COUPLED HEAT TRANSFER AND GAS FLOW SIMULATION IN CZOCHRALSKI CRYSTAL GROWTH

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Key Words: *Multiphysics Problems, Coupling, FEM, FVM, Elmer, FEniCS, OpenFOAM.*

The Czochralski (CZ) process is one of the most common techniques used to grow single crystals, that are the basis of many technologies such as computer chips, solar cells or power electronics. It involves a variety of physical phenomena from heat transfer to thermal stresses. Various simulation models investigating CZ growth have been published [1], however, their applicability remains limited: The validation is mostly insufficient due to missing in-situ measurements, and the models are either implemented in closed-source software or not published at all. In the ERC-funded NEMOCRYS project, therefore, a new generation of open source crystal growth models is being developed and validated using model experiments.

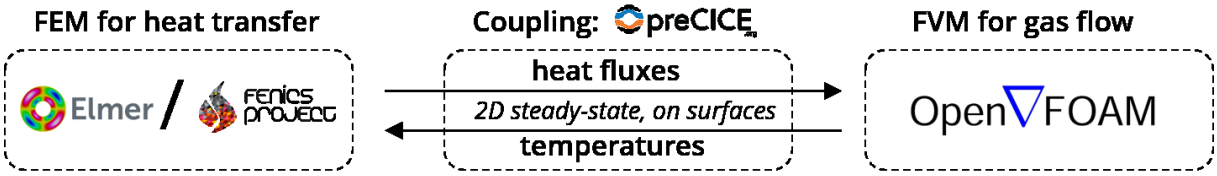

Figure 1: visualization of the coupling between heat transfer and gas flow simulation

We have selected finite element method (FEM) for modelling of heat transfer and induction heating in CZ growth, and two separate models have been implemented in the software Elmer [2] and FEniCS [3]. For gas flow modelling we use the finite volume method (FVM) in OpenFOAM software [4]. In this contribution, a 2D surface coupling of the heat transfer and gas flow simulation using the preCICE library [5] is presented. The coupling is performed in steady-state on a 2D axisymmetric domain using a Dirichlet-Neumann approach, see figure 1. Results obtained with both Elmer-OpenFOAM and FEniCS-OpenFOAM coupling are compared and validated with the model experiments for different growth conditions. Further extensions of the numerical simulation are discussed with focus on melt flow simulation.

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