PROJECT facts

U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Vision 21

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VIRTUAL DEMONSTRATION OF CIRCULATING FLUIDIZED BED PERFORMANCE

Coarse-Grid Simulation of Reacting and Non-Reacting Gas-Particle Flows

PARTNER

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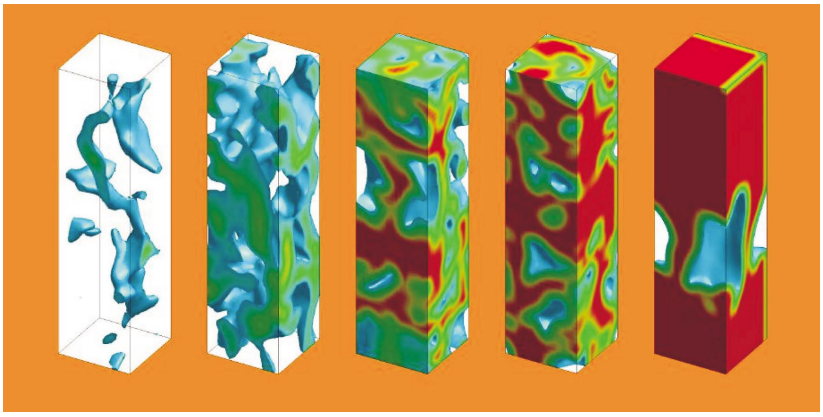
Description

Virtual simulation of Circulating Fluidized Bed (CFB) performance requires modeling and simulation of the entire spectrum of gas-solids flow conditions ranging from dense phase flows in standpipes and fluidized beds to dilute phase flow conditions of risers and cyclones. The virtual simulation tool developed in this work will be based on the open-domain Computational Fluid Dynamics (CFD) code MFIX that was originally developed at the National Energy Technology Laboratory. The MFIX computer code includes the capability to carry out reactive flow simulations. The computational model we will develop will permit both cold-flow and reactive flow simulations. The principal challenge in this effort is to devise and implement sound physical models for the rheological characteristics of the gas-solid suspensions.

Goal

The goal of this project is to develop a virtual simulation tool to model the flow of reactive gas-particle mixtures in circulating fluidized beds. New computer techniques will simplify the number of calculations in these simulations and reduce the time to produce the simulation. These advances will enable future simulations to study more complex and detailed particle flows than current simulations in a cost effective manner.



Computer simulation in three dimensions of particle volume fraction distribution in fluidized bed corresponding to volumes fractions of 0.025, 0.05, 0.15, 0.25, and 0.45. Color Scale as indicated in Figure 2.

Virtual Demonstration of Circulating Fluidized Bed Performance

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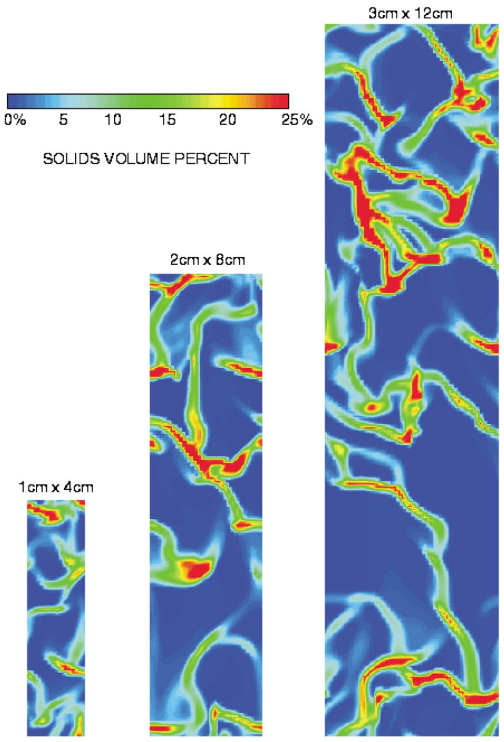
Benefit

Fluidized beds, circulating fluidized beds, and spouted beds are widely used in energy-related and chemical process industries. Their use in coal gasification, desulfurization and combustion processes are in varying degrees of commercial development and deployment. The current ability to simulate the performance of such processes is primitive, owing to the complexity of the hydrodynamics and chemistry encountered in these processes. An improved simulation capability is highly desirable both for process scale-up and modification.

There is significant value to both the energy-related industries and the DOE in the development of a fundamentally based mathematical model for flow in these processes. Also new and simplified experimental methodologies to determine model parameters and develop software tools to perform both reactive and cold-flow simulations is beneficial to the design of fluidized bed systems. The proposed virtual simulation tool in the form of a computational fluid dynamics (CFD) software based on a robust hydrodynamic models for gas-solid flow will have capabilities to simulate these reaction systems.

Information about these reacting processes can be gathered by the inspection of statistics developed in simulations such as those shown in figures 1 and 2.



Two dimensional computer simulations of particle volume fraction distribution showing clusters and streamers.

MILESTONES

Initiate Project - September 2000

Establish features and quantitative estimates of powder frictional stress models for coarse-grid simulations - September 2001

Validate features and quantitative estimates of the frictional stress models employed in the coarse-grid simulations - September 2002

Demonstrate capability to carry out simulation of a complete circulating fluidized bed (CFB) loop - September 2003