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# EXPERIMENTAL ANALYSIS OF HETEROPHASE FLOWS (LIQUID METAL - SOLID PARTICLES)

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## 1. Introduction

The process of mould filling with liquid alloy is one of the most important factors which determine whether a high-quality cast can be obtained. Computer simulation tools enable detailed analysis of this problem, both within the scope of scientific research and in an industrial setting [1]. In most commercial versions of simulation environment, the motion of liquid metal is treat as a single-phase or two-phase flow (liquid metal – gas) from the computational fluid dynamics' point of view. However, in most cases the liquid in motion 'carries' particles of various type, shape or size, such as: non-metallic inclusions, particles of the reinforcing phase (in composites), parts of moulding materials [2, 3]. All of these are elements of different phases and may affect the flow character and kinetics, as well as properties of the end product (its microstructure and mechanical properties). This topic is of particular interest to these scientific institutions and manufacturers dealing with production of cast composites, for which a precise distribution of reinforcement particles in the cast poses a technological challenge [4]. On the basis of the above-presented arguments, it may be state that further investigation in this issue has its scientific and economical reasoning.

Analysis of solid particles movement in liquid metals may pose many problems. Observations are complicated by a high temperature and non-transparent mould materials. Carried out within the scope of this paper, a detailed analysis of liquid - solid particles flows in the experimental systems may give appropriate basis to both creation of new (or validation of the existing) numerical models for the foundry industry and designing high technology solutions.

## 2. Experimental

In the paper, a number of experiments with the use of the PIV method and the particle path detection method were carried out. These experiments were cover dynamics of particles moving in selected model liquids. The authors used high speed digital camera system which enable recording of very rapid processes (up to 50000 frames per second), as well as recording of these processes which occur at longer intervals (e.g. sedimentation).

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The aim of the studies was to:

- determine particle distribution in liquids in consecutive stages of the flow,
- analyse the sedimentation process and the question of the agglomerate formation by particles present in liquid,
- determine local velocity vectors for individual particles (the PIV method),
- determine the motion paths for individual particles.

For determination of local motion paths for individual particles, an original method was applied, consisting in taking pictures of liquid in motion with longer exposure time, which results in particles leaving characteristic traces (smudges) visible in individual shots.

### *2.1. Experimental system*

Experimental system used in the current studies consisted of the gating system (sprue, runner) and three castings in the form of plates. For results analysis these plates were labelled with number from 1 to 3 according to the distance from the sprue (Fig. 1a). To ensure the proper transparency the mould was made of glued and sealed Plexiglas plates (Fig. 1b).

a) b)

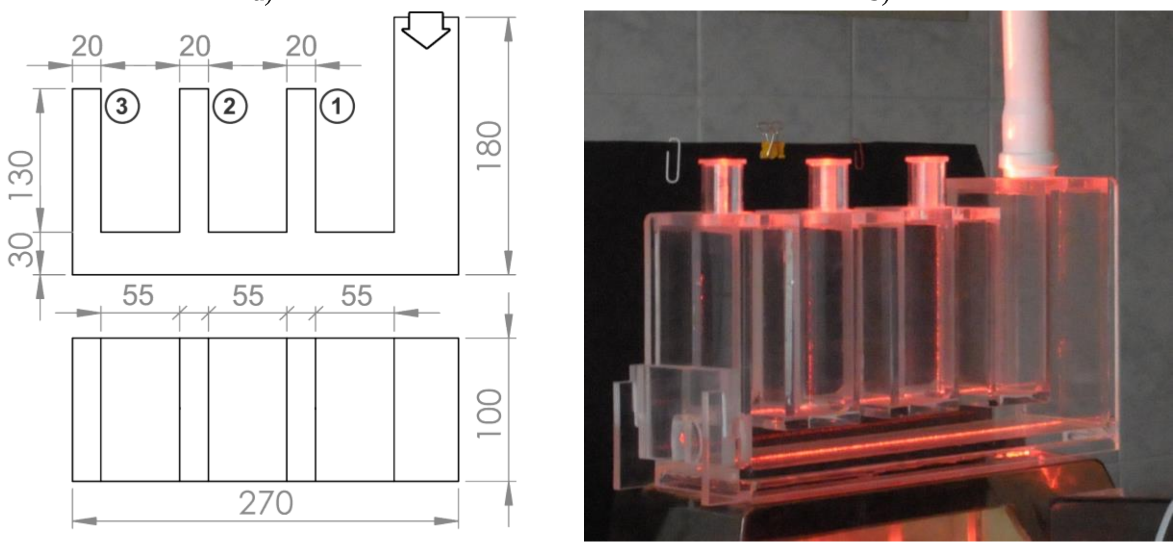


**Fig. 1**. Schematic presentation (a) and the real photo (b) of the experimental setup

### *2.2. Model liquids and particles*

Selected parameters of model liquids and particles used in experiments are presented in Table 1.

Table 1. Selected parameters of model liquids and particles used in experiments

| | **Model liquids** | | **Particles** | |
|---|---|---|---|---|
| | Water | Water + 50 vol.% glycerol | ABS (Acrylonitrile butadiene styrene) | Bee Pollen (for PIV analysis) |
| **Density, kg/m$^3$** | 1000 | 1145 | 1010 | - |
| **Dynamic viscosity, Pa*s** | 0.001 | 0.0084 | - | - |

## 3. Results and discussion

An example PIV results obtained during the experiments are shown in Fig. 2.

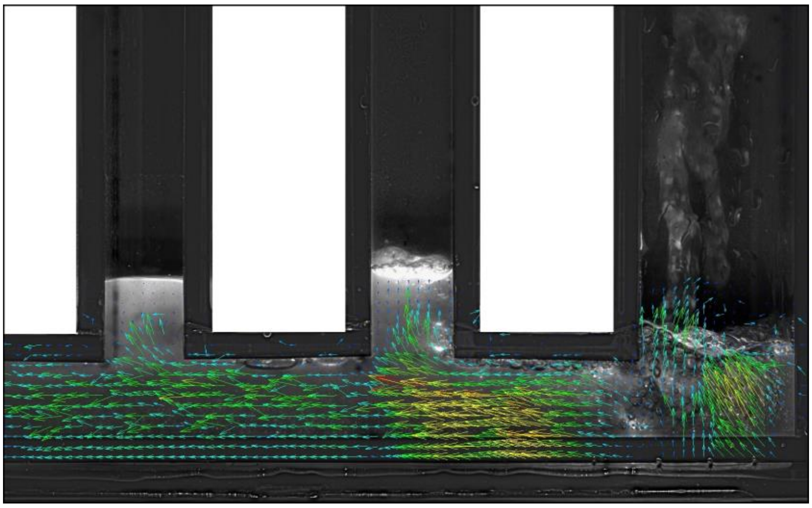

**Fig. 2**. PIV analysis in the part of model system

It is clear that the main liquid stream flows into the plate #1. Thus the highest particles concentration will be obtained in this plate.

## 4. Conclusions

Basing on the performed examinations the following conclusions can be drawn:

1. Only close values of metal matrix and particle density guarantees a uniform distribution of reinforcing component in the system.
2. In addition to the density difference, the most important factor influencing the particles distribution is a casting geometry.
3. Through a combination of PIV method and a technique that allows to track the motion paths for individual particles it is possible to analyse the behaviour of heterophase flows.


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