Meshless modelling of microstructure evolution in the continuous casting of steel

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ABSTRACT

The continuous casting is the most widely used technique in the steel production. Microstructure evolution during solidification in the continuous casting of steel has large impact on the material properties of the final product. The numerical models for simulation of the solidification phenomena represent a powerful tool for prediction of the microstructure evolution and can be therefore used for in-depth understanding and optimization of the casting process.

A two-dimensional double-scale slice model [1] has been developed to predict microstructure evolution in the solidifying strand with an arbitrary cross section geometry during continuous casting of steel. The enthalpy equation is solved at the macro level by using meshless Local Radial Basis Function Collocation Method (LRBFCM) [2] for spatial discretization and explicit Euler scheme for time discretization. The temperature and solid fraction in each computational point are calculated by using a continuum model formulation [3] while the lever rule is used as a supplementary microsegregation relation. The temperature field is interpolated to the micro level by using LRBFCM. At the micro level normal distribution and Kurz-Giovanola-Trivedi (KGT) [4] model are proposed to determine temperature dependent nucleation rate and grain growth velocity, respectively. Meshless point automata [5] algorithm is applied to implement nucleation and KGT equations.

The main originality of the presented paper is the meshless approach for solving the posed multiscale problem, usually solved by the cellullar-automaton-finite-element [6] method. The main advantage of the meshless approach is its flexibility, since there is no need for polygonization of the computational domain. Meshless point automata algorithm does not experience the mesh anisotropy, which represents a large problem in cellular automaton algorithms.

Model has been used to predict equiaxed to columnar and columnar to equiaxed transitions in the continuous casting of steel. Examples with circular, square, rectangular and H-shaped cross sections of the strand are presented.

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