Shrinkage Analysis of Smaller modulus Spheroidal Graphite Iron Castings Considering Expansion and Contraction

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Abstract

Shrinkage cavity prediction simulation considering theoretical volume changes such as liquid shrinkage, austenite shrinkage, and graphite expansion during solidification was performed and applied to castings with modulus less than 2 cm. The results showed that the accuracy of the shrinkage location and amount was improved over the conventional prediction method, and the calculation agreed well with the actual phenomenon. The results were satisfactory for casting engineers.

Keywords: CAE, Shrinkage, Spheroidal graphite iron

Introduction

As generally known, spheroidal graphite iron castings do not include shrinkage cavity even without the riser when castings are produced under the proper manufacturing conditions. The decision to apply the riser-less design can be determined by the shape factor. However, the most of castings manufactured in foundry practice have complex shapes. It is difficult to determine riser-less by shape factor. On the other hand, although many methods have been studied to predict shrinkage cavity in casting simulations. There seems to be no uniform method for predicting shrinkage cavity yet. In particular, the predicted results of the Niyama Criterion [1], which is often used for steel castings. It does not match the actual location of shrinkage cavity. This makes it difficult to prevent shrinkage cavity at the manufacturing site. The author reported a method for predicting shrinkage cavities in spheroidal graphite iron castings. It is a method to parameterize the expansion and contraction behavior during solidification. And it was applied to the prediction of shrinkage cavity for heavy section castings with modulus greater than 3 to 10cm [2]. In this study, the prediction method is examined for low-alloyed hypereutectic castings with Mc=2 cm or less.

Experimental Procedure

Fig.1 shows the casting design of the product for which shrinkage cavity was predicted. The casting has 165mm diameter and 100mm height. Casting designs were applied with both riser and riser-less. Mc of the castings is 1.2 cm. Chemical compositions were applied 3.67%C, 2.61%Si, 0.21%Mn, 0.029%P, 0.011%S, 1.00%Cu,

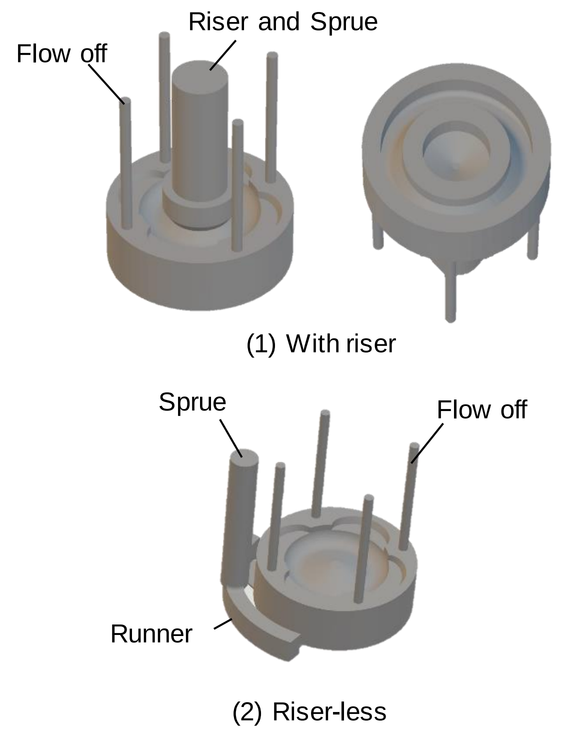

Fig.1 Casting design of product

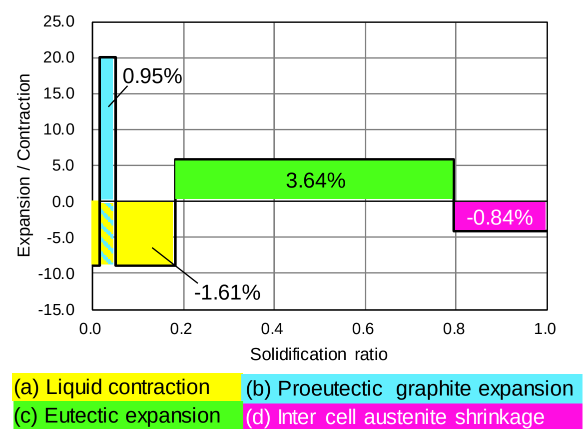

Fig.2 Expansion and contraction behavior

0.31%Mo, 0.017%Ce, and 0.040% Mg. In this study, the expansion and contraction behavior during solidification was quantitatively calculated. Casting simulation was used to predict shrinkage cavity. The quantitative calculation and the method of application to casting simulation was referred to those reported in the previous reports [2]. Fig.2 shows the expansion and contraction behavior of this study. The horizontal axis shows the solidification ratio, and the vertical axis shows the degree of expansion and contraction. The cooling curves with different solidification times were organized by solidus rate. The rate of each reaction interval that occurs during solidification can be shown by the same index even for different modulus.

Result and Discussion

Fig. 3(1) shows shrinkage cavity distribution of the castings at the cross section. Shrinkage cavities were observed in critical areas where it should not occur with riser-less design. On the other hand, no shrinkage cavities were observed in the castings with riser design. Fig. 3(2) shows the "I&M's criterion," which is a predictive index for shrinkage porosity in this study. In this study, it was assumed that the shrinkage cavities correspond to 0.0-99.99% of the values predicted. And conventional method, the Niyama criterion is also shown in Fig. 3(3). Each criterion was almost at the same position as the actual location of the shrinkage cavities with riser-less. In the case of riser design, the prediction using I&M's criterion is closer to the actual result.

Fig. 4 shows the appearance of prediction results. I&M's criterion was shown same spots that were actual area of the shrinkage cavity. Niyama criterion was shown in a position that was not the actual area of the shrinkage cavity. I&M's criterion was shown to be a practically useful prediction method as manufacturing spheroidal graphite iron castings in foundry practice.

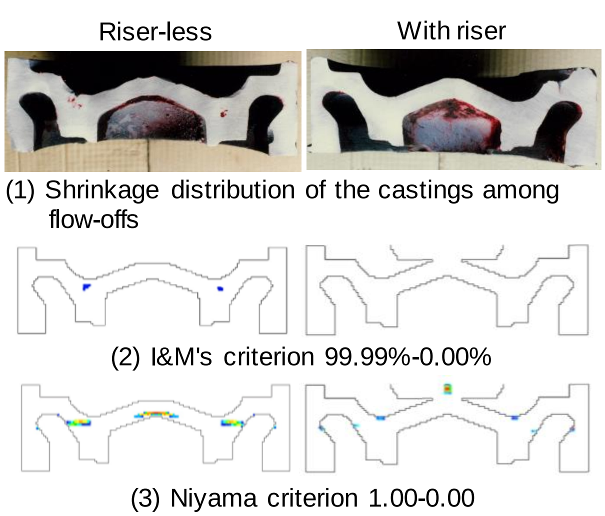

Fig.3 Comparison of shrinkage cavity distribution

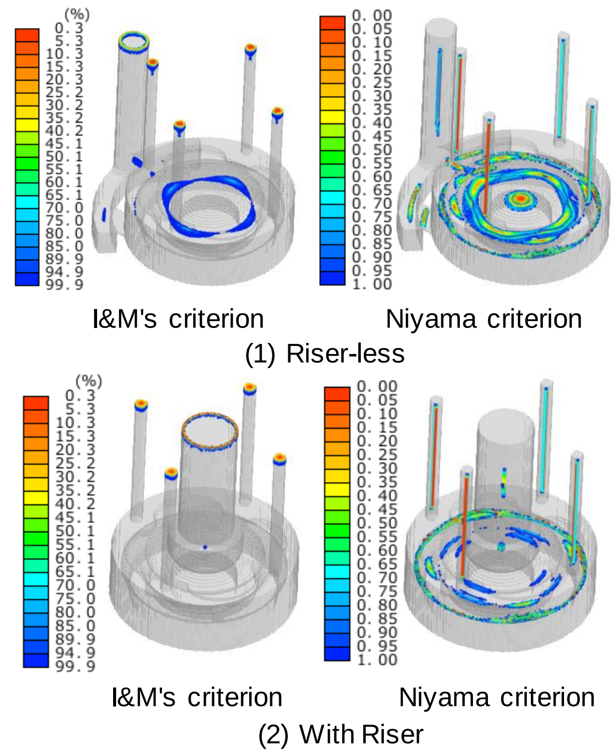

Fig.4 Appearance of prediction results

Conclusion

Shrinkage analysis was conducted by considering expansion and contraction behavior during solidification. As the results, it was confirmed that this method can be used for precise analysis of castings with Mc=2cm or less, improving quantity and position of shrinkage.

References

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