VII International Conference on Coupled Problems in Science and Engineering
Rhodes, Greece, June 12-14, 2017

Reduced Order Model for Fluid Flow and Transport of Passive Scalars in Fluidized Beds

Sohail R. Reddy[a], Janhavi Chitale[b], Paul G.A. Cizmas[c], George S. Dulikravich[a*], Seckin Gokaltun[b] and Dwayne McDaniel[b]

[a]Department of Mechanical and Materials Engineering, MAIDROC Laboratory, Florida International University, 10555 W. Flagler St., Miami, FL 33174, USA
E-mail: sredd001@fiu.edu; dulikrav@fiu.edu
[b]Applied Research Center, Florida International University, 10555 W. Flagler St., Miami, FL 33174, USA
E-mail: jchit002@fiu.edu; gokaltun@fiu.edu; mcdaniel@fiu.edu
[c]Department of Aerospace Engineering, Texas A&M University, College Station, TX 77843, USA
E-mail: cizmas@tamu.edu

ABSTRACT

Numerical simulations of unsteady transport phenomena in gasifiers, combustors, chemical reactors and mixers require large amounts of computational time. Alternative methods must be investigated that can lead to significant reductions of computational time in order to make multi-objective design optimization and control of such systems affordable.

A variety of Reduced Order Models (ROM) have been developed [1] capable of offering the level of accuracy comparable to that of Full Order Models (FOM) such as Navier-Stokes or Maxwell's equations, while reducing computational time by one to two orders of magnitude. This is especially attractive when studying complex phenomena governed by several highly non-linear, highly coupled, systems of partial differential equations. One such analysis is that of a two-phase, gas-solid flow where the two phases are linked though the momentum and energy transfer between the two phases. One can further complicate the problem by including chemical reactions.

This work analyzes two-phase, isothermal, gas-solid flow with transport of a scalar which is a chemically non-reacting additive in its solid, liquid or vapor phase. Any finite number of such scalars can be advected by either the gas or solid carrier phase assuming that these passive scalars obey the same velocity field as the main carrier fluid. Thus, one advection-diffusion concentration equation for each passive scalar must be added to the original two-phase FOM to create an appropriate FOM for such two-phase flows.

The model order reduction in this work utilizes Proper Orthogonal Decomposition (POD) which extracts an optimal set of spatial basis functions from the solution of the full-order model which in this work was the multiphase flow software MFIX [2]. The finite volume discretized equations governing the transport phenomena of gas-dust two-phase bubbling fluidized beds with a passive scalar transport were then projected onto the extracted basis functions using Galerkin projection to perform the model order reduction.

The results from the ROM were compared to those obtained from the full order model for an isothermal, mild-fluidization, 2D bed riser case. The ROM was shown to produce results with up to 99.99% accuracy compared to the FOM. The computational time required by the ROM was only 2 percent of the computing time required by the FOM.

REFERENCES

[1] T. Yuan, P.G. Cizmas and T. O'Brien, "Reduced-order model for a bubbling fluidized bed based on proper orthogonal decomposition", *Computers and Chemical Eng.*, 30, pp 243-259, (2005).
[2] M. Syamlal, *MFIX documentation numerical technique*. Technical Report DE- AC21-95MC31346. EG&G Technical Services of West Virginia (1998).