Chapter 10
Circulating Fluidized Beds

Ray Cocco
PSRI, USA

S.B. Reddy Karri
PSRI, USA

Ted Knowlton
PSRI, USA

ABSTRACT

In the last 20 years, significant improvements in the computational fluid dynamics (CFD) modeling have been made that allow the simulation of large-scale, commercial CFBs. Today, commercial codes are available that can model some of this behavior in large-scale, commercial units in a reasonable amount of time. However, the hydrodynamics in a riser or fluidized bed are complex with both micro and macroscale features. From particle clustering to large streamers to the core-annulus profile, the particle behavior in these unit operations rarely behaves as a "continuous fluid." Even the role of particle size distribution is often neglected and models that do consider particle size distribution don't always consider the role of particle size on granular temperature. Many models use insufficient boundary conditions by assuming uniform or symmetric profiles, which is rarely the case. Furthermore, grid sizing is usually based on computer limitations instead of model limitations, and many models of commercial systems extend beyond the capability of the constitutive equations being used. Successful application of today's CFD models requires a good understanding of the equations behind the code, the assumptions used for those equations and the capability or limitations of the code. CFD is nothing more than a guess without an understanding of the fundamentals, underlying assumptions and code limitations that are part of every model.

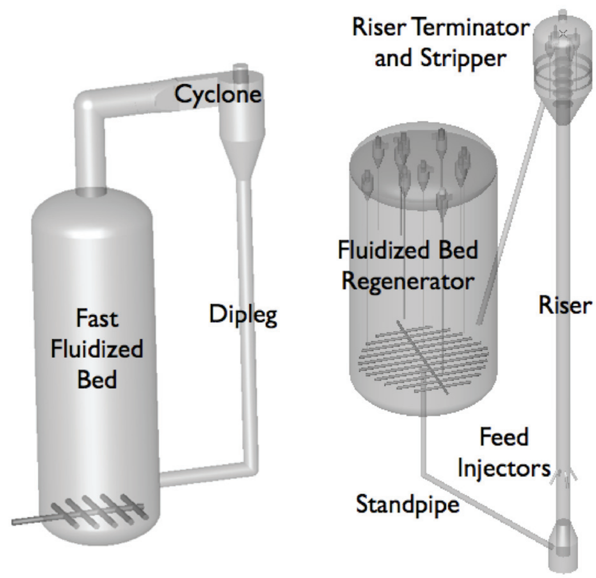
INTRODUCTION

The circulating fluidized bed (CFB) has been in large-scale operation since the 1970's with the advent of the fluidized catalytic cracking (FCC) riser reactor in the petroleum industry. One of the unique char-

DOI: 10.4018/978-1-61520-651-3.ch010

Copyright © 2011, IGI Global. Copying or distributing in print or electronic forms without written permission of IGI Global is prohibited.

Figure 1. Simple (left) and more complex (right) schematics of circulating fluidized beds



acteristics of these units is the ability to move catalyst from a reactive environment to a regenerative environment. As a result, catalyst with high activity but short lifetimes could be regenerated, sometimes close to a catalyst's initial activity.

In today's FCC units, highly active zeolite catalysts are commonly used. However, these catalysts have a useable lifetimes of only a few seconds due to a buildup of a carbonaceous material (coking) on the catalyst as a side reaction of the oil cracking process. By circulating the catalyst from the reactor section to an air regeneration section, coke is continuously removed from the catalyst, activity is resorted, and the added heat value from regeneration is delivered to the reaction section by way of the returning catalyst. A typical FCC unit requires about five pounds of catalyst per pound of feedstock, which can amount to catalyst circulation rates of ten million pounds per hour or more.

Circulating fluidized beds consist of several configurations. The simplest version is a fluidized bed operated in the fast fluidization or even transport regime where the solids are captured with a primary cyclone (and perhaps further captured with secondary cyclones). From the cyclone, the solids are returned to the fluidized bed through a dipleg.

The most common configuration of a circulating fluidized bed is one where solids move from a riser to one or more fluidized beds. Figure 1 shows schematics of circulating fluidized beds with and without additional units such as a regenerator. FCC units are based on this configuration where solids flow from the riser to a stripper to a regenerator and then back to the riser. Solids conveyed in the riser are separated from the product gas at the top of the riser using cyclones or a riser terminator. The riser terminator can be a simple vessel expansion or a more sophisticated device such as UOP's VSS and RSS (Lomas, 1996), ExxonMobil's swirl (Tammers, et al., 1993) or Stone and Webster's Ramshorn (Yawn, 2006) design. Cyclones are used downstream of these devices for additional separation of the solids from the product gases.

Interstitial gas is removed from gas/solid suspension using a stripper. Here, an inert gas or steam is used to further remove the product gases before they are sent to the regenerator. In many cases, strippers

39 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage:
www.igi-global.com/chapter/circulating-fluidized-beds/47498

Related Content

Liquid Products Characterization from Pyrolysis and Gasification: How Can It Be Classified?
Caio G. Sánchez, Renata Andrade Figueiredo, Flávio Augusto Bueno Figueiredo, Elisabete Maria Saraiva Sánchez, Jesús Arauzo, Alberto Gonzalo Callejoand Rolando Zanzi Vigouroux (2015). *Innovative Solutions in Fluid-Particle Systems and Renewable Energy Management (pp. 167-198).*
www.irma-international.org/chapter/liquid-products-characterization-from-pyrolysis-and-gasification/132885

Supercritical Carbon Dioxide and Its Application to Rankine Cycle
Hiroshi Yamaguchi (2017). *Advanced Applications of Supercritical Fluids in Energy Systems (pp. 335-368).*
www.irma-international.org/chapter/supercritical-carbon-dioxide-and-its-application-to-rankine-cycle/180276

Pretreatment of Lignocellulosic Biomass Feedstocks for Biofuel Production
Desikan Ramesh, Iniya Kumar Muniraj, Kiruthika Thangaveluand Subburamu Karthikeyan (2018). *Advanced Solid Catalysts for Renewable Energy Production (pp. 33-60).*
www.irma-international.org/chapter/pretreatment-of-lignocellulosic-biomass-feedstocks-for-biofuel-production/196144

Interactions Between Weighting Scheme and Similarity Coefficient in Similarity-Based Virtual Screening
John D. Holliday, Peter Willettand Hua Xiang (2012). *International Journal of Chemoinformatics and Chemical Engineering (pp. 28-41).*
www.irma-international.org/article/interactions-between-weighting-scheme-similarity/68019

Dynamics of Metal Distribution in Cultivated Soil and Vegetables in Vicinity to Industrial Deposition: An Inference to Chemical Contamination of Food Chain
Sumanta Nayek, Suprakash Roy, Suvanka Dutta, Rajnarayan Sahaand Tanmoy Chakraborty (2013). *International Journal of Chemoinformatics and Chemical Engineering (pp. 117-124).*
www.irma-international.org/article/dynamics-metal-distribution-cultivated-soil/78493