CFD Simulation and Modeling of Metallurgical Processes

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Flow of metallurgical melt is intricately related to several processes such as scrap melting, alloying, homogenization, refining, casting, welding or even the new innovative process like metal additive manufacturing. In the high temperature process, e.g. steelmaking, none of adequate measurement technique is available to investigate the melt flow behavior in the actual vessels (furnace, ladle, tundish and mold). Computational fluid dynamics (CFD) is therefore used extensively to simulate the fluid flow, heat and mass transfer and other related phenomena in the defined system. CFD provides information like temperature, velocity, turbulence kinetic energy and tracer mass fraction throughout the flow domain which can be used to analyze several hydrodynamic behaviors such as mixing time, residence time distribution (RTD) and inclusion separation in the unit operation. This information is useful for the process optimization and product quality improvement. In order to validate the results from CFD simulation of the flow in vessels, the small scale physical water model is usually performed based on the fluid dynamics similarity law. This presentation represents our examples of CFD simulation in some metallurgical processes: (1) The tracer injection simulation and RTD analysis of molten steel in the continuous casting tundish process using CFD and physical water model; (2) Mixing time prediction of molten steel stirring in the ladle using CFD; (3) A study on physical water model of ladle with particle image velocimetry (PIV) as a collaboration work between TGGS, KMUTNB and department of industrial furnaces and heat engineering (IOB), RWTH Aachen university, Germany under exchange student program sponsored by DAAD scholarship; (4) CFD simulation of laser powder bed fusion (L-PBF) metal 3D printing process using the CFD commercial software FLOW weld.