Heat Mass Transfer (2011) 47:1465–1478
DOI 10.1007/s00231-011-0808-6

ORIGINAL

Numerical simulation of the interface molten metal air in the shot sleeve chambre and mold cavity of a die casting machine

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Received: 21 February 2010 / Accepted: 20 April 2011 / Published online: 8 May 2011
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Abstract The objective of this study relates to the numerical simulation of the free surface during the two-dimensional flow and solidification of aluminum in the horizontal cylinder and mold cavity of the high pressure die casting HPDC machine with cold chamber. The flow is governed by the Navier–Stokes equations (the mass and the momentum conservations) and solved in the two phase's liquid aluminum and air. The tracking of the free surface is ensured by the VOF method. The equivalent specific heat method is used to solve the phase change heat transfer problem in the solidification process. Considering the displacement of the plunger, the geometry of the problem is variable and the numerical resolution uses a dynamic grid. The study examines the influence of the plunger speed on the evolution of the interface aluminum liquid–air profile, the mass of air imprisoned and the stream function contours versus time. Filling of a mold is an essential part of HPDC process and affects significantly the heat transfer and solidification of the melt. For this reason, accurate prediction of the temperature field in the system can be achieved only by including simulation of filling in the analysis.

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1 Introduction

At the end of the 19th century, the HPDC machines were developed per H.H. Doehler, one of the first founders of these machines. Many years were sacrificed so that this technology is implemented and the process is marketed. At the beginning, only the zinc alloys were employed in the die process. The request for other metals led the development of new processes and new materials. In 1915, die casting of aluminum alloys was born with great quantities of production.

The process of die casting with cold chamber comprises mainly a shot sleeve cylinder allowing the injection of the molten metal to the mould using a plunger. At the initial stage, the horizontal shot sleeve cylinder is partially filled with the molten metal whose the filling rate depends on the piece casted and the diameter of the shot sleeve cylinder. This technique makes it possible to obtain the very high quality pieces with a very good surface quality, but unfortunately, the air which is in the shot sleeve cylinder can be imprisoned in metal during the injection phase. Thus, the principal defects of this technique are the porosity and the occlusion of air. The improvement of this process requires the complete elimination of the pores in the final piece.

Previous work [1] has shown that there is a critical plunger speed which can cause a wave allowing to fill the shot sleeve cylinder with a minimum of air occlusions. If the plunger reaches a speed more important than this critical speed, the wave front can be rolled up and cause the air occlusions. If the plunger does not reach this critical value, the wave can be reflected against the bottom of the cylinder and imprison the air in the molten metal. The influence of the plunger speed, the acceleration and filling ratio on the process of injection was studied theoretically by several authors [2–6].