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Microstructure Refinement of Al Alloy by Ultrasonic Vibration.

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1. Introduction.

In this study the effect of ultrasonic vibrations on the microstructure of Al alloy was investigated during solidification. The common chemical agents for grain refinement was used to assess the structural enhancement. So, it casue the cost problem and complex process control.

Recently, it was found that the ultrasonic vibration during solidification affects the microstruture and results in refines grains and DAS [1,3,4,5]. Here, Promoting of smaller grains and dendrite arm spacing (DAS) during solidification of aluminum casting is generally advantageous especially in improvement of mechanical properties [2]. Retardation of grain growth and dendrite arm coasening is generally carried out by using chamical refiner such as TiB in aluminum casting. It this research, how ultrasonic vibration influences the solidification mode of aluminum casting and the mechanism of DAS refinement was discussed.

2. Experimental Setup

The ultrasonic vibration system consisted of a function generator with a maximum power of 800W as shown figure 1. The ultrasonic wave was generated by function generator (NF). And then the ultrasonic wave was increased by A Class amplifier. The resonance frequency was 20.50kH.

The Al alloy was melted high temperature at 680℃. When the temperature was increased, the ultrasonic vibration was decreased. It may cause the reduction of ultrasonic vibration effect. Due to the heat problem, 2 type cooling system which was adapted both water and air coolant was used for protecting the ultrasonic transducer and preventing the decreasing the power. The adapted cooling system was shown in figure 2. The resonance frequency change was verified due to usage of water pipe. The results were shown in figure 3; there was no large frequency change due to adaption of water pipe. Moreover, the ultrasonic transducer was melted by high temperature in Al alloy meting furnace. Therefore, from the results, it was found out that requirement for change the material for transducer end tip from SUS to Ti64.

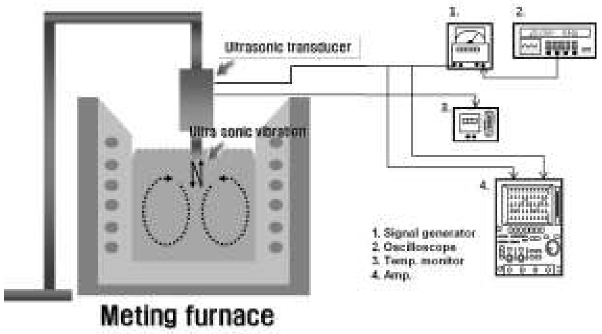

Fig. 1 Configuration of ultrasonic vibration system.

Fig. 2 Cooling system for ultrasonic vibration system.

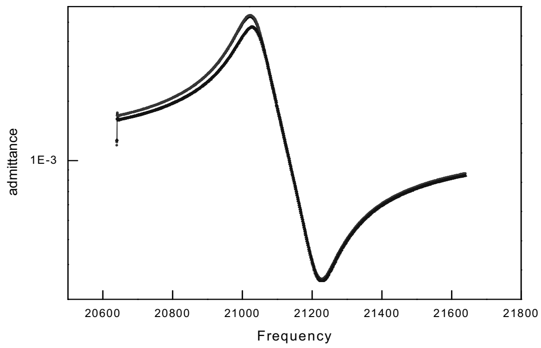

Fig. 3 Resonance frequency with and without water pipe.

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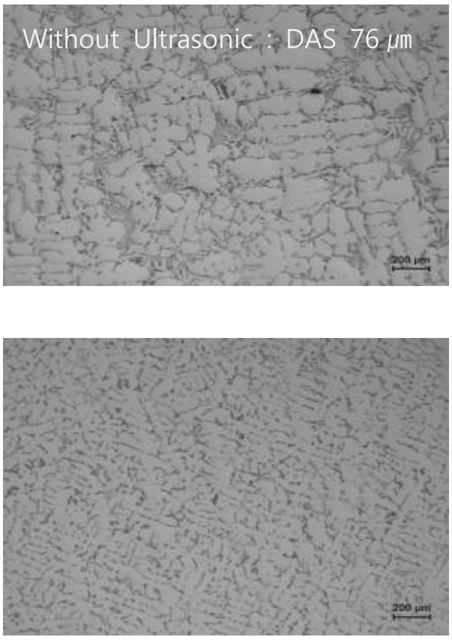
3. Discussion

In aluminum casting, dendrite arm spacing (DAS) is one of the most important structural parameters because the mechanical properties are strongly dependant on the DAS. As DAS decreases, ultimate strength especially ductility and elongation increase and the casting becomes more responsive to heat treatment [1].

As shown in figure 4, the DAS was greatly reduced, about 62% smaller, by applying ultrasonic vibration during solidification.

The mechanisms for the decrement of DAS can be as follows. First, the ultrasonic vibration retards the coarsening of dendrites. Because of the high frequency vibration, the solute in aluminum melt cannot be easily cumulated on the dendrite. Secondly, the ultrasonic vibration may increase the heterogeneous nucleation sites and it may result in finer DAS and grain size as well.

Besides the finer DAS, ultrasonic vibration also influences the evolution of the intermetallic compound. As shown in figure 6, the Fe bearing phases such as β-Al_5FeSi, $Al_{15}(Fe,Mn)_3Si_2$ became finer and shorter than the microstructure taken from the sample without the ultrasonic vibration.



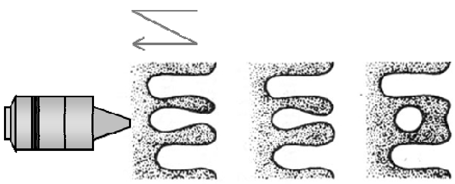


Fig. 5 Mechanism for microstructure refinement by ultrasonic action

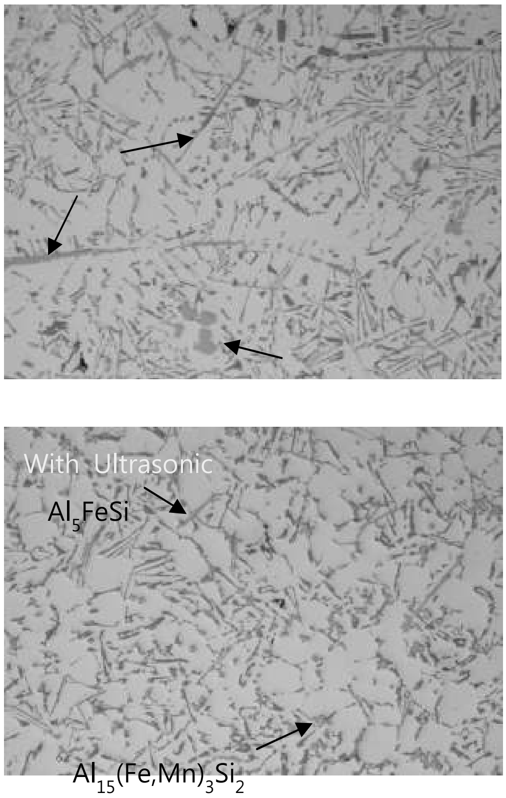


Fig. 6 Microstructure of the Fe bearing Phase change by ultrasonic action

4. Conclusions

The influence of ultrasonic vibrations using DAS was investigated. Due to the ultrasonic action, the DAS was greatly reduced about 62% smaller. It means that the ultimate strength especially ductility and elongation increase and the casting of Al alloy becomes more responsive to heat treatment. The mechanism of grain refinement was discussed based on the analysis of the solidification behavior under the ultrasonic vibration. It indicated that due to the acoustic cavitation and flows induced by ultrasonic vibration during the nucleation stage.

References

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