A decoupling strategy for a system of Stefan problem and Navier-Stokes equations with a free capillary surface

Jordi Paul[1] E. Baensch[2] A. Schmidt[3]

We consider an FEM approximation of a coupled system consisting of a Stefan problem and the Navier-Stokes equations with free capillary boundary. To use existing solvers and data structures, the Navier-Stokes equations have to be decoupled from the Stefan problem, with special attention paid to the phase boundary.

Inspired by coordinate transformation techniques we develop a decoupling that works well with the existing formulation for the free surface problem, which decouples the geometry and the flow field. Since the solver uses a finite element formulation on an unstructured tetrahedral mesh, the grid is transformed according to the movement of the phase boundary. This keeps elements from changing the phase but makes occasional remeshing necessary.

This problem arises from the mathematical modelling of a melting process, in which a thin wire is heated by a laser, and is currently under research in the SFB 747.

[1] Universität Erlangen-Nürnberg, Department Mathematik, Haberstr. 2, 91058 Erlangen, paul@am.uni-erlangen.de
[2] Universität Erlangen-Nürnberg, baensch@am.uni-erlangen.de
[3] Universität Bremen, schmidt@math.uni-bremen.de