World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:18, No:02, 2024

Modelling Fluidization by Data-Based Recurrence Computational Fluid Dynamics

Authors : Varun Dongre, Stefan Pirker, Stefan Heinrich

Abstract : Over the last decades, the numerical modelling of fluidized bed processes has become feasible even for industrial processes. Commonly, continuous two-fluid models are applied to describe large-scale fluidization. In order to allow for coarse grids novel two-fluid models account for unresolved sub-grid heterogeneities. However, computational efforts remain high – in the order of several hours of compute-time for a few seconds of real-time – thus preventing the representation of long-term phenomena such as heating or particle conversion processes. In order to overcome this limitation, data-based recurrence computational fluid dynamics (rCFD) has been put forward in recent years. rCFD can be regarded as a data-based method that relies on the numerical predictions of a conventional short-term simulation. This data is stored in a database and then used by rCFD to efficiently time-extrapolate the flow behavior in high spatial resolution. This study will compare the numerical predictions of rCFD simulations with those of corresponding full CFD reference simulations for lab-scale and pilot-scale fluidized beds. In assessing the predictive capabilities of rCFD simulations, we focus on solid mixing and secondary gas holdup. We observed that predictions made by rCFD simulations are highly sensitive to numerical parameters such as diffusivity associated with face swaps. We achieved a computational speed-up of four orders of magnitude (10,000 time faster than classical TFM simulation) eventually allowing for real-time simulations of fluidized beds. In the next step, we apply the checkerboarding technique by introducing gas tracers subjected to convection and diffusion. We then analyze the concentration profiles by observing mixing, transport of gas tracers, insights about the convective and diffusive pattern of the gas tracers, and further towards heat and mass transfer methods. Finally, we run rCFD simulations and calibrate them with numerical and physical parameters compared with convectional Two-fluid model (full CFD) simulation. As a result, this study gives a clear indication of the applicability, predictive capabilities, and existing limitations of rCFD in the realm of fluidization modelling.

Keywords : multiphase flow, recurrence CFD, two-fluid model, industrial processes
Conference Title : ICMFIPE 2024 : International Conference on Multiphase Flow in Industrial Plant Engineering
Conference Location : Melbourne, Australia
Conference Dates : February 01-02, 2024