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Optimization of Process Parameters in Material Production by Utilizing Artificial Neural Networks

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Submitted Abstract (accepted for publication):

Material production plants are often faced with the need of quickly adjusting processing parameters in order to satisfy customers' requirements with respect to material properties or quality of semi-finished products. At the same time, design of production process is restricted with the layout of the production line, which makes some kinds of modifications of the process (e.g. significant variation of geometry) infeasible.

A software framework has been developed for calculation of optimal adjustment of process parameters with respect to requirements regarding chemical composition and mechanical properties of the produced material. It was primarily intended for use in production of carbon nanomaterials in arc discharge reactors. Further development lead to more general framework and application in continuous casting of steel, which is described in the present work.

An advanced numerical model has been developed for simulation of the process, based on meshless spatial discretization method with radial basis functions (RBF). The model is combined with an optimization system, which controls its execution within optimization loop and enables flexible definition of the criteria that should be met by the casting process. Furthermore, the optimization process can be facilitated by replacing expensive numerical model by approximation of process outputs by an artificial neural network. With the described approach, numerical simulations needed in optimization process are prepared in advance, upon which the neural network-based approximation models of response functions are built. When process parameters must be adjusted according to new requirements, search for optimal parameter values is performed on response functions produced by the approximate model based on a trained neural network. Evaluation of approximated response is fast enough that the overall optimization procedure is applicable to design of process parameters in conditions of industrial production.

Presented examples include optimization of process parameters and chemical composition in continuous casting of steel in order to eliminate the risk of material defects and process failures while achieving the targeted mechanical properties such as hardness and tensile strength. Further steps are made towards simultaneous optimization of the whole process chain in the steel plant, and some preliminary results are shown for such attempts.