to increased values of tensile strength. At a low temperature of sintering - 950÷1050ºC this increase is in the range of 1,6÷2,0 times and at high – 1150÷1250ºC is 1,5÷1,8 times.

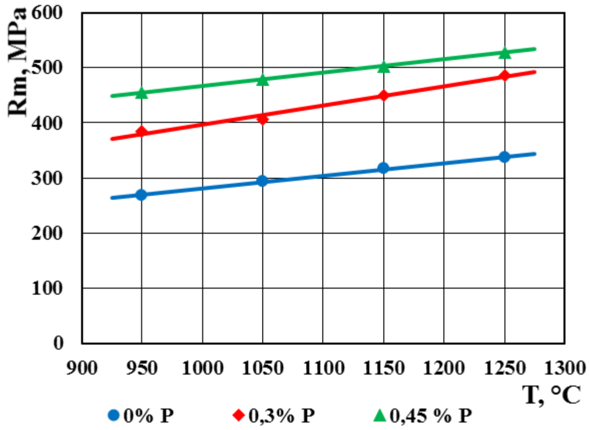
Conclusions for tensile strength refer in full force and the results obtained for the yield strength. To increase the carbon concentration in the samples containing phosphorus values of the yield strength increased from 1,4 to 1,5 times in all tested by us sintering temperature. Adding phosphorus to the iron-carbon matrix improves the values for the yield strength, such as at a low temperature of sintering – 950÷1050ºC they grow 1,6÷2,0 times and at high temperatures 1150÷ 1250ºC, 1,55÷ 1,85 times.

Higher values of tensile strength with increase of the carbon concentration of 0,2 to 0,8% in samples not containing phosphorus is a consequence of the phase changes in their structure. In the lower carbon concentration – 0,20%, structure of samples is mainly ferrite with small inclusions of cementite, while samples containing 0,8% carbon structure is primarily pearlite which is the reason for the higher values of tensile strength.

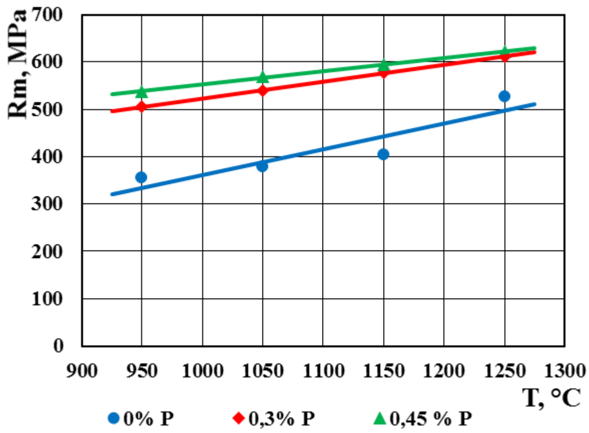
The addition of phosphorus to the iron-carbon matrix improves the values for tensile strength and the yield strength. In quantities of less than 0,50% phosphorus has a stabilizing effect on ferrite. It narrows substantially austenitic range in the diagram iron-phosphorus wherein the steels with a higher concentration of phosphorus is ferrite through its entire range of temperatures of sintering. Because the rate of diffusion in ferrite at the same temperature sintering significantly exceed that of austenite sintering process occurs very intense and there is a significant reduction in the total pore volume and the trend towards sferoidizirane the iron matrix. This inevitably improves the tensile strength of test samples. The lower values for tensile strength at higher temperatures can be explained by the growth of austenitic bean of iron-carbon matrix, resulting in a significantly reduced strength indicators of the test samples.



a.

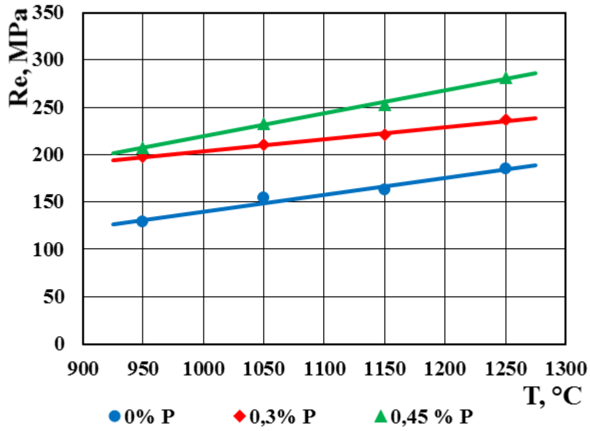


b.

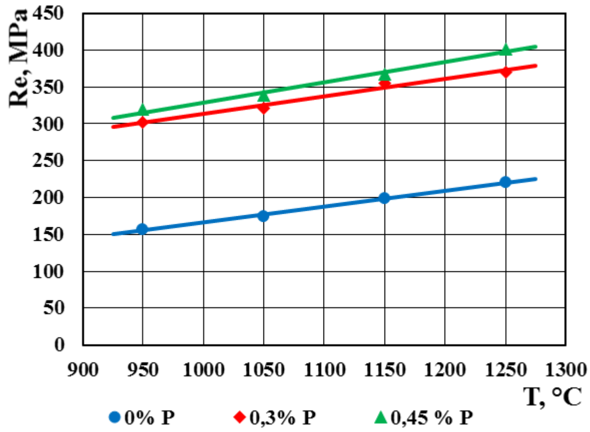


c.

Fig. 1. Tensile strength of powder samples from the system Fe-C-P a – 0,20%C;b – 0,50%C and c – 0,80%C



a.



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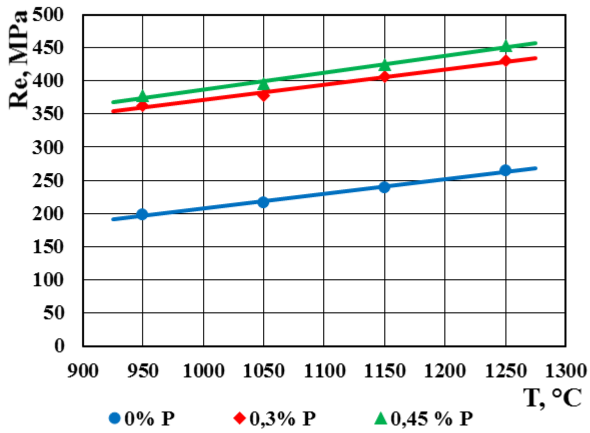
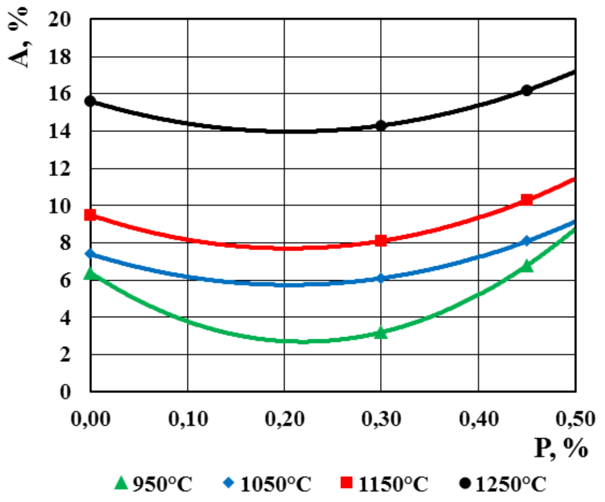
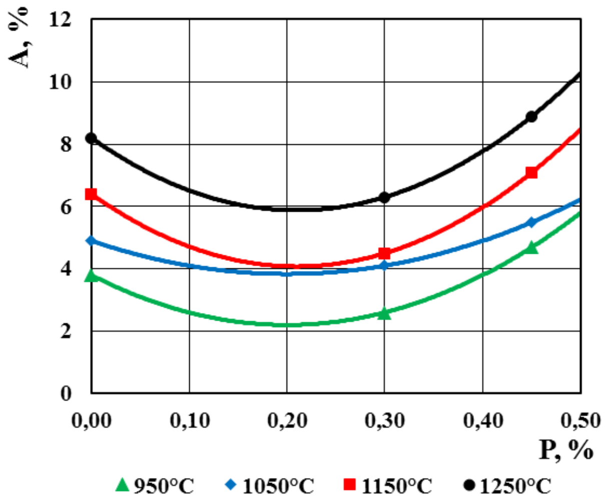


c.

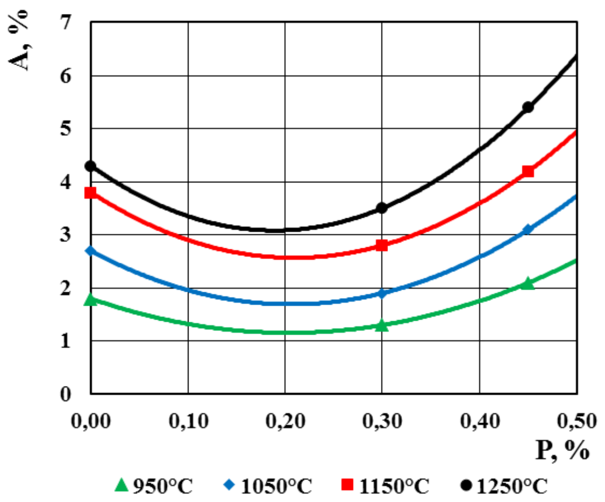
Fig. 2. Yield strength of particulate samples from the system Fe-C-P a – 0,20%C;b – 0,50%C and c – 0,80%C



a.



b.



c.

Fig.3 Elongation of particulate samples from the system Fe-C-P
a – 0,20%C;b – 0,50%C and c – 0,80%C

The increase in carbon concentration of 0,20 to 0,80% significantly reduces the plasticity of the samples, which is registered in the values of elongation. They decreased 2,5÷3,5 times. The addition of phosphorus to 0.30 percent will further reduce the values of elongation they reach their minimum in all investigated temperatures of us – Fig. 3.

When phosphorus concentration is 0,45% at the temperature of sintering closer to the area of pure ferrite from iron-phosphorus diagram, leads to improving the ductility of the samples and values of elongation are though slightly - 0,5 ÷ 1,1% higher than those of the samples not containing phosphorus.

CONCLUSIONS

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

- Alloyed iron-carbon powder materials of 0,30 ÷ 0,45% phosphorus leads to increase the strength properties of 1,5÷2,0 times, such as more significant increase in the samples sintered at the lower temperatures tested - 950÷1050ºC;
- Increasing temperatures up to 1150÷1250ºC leads to sintering purely austenitic area of the diagram iron-phosphorus, which hinders the diffusion of phosphorus in the iron and its impact on the strength characteristics is less.
- Sintering at temperatures 1150÷1250ºC is accompanied by a rise in austenitic grain. This negatively affects the strength characteristics of the tested samples. There fore we recommend temperature sintering of powder samples of the system Fe-C-P is 1000÷1100ºC.
- The increase in carbon concentration of 0,20 to 0,80% is accompanied by structural changes in iron-carbon matrix that of ferrite-pearlite becomes pure pearlite. This affects the plasticity of the tested samples and their relative elongation decreased 2,5÷3,5 times.
- The addition of phosphorus in the iron-carbon matrix initially leads to lower ductility of the studied samples. Reaching concentrations of phosphorus 0,45% of the surveyed us sintering temperatures closer to the area of pure ferrite from iron-phosphorus diagram, leads to improving the ductility of the samples and values of elongation are though slightly - 0,5÷1,1% higher than those of the samples not containing phosphorus.

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