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NUMERICAL ANALYSIS OF SOLID PARTICLES FLOW IN LIQUID METAL

Michał Szucki[1] Tomasz Goraj[2] Janusz Lelito[3] Józef S. Suchy[4]
[1-4]AGH University of Science and Technology. Faculty of Foundry Engineering.
23 Reymonta Street, 30-059 Krakow, Poland
[1]mszucki@agh.edu.pl (corresponding author)

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1. Introduction

The mould filling is one of the most important factors which determine quality of the cast. During this process liquid alloy often carries some solid particles of various type, shape or size, such as: non-metallic inclusions, particles of the reinforcing phase (in composites) and granules of moulding materials. Those particles can influence casting properties in both a positive and negative way. Reinforcing particles in Metal Matrix Composite (MMC) strengthen alloy structure, therefore its homogeneous distribution in the cast is required [1-2]. On the other hand small solid object like sand grains are treat as unwanted contaminants. In this case, such particles should be prevent from getting into the mould cavity. Thus, its highly important to understand behavior of solid particles in liquid metals.

2. Numerical analysis

During the real casting process tracking of solid particles in liquid alloy is very complicated due to high temperature and non-transparent mould materials. Usually it's only possible to verify final distribution of particles in a solid cast. For this reason, in this study computer simulations were used [3-4]. The figure 1 shows a model system consisting of runner and three casts in form of plates.

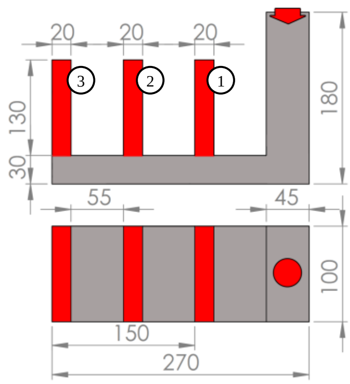

Fig. 1. Schematic introduction of model system; gray color - runner, red color - casts, arrow - inlet area

Table. 1. Particles types

diameter / density	$10\,[\mu m]$	$100\,[\mu m]$
$1350\,[kg/m^3]$	Type A10	Type A100
$2700\,[kg/m^3]$	Type B10	Type B100
$5400\,[kg/m^3]$	Type C10	Type C100

Simulations were performed for pure aluminium and six types of particles differing in size and density (Table 1). Authors used well known commercial simulation environment FLOW-3D to ensure proper fluid-particle interactions [5].

1, 2 – MSc, PhD Student; 3 - PhD D.Sc, 4 – Professor

3. Results and discussion

The figure 2 shows an example comparison of the particles type A100 distribution after 5.4 [s] from the start of the simulation (right after the filling was completed) and after 150 [s] (when plates are completely solidified).

a) b)

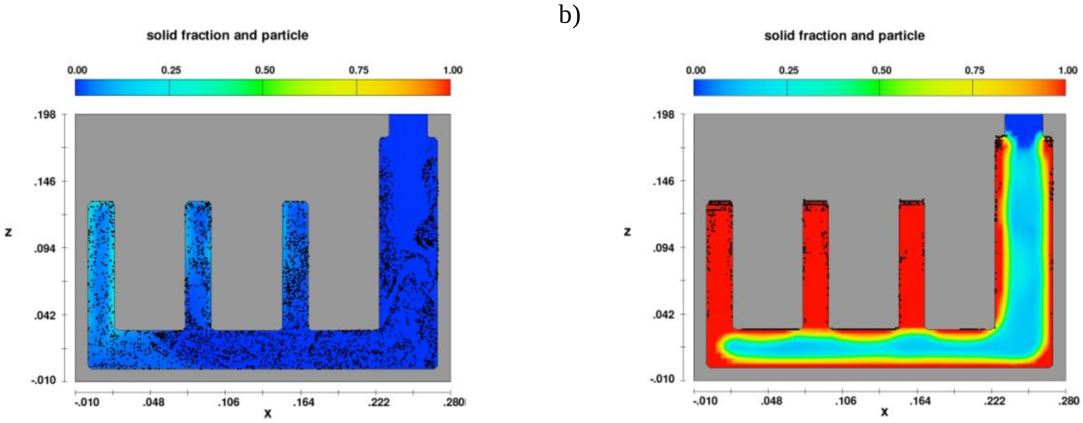

Fig. 2. Two dimensional distribution of particles type A10 (black points) on the plane passing through the center of model system after: a) 5.4 [s] and b) 150 [s]

It is clearly visible that particles which smaller density than liquid metal are floating to the top of the system from early beginning of mould filling. This motion continues when the mould is completely filled and the process of cooling and solidification starts. At the same time the final distribution of particles in the system strongly depends on the alloy temperature and the cooling rate. After filling, temperature in the part of cast located farther from inlet is lower, which means that crystallization process begins earlier in such area. Thus, particles have less time to flow up, which explains more uniform distribution in plates 2 and 3 than in plate 1 (where temperature is higher and the cooling rate lower due to runner neighborhood).

4. Conclusions

Final distribution of particles in the cast will be affected by both the filling process and particle movement during cooling and solidification. The most important factor influencing the behavior of the solid particles in the mould cavity is their density in relation to the density of the liquid alloy. Additionally, in the case of significant density differences between those two phases, final particles location will depend on the cooling rate and temperature distribution in the system after filling.

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