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The temperature gradient on section of casting in process of primary crystallization of chromium cast iron

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Abstract

The methodology of defining in article was introduced the temperature gradient in process of primary crystallization during cooling the casting from chromium cast iron on basis of measurements of thermal field in test DTA-K3. Insert also the preliminary results of investigations of influence temperature gradient on structure of studied wear resistance chromium cast iron.

Keywords: Chromium cast iron, Temperature gradient, Crystallization

1. Introduction

The crystallization process is of principle process, which decides about properties of usable castings [1, 2]. Continuous broadening knowledge about this process makes possible improvement founding technologies. Department of Foundry of Silesian University of Technology since many years [3] deal investigations connected with phenomena during cooling of cast in mould. The method of thermal and derivative analysis (DTA) is the basic investigative applied in investigations of crystallization process. Prof. Jura [3] the many years' scientific worker of Department of Foundry of Silesian University of Technology developed this method wide, both in range of scientific investigations and initiating industrial. The development of method the DTA in range with initiating industrial deals at present also prof. Pietrowski [8]. The applied in classic method DTA one-point registration of temperature does not permit on full description of kinetics crystallization, impossible the description e.g. the temperature gradient in cast. The basic advantage of classic test the DTA is her simplicity and easiness of initiating in foundries in sections of control of quality production doubtless, particularly for quality control of liquid metal [3].

The investigations over improvement the thermal and derivative analysis in Department of Foundry of Silesian University of Technology be led still, particularly in range of scientific investigations. It the method was initiated was to investigations DTA-K3 which makes possible the simultaneous registration it cooling in castings about different solidification module [4,5]. The thanks were it been possible to study this method the influence of speed the cooling of casting on parameters of crystallization process as well as structure.

Recently led by author of present article investigations include the questions the connected with analysis temperature gradient in cast. The presented article represents first relating results of investigations experimental marking the temperature gradient in cast from wear resistance chromium cast iron. It these investigations on basis were have worked out the methodology of defining the temperature gradient on section of casting in support

about results of measurements of thermal field received on modernized stand DTA-K3.

2. Modernization of DTA-K3 stand

The experimental delimitation temperature gradient on section of casting requires the acquaintance of thermal field, indispensable it is so the measurement of temperature in many points of casting. Testers in method DTA-K3 [4,5] became so constructed to it is possible will measure temperature in analysed area of casting. The thermocouples in testers were disposed so to they recorded temperature on direction of flow of warmth temperature from model cast to model form. The construction of the largest tester ϕ100 mm was presented on figure 1, and on figure 2 shown results of computer simulation cooling the cast from chromium cast iron in this tester. The simulation was conducted in programme NovaFlow the making full analysis of flooding and cooling process the testers. How to be visible (Fig. 2) the construction of tester assures put way from casting the flow of warmth model ϕ30 to model form. The results of measurement of temperature with thermocouples disposed in axis of tester permitted then to estimate average temperatures gradient between next measuring points (T1 and T0, T2 and T1, T3 and T2, T4 and T3).

The similar process of analysis was it been possible to conduct in next testers ϕ60 and ϕ30.

Gathered in this way tha set of information about crystallization process of casting will permit on deeper analysis of influence of different crystallization parameters on structure and property of studied alloy.

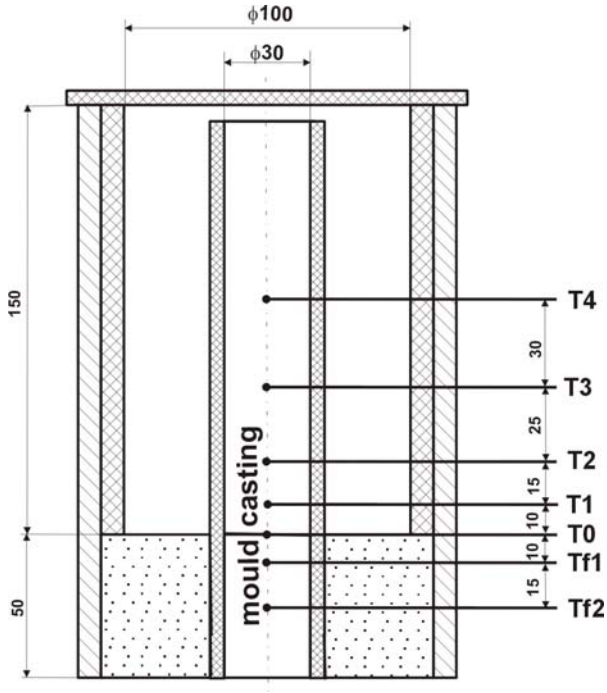

Fig. 1. The construction of tester ϕ100 mm

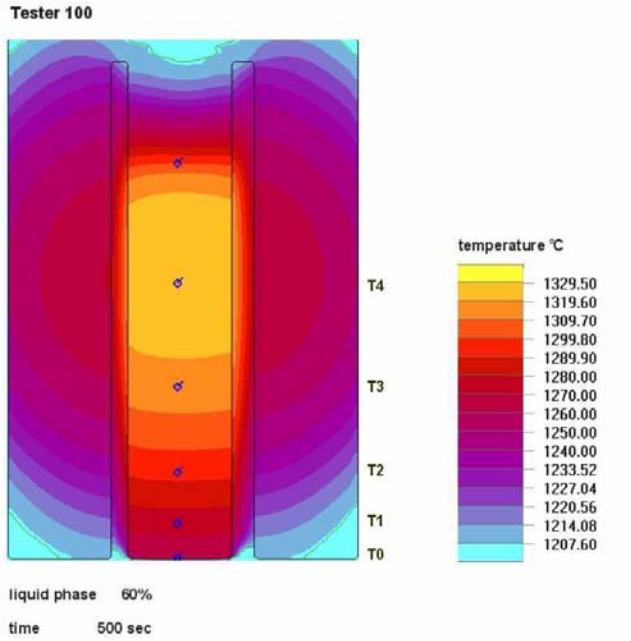

Fig. 2. Simulation cooling of tester ϕ100 mm

Research stand used in presented investigations was introduced on figure 3. In composition of research stand are 3 testers which they imitate the castings about different solidification modules. The distribution of thermocouple in casting and in form also makes possible the full description of cooling process the cast in form. The modernization of DTA-K3 stand depended on introduction the additional thermocouple recording the temperature on point of contact the casting - the form in testers ϕ60 and ϕ100 mm. The research stand was replenished about standard tester DTA-C, which was possible to conduct the classic analysis of crystallization of alloy according to Jura [3].

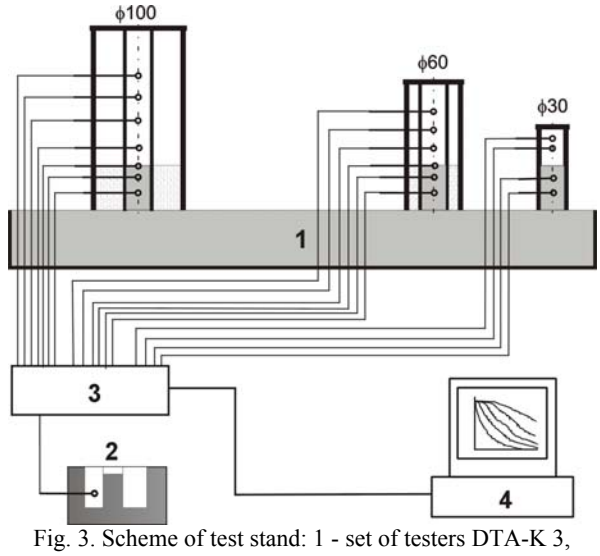

Fig. 3. Scheme of test stand: 1 - set of testers DTA-K 3, 2 - tester DTA-C, 3 - transducer A/C, 4 - computer PC

3. Qualification temperature gradient in casting from chromium cast iron

In present article was discussed only calculation of the methodology of temperature gradient in cast ϕ100 mm on example of cooling process of casting from wear resistance chromium cast iron cast about weight part of basic elements: carbon 3%, chromium 20%. It melting was produced in inductive furnace about capacity 20 kg and indifferent lying out.

The point of exit to calculations the temperature gradient are in well-known areas of casting the results of measurement of temperature always.

We in case of considered cast ϕ100 to instruction have five cooling curves recorded in suitable measuring points.

The curves of cooling on figure 4 were showed (T0, T1, T2, T3 and T4) the registered in put measuring points of casting ϕ100 according from signs on figure 1. On figure 4 were presented additionally cooling curves in form (Tf1, Tf2). The analysis of curves DTA-C shown that studied cast iron was the cast iron lightly hypoeutectic (Fig. 5).

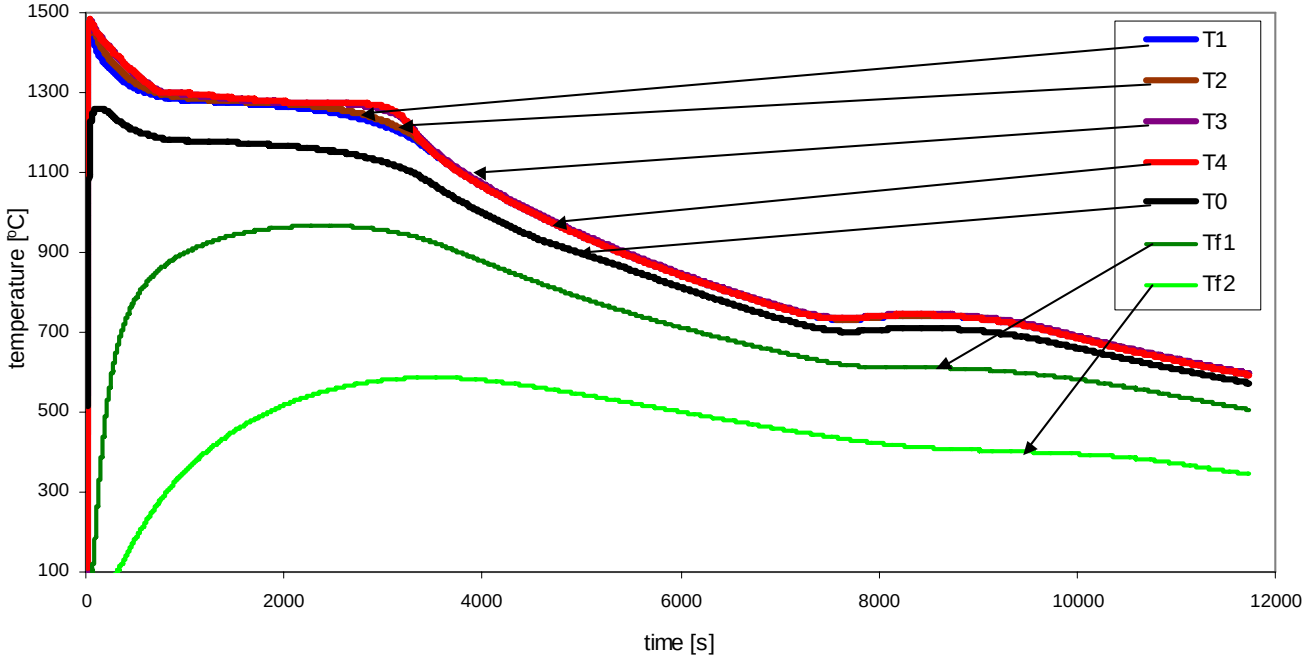

Fig. 4. Curves cooling in tester cast and form ϕ100

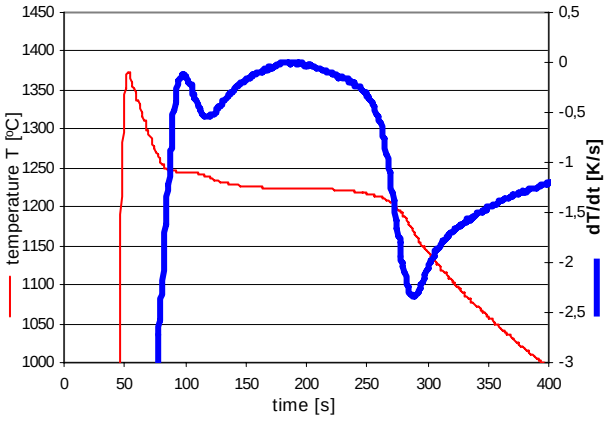

Fig. 5. Curves DTA-C studied chromium cast iron

The registration of temperatures be holds in computer and be recorded in text file which was it been possible easily to analyse, e.g. in spreadsheet. For calculation temperature gradient was used the spreadsheet Excel.

Calculation of temperature gradient, more exactly saying average temperature gradient between next measuring points in casting was conducted according to following dependence:

$$G\_1-0=\frac{T1-T0}{d\_1-0} \tag{1}$$

where:

G_1-0 - the average temperature gradient between measuring points 1 and 0 in K/cm,

$T1$ - temperature in measuring point 1 in ^{0}C,

$T0$ - temperature in measuring point 0 in ^{0}C,

d_1-0 - distance between measuring points 1 and 0 in cm.

Presented on figure 6 counted temperature gradient according dependence 1 show how on section of cast and what in time of whole course of process primary crystallization undergoes change. On figure 6 was showed the picture of metallographic structures answering the areas of cast about appointed average temperature gradient. It will give was to notice that size gradient has influence on crumbling structure. This confirmed the quantitative investigations of carbide phase of studied chromium cast iron.

On figure 7 was showed how the quantity of carbides introduces in function of curve temperature gradientu.
It the also changing sign was observed the gradient G_4-3 in time of crystallization, which testifies about change of direction of flow warmth. It is this the well-founded the position of measuring point of temperature T4 which in time cooling is in different position in relation to temporary centre of thermal of casting probably. This conclusion confirms in this place the analysis of structure of cast iron also.

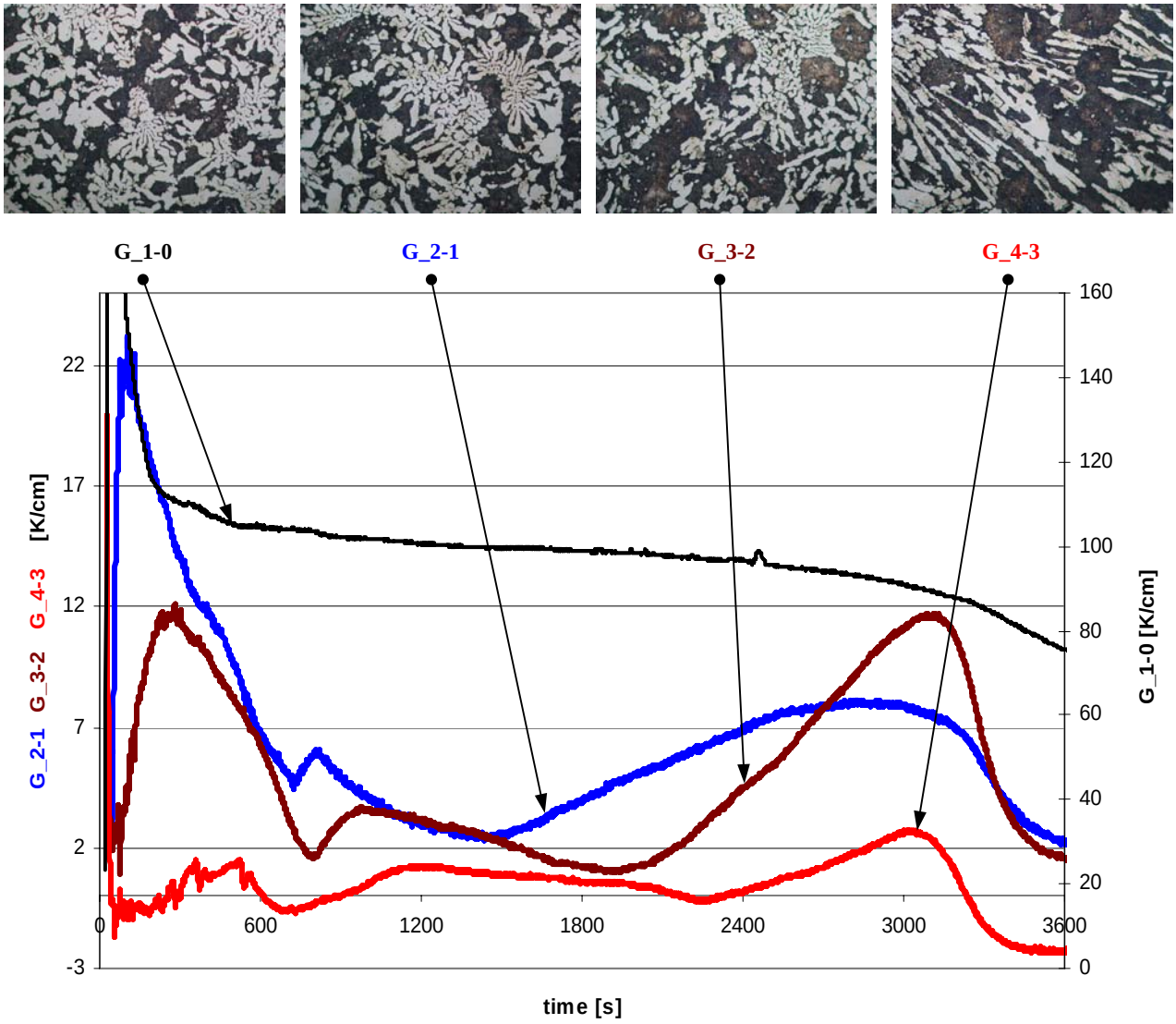

Fig. 6. Curves temperature gradient in range of primary crystallization of chromium cast iron on section of casting the ϕ100 and answering them structures with clear carbide phase (x200)

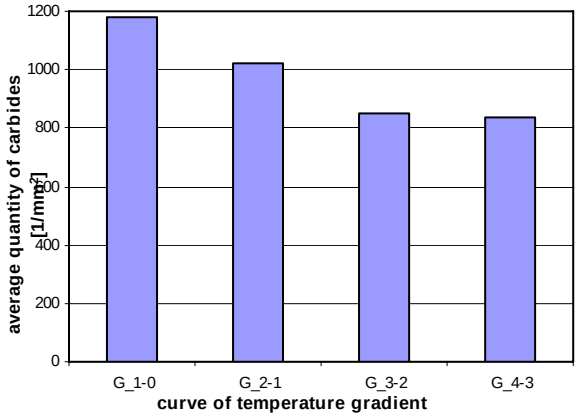

Fig. 7. The average the quantity of carbides in function of curve the temperature gradient on section of casting ϕ100

4. Summary

The introduced results of investigations show that the analysis temperature gradient in casting from chromium cast iron can be helpful in analysis of crystallization of casting from this alloy. This parameter of crystallization answers for also "births" structure which decides about interesting us the properties of casting. Led by author of investigation shew the usefulness of method DTA-K3 to experimental defining the temperature gradient on section casting. The addition in testers ϕ60 and ϕ100 of thermocouples permitted on preciseness delimitation the gradient in interesting us areas of casting. The idea of enlargement in tester ϕ100 the quantity of measuring points requires considering yet.

Acknowledgements

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