

Simulation of multiphase flow in the steelmaking industry

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The governing processes occurring in the steelmaking industry are without exception related to complex multiphase flows. Because of the large scales, inaccessibility, and hostile chemical and thermal conditions in processing equipment, it is extremely difficult to obtain detailed information of these processes. Therefore, numerical simulation is a valuable tool in understanding, optimising and designing metallurgical processes and process equipment. With the advance of affordable computing power and efficient parallel algorithms, computational fluid dynamics methods are now being applied to a wide class of industrial flow problems that were considered too complex only less than a decade ago. This paper will highlight the approaches presently used to simulate complex metallurgical flows, illustrating their strengths and topics for future development. In particular, several stages of the process of steelmaking and casting will be discussed, including multiphase flows in the steelmaking converter, secondary metallurgy in the ladle, and continuous casting.

In a converter, hot metal is decarburised by intense mixing with oxygen. CFD models need to deal with supersonic flow, exothermal reactions, and multiphase mixing between continuous phases (hot metal, slag, oxygen jets) and dispersed phases (metal droplets, argon bubbles, oxygen bubbles, slag droplets). The impact of these phenomena on mixing in the metal bath will be highlighted.

In a steelmaking ladle, final trimming of the chemical composition of steel is achieved by alloying. Mixing is ensured by electromagnetic stirring or bubble plume stirring. The correct description of mixing in a ladle is essential for an optimal process. Results of physical modelling and CFD modelling will be shown to illustrate the state of the art. In a continuous casting mould, multiphase flow has a strong effect on quality of the cast product. Argon bubbles are used to avoid clogging of the feeding system, yet inclusion of bubbles and small particles in the solid steel should be avoided. It is the challenge of CFD models to guide the design of the feeding system and the control of argon flow in liquid steel to meet product quality requirements.