Proceedings of the 72nd World Foundry Congress
21-25th May 2016, Nagoya, Japan

Surface roughness of casting solidified in the frozen mold

Naoki Omura and Shuji Tada
National Institute of Advanced Industrial Science and Technology (AIST)
2266-98 Shimo-Shidami, Moriyama-ku, Nagoya 463-8560, Japan

Effects of frozen mold conditions such as the particle size of sand and the water content on the surface roughness of castings solidified in the frozen mold were demonstrated. The surface roughness of castings increases with increasing the particle size of sand. Furthermore, the surface roughness was also affected by the water content of mold. The fewer the water content, the smoother the surface of casting. When water content was 3 mass% (minimum value in this study), the arithmetic mean roughness of the casting was about 15 μm and was comparable with that fabricated using the green sand mold.

Keywords: *AC4CH aluminum alloy, water content, grain size*

1. Introduction

A frozen mold that is fabricated by freezing the mixture of only sand and water is a kind of sand mold. The frozen mold has many advantages such as reducing environmental loads and improving the casting environments because it doesn't include any organic compounds. Reduction of environmental load is desired in various fields nowadays, so the technique using the frozen mold in casting is received remarkable attention as a future casting process. Several studies on the properties of frozen molds such as strength, heat-transfer characteristic, cooling ability, fluidity and so on, have been reported [1-4]. However, there has been little information about the properties of casting fabricated using the frozen mold [5]. In this study, we examined effects of the mold conditions such as the grain size of silica sand and the water content of mold on the surface roughness of AC4CH aluminum alloy casting solidified in the frozen mold.

2. Experimental procedure

Silica sands having different mean particle sizes were used to fabricate frozen molds in this study. The grain size distributions of these silica sands are shown in Table 1. 5 mass% water was added to these silica sands, and they were blended for 180 seconds by a mixer to prepare the sand mixtures for sand mold.

Table 1 Grain size distribution and fineness number of sand used in this study

Grain size μm	850	600	425	300	212	150	106	75	53	<53	AFS. FN
R5	0.2	20.0	77.8	1.8	0.2						28.2
R6			0.2	8.6	52.4	34.6	3.8	0.4			58.3
R7					13.8	55.0	27.4	3.6	0.2		78.2
R8						10.0	56.8	23.8	7.4	2.0	117.9
GSM※			1.2	3.6	10.0	35.0	37.6	4.7	0.5	0.7	84.3

※Green sand mold

Furthermore, three kinds of sand mixtures consisted of R6 silica sand and different amount of water (3, 8 and 10 mass%) were prepared.

The sand mold was formed for each sand mixture using a plastic mold. The sand mold was frozen by keeping in the freezer held below 238K for more than 14.4 ks. Fig. 1 shows the photograph of frozen mold used in this study. Upper mold had a sprue and a degassing hole, and lower mold had a plate-like cavity. The cavity size of the plate is as follows; length: 135mm, width: 22mm, and height: 7mm.

The AC4CH aluminum alloy ingot was put in a graphite crucible and heated up to 993K by a high-frequency induction furnace. Then, the crucible was taken out from the furnace. When the melt temperature goes down at 983K, the molten aluminum alloy was cast into the frozen mold.

The surface roughness of the specimen solidified in the frozen mold was measured by a contact type surface roughness tester (SURFTEST SJ-310, Mitutoyo Corporation), and arithmetical mean roughness, Ra, was calculated. The measuring

Fig. 1 Photograph of frozen mold.

conditions were as follows; the evaluated length was 16mm, the cut-off value was 8.0mm, and the measuring speed was 0.25mm/s. For comparison, the surface roughness of the casting fabricated in a green sand mold was also measured. The green sand mold consisted of silica sand, clay, additives, and 2.6 mass% water.

3. Results and discussions

The effects of grain size of silica sand and water content of mold on the surface roughness of castings solidified in frozen molds are shown in Fig. 2 and Fig. 3, respectively. For comparison, the data from the green sand mold were also included in these two figures. It is revealed that the surface roughness of casting fabricated by frozen mold decreases with a decrease in the particle size of the sand. Moreover, the scattering of the surface roughness increases with an increase of the particle size. The specimen fabricated using frozen mold prepared from the sand with large particle size (R5) showed a very rough surface. The

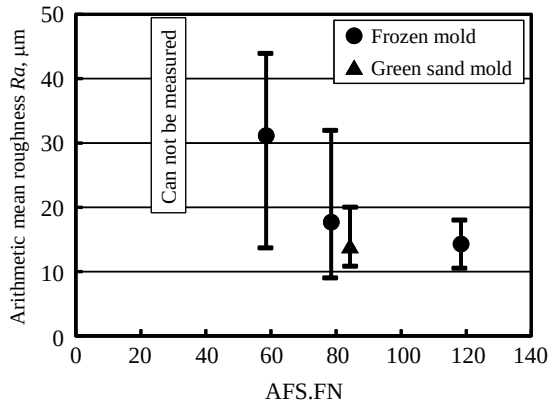

Fig. 2 Variation in the surface roughness of castings as a function of grain size of silica sand.

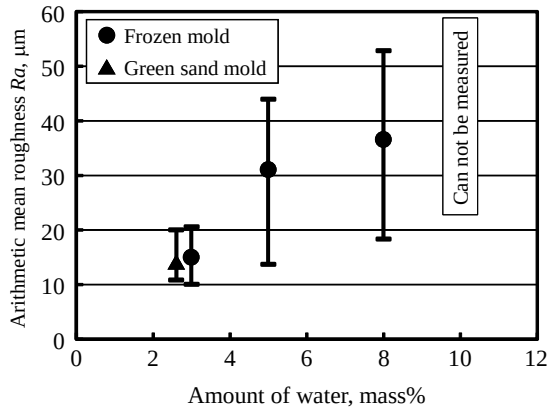

Fig. 3 Variation in the surface roughness of castings as a function of water conten in mold.

height difference of the surface of this specimen exceeded the measuring range of the apparatus (360μm), making it impossible to acquire the surface roughness of this specimen. The frozen mold consists of only sand and water. So the particle size of sand directly influences on the surface roughness of the frozen mold. That is, the finer the sand is used, the smoother the surface of a frozen mold will be. This may be the reason that the surface roughness of castings solidified in the frozen mold varied with the particle size of sand.

In addition to the particle size of sand, water content plays the other important role in influences the surface roughness. It is clearly seen that the surface roughness of casting increases with increasing the water content of mold. When water content was 3 mass%, the casting showed relatively smooth surface. The arithmetic mean roughness value of this specimen was about 15 μm. This value was comparable with that fabricated using the green sand mold. In contrast, the specimen cast in the frozen mold which included water 10 mass% showed rough surface. The surface roughness of this specimen can't be measured because the height difference of surface goes beyond the measuring range. The more the frozen mold includes water, the more the vapor generates at casting process. It is considered that large amount of vaper produces high back pressure in the mold and has a negative impact on the surface roughness of castings.

4. Conclusions

The surface roughness of castings fabricated using frozen mold was affected by the particle size of sand and the water content of mold. The frozen mold prepared from the fine sand and less amount of water can provide the casting with smooth surface.

References

[1] S. Tada, T. Nishio, and K. Kobayashi: Inter. J.Cast Metals Research 21 (2008) 260-264.
[2] T. Nishio, K. Kobayashi, and H. Nakayama: J. Jpn. Foundry Soc. 82 (2010) 350-355 (in Japanese).
[3] H. Nakayama, S. Tada, T. Nishio, and K. Kobayashi: J. Jpn. Foundry Soc. 81(2009) 371-376 (in Japanese).
[4] N. Omura, Y. Murakami, and S. Tada: J. Jpn. Foundry Soc. 85(2013) 659-664 (in Japanese).
[5] K. Shimizu, Y. Xinba, M. Tanaka, and H. Shudai: Mater. Trans. 50 (2009) 1128-1134.