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MULTISCALE AND MULTIPHASE APPROACH FOR SOLIDIFICATION PROCESSES

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Hot-working processes have gained significant importance in steel industries. Numerical simulation of such processes needs to consider macroscopic thermal and mechanical loading as well as the physics of microscopic solidification of the melt. We capture both phenomena utilizing a multiscale approach containing two scales. The macro-scale is described with help of theory of porous media (TPM) [1]. Here, the solid and liquid phases represent the physical states of the steel. This theory simplifies the description of phases where local distribution is not considered. Instead, a smearing over a certain domain is applied. Furthermore, a strong thermal coupling including the following simplification was applied. Each material point has one temperature for all phases and an interphase energy exchange is neglected [2]. We use a elastic-plastic material law for the solid phase, where the Simo and Pister free energy function and the Von Mises plasticity for finite deformation is used for the elastic and the plastic part [3].

The microscopic model for solidification is supposed to predict columnar to equiaxed transition (CET). This model is based on a multiphasic approach containing three phases (solid, extradendritic and interdendritic liquid). The solidification itself is heat and solute diffusion controlled [4].

From the numerical point of view, we use a standard Galerkin finite element method and a fully implicit one-dimensional finite difference method for the macro-scale and the micro-scale as well. A weak interconnection of these scales was accomplished. Each macroscopic gauss point solves its own microscopic boundary value problem.

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