Simulators for the AOD and CAS-OB processes

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Introduction

Process simulators enable testing of new steelmaking practices with less time and costs. The objective of this work was to develop thermodynamic-kinetic simulators for the Argon-Oxygen Decarburisation (AOD) and Composition Adjustment by Sealed argon blowing – Oxygen Bubbling (CAS-OB) processes. Both simulators employ a Law of Mass Action based kinetic approach [1].

Converter Process Simulator

The Converter Process Simulator (CPS) is a modular thermodynamic-kinetic model for the AOD and similar converter processes (Fig. 1). The studied process stage and the modules required for calculation are determined based on inputs from the graphical user interface (Fig. 2). The simulator consists of three main reaction models:

1. The side-blowing model [2–3] assumes that the reactions take place in the gas plume, which is treated as a three-phase plug flow reactor.
2. In the top-blowing model [4–5] reactions take place simultaneously on the cavity and on the surface of the splashed metal droplets.
3. The reduction model [6–7] is based on the assumption that reactions take place between steel bath and slag droplets.

CAS-OB Simulator

The CAS-OB process simulator is divided into two main reaction models:

1. The heat-up model [8] considers chemical heating of steel bath by oxidation of aluminium with an oxygen jet (Fig. 3). The heat and mass transfer coefficients of the gas jet were determined with separate Computational Fluid Dynamics (CFD) simulations [9]; an illustration is shown in Fig. 4.
2. The reduction model [10] considers reactions and heat transfer between steel bath and top slag during the reduction stage. The development of the reduction model was preceded by a CFD study on the generation of slag droplets during bottom-blowing [11].

Benefits

The simulators can predict the dynamic changes in the compositions and temperatures of the metal, slag and gas phases (Figs. 5 and 6). Hence, the simulators are well-suited for decision support and process optimisation. They can be employed for optimising several process parameters including:

- composition and temperature of the material inputs,
- composition and injection rate of gas, and
- types of material additions and their feed rates.

At Outokumpu Stainless Oy, the length of the AOD treatment of certain steel grades was reduced by 10% with the help of simulations with CPS and automation system [12]. The annual savings were valued at EUR 3 million in the case of full production.

Summary

The objective of this work was to develop computational simulation tools for the AOD and CAS-OB processes. Results from validation of the models suggest that the models yield reliable predictions for the composition and temperature of the steel produced. The simulators are powerful support tools for decisionmaking and process optimisation. As illustrated by the reduced length of the AOD process at Outokumpu Stainless, the potential financial benefits of mathematical modelling can be considerable.

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References