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Dynamic measurements of the load on GCI castings and the contraction of castings during cooling in green sand molds

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For cylinder head of diesel engine and bed of machine tools which are made of sand casting, residual stress and deformation are serious problems. These defects are known to be due to the restraint by sand mold of heat shrinkage during casting. In previous studies, Motoyama et al. [1-4] conducted dynamic measurement of the aluminum alloy casting the resulting sand mold reaction force and the casting shrinkage, but studies in iron castings has not been performed so far. A continuous measuring device of sand mold reaction force and casting shrinkage of the green sand was newly developed. In this study, using the newly developed device, the authors conduct continuous measurement of the sand mold reaction force and casting shrinkage that occur in iron casting in green sand mold. The measured results provide valuable information to produce high quality casting.
Keywords: *sand mold, sand casting, gray cast iron, dynamic measurements*

1. Introduction

Residual stress and warpage have been severe defects of sand castings, such as cylinder heads or machine tool beds. The authors developed a dynamically measuring device of restraint force from green sand mold and contraction of a GCI. This device can apply squeezing pressure to green sand mold.

2. Experimental procedure

The table 1 shows the properties of the green sand. Fig.1 shows the squeezed mold. The green sand mold was controlled to the compactability ranging from 40 % - 45 % and squeezed in metal molding box at 0.8 MPa. Fig.2 shows schematic illustration of the device. An upper mold and a lower mold were formed through the same operation. When the molds were assembled, a quartz rod and the cast part were set. Then, tie bar, load cell (Maximum load 100 kN) and rigid plate were assembled.

The dimensions of the flange were 90 mm square. The casting was made from gray cast iron JIS FC 300(almost same as ASTM 45). The end of the casting opposite side of the flange was fixed by a cast part after pouring. Longitudinal contraction of the casting was obtained dynamically by measuring displacement of the quartz rod by using laser displacement gauge. Simultaneously, restraint force reacted on the flange of the casting was measured dynamically by using a load cell.

Table 1. Properties of green sand

Moisture (mass %)	Bentonite (mass %)	Active Bentonite (mass %)	Compactability (%)
3.2	10.8	7.6	38

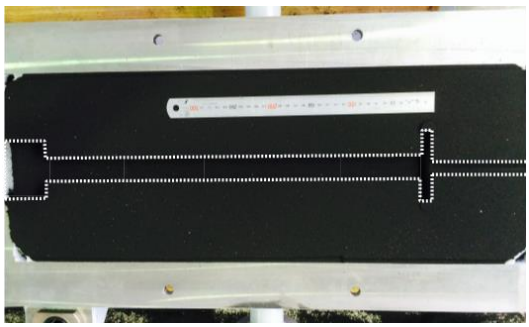

Fig. 1 The squeezed mold
(The dashed lines show the edge of the mold)

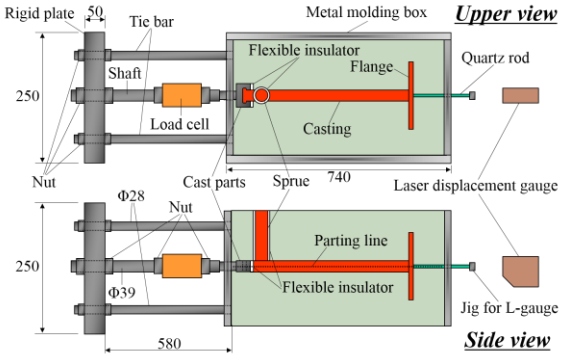

Fig. 2 Schematic illustration of the device

3. Result

Fig.3 shows the dynamic measurements of the load on the casting and the contraction of the casting. The horizontal axis shows the temperature of the center of the casting.

The load on the casting reached -0.3 kN after beginning of solidification (1210 ºC). This means that the casting expands. Then, the load on the casting increased with cooling. After reached 2.5 kN at 730 ºC, it decreased to 0.7 kN at 700 ºC. After that, the load on the casting increased linearly with cooling again. It stayed constant under 650 ºC.

The contraction of the casting reached -0.4 mm after beginning of solidification. This result indicates that casting expands in this temperature. Then, the contraction increased with cooling, but it stayed constant between 730 ºC and 700 ºC. After that, the contraction increased linearly with cooling again. The contraction increased while the load of casting stayed constant.

Summarizing the above, the contraction of the casting or the load on the casting, dropped or stayed constant in the following temperature range.

Range 1: 1210 ºC - 1150 ºC
Range 2: 730 ºC - 700 ºC
Range 3: 650 ºC - 500 ºC
Range 4: 500 ºC - 200 ºC

The phenomena in the four temperature ranges will be discussed in next section.

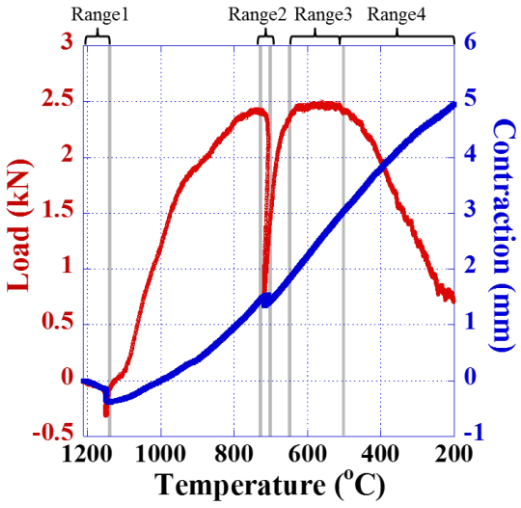

Fig. 3 The dynamic measurements of the load on the casting and the contraction of the casting

1. Discussion

Range 1;

The casting expands between 1160 ºC - 1150 ºC by crystallization of graphite during the solidification. Thus, these experimental results indicate that the cast iron casting expanded while it receiving the reaction force from the sand mold during the solidification.

Range 2;

This is caused by the expansion of the cast iron casting during A1 transformation. The experimental results indicate that the reaction force on the cast iron casting from the sand mold is relieved by the expansion during the A1 transformation.

Range 3;

In this range, the load on the casting stayed constant. This should be caused by the fracture of the sand mold around the flange. The load when the sand mold stayed constant was approximately 2.5 kN. Since the dimensions of the flange were 90 mm square, the sand mold would fracture in approximately 0.3 MPa compressive stress. The mold started to fracture in this stage.

Range 4;

The fracture of mold progressed in this stage. Therefore the load on casting was decreasing and the contraction of the casting was still increasing.

2. Conclusion

The authors developed the device which can measure dynamically both the restraint force from the green sand mold and the contraction of the GCI casting. By using the device, changing in the restraint force and contraction of the casting, which provide valuable information to produce high quality casting, were successfully obtained.

References

[1] Y. Motoyama, H. Takahashi, Y. Inoue, K. Shinji, M. Yoshida, 2012: Journal of Materials Processing Technology 212(6), pp.1399-1405.

[2] Y. Motoyama, H. Takahashi, Y. Inoue, K. Shinji, M. Yoshida, 2012: Journal of Materials Processing Technology 213(2), pp.238-244.

[3] Y. Inoue, Y. Motoyama, H. Takahashi, K. Shinji, M. Yoshida, 2013: Journal of Materials Processing Technology 213(7), pp.1157-1165.

[4] Y. Motoyama, Y. Inoue, G. Saito, M. Yoshida, 2013: Journal of Materials Processing Technology 213(12), pp.2270-2277.

[5] H. Polzin, W. Tilch, M. Strehle, 2013: International Foundry Research 65(2013) No.4, pp.18-24

[6] A. Baghani, P. Davami, 2014.: Metallurgical and Materials Transactions B 45, pp.1157-1169.