Modelling, Optimisation and Control of the Electroslag Remelting Process

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The Electro-Slag-Remelting is an advanced technology for the production of components of e.g. high quality steels. An alternating current is passed from a conventionally melted and cast solid electrode through a layer of molten slag to the baseplate (Figure 1). Because of the electrical resistivity of the slag, Joule heating is generated and the slag transfers this energy to ingot and mould surfaces and to the melting electrode tip. The molten metal produced in the form of droplets passes through the slag and feeds a liquid pool from where directional solidification takes place. The slag and the ingot are contained in a water cooled copper mould. As also the baseplate is water cooled, a heat flow regime is imposed that gives controlled solidification, and this results in improved structure characteristic of ESR ingots. Proper modelling of this melting process depends on the ability of the model to predict the right electric current patterns in the system which controls the magnitude and the location where the Joule heating occurs.

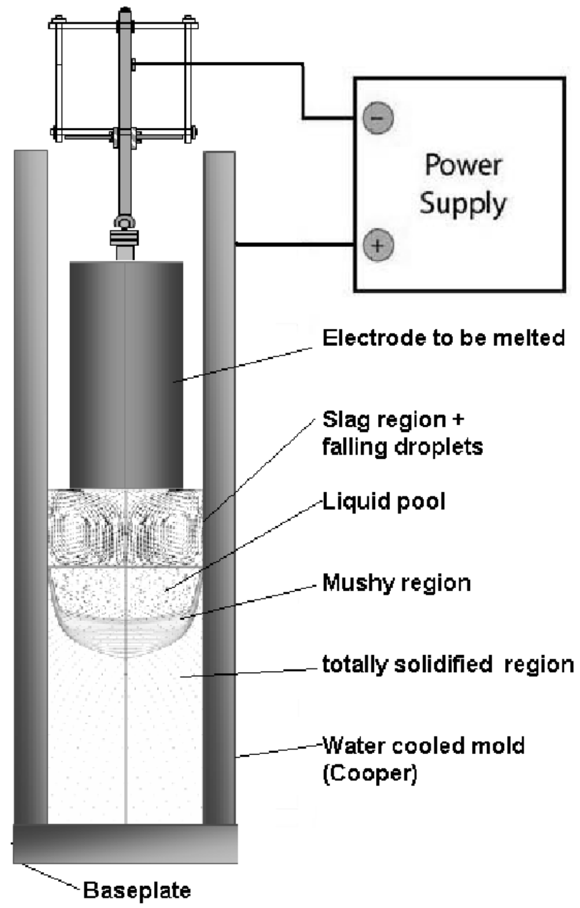

Figure 1: schematic view of the ESR system

High quality ESR casting requires that the electrode melting rate be controlled at all times during the process. This is especially difficult when process conditions are such that the temperature distribution in the electrode has not achieved, or has been driven away from, steady state. This condition is encountered during the beginning and closing stages of the ESR process.

To address these transient melting situations, a new method of ESR melt rate control has been developed that incorporates a simple 1 D model and an accurate CFD (Computational fluid dynamic) model to continually estimate the temperature distribution in the electrode. The simple 1D model is used at each control time, while the accurate CFD model is used at lower frequency to re-estimate parameters needed by the simple model. Measures of temperatures and magnetic field intensity are continuously used by the CFD model to compute the optimised process parameters.

During the highly transient periods, this approach has showed excellent performance for controlling the melt rate. The present paper shows an excellent example of how a highly non-linear process can be accurately controlled and optimized with the help of CFD simulation.