2012 International Pittsburgh Coal Conference
Pittsburgh, PA, USA
October 15 – 18, 2012

Abstract Submission

CARBON MANAGEMENT

Dynamic Modeling and Transient Analysis of a Solid-Sorbent Adsorber for CO_2 Capture

Srinivasarao Modekurti. Post-Doctoral Fellow
Department of Chemical Engineering, West Virginia University, Morgantown, WV 26506
Srinivasarao.Modekurti@mail.wvu.edu

Debangsu Bhattacharyya, Res. Assoc. Professor
Department of Chemical Engineering, West Virginia University, Morgantown, WV 26506
Debangsu.Bhattacharyya@mail.wvu.edu
Tel: 3042939335, Fax: 3042934139

Stephen E. Zitney, Director, AVESTAR Center
National Energy Technology Laboratory, U.S. DOE, Morgantown, WV 26507
Stephen.Zitney@netl.doe.gov
Tel: 3042851379, Fax 3042850903

Abstract:

The U.S. Department of Energy's *Carbon Capture Simulation Initiative* (CCSI) is dedicated to accelerating the commercialization of carbon capture technologies from discovery to development, demonstration, and ultimately the widespread deployment to hundreds of power plants. In this multi-lab initiative in partnership with academic and industrial institutions, the National Energy Technology Laboratory (NETL) leads the development of a multi-scale modeling and simulation toolset for rapid evaluation and deployment of carbon capture systems. One element of the CCSI is focused on optimizing the operation and control of carbon capture systems since this can have a significant impact on the extent and the rate at which commercial-scale capture processes will be scaled-up, deployed, and used in the years to come. Capture processes must be capable of operating over a wide range of transient events, malfunctions, and disturbances, as well as under uncertainties. As part of this work, dynamic simulation and control models, methods, and tools are being developed for CO_2 capture and compression processes and their integration with a baseline commercial-scale supercritical pulverized coal (SCPC) power plant.

Solid-sorbent-based post-combustion capture technology was chosen as the first industry challenge problem for CCSI because significant work remains to define and optimize the reactors and processes needed for successful sorbent capture systems. Sorbents offer an advantage because they can reduce the regeneration energy associated with CO_2 capture, thus reducing the parasitic load. In view of this, the current paper focuses on development of a dynamic model of a solid-sorbent CO_2 adsorber-reactor and an analysis of its transient performance with respect to several typical process disturbances.

A one-dimensional, non-isothermal, pressure-driven dynamic model of a two-stage bubbling fluidized bed (BFB) adsorber-reactor is developed in Aspen Custom Modeler (ACM). The BFB stages are of overflow-type configuration where the solids leave the stage by flowing over the overflow-weir. Each bed is divided into three regions, namely emulsion, bubble, and cloud-wake regions, that co-exist along the height of the adsorber. In all three regions, the model considers mass and energy balances that are mainly dominated by the characteristics of the rising bubble of the flue gas. The sorbent used in this process has been developed at NETL and is known as 32D. Along with the models of the BFB stages, models of the downcomer, outlet hopper, distributors, control valves, and other pressure-drop devices are developed and integrated in one overall ACM process flowsheet. Consistent boundary and initial conditions are considered for simulating the dynamic model. Equipment items are sized and appropriate heat transfer options, wherever needed, are provided. Finally, a valid pressure-flow network is developed and a lower-level control system is designed so that the overall CO_2 capture can be maintained at a desired level in face of the typical disturbances. The dynamic model is used to study the transient responses of various process variables such as exit sorbent and flue gas temperatures, concentration of CO_2 in the flue gas and in the outgoing solid sorbent. The simulated disturbances include change in the flue gas temperature, flowrate, and composition.