Ultrasonic Processing Refines Alloy Microstructure

Researchers at Oak Ridge National Laboratory and the University of Tennessee have demonstrated the ability to use ultrasonic technology to control the microstructure of metals. Aluminum and steel alloys are cast to produce a wide variety of components for industrial and consumer products. A barrier to improving the part quality is related to the inability to minimize the grain size and porosity and to control the secondary phase morphology during alloy solidification, which is strongly influenced by the processing method. Ultrasonic contributions to the casting process can reduce the energy required to produce alloy components; and produce superior grain refinement, reduced porosity, and improved secondary phase morphology.

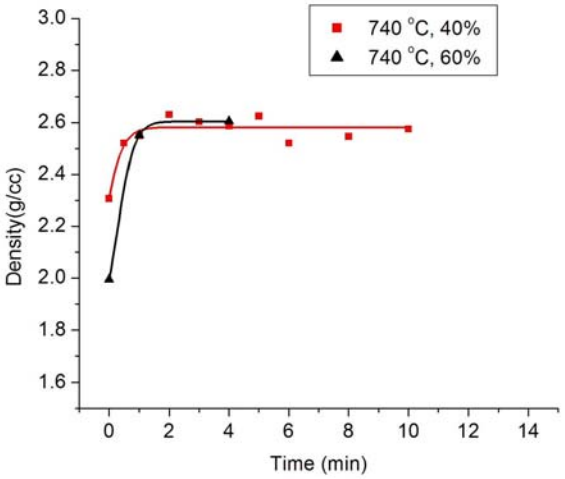
A series of aluminum alloy solidification experiments was conducted varying the following parameters:

- Acoustic power
- Exposure time to acoustic power
- Cooling rate
- Casting temperature

The experimental results showed ultrasonic technology can eliminate porosity in aluminum alloy melts in a matter of minutes as shown in Figure 1. Elimination of porosity during conventional processing takes approximately 3 times longer and often involves the use of chemical additives and mechanical stirring.

Figure 2 shows spherical grains, 20μm in diameter, that are observed in metal mold casting samples produced with ultrasonic vibration compared to a dendritic microstructure that is produced under normal conditions. The ultrasonic processing technology has also resulted in grain refinement in steel alloys.

Temperature: 740°C, humidity: 60%



The measured density of the sample as a function of ultrasonic processing time in the melt of different initial hydrogen concentrations

Figure 1. Degassing of aluminum alloys can be achieved in several minutes with ultrasonic processing. a) 0 minutes, b) 1 minute, and c) 4 minutes.

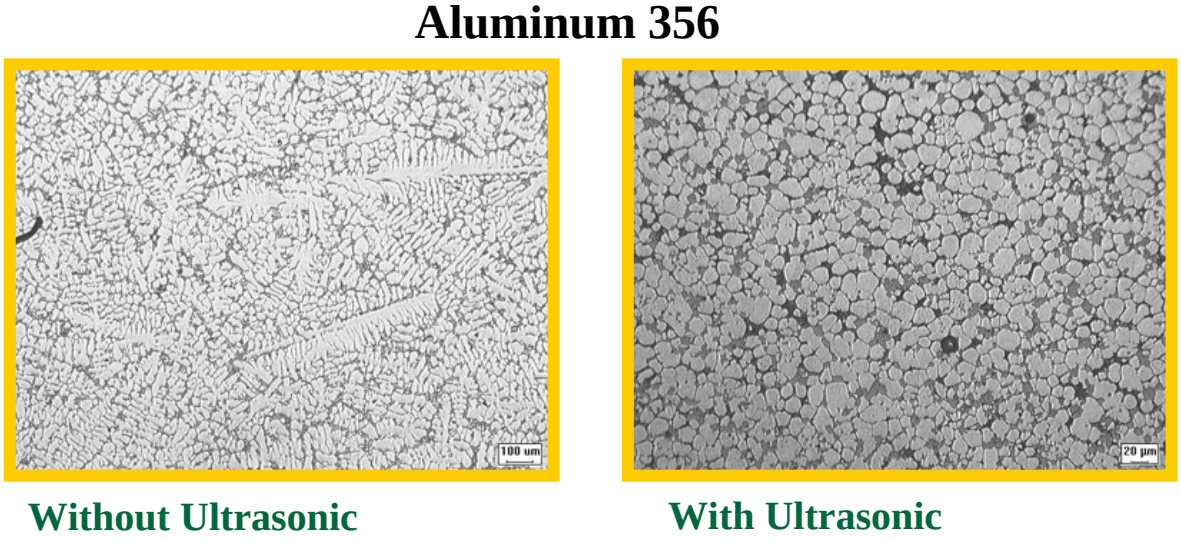


Figure 2. The solidification of aluminum results in a dendritic microstructure when cooled without ultrasonics and relatively spherical grains when processed using the ultrasonic technology.

A concept has been developed to integrate the ultrasonic technology into a semi-solid metal casting process in which several energy consuming steps in conventional thixocasting would be eliminated. Spherical, non-dendritic grains, produced directly from the melt by ultrasonic processing are expected to have better flow properties for filling complex mold designs.

The initial porosity reduction and grain refinement development studies are complete. The next steps are to identify industrial partners interested in supporting the modification of existing casting equipment to create a prototype facility for semi-solid metal casting trials.

For additional information about ultrasonic processing of metals please see the project factsheet at:
http://www.eere.energy.gov/industry/imf/pdfs/1784_ultrasonic_processing_of_materials.pdf

or contact:

Qingyou Han
Oak Ridge National Laboratory
Bldg 4508, MS 6083
Oak Ridge, TN 37831
Phone: 865-574-4352 Fax: 865-574-4357
Email: hanq@ornl.gov