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The influence of external factors on morphology of graphite in grey cast iron

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Abstract

One of the methods, which improved unification of structure may be application of forced movement in time of metal crystallization. In studies to generating of forced movement of liquid metal was applied electromagnetic filed.

In aim of determination of electromagnetic field influence on morphology of graphite was made a comparison between microstructure of cast iron ingots, which were poured in conventional conditions and with action of electromagnetic field. The results of studies show improvement in graphite morpholgy on condition that suitably slow process of casting solidification.

Keywords: Electromagnetic field, Graphite morphology, Grey cast iron

1. Introduction

On abrasive wear resistance of cast iron castings influences conditions in which proceed the wear processes and in consequence the structure of cast iron.

In aim of explanation of this thesis in paper was presented two cases of abrasive wear (wear at dry friction and wear at friction with lubrication), on which strongly influences form of graphite in cast iron structure.

Wear at dry friction presents during turning or slide of co-acting parts. In these conditions work rollers, clutches, jaws and brake drums. Strongly influence in dry friction has graphite, which has lubrication properties and counteracts of co-acting parts seizing. Therefore for cast iron with graphite does not occur fully dry friction.

Second case is wear at friction with lubrication. This type of wear is most often cause of cooperative materials damage. In these conditions work cylinders, piston rings, shafts, bearings, cams of crankshafts and valve rockers. In spite of lubrication the wear conditions are very diversified and strongly depend from material structure (such as in case of wear at dry friction). Suitable material, which works in these conditions has small coefficient of friction, good ability to grind in co-acting parts, ability to maintain of constant lubricant layer on surface, high mechanical properties in high temperature.

These demands perform cast iron, which has non-homogeneous structure, because one phase has considerably larger hardness than second, which wear off faster and which is source of „natural lubricant tank".

Strongly influence on wear at friction with lubrication resistance have: quantity, form and distribution of graphite. The best is graphite, which has medium size of flakes. Size reduction of graphite, independent from form result in decrease in abrasive wear resistance, such as dry friction [1]. Also presence of non-uniform distribution of graphite for example: local concentration of large flakes or interdendritic graphite (particularly with simultaneously presence of ferrite) decrease in abrasive wear resistance [2].

In consequence of presented data necessary is attainment of grey cast iron with uniform and suitable form of flake graphite. This problem concerns production of grey cast iron in continuous casting line, where heat abstraction conditions are different in dependence of distance on cross-section of casting from core to wall of continuous casting mould.

In paper [3] authors presented application of electromagnetic field to changes of graphite morphology. The range of studies contains research on two types of grey cast iron i.e. hypoeutectic and hypereutectic. Microstructure of cast iron, which was poured without influence of electromagnetic field has non-uniform distribution of graphite with considerable length. Results of work [3] show advantageous influence of electromagnetic field on graphite morphology.

Application of electromagnetic field influence on liquid metal as inoculation method, in aim of mechanical properties improvement is presented in paper [4÷8].

2. The aim of studies

The aim of studies was to determine a influence of stirring of liquid metal in cylindrical mould with use of rotate electromagnetic field on graphite morphology in grey cast iron castings. In research take the criterion, that suitable graphite has uniform distribution of type „A" and form of type „I" [9] – particularly at outside surface of ingot.

3. Range of studies

In range of studies was poured standard ingots without and with influence of rotate electromagnetic field during solidification process. Next, was made analysis of influence of electromagnetic field on graphite morphology.

In research was used „sibral" moulds, which have thermal conductivity $\lambda = 0{,}342$W/mK. Application of this mould material assure attainment of stable conditions of solidification. Dimensions of used „sibral" moulds are following: inside diameter Ø30mm, full diameter Ø50mm, high 200mm.

During the studies cylindrical cast iron ingots with dimensions of 30 mm diameter and 190 mm length were poured. Cast ingot was then cut at 100 mm from the base.

Range of studies contains following stages:

- pouring of standard samples without influence of electromagnetic field,
- pouring of samples with influence of electromagnetic field (value of magnetic induction B for internal wall of mould was 58mT),
- analysis of graphite morphology and assessment of microstructure of matrix.

Source of electromagnetic field was inductor with three-phases winding, which scheme is show in work [6, 10].

3.1. Chemical composition analysis

To chemical composition analysis of charge material for all melts was used spectrometer QuantoDesk of ARL and spectrometer LECO to control of carbon and sulphur quantity. Chemical constitution of investigated cast iron was following: 4,14%C; 0,054%S; 1,92%Si; 0,35%Mn; 0,372%P; 0,433%Cr; 0,2%Ni; 0,074%Mo; 0,057%Cu; 0,101%Al; 0,017%Ti.

3.2. Metallographic analysis

Metallographic examinations was made with use of light microscopy Nikon OPTIPHOT. Surfaces of samples which were prepared for microstructure analysis were etched with use of Nital on composition: 3cm^3 nitric acid and 100cm^3 ethyl alcohol. On figure 1 is presented scheme of measurement fields on cross-section of test castings.

On the basis of metallographic analysis and [9] was made assessment of graphite morphology (form and distribution).

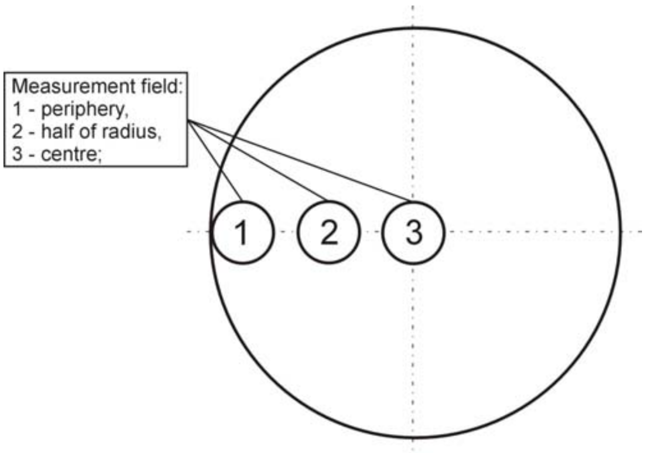

Fig. 1. Scheme of measurement fields on cross-section of test castings

On figure 2÷7 are presented microstructures of samples, which were poured in „sibral" moulds with and without influence of electromagnetic field.

4. Summary

On figure 2÷4 are presented microstructures of standard ingot, which was poured without influence of electromagnetic field, whereas o figure 5÷7 are presented microstructures of ingots, which were poured with influence of rotate electromagnetic field on crystallization process. Standard sample in strukture contains pearlite with phosphide eutectic.

The same matrix structure as standard sample has ingot (Fig. 5÷7), which was poured with influence of electromagnetic field.

Whereas, visible change concerns graphite morphology, particularly in periphery field (Fig. 2 and 5) in comparison of both ingots. Form of graphite in periphery zone for standard ingot is of type I (in accordance with standard PN-EN ISO 945), whereas for ingot, which was poured with influence of electromagnetic field, form of graphite is mainly of type I and III.

For both of analysed measurement fields (ingots field with number 1), we have uniform distribution of graphite of type A.

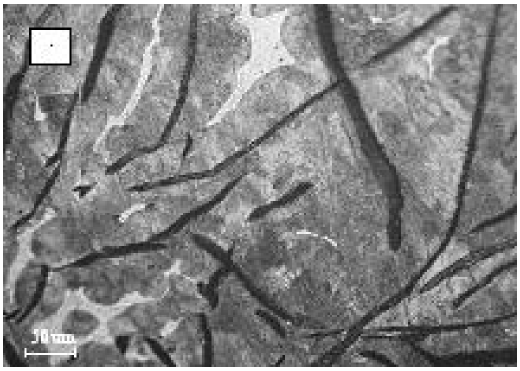

Fig. 2. Microstructure of standard casting, which was poured in „sibral" moulds without influence of electromagnetic field (measurement field 1), etching Nital

Fig. 5. Microstructure of standard casting, which was poured in „sibral" moulds with influence of electromagnetic field B = 58mT (measurement field 1), etching Nital

Fig. 3. Microstructure of standard casting, which was poured in „sibral" moulds without influence of electromagnetic field (measurement field 2), etching Nital

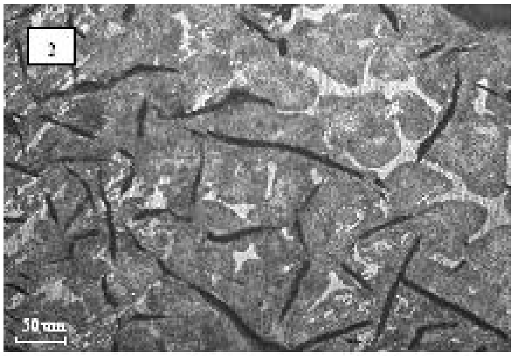

Fig. 6. Microstructure of standard casting, which was poured in „sibral" moulds with influence of electromagnetic field B = 58mT (measurement field 2), etching Nital

Fig. 4. Microstructure of standard casting, which was poured in „sibral" moulds without influence of electromagnetic field (measurement field 3), etching Nital

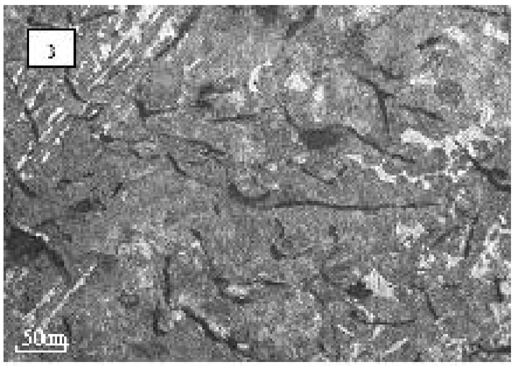

Fig. 7. Microstructure of standard casting, which was poured in „sibral" moulds with influence of electromagnetic field B = 58mT (measurement field 3), etching Nital

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