Research Programs

Determination of the Effective Interfacial Heat Transfer Coefficient Between Permanent Molds and Aluminum Castings

Research Team:

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Objectives

The objective of this project was to improve the accuracy of casting simulation software through the development of a method for accurately determining the effective interfacial heat transfer coefficient between a steel permanent mold and an aluminum alloy.

The heat transfer coefficient at the metal-mold interface is a critical parameter in solidification modeling. Unfortunately, the development and accumulation of a complete database of heat transfer coefficients is extremely difficult since the magnitude of the heat transfer coefficient can take on an infinite number of values depending on a number of factors. These include the casting and mold materials, the type and thickness of mold coatings, geometry of the mold, the interfacial pressure, interfacial air gap development, and the temperature in the vicinity of the interface. Nevertheless, because of the considerable interest in computer modeling of the casting process, and the importance of the heat transfer coefficient to the accuracy of computer simulations, extensive research has been devoted to the measurement and determination of this boundary value. The measurements were performed under limiting conditions, and as such are limited in their usefulness. Thus, there exists a need for a method that allows the accurate determination of heat transfer coefficient for a variety of casting conditions.

A method has been developed to determine the interfacial heat transfer coefficient between an H-13 steel permanent mold and metallic castings. The mold has been designed to allow the interfacial contact pressure to be varied from one experiment to the next. Also, a procedure and apparatus has been developed to apply uniform reproducible coating to the mold surface. As a result, the method can be used to investigate the major variables affecting the heat transfer coefficient in permanent mold castings. These include the contact pressure, the coating type and thickness, the casting material, the mold preheat temperature, and the casting pouring temperature. The method uses thermocouple measurements from within the casting and the mold to generate cooling curves. These cooling curves are then used to determine the effective heat transfer coefficient at the casting/mold interface as a function of the casting temperature at the interface using an inverse modeling software.

The method was used to investigate the effect of the interfacial contact pressure on the heat transfer coefficient for A-356 alloy and a graphite mold coating. Three contact pressures were investigated: 1.6, 2.6 and 5.6 psig. The results showed that the average value of the heat transfer coefficient was higher at the higher contact pressure. Furthermore, all three curves experienced an increasing heat transfer coefficient during solidification due to the large mushy zone of the alloy investigated. Figure 1 shows the temperature profile in casting pressurized with 5.6psig at various times (160, 180, 200, 220, 240, and 260seconds) during solidification.

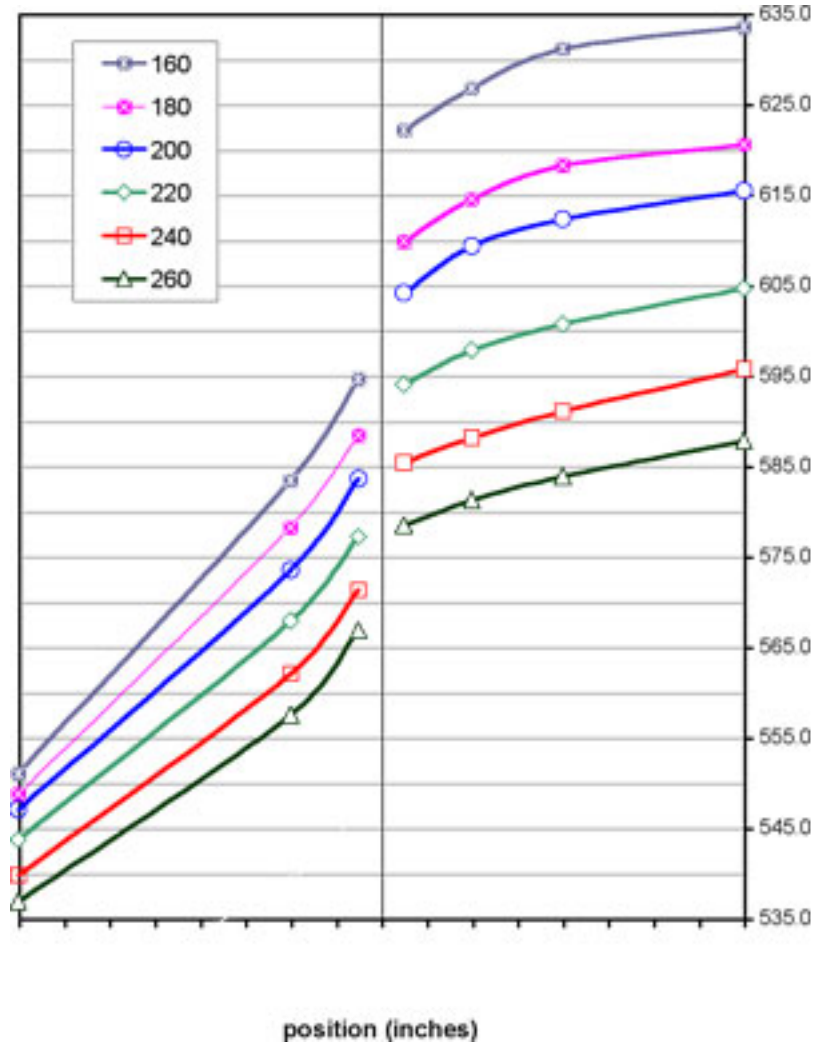

Figure 1 Measured temperature profile in the vicinity of the casting/chill interface. The chill is on the left and the casting is on the right.

Publications

1. C. Walsh, M. Carroll, and M. Makhlouf, "Determination of the Effective Interfacial Heat Transfer Coefficient between Metal Molds and Aluminum Alloy Castings," *AFS Transactions*, vol. 146, pp. 307-314, 1999.