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Charge materials and technology of melt and structure of gray cast iron

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Abstract: In article results of quantitative and qualitative analysis of graphite in gray cast iron have been presented. Specimens from six melts that had been realized in different way, taking into account charge materials as well as melting practice were tested. Melt I and II had been made in traditional way from special pig iron Sorel, III from steel-making pig iron, IV, V and VI are synthetic cast iron made from steel scrap and graphite scrap. The four pictures of structure that had been made on casting specimen of 30 mm diameter for each melt as well as for special and steel-making pig iron were analyzed. The quantitative and qualitative analysis has been made using MultiScan v13.01 computer software. Several conclusions from the comparative analysis of histogram taking into account differences between cast irons and similarity of cast irons to pig iron for melts I, II and III have been presented.

Keywords: Gray cast iron, Charge materials, Properties.

1. INTRODUCTION

Conditions of the melt are given by type of furnaces and melt's technology. These conditions as: overheating temperature, possibility of holding the metal in required temperature during right range of time, pressure over liquid metal in period of overheating or holding, type of atmosphere in furnace during melting and overheating, etc. Factors, mentioned above, determine in greater or smaller degree physical and chemical state of liquid metal from the point of view its capacity for graphite nucleation during crystallization.

2. GOALS AND RESEARCH RANGE

From analysis of literature follows that heredity and genetic phenomenon in technical alloys are current and important problems of contemporary materials engineering. Unfortunately research results, although give essential data do not give clear-cut proofs of heredity and genetic phenomenon in technical alloys, similar that in biology, exist. Therefore it is important to answer following question: is the heredity of gray cast iron structure and properties exist? if yes, is it possible to detail hereditary features in industrial conditions? and is it possible to control cast iron properties by influencing on hereditary features or hereditary mechanism? In the light of literature's analysis it may be said that in technical alloys some phenomenon that shows the occurring of structure and properties heredity exist but mechanism of this phenomenon in lab conditions, such different from industrial, couldn't be determined.

Thus, the following thesis may be given that structure and properties of gray cast iron melted in industrial conditions do not depend, in significant way, on charge materials type. Differences of cast iron quality are made by quality of charge materials (non-metallic impurities and gas-forming compounds) their preparation and culture of melt realizing.

In order to prove given thesis as a main goal of this work the compare of strength properties and structure of gray cast iron EN-GJL-250 melted in traditional way i.e. from special and steel-making pig iron as well as melted from steel scrap and graphite scrap with different carburization degree has been stated.

Realizing the goal of the work following general range of activity have been determined:

1. Realization of 2 model melts only from special pig iron and steel scrap;
2. Realization of 1 melt only from steel-making pig iron and steel scrap;
3. Realization of 3 melts from steel, process (white cast iron) and graphite scrap with different carburization degree;
4. Preparation of specimen for mechanical properties determination and realization of hardness, tensile strength and impact strength measurements;
5. Preparation of micro-sections;
6. Analysis of pig iron and cast iron from each melts structure;
7. Work out of obtained tests results and their analysis;
8. Resume and conclusions.

3. RESEARCHES

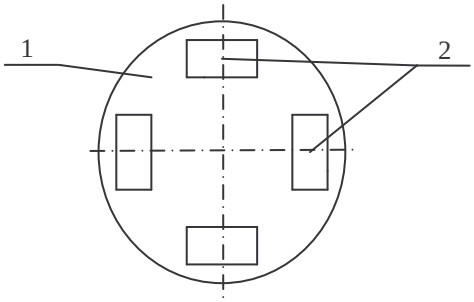


Figure 1. Places on specimen surface in which have been made photos; 1- specimen, 2- places of photo made

In lab conditions – inductive furnace, neutral liner, capacity 25 kg – 6 melts of cast iron EN-GJL-250 according to plan from point 2 have been realized, alloys with chemical composition presented in table 1 have been obtained. For each melts, specimens for measurement mechanical properties as well as for micro-section preparation in aim of quantitative and qualitative analysis have been produced. Micro-section for cast iron were made of cast specimens 30 mm in diameter and for pig irons of specimen cut off from pig sow. Photos of structure non-etching micro-section have been made in the way shows in the figure 1.

Quantitative and qualitative analysis of graphite in cast iron and pig iron were made using MultiScan v 13.01 software.

4. RESULTS

Tensile strength Rm, hardness HB and impact strength U measurement's results as well as overheating temperature and contents of basic chemical elements have been compared in table 2. Results of quantitative and qualitative analysis of graphite in pig iron and cast iron have been shown in figures 2 as a statistical fitted to histograms of graphite number in modulo (P/O) (where P-area, O-perimeter of graphite grain) size classes distribution, according to approximation function (1), distribution curves.

$$Na(P/O) = U\frac{Z\exp(Z(W-\ln(P/O)))}{(1+\exp(Z(W-\ln(P/O))))^2} \quad (1)$$

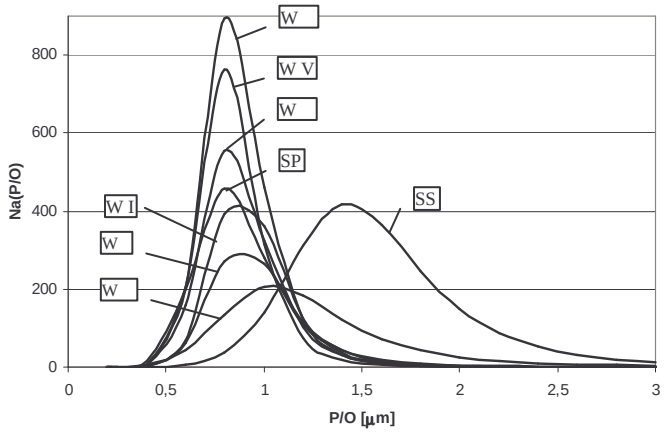
Graphic comparison of this curves as well as values of approximation function's coefficient have been shown in figure 10.

Table 1.
Chemical composition of cast iron from each melts and pig iron

melt No	C [%]	Si [%]	Mn [%]	P [%]	S [%]	Cr [%]	Cu [%]	Mg [%]
Melt I	3,39	1,651	1,23	0,048	0,023	0,064	0,244	0,002
Melt II	3,34	1,866	1,208	0,047	0,022	0,12	0,034	0,002
Melt III	3,41	1,782	1,1	0,051	0,022	0,068	0,047	0,002
Melt IV	3,69	1,788	1,103	0,013	0,019	0,061	0,239	0,003
Melt V	3,36	1,757	1,206	0,013	0,013	0,049	0,115	0,002
Melt VI	3,40	1,737	1,043	0,017	0,015	0,048	0,083	0,002
SPI Sorel	4,5	0,81	0,037	0,049	0,019	-	-	-
SMPI	4,5	0,634	0,136	0,024	0,020	0,007	0,002	-

Table 2.
Basic information about tested cast irons

Melt	Tp [°C]	C[%]	Si[%]	Mn[%]	SC [%]	SCI [%]	U [kJ/cm^2]	Rm [MPa]	HB
I	1480	3,39	1,651	1,23	0,907	0,901	25,46	335,93	227,6
II	1464	3,34	1,866	1,208	0,913	0,906	31	315,03	185
III	1450	3,41	1,782	1,1	0,925	0,919	30,81	326,39	171
IV	1407	3,69	1,788	1,103	0,997	0,990	33,69	310,33	159,3
V	1430	3,36	1,757	1,206	0,906	0,899	28,17	288,66	185
VI	1435	3,40	1,737	1,043	0,916	0,911	27,22	330,68	185
average	1444,3	3,43	1,763	1,148	0,927	0,921	29,39	317,83	185,4
st. dev.	25,990	0,129	0,070	0,076	0,035	0,035	2,991	17,210	23,108
% st. dev	1,799	3,767	3,999	6,639	3,756	3,753	10,178	5,415	12,464



	U	Z	W
SS	257,19	6,50	0,35
SP	273,16	6,69	-0,22
W1	223,39	8,32	-0,12
W2	172,47	7,28	-0,12
W3	160,90	5,18	0,04
W4	283,49	7,91	-0,20
W5	340,87	8,95	-0,23
W6	411,54	8,80	-0,20

Figure. 2. Graphic comparison cast iron and pig iron graphite size curve distribution as well as values of approximation function's coefficient

5. RESUME AND CONCLUSIONS

Some differences in qualitative and quantitative descriptions of graphite between so-called synthetic cast iron (without pig iron in charge materials) and cast iron melted in traditional way (with pig iron) may be noticed. The most of all, taking into account graphite, stand out cast iron from melt III (steel-making pig iron). It is not be confirmed by values of mechanical properties and chemical compositions that are similar to average values. If occur close similarity of synthetic cast iron melts IV, V and VI structure despite of differences in melt technology and bit differences between these melts and melts realized in traditional way I, II and III, that similarity between special pig iron and steel-making pig iron structure and structure of cast iron melted from each of them couldn't be found. Every of tested cast iron are characterized by similar mechanical properties and chemical composition. For every of them values of basic elements C, Si and Mn contents and mechanical properties differ only in 10% limits (table 2). On this basis may be said that in technical sense tested cast irons are identical. Therefore the following conclusions may be formed:

1. Structure – form, size and number of synthetic cast iron (melt IV, V and VI) graphite are very similar, despite of differences in melt technology;
2. Structure – form, size and number of cast iron melted from pig iron graphite are a bit differ from structure of synthetic cast iron;
3. Results of mechanical tests are pointing a full technical similarity of tested cast iron;
4. Obtained results confirm influence charge materials quality, in sense of purity, on finished alloy structure, the influence quality and number of graphite in charge materials on cast iron properties couldn't be confirmed. Thus on the basis of obtained results the exist of heredity phenomenon in tested gray cast iron couldn't be confirmed.

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