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Prediction of Graphite Nodule Count and Shrinkage Tendency in Ductile Cast Iron, with 1 Cup Thermal Analysis

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We have succeeded in investigating the graphite eutectic temperature (TEG) and cementite eutectic temperature (TEC) in ductile cast iron, from the chemical composition of the molten metal, as follows;
TEG=1149.1(℃)+4.7Si%-4.0Mn%-44P% etc.
TEC=1142.6(℃)-11.6Si%-0.75Mn%-46.2P% etc.
We added various kinds of inoculants into the molten metals, and then cast them at various fading time into 1 cup. Using the cooling curve of 1 cup and above equations, we calculated eutectic graphitization ability (EGA).The graphite nodule count (N) of CE cup T.P. is determined by (DT1/DTE), as follow; N = 6.13 x (100 x DT1/DTE) - 126 In addition to, when EGA becomes over 70%, shrinkage tendency (θ) becomes low as near 60°. Consequently, 1 cup thermal analysis is a good system to predict graphite nodule count and shrinkage tendency (θ) correctly in ductile cast iron, before pouring it.

Keywords: *1 cup thermal analysis, ductile cast iron, eutectic graphitization ability, molten metal's quality*

1. Introduction

T. Kanno developed the 3 cups thermal analysis system[1)]. It consists of 3 cups (First: Inoculated, Second: Base melt, Third: Tellurium added). Using this system, the eutectic graphitization ability (EGA =DT1/DTE) can be investigated and the graphite ability, chilling tendency and tensile strength can be predicted, in gray cast iron. Here, DTE means the difference between the graphite eutectic temperature (TEG) and cementite eutectic temperature (TEC). DT1 means the difference between the supercooling turning point temperature (TSC) and cementite eutectic temperature (TEC).

However, this 3 cups thermal analysis system cannot be used in ductile cast iron. In the ductile iron, as austenite solidifies ahead of graphite, TEG cannot be shown even with inoculated cup (a). In addition, as Te bonds to make MgTe, so it cannot work for making chill and TEC cannot be shown, even with Te added cup (c).

In this study, using 1 cup thermal analysis system, we calculated EGA and investigated the relationship between EGA and the molten metal's quality in ductile cast iron.

2. Experimental procedure

2.1 Principle of 1 cup thermal analysis system

Fig.1 shows the 1 Cup Thermal Analysis System. With the cooling curve of 1 cup (no addition), the supercooling turning point temperature (TSC) can be searched.

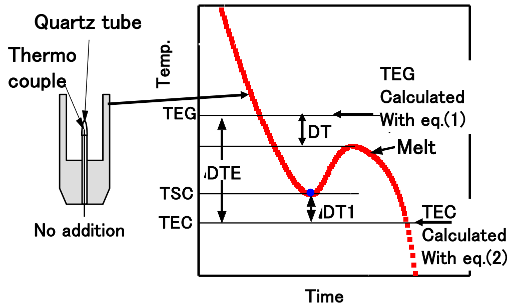

Fig.1. 1 Cup Thermal Analysis System

TEG and TEC can be calculated from the following principle. There is a report about the effect of element on eutectic temperature TEG and TEC[2)]. From this data, we can calculate TEG and TEC in ductile cast iron, from the chemical composition of the molten metal, as follows;

TEG=1149.1(℃)+4.7Si%-4.0Mn%-44P%+2.7Cu%+1.0Ni%+1.8Co%+13.9Al%-17.7Mo%-10.5Cr%-9.3Sn%-5.2Sb%-6.1W%-3.7Nb-14.8V%-80.3B% (1)

TEC=1142.6(℃)-11.6Si%-0.75Mn%-46.2P%-1.4Cu%-1.1Ni%-0.7Co%-1.8Al%-14.5Mo%+5.9Cr%-6.0Sn%-5.1Sb%-2.8W%+0Nb%+3.3V%-26.0B% (2)

In Ductile cast iron, S bonds Mg to makes MgS, so we do not consider its effect. Mg amount is small enough to ignore. As these results, EGA can be calculated. (EGA = 100 x (TSC - TEC) / (TEG - TEC)

2.2 Pouring test

Melting was done in a silica lined high frequency furnace of 60 kg, 3000 Hz. The basic composition was as follows: 3.7mass% C (hereafter simply shown as %), 2.15% Si, 0.3% Mn, 0.02% P, 0.01% S and 0.05% Mg. After Mg spheroidizing treatment as sandwich method, the molten metal was returned to furnace and was held at 1350 ℃. We added various kinds of inoculants (Graphite type, Ba type, Ba-Ce type, Ca-Si type and Bi type) into the molten metals, and then cast them at various fading time (0, 1, 2.5, 5.0, 7.5, 10, 15 and 20 min) into 1 cup (D30xH50mm, 250g). Using the cooling curve of 1 cup and above equations, we calculated EGA and investigated the relationship between EGA and the molten metal's quality of ductile cast iron.

2.3 Principle of investigating shrinkage tendency

Fig.2 shows the principle of investigating shrinkage tendency (θ), with 1 cup thermal analysis system. When shrinkage cavity forms, thermal conductivity becomes smaller, owing to the cavity in the casting, and cooling speed becomes slower and the tendency (θ) becomes larger. That is, the larger the θ is, the larger the shrinkage is.

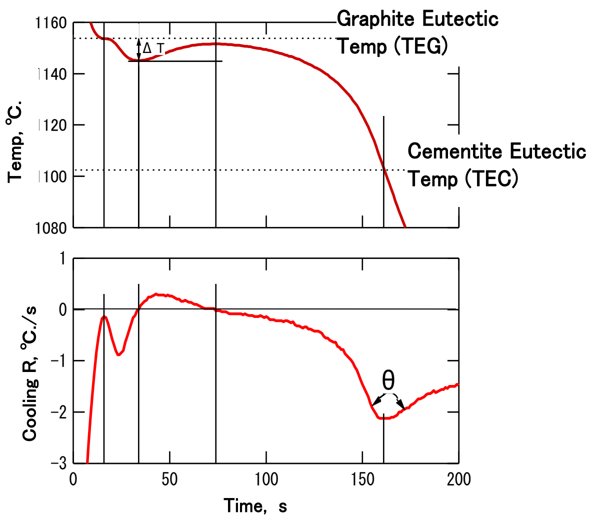

Fig.2 Principle of investigating shrinkage tendency (θ), with 1 cup thermal analysis system.

3.1 Prediction of graphite nodule count

Fig.3 shows the relationship between (DT1/DTE) and the graphite nodule count (N) of CE cup. T.P. The graphite nodule count (N) is determined by (DT1/DTE), as follow.

$$N = 6.13 \times (100 \times DT1/DTE) - 126 \qquad (3)$$

1 Cup thermal analysis is a good system to predict graphite nodule count correctly.

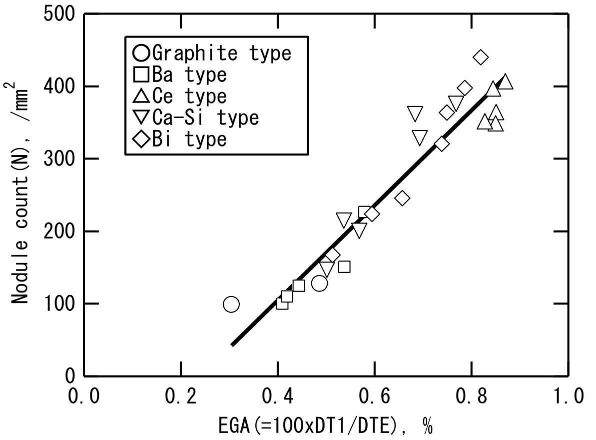

Fig.3 Relationship between EGA and the graphite nodule count (N) (T.P.: CE cup, D30xH30mm, 250g)

3.2 Prediction of shrinkage tendency

Fig.4 shows the relationship between EGA and shrinkage tendency (θ). When EGA becomes over 70%, shrinkage tendency (θ) becomes low as near 60°. 1 Cup thermal analysis is a good system to predict shrinkage tendency (θ) correctly.

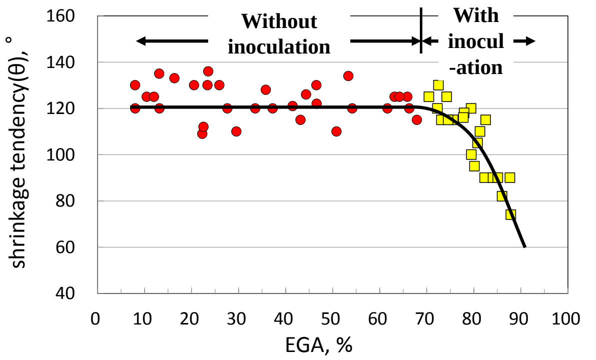

Fig.4 Relationship between (EGA=100 x DT1/DTE) and shrinkage tendency (θ).

Conclusion

1 cup thermal analysis is a good system to predict graphite nodule count and shrinkage tendency (θ) correctly in ductile cast iron, before pouring it.

Reference

[1] T. Kanno, M. Morinaka and H. Nakae: J. Japan Foundry Society, 70 (1998) 773-778.

[2] T. Kanno, M. Morinaka and H. Nakae: J. Japan Foundry Society, 70 (1998) 465-470.