Applications of CFD Modelling in Smelting Industries – Some Recent Developments

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Recent advancement in the high performance computing facilities has enabled Computational Fluid Dynamic (CFD) modelling technique as a powerful tool for the researchers working in the metallurgical field. CFD can predict flows ranging from simple single phase flows to complex multiphase flows in high temperature combusting environment associated with metallurgical process and smelting industries. Successful and efficient development of a CFD model can predict the fluid flow behaviour, combustion behaviour, generation of turbulence and splashing and other fluid dynamic parameters inside the furnace. Present authors have developed a CFD model for zinc slag fuming process for top submerged lance smelting furnace. The model integrates complex combustion phenomena and chemical reactions with the heat, mass and momentum interfacial interaction between the phases present in the system. The model is based on 3-D Eulerian multiphase flow approach and commercial CFD package AVL FIRE 2009.2 (AVL, Graz, Austria) coupled with a number of user defined subroutines (UDF) in FORTRAN programming language were used to develop the model. The model predicted the velocity and temperature field of the molten slag bath, species mass fractions for CO, CO\textsubscript{2}, H\textsubscript{2}O, CH\textsubscript{4}, O\textsubscript{2} and N\textsubscript{2}, generated turbulence, vortex and plume shape at the lance tip. Effect of lance submergence level on zinc fuming rate were investigated with the model by using three different submergence levels ($H'/L' = 1/5$, 1/4 and 1/3). The model predicted that overall zinc fuming rate for 1/3 lance submergence level is 1.3 times higher than 1/5 lance submergence level. The model was applied to rectangular zinc fuming furnace with submerged tuyers and ran successfully. The model is a significant advancement for further research in smelting industries by using CFD tool.

Figure 1 shows the schematic diagram of the modelled TSL furnace. Figure 2 shows the volume fraction distribution for molten slag phase of the transient simulation. Figure 2(a) shows the cross sectional view of the volume fraction on the vertical X-Z plane. The generated plume shape at the lance tip due to gas injection and combustion is clear from this figure. Figure 5(b) shows the 3D view of the generated splashing inside the furnace.
Figure 1: Schematic diagram of the modelled TSL furnace

Figure 2: Volume fraction distribution for molten slag phase only (a) Cross section view along X-Z plane, (b) 3D view of generated splash above the bath