Through-Process Modelling of Steel Production Path in Štore-Steel Company

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A part of digitalization efforts in the steel industry concerns the numerical optimization of the steel production chain for increased quality, productivity and sustainable production. We present the computational modelling of the steel processing route in Štore-Steel company, composed of continuous casting, controlled cooling, annealing, reheating, reverse and continuous hot rolling, cooling bed, and heat treatment. The modelling concept is based on the Hybrid Integrated Computational Materials Engineering (ICME) approach, composed of a combination of Horizontal ICME, where the simulation codes for different processing or product usage steps are connected with their associated multiscale structures and material properties, and Vertical ICME, where the simulation codes at multiple length scales are involved in describing the product properties. The scales we cope with range from the grain size to several tenths of meters. We present the novel solution methods for describing the related multiscale and multiphysics thermomechanical problems. The microstructure is formulated with the phase-field method, the meso-structure with the cellular automaton method and the macroscopic electromagnetic, fluid mechanics and solid mechanics fields with the continuum mechanics concept. We elaborate on a space-time adaptive meshless solution based on collocation with radial basis functions for solving the microscopic and macroscopic scales and the point automata concept for solving the mesoscopic scale. The phenomena tackled by this novel meshless technique range from the large-eddy simulation of continuous casting to the elastoplastic deformation of the products on the cooling bed. The validation of the models, based on plant and laboratory measurements, is shown. A coupling of the physical models with artificial intelligence for quality, energy and productivity optimisation is presented. The presented research was funded by the Slovenian Grant and Innovation Agency within Program Group P2-0162 Multiphase Systems, and project L2-3173 Advanced Simulation and Optimization of the Entire Process Route for Production of Topmost Steel, co-financed by the Štore-Steel company.