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Effect of Ultrasonic melt treatment on Grain size and tensile properties of A356 alloy

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1. Theoretical background

The primary mechanism of applied technologies using ultrasound within the melt is reported to be the result of cavitation and acoustic streaming. The ultrasonic vibration energy applied to the melt forms cavitation bubbles. Due to acoustic power accumulated, these cavitation bubbles expand and move causing hydrogen bubbles to be discharged out of the surface.[1] Also, nano-sized Ti particles generated by the erosion of the Ti sonotrode are distributed uniformly in melts because of the acoustic streaming effect. These particles refine the grain structure by forming heterogeneous nucleants.

The purpose of this study is to evaluate the effect of ultrasonic melt treatment on degassing and mechanical properties of Al alloy. In this study the concentration of dissolved hydrogen is measured when ultrasonic energy is injected to melts. On the basis of these measurements, this study assesses grain size and tensile characteristics so as to find ways to improve melt quality.

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 frequency of the ultrasonic generator (a) is 15kHz and maximum output of generator is 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 alloy.

5 kg of A356 alloy was melted (e) in the graphite crucible (f), and the A356 alloy was maintained at a molten state of 700℃ (g). In this temperature state, Ultrasonic melt treatment was carried out for 1 to 10 minutes, and the melt after ultrasonic melt treatment was poured into the steel mold.

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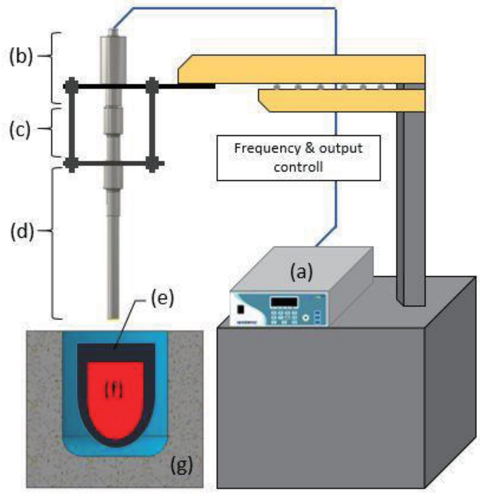

Fig. 1 schematic diagram of experimental apparatus; (a) Ultrasonic Generator, (b) horn controller, (c) Converter horn(PZT), (d) Converter(PZT), (e) Molten metal, (f) Graphite crucible, (g) Electric furnace

2.2 Sample analysis

(1) To measure the porosity of specimen according to duration of ultrasonic application, X-ray was used based on the KS D 0241 standard in this study; measurement was conducted with GE Phonix's vltomelx model. Range of measurement excluded the upper portion of the riser containing the shrinkage cavity. And in order to target an uniform area within all conditions, observations were made using 3D measurements from the bottom up, to a height of 65 mm.

(2) To measure the aluminum's grain size, this study was carried out according to ASTM E 112 standards and used MEIJI's EMZ-5TR stereo microscope.

(3) For tensile tests, specimens were manufactured in accordance with the ASTM E 8 standard and tensile speed was conducted at 2 mm/min. After testing at least 3 times under each condition, this study calculated and showed the arithmetic means.

3. Results and discussion

3.1 Changes in porosity depending on ultrasonic treatment condition

Figure 2 shows the changes of porosity in A356 alloy with injection time of ultrasonic melt treatment. Results show a trend towards gradual reduction of porosity with increasing injection time.

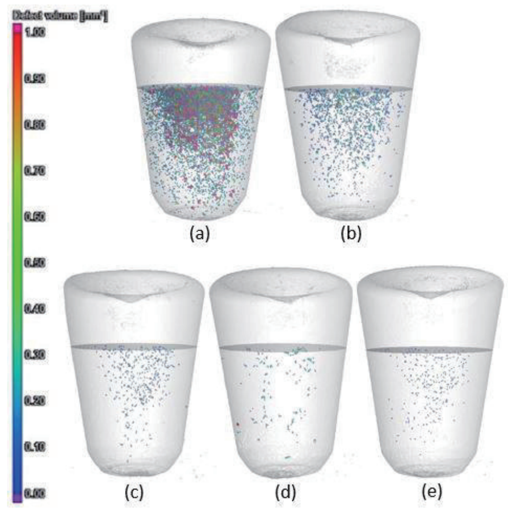

Fig. 2 3D-Porosity analysis of A356 alloy ultrasonic melt treated during (a) As cast, (b) 60 s, (c) 180 s, (d) 300 s, (e) 600 s

3.2 Changes in grain size depending on ultrason ic melt treatment condition

Figure 3 shows the result of the grain size according to application of ultrasound. Grain size is reduced gradually with increasing injection time

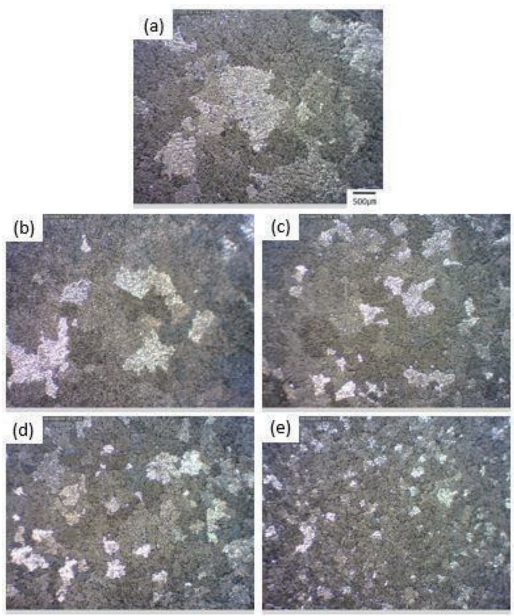

Fig. 3 Grain size analysis of A356 alloy ultrasonic melt treated during (a) As cast, (b) 60 s, (c) 180 s, (d) 300 s, (e) 600 s

3.3 Changes in tensile properties according to grain size.

Figure 4 shows changes in grain size and tensile strength according to the duration of ultrasound treatment. Grain size and tensile strength are shown to be in inverse proportion.

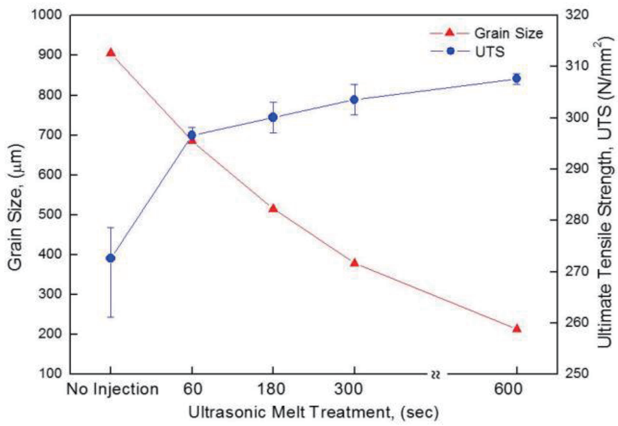

Fig. 4 Changes in tensile properties according to grain size

5. Conclusions

This study researched the impact of ultrasound melt treatment on changes in porosity, grain size, and tensile properties of A356 aluminum alloy. Results of the ultrasound melt treatment show that the porosity was reduced by 98.63% to 0.0099% when ultrasound melt treatment carried out for 600 seconds. Also, measurement of the grain size shows that the grain size with ultrasonic melt treatment was reduced by 76.5% to 213㎛ compared to grain size of non treated melt. Also, maximum tensile strength was increased by 12.8% to 307.62 N/mm^2.

6. Acknowledgment

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7. References

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