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Identification Trial of Crystallization Parameters of Modified Chromium Cast Iron

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Abstract

In the paper results of researches of abrasion-resisting chromium cast iron inoculated with boron carbide B_4C primary crystallization are presented. The main aim of work was make an attempt to identification of crystallization parameters that changed in reason of inoculation. Essential primary crystallization parameters, with the help of which, will be possible to evaluate the inoculation capacity were searched. It was found that in the result of inoculant actions characteristic temperatures were changed and time of primary crystallization was decreased. For tests the new broadened Derivative Thermal Analysis method, in which three samples with different solidification module were applied, was used. Thanks to this inoculation capacity in casts with significant diversified self-cooling ranges was possible to observe.

Keywords: Chromium cast iron, Crystallization, Modification

1. Introduction

Chromium cast iron has a wide application in economy [1,2]. Traditional they have been used among other things in applications on elements with high wear resistance and corrosion. High wear resistance of this cast iron is link with occurence in its structure hard carbon phase which distributed in metal matrix, for example martensite. The imporrtant defect its material is low impact strength what much limited field application.
High wear resistance chromium white iron are typically cast as hypoeutecic alloys having a primary phase of dendritic austenite with the eutectic (austenite and M_7C_3 carbides).
Traditional production process of castings with hypoeutectic chromium cast iron produce structures containing net of eutectic carbides, which are detrimental to properties such as impact resistance, fracture toughness and fatigue resistance.
I think that the best dissolution of this problem will be work towards modification of carbide phase through different kind of technological activity, for example change melting and casting process, addition alloys, inoculants, heat treatments.
The present work was aimed at studying the effect of inoculant (boron carbide) on the crystallization parameters.

2. Research method of crystallization

Crystallization of casting alloy processes, on Foundry Department, has been researched with DTA method (Derivative and Thermal Analysis), which was constantly developed and improved by professor S. Jura. DTA method is at length described in paper [3,14]. It has been also used to evaluation of chromium cast iron quality in range of chemical composition and for determination eutectic carbon equivalent CE. Moreover the work on description of crystallization kinetic and determination of crystallization function for each phase has been taken up for chromium cast iron [4].

With this method can be described crystallization process only for equal dimension castings. But casting alloy in depends on casting geometry and type of mould and cast technology gets different utilitarian properties. This fact must be taking account in physical modeling. Thus a series of three testers, cylindrical shaped, different diameter, selected to more diverse kinetic of casting cooling (different castings modulus) have been constructed [11-13]. For selecting geometric features of testers computer simulation has been used. For minimization of model casting and model mould dimensions the heat-insulating material have been used. In conducted tests heat-insulating with trade name SIBRAL 300 was used. Finally following diameters *d* of testers have been assumed ϕ30 mm, ϕ60 mm, and ϕ100 mm as well as the high of testers 1.5*d*. In the figure 1 the biggest tester with thermal insulation and in figure 2 scheme of whole research stand are presented. The new method of crystallization process research with three testers has been called DTA – K3. The DTA – K3 method makes possible to characterize a sensitivity of chromium cast iron on cooling kinetic. In real castings alloys cool in non-equilibrium conditions. Model castings in DTA – K3 method also alloys cool in condition different from equilibrium. Its influence on crystallization parameters such as: characteristics transformation temperatures and intensity transformation.

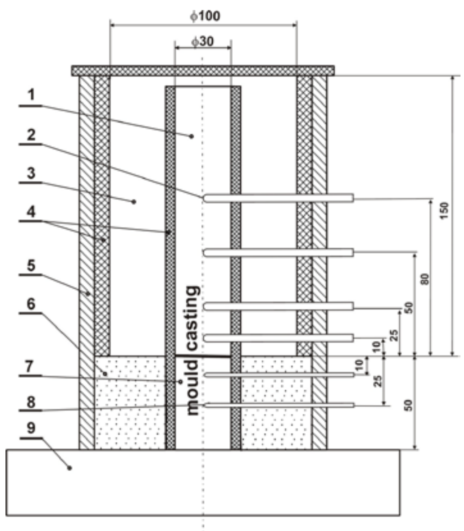


Fig. 1. Construction of tester ϕ100 mm with thermal insulation 1 – model casting ϕ30 mm 2 – quartz protector of thermocouple in casting, 3 – thermal insulator, 4 – insulation material, 5 – steel pipe, 6 – mould insert, 7 – model mould ϕ30 mm, 8 – quartz protector of thermocouple in mould, 9 – base

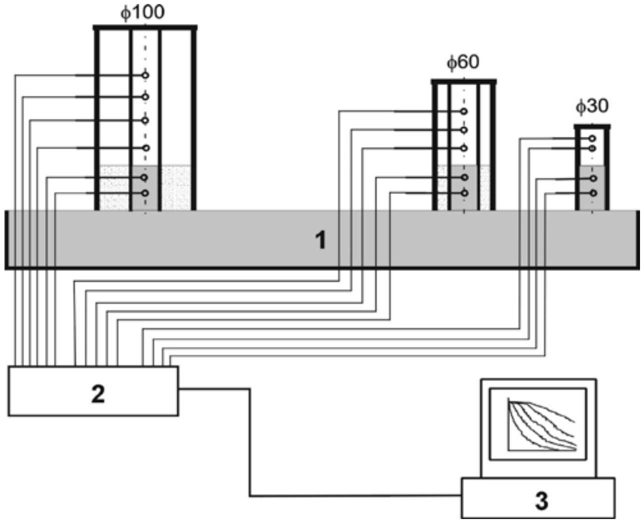


Fig. 2. Research stand scheme in DTA – K3 method, 1 – set of testers, 2 – multi-channel converter A/C, 3 – PC

3. Experiments

Within a framework of experiments two tests melts were made. First melt, follows marked W1 (non-inoculated chromium cast iron), was melted by melting of “initial” chromium cast iron witch was a charge for melts in whole series of experiments. Second melt, follows marked W2 (inoculated chromium cast iron), was melted by melting and inoculating with boron carbide in ladle of “initial” chromium cast iron.

Into the ladle before cast iron tapping the inoculant was inserted in amount of 0,2% of whole melt mass.

The chemical compositions of the investigated chromium cast iron are listed in table 1.

Table 1.
Chemical analysis of the chromium cast iron

	composition wt %							
melt	C	Cr	Mn	Si	P	S	Ni	Al
W1	2,90	17,52	0,15	0,34	0,036	0,013	0,061	0,054
W2	2,88	18,06	0,12	0,33	0,036	0,018	0,062	0,073

Registration of chromium cast iron crystallization process was made on DTA–K3 stand, described above. Preliminary qualitative evaluation of inoculation was carried out basis on metallographic cross section by observing microstructure under the optical microscope for different magnification. Next detailed analysis of cast iron crystallization process, basis on registered self-cooling and crystallization curves, was carried out. DTA curves were described with characteristic point in accordance with principals had been applied by prof. Jura [3,4].

In figure 3 analyzed points were marked. In case of testers ϕ60 and ϕ100, significant thermal effect was noticed, before occurring maximum of the primary austenite crystallization thermal effect (point A). This point was marked as A0. It considered as a beginning of crystallization process by Prof. Pietrowski [5,6].

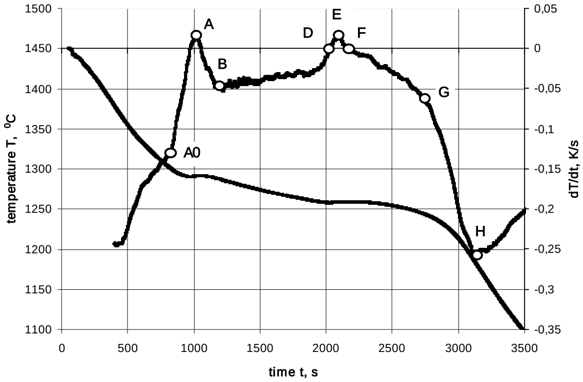


Fig. 3. DTA-K3 graph of chromium cast iron with characteristic point marked

4. Results and discussion

Inoculation effect was observed during qualitative analysis of metallographic microstructure. In figure 4 are presented pictures of microstructure in x100 and x400 magnifications, it could be noticed how the microstructure was changed after inoculation with boron carbide. Significant fragmentation of dendritic structure, typical for primary crystallization of non-inoculated chromium cast iron, can be observed. Such result is advisable effect of every inoculation for casting alloys. Effect of carbide phase modification also was noticeable. Carbides after inoculation of tested chromium cast iron became less elongated.

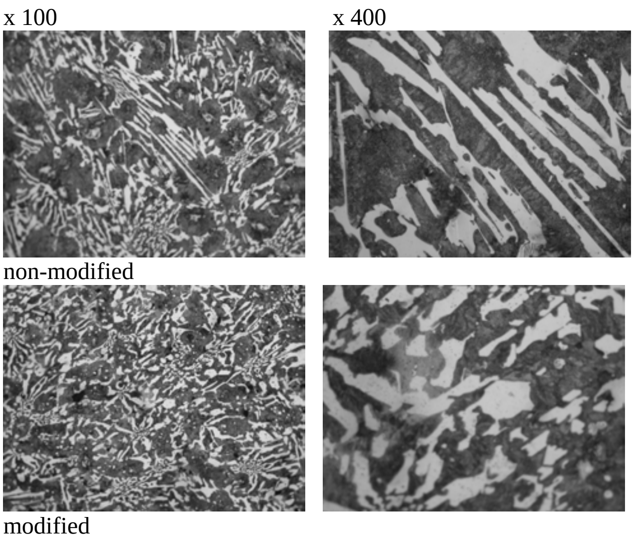
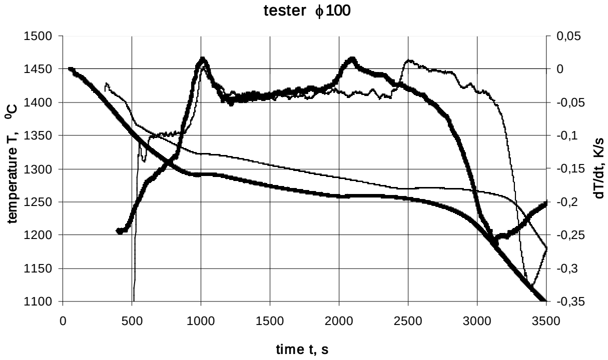


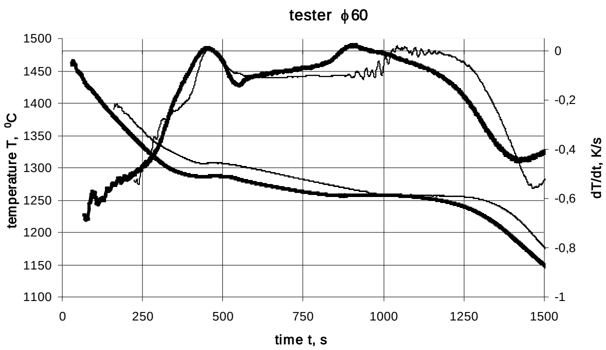
Fig.4. Microstructures of research chromium cast iron

The next step after qualitative analysis of microstructure was the self-cooling and crystallization curves analysis. The significant changes in course of these curves were noticed. In figures 5, 6 and 7, self-cooling and crystallization curves with primary crystallization parameters for each casting, were appropriately set out. Only curves registered in thermal center of casting were analyzed. For analysis facilitation on one diagram crystallization curves both for inoculated and non-inoculated cast iron were drawn.



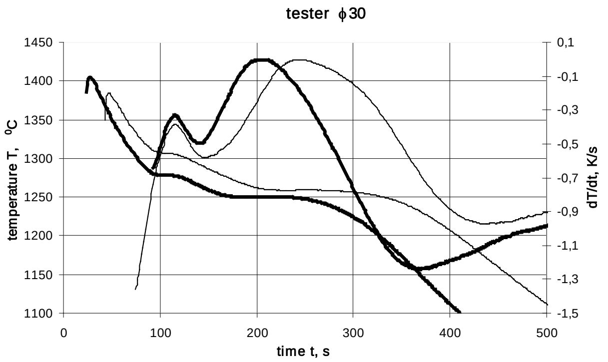
	non-modified (___W1)		modified (▬▬W2)	
point	T, ^{0}C	dT/dt, K/s	T, ^{0}C	dT/dt, K/s
A0	1328	-0,09	1300	-0,13
A	1322	0,002	1291	0,017
B	1317	-0,034	1288	-0,051
D	1269	0	1258	0
E	1271	0,013	1259	0,015
F	1270	0	1258	0
G	1260	-0,057	1240	-0,075
H	1209	-330	1183	-0,258

Fig.5. DTA graph of chromium cast iron for tester ϕ100



	non-modified (___W1)		modified (▬▬W2)	
point	T, ^{0}C	dT/dt, K/s	T, ^{0}C	dT/dt, K/s
A0	1311	-0,17	1308	-0,04
A	1307	0,007	1286	0,007
B	1300	-0,103	1280	-0,134
D	1257	0	1256	0
E	1256	0,017	1257	0,023
F	1256	0	1257	0
G	1252	-0,081	1236	-0,196
H	1188	-0,552	1182	-0,448

Fig.6. DTA graph of chromium cast iron for tester ϕ60



	non-modified (____W1)		modified (▬▬W2)	
point	T, ^{0}C	dT/dt, K/s	T, ^{0}C	dT/dt, K/s
A0	-	-	-	-
A	1304	-0,41	1276	-0,33
B	1286	-0,57	1263	-0,48
D	1259	-0,008	1250	-0,002
E	1259	-0,008	1250	-0,002
F	1259	-0,008	1250	-0,002
G	1253	-0,24	1249	-0,11
H	1169	-0,98	1147	-1,23

Fig.7. DTA graph of chromium cast iron for tester ϕ30

Application of inoculant caused the primary crystallization time shortening. Moreover characteristic temperatures of transformations significantly decreased. After crystallization curves analysis it may be claimed that applied technology of chromium cast iron inoculation with boron carbide increased alloy super-cooling, which caused the primary crystallization time shortening and refinement of microstructure. Ultimate statement, which of crystallization parameters best characterize the influence of applied inoculant on microstructure and what modification mechanism occurs for boron carbide addition, requires carry out more experiments, which author is carrying out now.

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