1P4-6

Proceedings of Symposium on Ultrasonic Electronics, Vol. 37 (2016)
16-18 November, 2016

Effect of Ultrasonic Frequency on degassing efficiency in molten Aluminum alloy

Young Ki Lee[1‡], Jeong IL Youn[1], Young Jig Kim[1] and Jeong Wook Park[2]
([1]School of Advanced Science and Engineering, Sungkyunkwan Univ. Korea;
[2]R&D Center, DR AXION Co., Ltd., Korea)

1. Introduction

Gas porosities in casting alloys are caused by precipitation of gas during solidification. Especially in aluminum casting alloys, the main source of gas porosities is hydrogen, which is the only gas that considerably dissolve in aluminum melts.[1] For this reason, the remover of the dissolved hydrogen in aluminum melts is critical process for the high quality castings. [2]

So several methods are generally used to degas in aluminum melts such as addition of hexachloroethane, vacuum degassing, gas purging and rotary degassing. However all of which generate substantial oxide layer and great amount of slag, so present an important environmental and economical problems. [3-4]

Ultrasonic degassing is an effective way for degas in aluminum melts to overtake such problems. When high intensity ultrasonic vibration inject above the cavitation threshold in aluminum melts, it generate alternating pressure which creates numerous cavities. [5] Generated cavities in aluminum melts repeatedly expand and compress, and the dissolved hydrogen in aluminum melts diffuse into the cavites. And these bubbles coagulate and float to the surface of the melt by the acoustic streaming. [6] But the majority of the previous studies of ultrasonic degassing are focused on effect of electric power and injection time with fixed resonant frequency on degassing efficiency in aluminum melts. However degassing efficiency is quite sensitive to the resonant frequency and amplitude which are related to cavitation threshold and aspect of bubble generation. [7]

So this study presents an experimental study developed in order to evaluation the influence of resonant frequency and amplitude on the degassing efficiency and cavitation in A356 Al alloy.

2. Experimental procedure

A356 Al alloy was used in this experiments, and its chemical composition is shown in **Table I.** About 2 kg alloy ingot was melted by the electric resistance furnace in a graphite curcible and the alloy was melted at 700 ℃.

The ultrasonic device consists of an ultrasonic generator, a transducer, a sonotrode to inject ultrasonic vibration into an aluminum melts. The transducer was capable of converting up to 2 kW of electric energy, and the sonotrode made by titanium was used for the experiments. Ultrasonic degassing was carried out for an A356 melts for 0, 1, 3, 5, 10 minutes. The resonant frequency was controlled as 15, 20, and 25 kHz and the amplitude varied as 12, 18 μm.

After ultrasonic treatment, reduced pressure test (RPT) was employed to determine the porosity level of the specimens. A356 melts (~100 g) was poured into a preheated thin-walled iron cup and allowed to solidify under a reduced pressure of 50 mm Hg. The RPT specimens were sectioned in the middle vertically and were polished to analyze the extent of hydrogen porosities. Density of RPT specimens were measured by using Archimedes' principle. And to evaluate the effect of resonant frequency and amplitude on cavitation, ultrasound was injected into 350 cS Si oil for the visible model.

3. Results and discussion

Fig. 1 shows the effect of resonant frequency on porosity levels in the RPT specimens for different degassing times at 12, 18 μm amplitude respectively. **Fig. 2** are plotted the measured density at 12, 18 μm amplitude with various resonant frequency. It is clear from **Fig. 1** and **Fig. 2** that porosity levels and density of RPT specimens decrease with increase of ultrasonic degassing time.

Table I. Chemical composition of A356 Al alloy.

Elements	Content (wt %)
Si	6.9
Mg	0.4
Cu	0.2
Fe	0.1
Mn	0.1
Al	Bal.

---

galeans@skku.edu

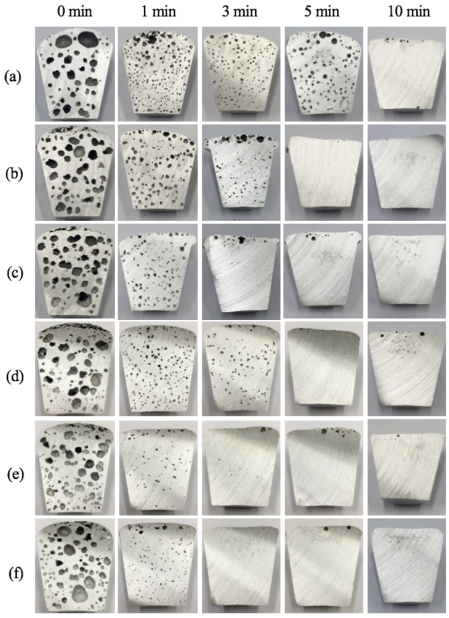

Fig. 1. Cross sections of RPT specimens with increasing ultrasonic injection time; (a) 15 kHz 12 μm, (b) 20 kHz 12 μm, (c) 25 kHz 12 μm, (d) 15 kHz 18 μm, (e) 20 kHz 18 μm and (f) 25 kHz 18 μm

But the result shows that with increasing the resonant frequency from 15 to 25 kHz, the density of A356 alloys increase rapidly with increasing ultrasonic injection time. In **Fig. 2**, in case of 15 kHz resonant frequency, the maximum alloy density was obtained after 10 and 5 min ultrasonic injection at 12, 18 μm amplitude respectively. But in case of 25 kHz resonant frequency, the maximum density was obtained after 3 and 1 min ultrasonic injection. **Fig. 3** shows the occurrence of cavities in the 350 cS Si oil with different conditions. The results show that when resonant frequency increase at same amplitude, density of cavities increases rapidly. The reason for this increase is that increasing resonant frequency causes the rapid pulsation of cavities. Result from increasing of density of cavities, the diffusion of hydrogen in cavities activated, so degassing efficiency is higher when resonant frequency increases.

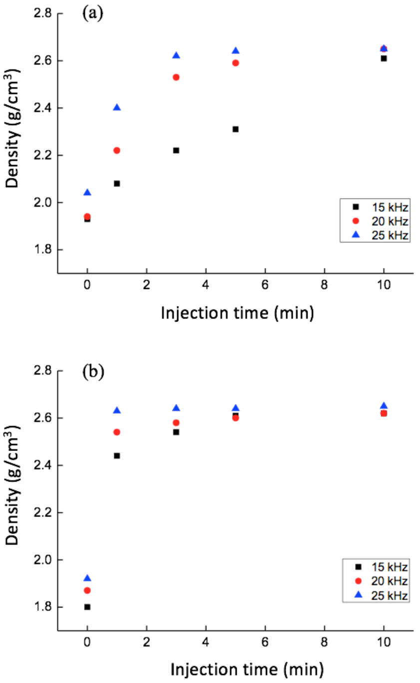

Fig. 2. Result of density under various resonant frequency with increasing ultrasonic injection time; (a) amplitude: 12 μm (b) amplitude: 18 μm

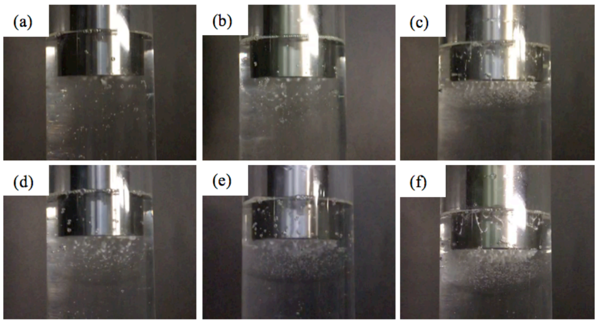

Fig. 3. Occurrence of cavities in the 350 cS Si oil; (a) 15 kHz 12 μm, (b) 20 kHz 12 μm, (c) 25 kHz 12 μm, (d) 15 kHz 18 μm, (e) 20 kHz 18 μm and (f) 25 kHz 18 μm

3. Conclusion

This study is focused on the influence of resonant frequency at same amplitude on ultrasonic degassing efficiency. The density results show that with increasing of the resonant frequency from 15 to 25 kHz, degassing efficiency of A356 alloy increases because of increasing density of cavities, thus hydrogen in A356 alloy activate diffusion in cavities.

References

1. H. Puga, J. Barbosa, E. Seabra, S. Ribeiro and M.Prokit: Mater. Lett. **63** (2009) 806.
2. Q. Han, S. Viswanathan: Metall. Mater. Trans. A **33A** (2002) 2067.
3. A.M. Samuel and F.H. Samuel: J. Mater. Sci. **27** (1992) 6533
4. O. Richly: Aluminum **57(8)** (1981) 546
5. G.I. Eskin: *Ultrasonic Treatment of Light Alloy Melts* (Gordon&Breach, Amsterdam, 1998) P. 87
6. H. Xu, X. Jian, T.T. Meek and Q. Han, Mater. Lett. **58** (2004) 3669
7. A.R. Naji Meidani and M. Hasan, J. Mater. Process. Technol. **147** (2004) 311