A RBF-based local collocation method for modelling thermomechanical phenomena during DC casting of aluminium billets

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ABSTRACT

The thermomechanical phenomena that occur during DC casting of aluminium billets can have a significant impact on the quality of the ingot. Under specific stress conditions hot tearing and cracking of ingot can occur. A large deformation of the billet can lead to its instability and to the change in heat transfer efficiency on the boundary, which can lead to unwanted remelting and melt bleed-outs.

Modeling of thermomechanical phenomena during this process is not trivial due to involved strong thermomechanic coupling. In addition to elastic deformation the strain field also has contributions from viscoplastic creep, plastic deformation and thermal expansion. All these phenomena occur in nonhomogeneous material with strong temperature dependence of material properties.

Many models describing the DC casting process already exist [1] and can provide accurate results. Existing models mainly use the standard finite element method (FEM), which may prove inefficient in some circumstances. The local meshless method used in our work has several advantages over FEM [2]. There is no need for expensive polygonization of the domain, since the only information needed are the distances between points. The computational points can be easily added or removed to achieve better accuracy [3] and complex geometries can easily be described since irregular node arrangements can be used.

The method is structured as follows: for each discretization node the domain of influence is determined on which the unknown solution is approximated by RBF interpolation. The interpolation is constructed in such a manner that it already satisfies the boundary conditions in boundary points. The expansion coefficients of the interpolant are expressed in terms of unknown solution values, which allows us to construct a sparse system of linear equations describing the governing equation.

The model that is being developed is intended to complement the meshless model of mass and heat transfer, which is being developed in our group [4]. In this contribution formulation of the new approach is given first, followed by several standard benchmarks. The models used are described and the results for stationary state of DC casting are presented.

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