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A Partitioned Two-Step Resolution Algorithm for Solid-Mush-Liquid Interaction Modelling in Solidification Processes

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The paper presents a partitioned resolution algorithm for concurrent simulation of fluid flow and solid mechanics with application to solidification processes. The general objective is to concurrently model liquid flow in the non-solidified regions and solid deformation in solidified regions. The scheme is developed to include partially solidified regions (i.e. mushy zone) as this is the locus for segregation and stress related defects such as hot tears. This should be achieved while simulating *i*- filling of cast parts or ingots, *ii*- cooling of products, with special emphasis on *iii*- continuous casting of billets or slabs.

The solution algorithm for momentum conservation consists in a two-step resolution performed at each time increment. In the first step, a solid-oriented resolution deriving from an existing thermomechanical solidification model [1,2] is performed, in order to calculate stress and deformation fields in the regions containing solid. In the second step, a liquid-oriented resolution is derived, which addresses fluid flow in the bulk liquid, and in the mushy zone. Volume averaging and Darcy's law is used to model the interaction between solid and liquid phases in the mushy zone.

Both resolutions are formulated with 3D finite elements on the same domain which includes the metal (*whatever its state: liquid, mushy, or solid*), and a surrounding gas domain. The level-set method is used to track the motion of metal/air interface induced by hydrodynamics, solidification shrinkage, thermal dilatation and deformation phenomena. The algorithm is coupled with an existing non-linear energy solver to calculate the temperature field [3]. Validation is demonstrated by comparison with analytical solutions in the context of directional solidification. The paper will present and discuss its application to case studies approaching the complexity of industrial solidification processes.

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