Modelling of electromagnetic breaking and electromagnetic stirring in the process of continuous casting of steel

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ABSTRACT

Continuous casting (CC) of steel is a process that nowadays produces more than 95 % [1] of crude steel. To further advance this process, electromagnetic (EM) field, which affects the fluid flow as well as the temperature and segregation is added to the CC process. In general, there are two types of electromagnetic devices applicable to the CC process; one are the electromagnetic breakers (EMBR) which implement direct current, and the other are the electromagnetic stirrers (EMS) which implement the alternating current. Which of the process is used depends on what are the desired effects. Both of the processes are modelled by implementing the Lorentz force into the momentum equation and if necessary the Joule heating term into the energy equation. However, the way how these two terms are modelled depend on the type of the implemented device. In case of EMBRs the assumption of low Re_m is made and consequently, the current density is calculated by solving the Poisson's equation for electric potential. The EMS on the other hand, requires a low-frequency approximation and the solution of induction equation The complete set of governing equations for CC process [2] under the influence of magnetic field includes mass, momentum, energy, species concentration, and Maxwell's equations together with Ohm's law and charge conservation equation. Additionally, the turbulent kinetic energy and dissipation rate equations together with Abe-Kondoh-Nagano closures are used to account for the turbulence, the lever rule model is used to model the microsegregation, the mixture continuum model is used to model the macrosegregation, fractional step method is used to model pressure-velocity coupling and the enthalpy-temperature relation is used to calculate the temperature from the enthalpy. The solution is sought for on a five-nodded local subdomain by constructing an approximation function with multiquadric radial basis functions as a basis and collocation is used to find expansion coefficients [3,4]. Present paper presents the discretization of governing equations, together with boundary condition for both EMBR and EMS devices with meshless local radial basis function collocation method [5].

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