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SHAPING OF DUCTILE CAST IRON DEDICATED FOR SLAG LADLE

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ABSTRACT

In industrial conditions, ductile iron was prepared and two molds were made, in which a 600mm thick plate was formed. Filling system for one mold was placed vertically and for the second -horizontally. In order to obtain cooling curves, "S" type thermocouples have been placed in the mold. After cooling the casts, the samples from the fixing points of thermocouples were cut by the trepanning method. In the "vertical" cast sample shrinkage porosity was observed, while in the "horizontal" cast sample no porosity was detected. A significant difference in the recorded temperature in the center of the casts was discovered, indicating a defect in "vertical" cast.

Keywords: slag ladle, cast iron, porosity, casting; thermal analysis

INTRODUCTION

Slag ladle or slag pot (Fig. 1) belong to the group of massive and thick-walled casts. Their shaping microstructure (during crystallization) is significantly different from the castings with smaller dimensions, which in turn consequently can lead to elements segregation and shrinkage porosity [1-7].

Fig. 1 Examples of slag ladles produced in Krakodlew S.A.

Crystallization of heavy-section casting affects the final quality of cast iron castings, because off its wall thickness and longer cooling time. Due to the fact that these castings are exposed to thermal loads during usage and must be characterized by adequate strength, it is important to properly carry out the casting process. It can be made of various grades of cast iron, but to make extend service life, it should be made of GJS cast irons, which, unlike the GJL grade, contain nodular graphite (Fig. 2) instead flake graphite (Fig. 3). Changing the shape of graphite particles (from flake to nodule) give an increased chance of shrinkage porosity. The method of preventing this defect is the appropriate metallurgical quality of the metal [8], but also the appropriate mould technology. Increasing demand for this type of castings requires more extensive research in this area.

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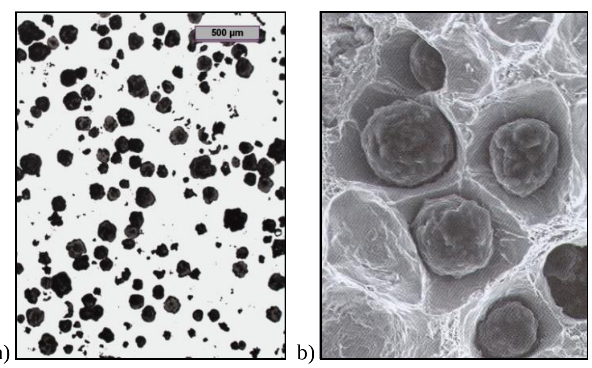

Fig. 2 Example of microstructure of ductile cast iron, light microscope – a), SEM – b)

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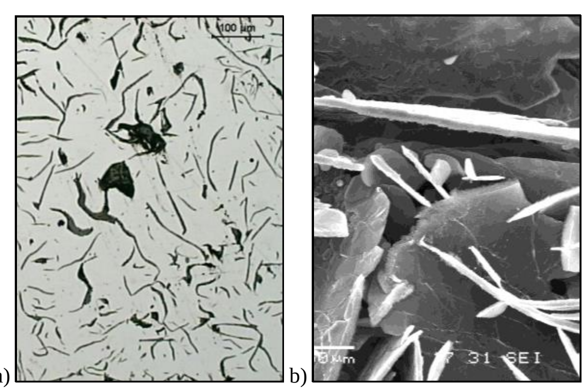


Fig. 3 Example of microstructure of lamellar cast iron, light microscope – a), SEM – b)

MATERIAL AND METHODS

In order to check the metallurgical quality of metal in relation to mold technology, in industrial conditions of Krakodlew S.A. foundry, it was made two casting molds made of furan resin sand. In each form a plate (600x600x75mm) was formed. The first – vertically and the second – horizontally. The plates were used as a model tests for optimizing the production process of slag ladles. In the mold cavity, "S" type thermocouples have been placed for the measurement of cooling and crystallization curves. The article presents the results to measurements of two thermocouple. One was placed in center of the the plate and second – 75 mm from its edges (Figs. 4, 5). The thermocouples were covered by quartz casings. Additionally, a metallurgical quality test was performed using a standard „K“ type cup. Then the ductile iron (from the same melt and the same ladle), which nodularization and inoculation process was carried out using cored wire method, was poured into the molds. After cooling the casting, from the thermocouples fixing points, the samples for metallographic examinations were cut out by the trepanning method.

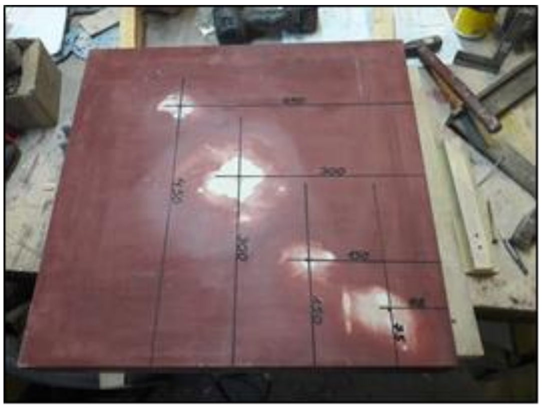


Fig. 4 Scheme of the thermocouple arrangement in the plate

Fig. 5 View of the mold cavity after installing the thermocouples

RESULTS AND DISCUSSION

The symbols of the obtained samples are shown in Tab. 1. The number of graphite eutectic grains in the tested samples is presented in Fig 6. The results of the thermal analysis of the casting are presented in Fig 7. The photos of the trepanation samples are shown in Fig. 8 and 9. Obtained microstructures are shown in Fig. 10.

Table 1 Symbols of the obtained samples

Samples	**Location of the thermocouple / sample**	**Forming a casting**
VE	75 mm from its edges	vertically
VC	in center	
HE	75 mm from its edges	horizontally
HC	in center	

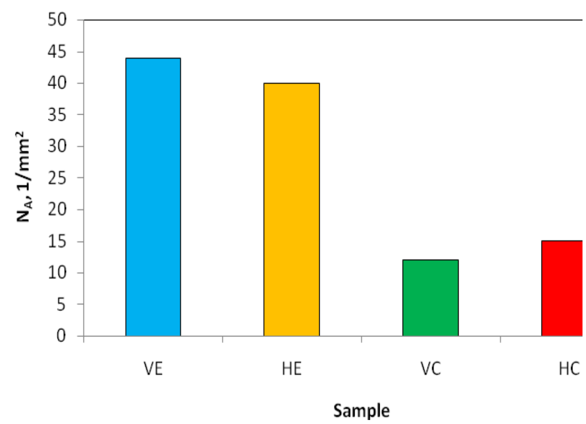


Fig. 6 The number of graphite eutectic grains in the tested samples of nodular iron casting

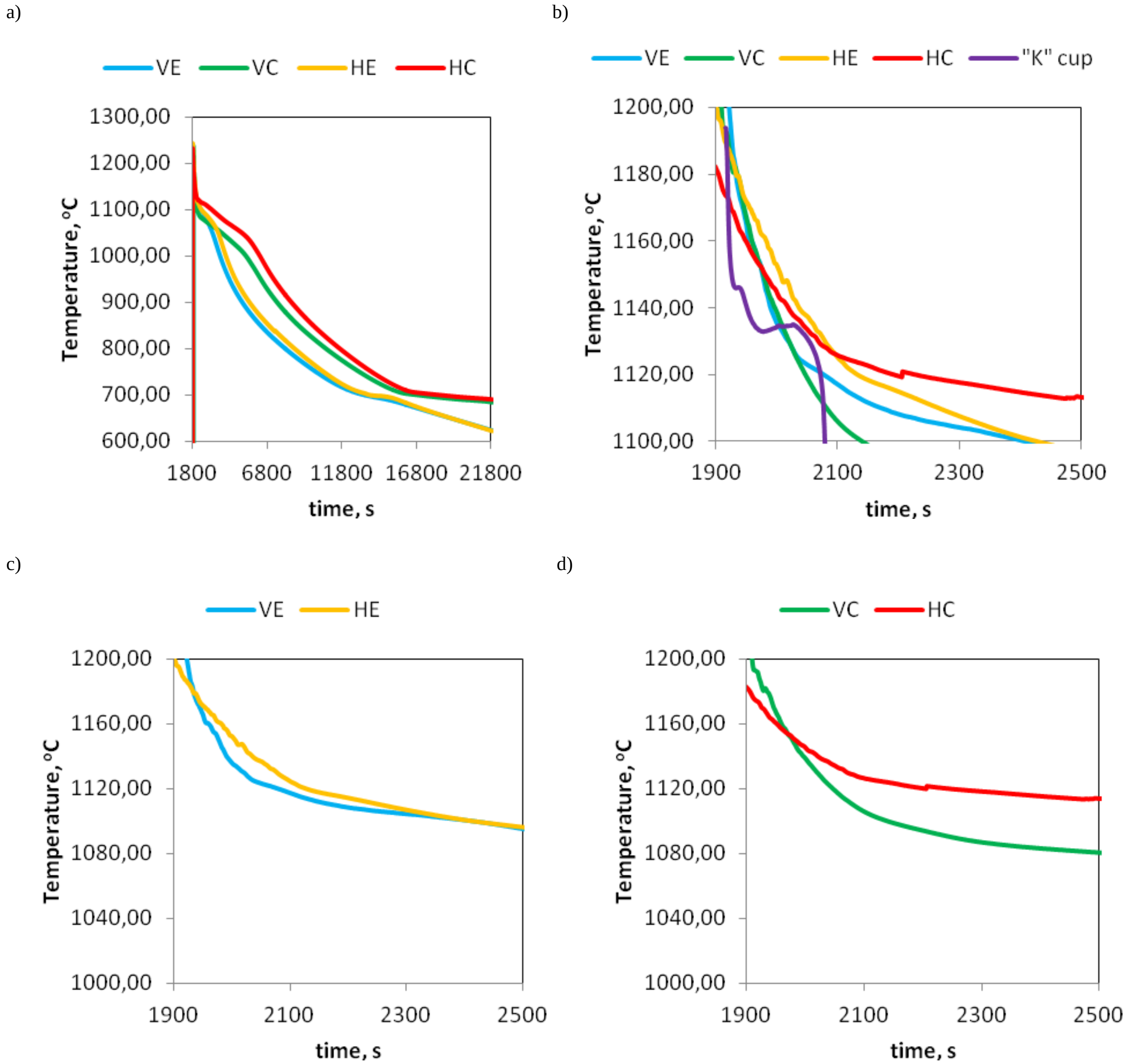


Fig. 7 Received cooling curves: collective – a), collective with "K" cup – b),, HE and VE – c), HC and HV – d)

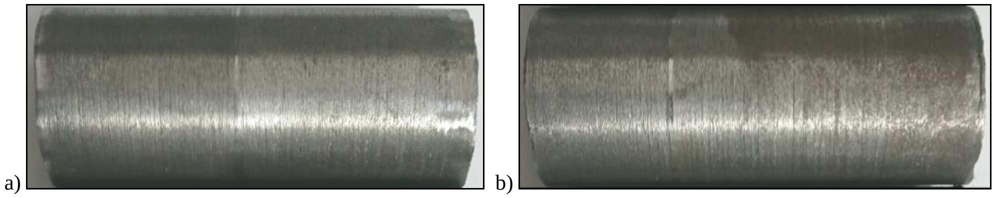
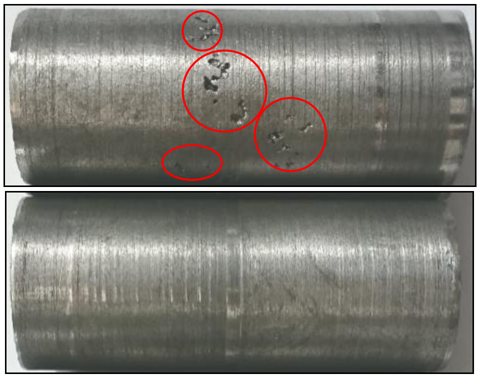
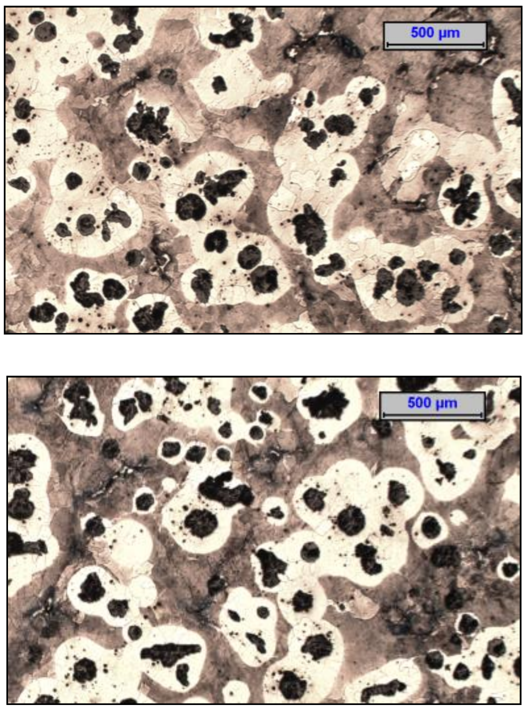


Fig. 8 Trepanning samples cut from the plate: HC – a), HE – b)



c) d)

Fig. 9 Trepanning samples cut from the plate: VC (visible porosity) – c), VE – d)



a) b)

Fig.10 Microstructure of sample HC –a), VC – b)

Discussion

Tests have shown that castings of the same shape but differing in the way of forming and the location of the running system can show differences in the obtained quality. The experiment showed that the vertical plate has shrinkage porosity in the center of the casting, while horizontal plate was devoid of these defects. The analysis of cooling curves showed that the temperatures near of edge of the casting was similar in both cases. In the case of thermocouples installed centrally, it can be observed that the vertically plate has a solidus temperature significantly lower than horizontally plate. Clearly, this indicates a smaller amount of crystallizing metal within a thermocouple research area.

CONCLUSION

1. In the vertical sample (VC) shrinkage porosity was observed, while in the horizontal sample (HC) no porosity was detected.
2. A significant difference in the recorded temperature in the center of the casts was discovered, indicating a defect in vertical plate.
3. The solidus temperature recorded in the VC was 50° C lower than in HC.

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