

# A Semi-implicit (Non-)hydrostatic Free-surface Numerical Model of Horizontal Centrifugal Casting

Jan Bohacek, Abdellah Kharicha, Andreas Ludwig

Department of Metallurgy, Montanuniversitaet Leoben, Franz-Joseph Strasse 18, 8700 Leoben, Austria

jan.bohacek@unileoben.ac.at, abdellah.kharicha@unileoben.ac.at,  
andreas.ludwig@unileoben.ac.at

Menghuai Wu

Christian Doppler Lab for Advanced Simulation of Solidification and Melting, Dept. of Metallurgy, Montanuniversitaet Leoben, Franz-Joseph Strasse 18, 8700 Leoben, Austria

menghuai.wu@unileoben.ac.at

## Abstract

The horizontal centrifugal casting is a metallurgical process, in which a liquid metal is poured inside a horizontally rotating cylindrical mold. The centrifugal force pushes the liquid metal towards the mold wall resulting in a formation of a sleeve with a uniform thickness. The mold gradually extracts the sensible and the latent heat from the sleeve, which eventually becomes solid. Often a second layer of another material is introduced during the solidification of the first layer. A fluid flow was described by the Navier-Stokes (N-S) equations and the continuity equation in the cylindrical coordinates. The pressure term in the N-S was decomposed into the hydrostatic and the non-hydrostatic pressure. At the free-surface a kinematic boundary condition was applied. A structured staggered grid was used for the space discretization. The convective term was discretized using the Lagrangian trajectory reconstruction. Firstly, only the hydrostatic flow was solved by omitting the non-hydrostatic pressure term. Afterwards, the Poisson's equation was solved for the non-hydrostatic pressure. Finally, velocity fields and the free-surface position were corrected. In addition to the fluid flow, the heat advection-diffusion equation together with the solidification represented by a stiff source term was solved. Due to the density differences the natural convection may take place, which can be included by incorporating the baroclinic pressure in the N-S equations. Numerical model has been successfully verified against measurements from the plant.

## References

1. V. CASULLI AND P. ZANOLLI. Semi-Implicit Numerical Modeling of Nonhydrostatic Free-Surface Flows for Enviromental Problems. *Math. Comput. Model.* 36 (2002) 1131-1149.
2. N. SONG AND Y. LUAN AND Y. BAI AND Z. A. XU AND X. KANG AND D. LI. Numerical Simulation of Solidification of Work Roll in Centrifugal Casting Process. *J. Mater. Sci. Technol.* 28 (2012) 147-154.