Success Story
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K1-MET
Competence Center for Excellent Technologies in Advanced Metallurgical and Environmental Process Development
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Flowstructure investigation on a tundish with a line sparger

In the continuous casting process of steel, one of the last chances to remove non-metallic particles from the melt is the tundish. To improve its efficiency, argon bubbles can be used. These bubbles remove small particles from the melt, but they alter the global velocity field in the tundish as well. The measurement results were used to estimate the error of different simulation approaches for the tundish flow. The influence on the global flow field was measured in a 1:3 water model during an outgoing research stay at Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen.

Motivation

The demands on steel quality are constantly increasing. One major parameter on the quality is the share of non-metallic particles in the final product. One of the last possible stages in steel production to remove these particles from the melt is the tundish of the continuous casting plant. Many strategies exist to improve the particle removal in the tundish, e.g. optimizing its shape or inserting flow barriers.

A part of the current Project 4.4 is focused on an improved particle removal efficiency of the tundish. One option is to introduce argon bubbles into the tundish. Non-metallic particles stick to the bubbles and rise with them to the surface of the tundish where they are caught in the slag layer.

The rising bubbles in the tundish affect its global flow field. Preliminay CFD-simulations (Computational Fluid Dynamics) showed a strong influence. The example in Figure 1 shows the calculated velocity magnitude in the center plane of the tundish. On the left, the liquid steel from the ladle forms a jet, which is supposed to hit the center of the structure at the bottom: a turbulence inhibitor. In the middle of the, tundish bubbles are introduced. The flow induced by the rising bubbles is strong enough to significantly deflect the liquid jet and reduce the positive effect of the turbulence inhibitor.

The CFD-simulation of a tundish with rising bubbles involves the combination of several complex models. Accordingly, it is necessary to validate the simulation results with experimental data.

The experiments were performed on a 1:3 scale water model of a continuous casting tundish with a line sparger in the center. They were executed during an outgoing research stay at the RWTH Aachen.

Experiments

For the experiments, an existing tundish model at the IOB (Institut für Industrieofenbau) was used. A line sparger was inserted in the middle

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of the tundish to introduce air bubbles. The velocity field in a plane perpendicular to the sparger was measured using PIV (Particle Image Velocimetry).

The experiments covered a wide range of water and air flow rates. From the time averaged velocity fields, the deflection of the water jet was calculated. This deflection was used to evaluate the errors of different simulation models.

In addition, the main driving forces in the tundish were isolated to define a dimensionless influence parameter, which is proportional to the air flow rate and the square of the water volume flow rate. Using this parameter as an x-axis, the experimental results converged to a single line (Figure 2).

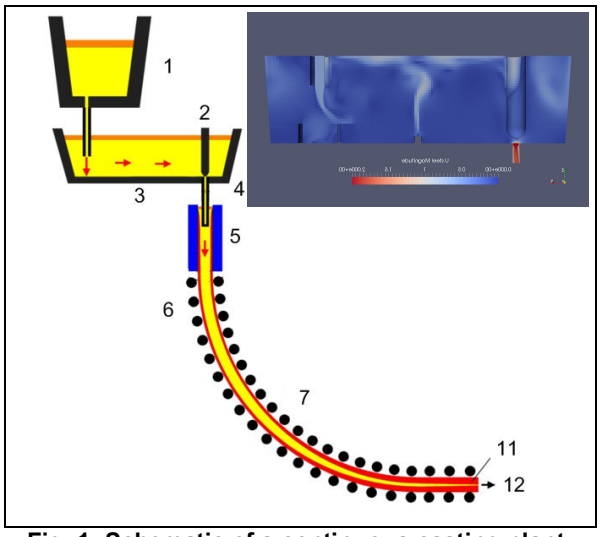

Fig. 1: Schematic of a continuous casting plant: (1) ladle, (3) tundish, (5) mould, (12) solidified strand (source Wikipedia); simulated velocity field in a tundish with a line sparger at the top right corner (source K1-MET).

Impact and effects

The experiments were part of an outgoing research stay. This three months visit has significantly improved the scientific exchange to the RWTH Aachen.

The experimental results proved that bubbles in the tundish can significantly alter its global flow field. The influence can be large enough to be important for the design of the tundish geometry.

The main influence parameters on the jet deflection were determined. This knowledge helps to scale the experimental results to the industrial process.

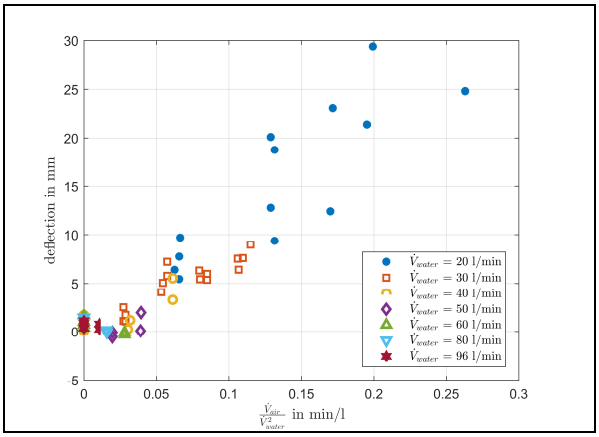

Fig. 2: Measured jet deflection in a tundish model with a line sparger (source K1-MET).

Subsequently to the experiments, different simulation models for the turbulence and the free fluid surface were tested. The experimental data was used to determine the errors of the different approaches, and the model setups were made available to the project partners.

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