Modeling of Steel Continuous Casting

Continuous casting of steel is an important commercial process that involves many complex, coupled physical phenomena, which have been the subject of significant computational modeling efforts over the past half-century. This paper summarizes the current state of the art in modeling and simulation of these phenomena. This includes models of heat transfer and solidification of the steel shell, interfacial heat transfer between the shell and the mold, flow and pressure distribution in the metal delivery system, fluid flow in the nozzle, nozzle clogging, multiphase turbulent flow in the mold region, electromagnetic effects, argon gas effects, particle entrapment, interfacial interaction with the surface slag layers, level fluctuations and slag entrainment, initial solidification at the meniscus during mold oscillation, thermal-mechanical behavior of the solidifying steel shell, mold distortion and taper design, stress, surface-depression and crack formation, segregation, and microstructure formation. These models are challenged by the wide range of length and time scales which govern the phenomena of interest. Attention will focus on the importance of model verification (with other calculations) and validation (with experimental measurements) at every step. Finally, examples will emphasize the application of advanced, computational models to gain practical insights into this widely-used, mature process, where even small improvements can have a big commercial impact, but where technology development by experimental trial and error alone is cost prohibitive. Lessons learned from the modeling of continuous casting can be applied to the modeling and simulation of other complex manufacturing systems, including other metallurgical processes in steelmaking.