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Effect of Hydrogen concentration and microporosity on high cycle fatigue property of ultrasonic molten metal treatment A356 alloy

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1. Introduction

Recently, in response to the growing seriousness of global warming, industries across all sectors have been showcasing diverse new technologies in the manufacturing process for reducing the overall amount of CO_2 generated. In particular, the automotive parts industry has sought to address the issue of CO_2 reduction by actively using lightweight materials. This being the case, aluminum composite materials are receiving a great deal of attention. Microporosity is formed by the hydrogen solubility limit of the liquids in aluminum alloy. The micro-pores cause inhibiting the mechanical characteristics of material. Thus, most recently there has been a great deal of research regarding the reduction of the rate of microporosity formation in the phase casting process. This study deals with the state of molten aluminum brought about by applying ultrasonic energy in the melt process and is also concerned with the inter-relationship between the molten aluminum and the mechanical characteristics of the components that use it.

This study uses casting A356 aluminum alloy and measures the rate of microporosity and also measures changes in hydrogen concentration brought on by application of ultrasonic energy during the molten aluminum treatment. This study is investigated to assess the degree to which fatigue properties rely upon the aforementioned factors.

2. Experimental

2.1 Sample production

Figure 1 is a schematic drawing of the device containing the ultrasonic oscillation equipment employed in this study. The generator (a) is a 15kHz band generator generating a maximum output of 2kW. It connects to the Converter (PZT(b) ; Lead Zirconate Titanate) which converts the electrical signal into a mechanical signal. The role of the booster (c) is to amplify the resultant oscillation energy and the Sonotrode (d) relays this oscillation energy to the molten aluminum.

After loading 5 kg of A356 aluminum alloy (e) into the graphite crucible (f) the aluminum is maintained at a molten state of 700℃ (g). In this temperature state, it is subjected to ultrasonic treatment from 30 to 600 seconds, thus producing the test sample.

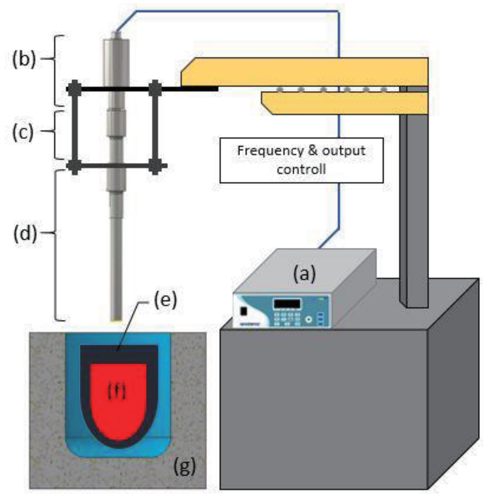

Fig. 1 schematic diagram of experimental apparatus; (a) Ultrasonic Generator, (b) horn controller, (c) Converter horn(PZT), (4) Converter(PZT), (e) Molten metal, (e) Graphite crucible, (f) Electric furnace

2.2 Analysis of hydrogen concentration in molten metal

To measure hydrogen concentration of the molten metal, this study used an ALSPEK H-mini portable pH device. After measuring hydrogen concentration of the molten metal at 700℃ both 3 times prior and 3 times after the application of ultrasonic melt treatment, this study calculated the value of their arithmetic means.

2.2 Assessment of high cycle fatigue properties

High cycle fatigue tests were performed using CRS's CR-RBT-01 device based on ASTM E 466 standard test specifications. Testing conditions were set as follows: average stress 0, stress ratio R as (σmin/σmax) -1 and frequency as 50Hz. The

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fatigue strength range was 100~240 MPa and after testing 3 times per condition, this study calculated this as the arithmetic means.

2.3 Analysis of microstructures and fracture surface

In order to measure microporosity of the specimen in this study, the total density of specimen was measured firstly using Archimedes' principle, then calculated the microporosity by comparing the total density with the specimen's theoretical density. By observing the fracture surface, this study was then able to evaluate the impact of microporosity on proliferation of fatigue.

3. Results and discussion

3.1 Changes to hydrogen concentration within molten metal according to application or non-application of ultrasonic

Figure 2 shows the results of measuring hydrogen concentration in A356 alloy before and after the application of ultrasonic. Prior to ultrasonic treatment, the molten metal's hydrogen concentration was within the range of 0.19~0.21 ml/100 g. However, as ultrasonic was applied, the mixture showed a gradual decrease in hydrogen concentration. After 10 minutes of ultrasonic application, the hydrogen concentration of molten metal was at 0.08 ml/100 g showing a reduction by approximately 56%.

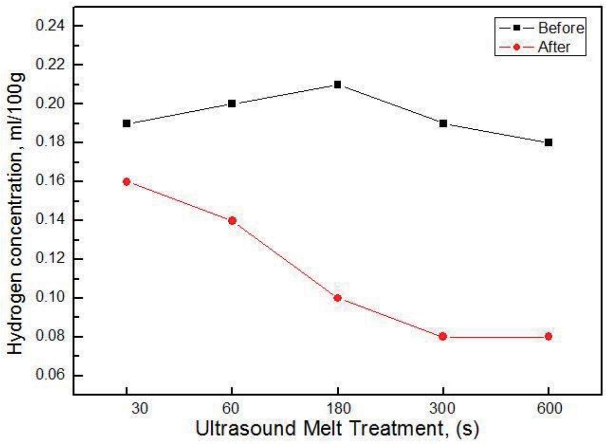

Fig. 2 changes to hydrogen concentration for befor/after to application of ultrasonic

3.2 Fatigue characteristics based on changes in the rate of microporosity

Results of fatigue tests based on ultrasonic treatment conditions were shown as an S-N curve. It is evident that the cycle fatigue while in casting showed results with fairly wide variation distribution. On the other hand, the longer the duration in which ultrasonic was applied, the more the fracture cycle's range of variation was gradually reduced.

3.3 Results of observing fracture surface

Observation of the fracture surface shows the presence of microporosity within the dendritic shape. This study was able to observe indications of fatigue cracks resulting from microporosity.

5. Conclusions

This thesis studied changes in hydrogen concentration in A356 alloy based on application of ultrasonic, the rate of porosity according to hydrogen concentration, and finally the impact of micropores on fatigue characteristics. Results show that through the application of ultrasonic, hydrogen concentration can be reduced to as little as 0.08 ml/100g. As the hydrogen concentration is gradually reduced in accordance with the length of the injection in which it is subjected to ultrasonic, a proportionate decrease in microporosity was evident as well. More than 300 seconds of ultrasonic treatment, the fracture cycle showed similar tendencies also.

6. Acknowledgment

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7. References

1. Suk-Jong Yoo, Choong-Do Lee, Korea Foundry Society, 198-204, 2011

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