Research Programs

The Effect of Key Elements on the Feeding Characteristics of Aluminum-Silicon Casting Alloys

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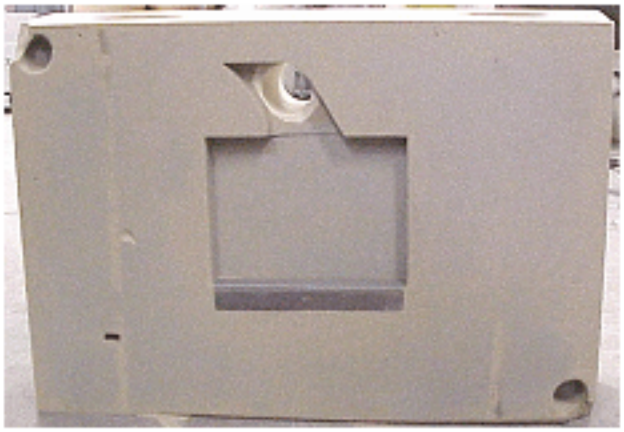
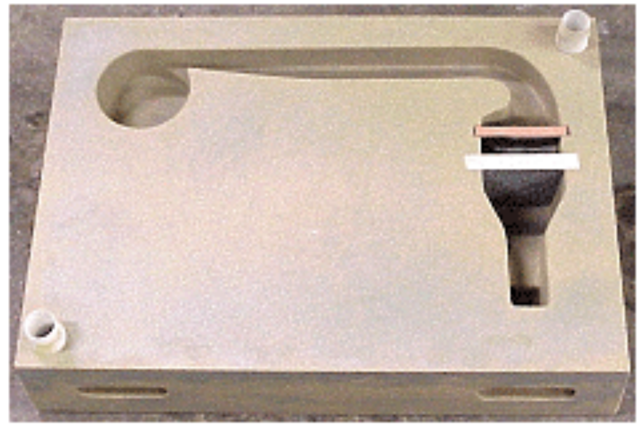
The most common and serious defect in aluminum castings is porosity, which is a result of two phenomena, insufficient feeding and/or hydrogen precipitation during solidification. This defect causes costly scrap loss and limits the use of castings in critical, high-strength applications. In this research, the effect of alloying elements Si, Fe, Mg, Mn, Cu, Sr, and Ti, as well as cooling rate on the amount of porosity retained in aluminum castings was quantified. The density of samples taken from locations along the length of a plate cast in sand is measured using Archimedes' principle following ASTM procedures. Hot isostatically pressed samples were used to determine the theoretical density of each of the alloys. The percent porosity was calculated from the difference between the theoretical and measured densities. The relative contribution of each of the alloying elements to porosity formation was calculated using analysis of variance. Scanning electron microscopy was performed on the samples in order to correlate the results obtained from the analysis of variance to the intermetallics formed. The research showed that the morphology of the intermetallics greatly affects the feeding ability of the alloy. Iron and silicon alone do not significantly contribute to porosity; however, they form intermetallics whose morphology affects feeding. Fe and Si form Al5FeSi, which is needle like. In the absence of Mn, the length of the Al5FeSi needle like phase increases with increasing the Fe content of the alloy and with decreasing cooling rate. On the other hand, in the presence of Mn, the effect is reversed. Al5FeSi heavily blocks the interdendritic path and hinders liquid flow. Fe and Si, along with Mn, form Al15(MnFe)3Si2 which resembles the Chinese script in appearance. This morphology impedes feeding and leads to microshrinkage porosity. Through the length of the casting, low levels of iron and high levels of silicon give better feeding characteristics and high levels of manganese promote feeding. Fe and Si together with Mg and Cu form an Al5Mg8Cu2Si6 compound, which along with Al2Cu forms clusters. Al2Cu also forms on the Al5FeSi needle like phase. Together the three compounds form a net like structure that hinders liquid metal flow. The compound Al8Mg3FeSi6 is formed by the transformation of the Al5FeSi needle like phase. TiB2 added in order to refine the grains, evenly distributes porosity in the casting and thus has an overall positive effect on porosity. The effect is more pronounced at the middle of the casting due to the effectiveness of TiB2 in re?ning the grains. In sand castings, which freeze slowly, the presence of strontium increases porosity. The presence of high amounts of copper, around 3.5%, forms Al2Cu, which, along with the Al5FeSi needle like phase, blocks the feeding path. Finally, cooling rate plays the most significant role in feeding issues.

PUBLICATIONS:

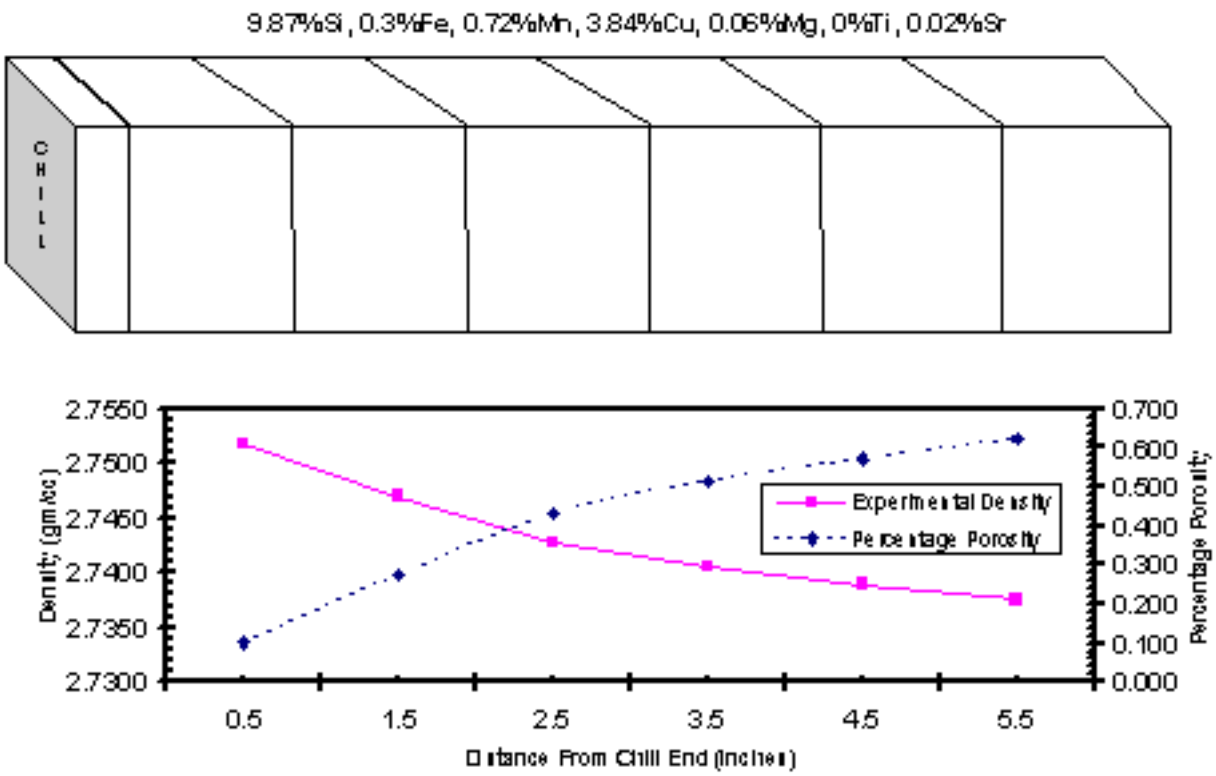
M. Dash and M. Makhlouf, "Effect of Key Alloying Elements on the Feeding Characteristics of Aluminum-Silicon Casting Alloys," J. Light Metals, vol. 2, No. 1, pp. 251-265, May 2002.



The cope showing the plate cavity and the iron chill



The drag showing the flow path, screen, and filter



Average density and percent porosity *vs.* distances from chill end.