Research Programs

Effect of Mold Vibration on the Performance and Casting Characteristics of Aluminum Alloys

Research Team:

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Introduction

Experimentation with mold vibration in order to alter the as-cast microstructure of cast components date back to 1868. In one of the earlier investigations, Chernov [1] found that application of mechanical vibration during solidification of steel caused refinement of austenite. More recent investigations by Abu-Dheir *et al* [2] shows a positive effect of mechanical vibrations on the morphology of silicon in Al-Si alloys, which manifests itself in significant enhancement of mechanical properties. Also recent work by Dommaschk [3] showed that a refined grain structure of Al-Si alloys could be obtained by mold vibration.

In addition to establishing and quantifying the effect of mechanical vibrations on the microstructure and mechanical properties of Al-Si alloys, this project quantified the effect of mold vibration on the casting characteristics of these alloys, particularly on the hot tearing tendency of the alloy. The vibrations enhanced liquid and mass feeding during the later stages of solidification and therefore minimize the incidence of hot tearing. Accordingly, vibrations eased difficulties in casting alloys that are traditionally prone to hot tearing, e.g., 206 alloy.

Objective

The objective of this project was to investigate the effect of mechanical mold vibration on the following:

1. The casting characteristics of Al-based casting alloys, including:
    a. The ability of the molten alloy to feed the mold cavity (feedability)
    b. The tendency of the alloy to hot tear during solidification
    c. The dendrite coherency point
    d. The tendency of the alloy to form shrink porosity
2. The as-cast microstructure of Al-based casting alloys, including:
    a. The morphology of silicon particles including eutectic Si particles, as well as primary Si particles (in the case of hypereutectic alloys)
    b. The as-cast grain size
    c. The size and distribution of pores

Methodology

The project was performed in two phases. Phase I involved casting the alloys without vibrating the mold and establishing the baseline for castability, mechanical properties, and microstructure. This baseline was used for comparison with corresponding information obtained in Phase II of the project where similar castings are made while the mold is mechanically vibrated.

Phase II involved casting the alloys while the mold is mechanically vibrated with pre-determined vibration parameters and measuring castability and characterizing the resultant microstructure.

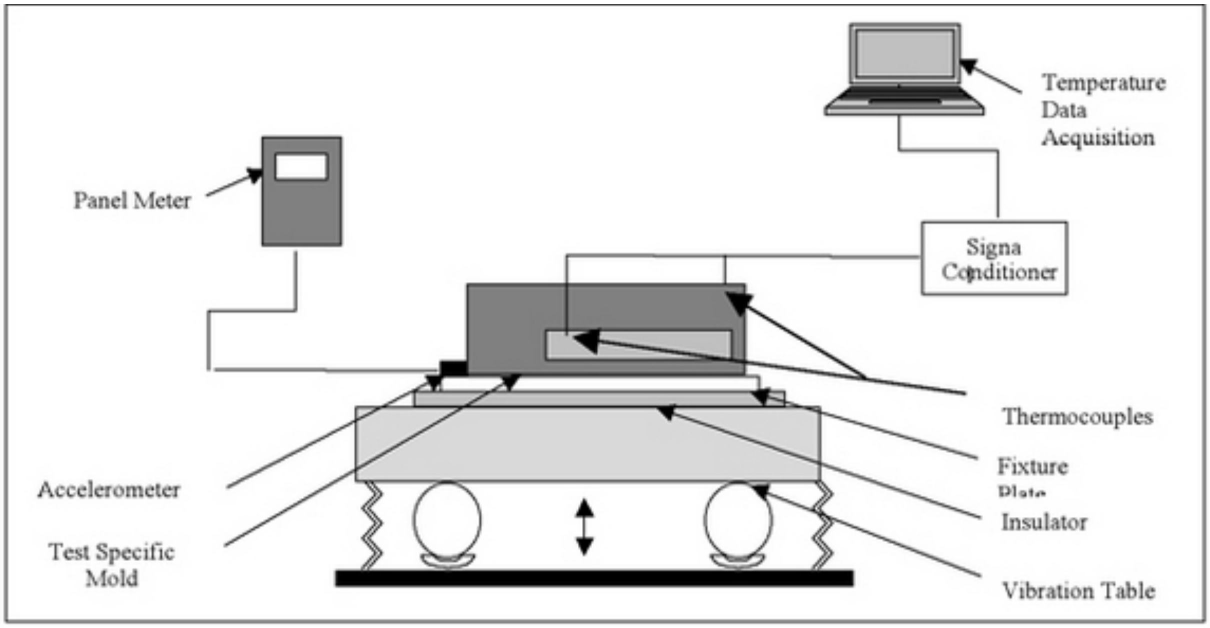
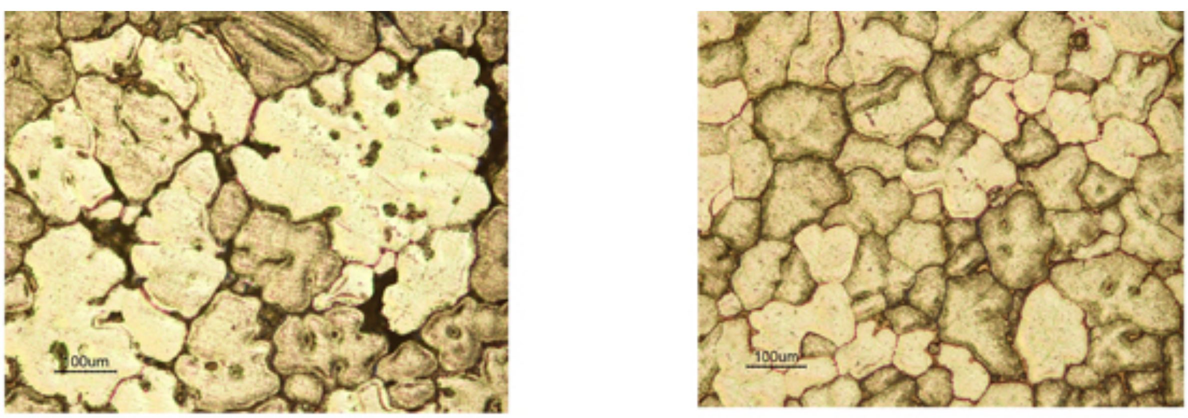


Figure 1. Schematic illustration of the assembled apparatus for applying mechanical vibrations to a permanent steel mold.

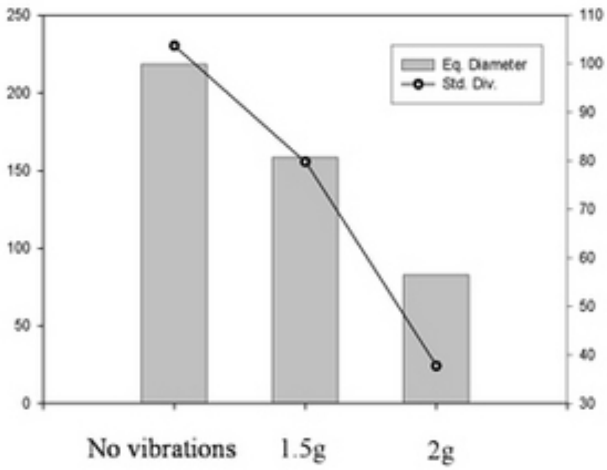
Figure 2 shows the grain structure of B206 alloy solidified with (i) no vibrations, and (ii) vibrations at 2g. Figure 2 shows significant reduction in grain size with vibrations, grains become more compact and more uniform throughout the casting.



(i) (ii)

Figure 2 Grains structure of B296 casting (i) un-vibrated and (ii) vibrated at 2g.

Figure 3 shows the effect of vibrations on the equivalent diameter and the compactness of the grains in B206 alloy.



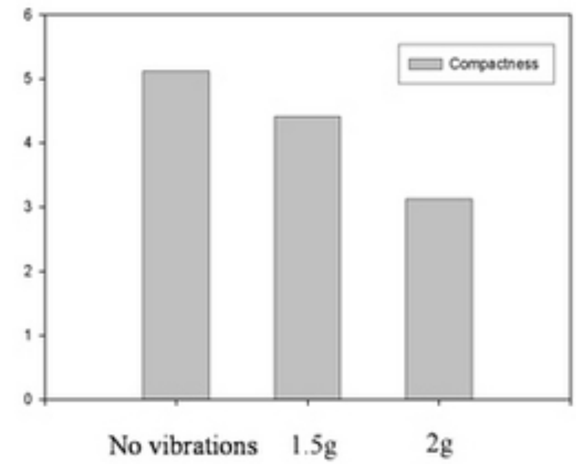


Figure 3 The effect of mechanical vibrations on (i) grain size and (ii) grain compactness of B206 alloy.

Project Deliverables

Deliverables from this project were:

1. A quantitative measure of the effect of mechanical vibrations on the casting characteristics of Al-based alloys during solidification in permanent molds; including feedabilty, hot tearing tendency, formation of shrinkage porosity and dendrite coherency point.
2. A quantitative measure of the effect of mechanical vibrations on the microstructure of Al-based alloys including the morphology of eutectic and primary silicon particles, the as cast grain size, and the size and distribution of pores.