논 문

Thixo Die Casting with Extrusion Billets and its Mechanical Properties

Jung-Woon Bae and Chung-Gil Kang†
School of Mechanical Engineering, Pusan National University, Busan 609-735, Korea

Abstract

틱소오 다이캐스팅을 위하여는 재가열 시 고상율을 제어할 때 구상화 조직을 가진 소재가 필요하다. 현재까지 전자교반법에 의하여 제조한 빌렛을 이용하여 틱소오 다이캐스팅에 이용하였다. 그러나 제품의 원가절감과 소재개발 측면에서 틱소오 다이캐스팅을 위한 압출소재의 개발 공정을 설명하고자 한다. 재가열시 압출비가 구상화 조직에 미치는 영향과 기계적 성질 사이의 관계를 규명하였다.

Key words : Thixo-diecasting, Reheating process, Extrusion ratio

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1. Introduction

With thixo-forging and thixo-casting, if the microstructure can be controlled so that it has fine and globular grains through reheating the materials, the net shape components, which have uniform mechanical properties without defects like porosity, can be developed even if the components have complex shapes [1-4]. To replace the conventional casting and forging processes by a semi-solid forming technique, the development of raw material is essential [5-8]. Therefore in study, the development of the material applicable to semi-solid diecasting using an extruded rod is mainly investigated. A processing condition to control the microstructure through reheating after continually extruding cast billets prior to diecasting is suggested in order to develop materials applicable to semi-solid diecasting. Moreover, the difference in the evolution of the microstructures has been after reheating the continually cast-billets produced by the EMS and extruded billet.

2. Experiments

The billets manufactured both by continuous casting employing the EMS and by direct extrusion process were used in the semi-solid diecasting process. The four inches in diameter material produced by SAG (Austria) was defined as material A, and the material, which were hot-extruded using the continuous casting billet, were defined as material B with an extrusion ratio of 3.06 and C with an extrusion ratio of 6.06, respectively. To reheat the three materials, the horizontal high-frequency induction heating system with a multi-step reheating method was used, with a maximum of 80 kW. Temperature was measured by two 1.6 mm diameter K-type thermocouples during reheating. These devices were inserted at both the center and midway between the center and the edge of the material lengthwise length, as is shown in Figure 1, and then the material was placed in the coil [9-10]. In order to achieve the material state to be reheated, the temperature corresponding to 60-70% of that needed for the solid fraction was set when the experiment was performed. Applicability of diecasting process was examined through analysis of solid fraction, globularization, and roundness of the microstructure after cutting the slug at each part.

3. Results and discussion

Figure 2 shows the photographs of the microstructure at position (a), (b), and (c) positions of the center of the

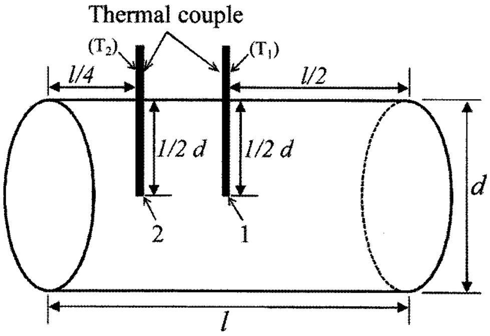

Fig. 1. The thermal couple positions to measure the temperature during reheating (d = 101 mm, l = 220 mm).

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†E-mail : cgkang@pusan.ac.kr

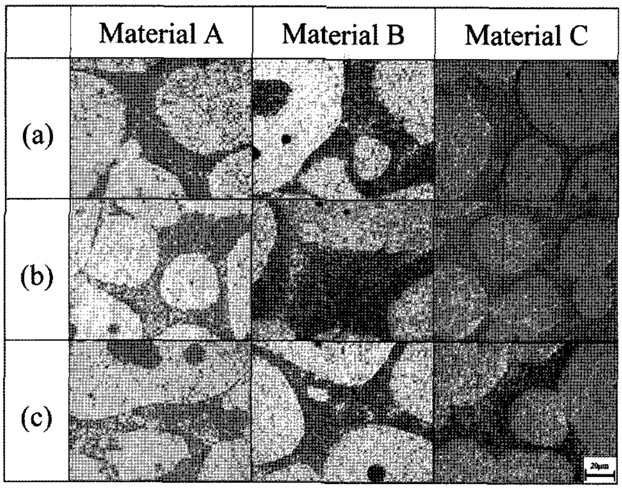

Fig. 2. The microstructure of three different materials (d = 101 mm, l = 220 mm) after reheating to solid fraction control at the center position of Figure 1.

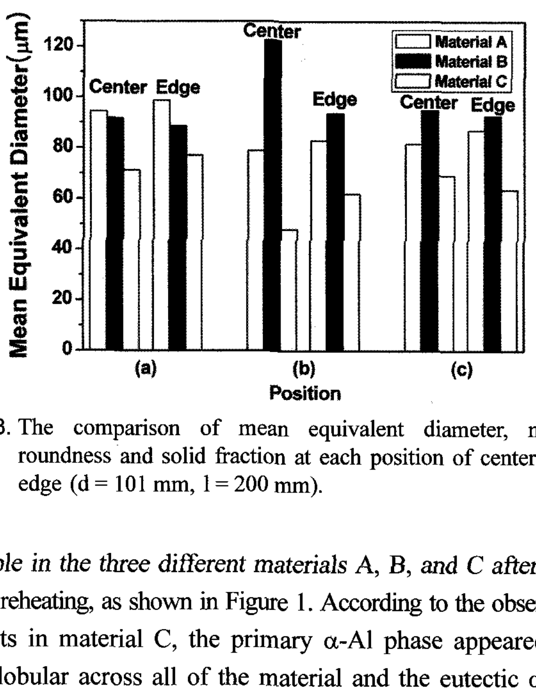

Fig. 3. The comparison of mean equivalent diameter, mean roundness and solid fraction at each position of center and edge (d = 101 mm, l = 200 mm).

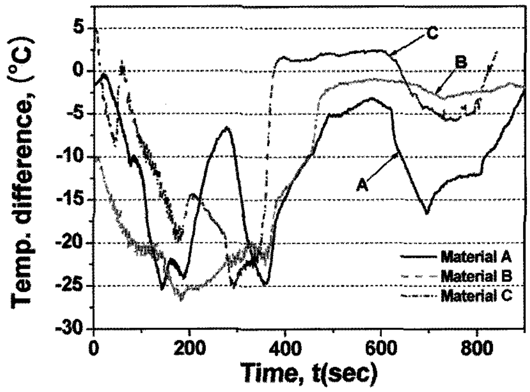

Fig. 4. The comparison of measured temperature different obtained from thermo-couple at material A, B and material C between positions 1 and 2.

sample in the three different materials A, B, and C after the final reheating, as shown in Figure 1. According to the observed results in material C, the primary α-Al phase appeared to be globular across all of the material and the eutectic α-Al phase was also fine. A fine distribution of Si particles along the grain boundary was observed. Unlike the EMS material, the microstructure in the reheated material exhibited a tendency to be similar to that of A356 produced by conventional casting.

Figure 3 quantitatively shows the mean equivalent diameter. In material C, the equivalent diameter appears to be 80 μm to 100 μm over each sample. The mean roundness was estimated to be about 1.5 to 2. Figure 4 compares the deviations in measured temperatures obtained from the thermocouple positions 1 and 2 for materials A, B, and C during reheating, as shown in Figure 1. The material C had the lowest temperature deviation in the final period of reheating. Roundness, equivalent diameter, and the fraction of solid are uniform over all the materials, but the microstructural feature of material C such as refinement and uniformity was better than in materials A and B. The higher the extrusion ratio, the narrower the interface between grains, and hence a more enhanced microstructure was able to be obtained as heat transfer improved when heating.

Figurer 5 depicts the position of the test piece to measure the mechanical properties and compares the tensile strength and elongation in each material. Material A has higher

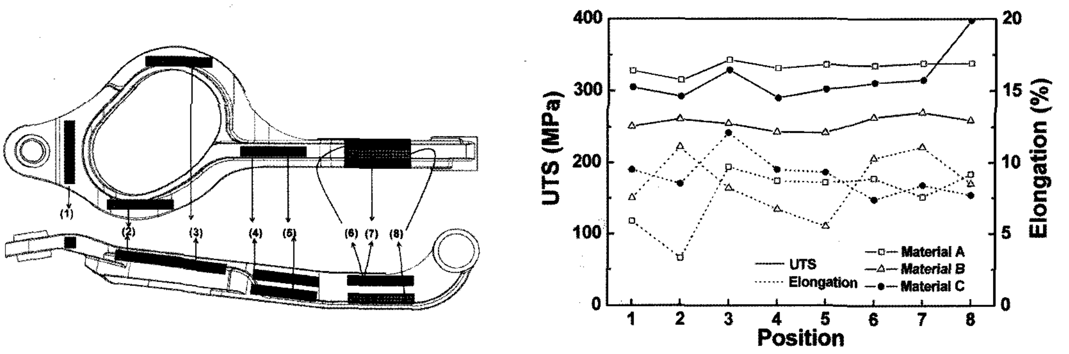

Fig. 5. The position of the test piece to measure the mechanical properties and compares the tensile strength and elongation in each material.

tensile strength than B and C do with the exception of the end (8), and the strength of the sample with the higher extrusion ratio increases. The elongation in material A is comparatively nonuniform. Elongation rates ranged from a maximum of 10.2 and a minimum of 3.2 (in specimens (1) and (2)) where coarse Si particles were observed during filling. The difference between the maximum and minimum of material A is large in comparison with materials B and C.

Regardless of the position of the parts, in order to have a uniform elongation rate, refinement of the Si particles was necessary. This requirement was better met by the billet produced by the extrusion process which was remarkable more formable than that produced by using the continually cast billet by EMS.

4. Conclusions

As a result of the reheating and semi-solid forming experiments using thixo-forming material produced by EMS and extrusion, the following conclusions are derived:

The reheating cycle time reduced in accordance with an increase of the extrusion ratio. Deviations in temperatures between the center and the edge of the material were reduced. The microstructure of extruded materials had similar results as that of the material produced by EMS.

Under the identical conditions of thixo-diecasting, the products produced by the extrusion process had fine microstructures and no observable defects, whereas those produced by EMS had surface defects due to Si segregation.

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