Coupling boundary element and finite element analysis for the efficient simulation of thermomechanical interactions between fluids and solids and its application to shaping processes

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Abstract

A new method to model shaping processes like metal casting and polymer molding is presented in this work. A detailed description of these manufacturing processes requires the consideration of several thermal and mechanical phenomena: Fluid mechanics and heat transfer with resulting solidification of the melt, fluid-structure interaction (FSI) between the melt and its surface and the thermomechanical contact between liquid melt and solid mold.

The boundary element method (BEM) and the finite element method are coupled to model these phenomena efficiently. The motion of a creeping melt is described by the transient Stokes equations, which are solved with BEM. The interaction between the melt, its surface and the mold is modeled with an efficient finite element formulation for liquid membranes [1]. Since volume discretization is avoided for BEM and the membrane, the computational as well as the meshing effort of the entire method is highly reduced.

The membrane formulation is validated for liquid-solid contact [2] and for FSI problems. It is further investigated in a detailed parameter study for mechanical contact between liquid droplets and rough solid surfaces [3]. The BEM is also suitable to model heat conduction and (linear) elastic deformations. Thus, solidification of the melt can be efficiently considered by interpolation of linear fluid and solid mechanics.

Keywords: boundary element method, contact mechanics, creeping flow, finite elements analysis, fluid-structure interaction, liquid membranes, mold filling simulation, Stokes flow

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