CENTER FOR THERMO-FLUID MECHANICS

SPRING 2019 SEMINAR SERIES

Industrial Applications of a Filtered Two-Fluid Model for Gas-Solid Flows

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WHEN: April 26, 2019 1:00 PM - 2:00 PM
WHERE: MREB ROOM 200

ABSTRACT

With the advent of readily-available high-performance computing hardware, the use of computational fluid dynamics (CFD) in the study, design, and scale-up of gas-solid ow reactors and process equipment has become commonplace. In research-oriented studies, reactor sizes are generally limited to smaller-scale reactors facilitating comparison with experimental data and computational tractability owing to smaller mesh sizes. In contrast, the industrial practitioner is most interested in simulating industrial-scale equipment either to understand full-scale performance in the context of new development or to troubleshoot and remediate under-performing production assets. Agrawal et al [1] have indicated that the mesh resolution used in simulating rapid gas-solid flows should not exceed ten particle diameters if standard interphase drag laws are used and solution accuracy is to be preserved. For the industrial practitioner seeking to simulate full-scale process equipment, the recommended mesh size poses a formidable simulation challenge.

Filtered gas-solid flow models can offer relief from the large computational loads required for accurate simulation of commercial-scale equipment. As discussed by Igci et al [2], the filtered model seeks to replace the traditional micro-scale drag laws with drag laws better suited for the larger cell sizes required for timely commercial-scale simulations. The development of such meso-scale drag laws is done by performing a number of simulations in a periodic domain and filtering the results using filters of various sizes. These filtered results are consolidated into a composite drag relation that can be used across various cell sizes without compromising accuracy.

In this presentation, industrial experience involving the use of a filtered two-fluid model for simulating reacting gas-solid flows in refinery processes will be discussed. The discussion will emphasize hardware modifications conceived with the aid of CFD analysis and before-and-after comparisons.

BIO:

Timothy M. Healy holds a BS in Chemical Engineering from the University of Minnesota and a PhD from the Georgia Institute of Technology. Upon completing his PhD, Timothy joined ExxonMobil Research and Engineering as part of the Chemical Engineering Technology section as a specialist in single and multiphase fluid dynamics and computational fluid dynamics (CFD). In his career to date, Timothy has developed fast, efficient, and accurate computational models for various types of single and multiphase flow and reacting systems including fluid catalytic cracking risers and regenerators and fluidized bed cokers. These models have been applied and extended successfully to improve existing process performance and aid in the development of novel processes for refining and chemicals applications. As Fluid Dynamics and CFD Group Head, Timothy directed all fluid dynamics consulting work done by the group as well as mentoring engineers in fluid dynamics analysis and industrial practice. Currently, Timothy serves as the company's subject-matter expert in the areas of fluid dynamics and CFD. Timothy has been with ExxonMobil for 18 years. In this time, he's won numerous awards highlighted by two consecutive Innovator of the Year Awards given by the Process Technology Department in 2014 and 2015 and the Dow Particle Processing Recognition Award given by the Particle Technology Forum of the American Institute of Chemical Engineers in 2017.

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[1] Agrawal, K., Loezos, P. N., Syamlal, M., and Sundaresan, S. The role of meso-scale structures in rapid gas-solid flows. Journal of Fluid Mechanics 445 (2001), 151-185.
[2] Igci, Y., Andrews IV, A. T., Sundaresan, S., Pannala, S., and O'Brien, T. Filtered two-fluid models for fluidized gas-particle suspensions. AIChE Journal 54, 6 (2008), 1431-1448.