CFD-DEM Modelling of Blast Furnace Tapping

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ABSTRACT

The campaign length of a blast furnace is limited by the hearth inner lining lifetime. In order to maximize the campaign length and ensure a good draining of hot metal and slag, a good understanding of the flow in the hearth is essential. Challenges in modelling the flow involve several continuous phases (hot metal, slag and hot blast) as well as the presence of the deadman, a dense bed of coke particles. The shape and position of the deadman depend on the weight of the burden column above and the buoyancy forces from the liquid metal and slag in the hearth.

We present a numerical coupled CFD (Computational Fluid Dynamics) – DEM (Discrete Element Method) model to account for the transient behavior of the deadman. A VOF (Volume of Fluid) method is used to model the multiple continuous phases and the DEM method to model the discrete particles. The VOF and DEM models are coupled together in a 2-way manner, resulting in a complete 4-way coupled CFD-DEM model. Experimental validation was performed on a small-scale particle filled tank. The tank was drained of the fluids through sitting and floating particle beds.

Issues due to artificial local pressure fluctuations, arising from incorrect void fraction calculation as reported by Peng et al. [1] were encountered. It was observed that, while for heavy particles these fluctuations have no significant effect on the simulation, they are critical for light particles in terms of stability. We propose a novel smoothing approach in order to significantly stabilize simulations involving low-density particles. In difference to existing spatial smoothing approaches as done by e.g. Pirker et al. [2] and Radl et al. [3], our method is based on a temporal approach.

Finally we present our latest advancements of our efforts towards application in blast furnaces. Due to geometrical restrictions to the hearth, as well as the multi-scale problem of small coke particles and a big blast furnace, additional treatment regarding boundary conditions and coarse graining is necessary.

REFERENCES

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