Pärssinen, JH, Ph.D., “Hydrodynamics of Low-Flux and High-Flux Circulating Fluidized Beds”, HelsinkiUniversity of Technology, October 2002.

Abstract

The ongoing growth of world population and industrialization is increasing the primary energy demand, and also the need for transport fuels. The increasing carbon dioxide and other emissions are fostering the political atmosphere to demand for a more sustainable development with more efficient usage of raw materials and resources.

In order to improve some key processes in refineries, such as Fluidized Catalytic Cracking (FCC), a better understanding of high-flux flow hydrodynamics is necessary. FCC units are producing a large proportion of gasoline world-wide, and some other valuable products such as light olefins and light cycle oil. Nearly all FCC units in production utilize a riser reactor, where the solids (catalyst) circulation rate could range from 400 kg/m2s to 1.200 kg/m2s, and the superficial gas velocity from 6 m/s to 28 m/s. Therefore, it is surprising that nearly all studies of CFB pilot hydrodynamics have been carried out at low solids fluxes of less than 200 kg/m2s, whereas only a few limited but helpful studies are discussing higher solids fluxes of over 500 kg/m2s. Such studies are regarded very useful for industrial processes and unit design, development and optimization.

In comparison to those studies carried out in the dense suspension upflow (DSU) regime, this thesis will discuss high-flux operations where the axial solids holdup profile is not flat and the cross-sectional solids concentration is clearly less than 10%-vol in the upper portion of the riser. Consequently, the operation has similarities to both DSU and fast fluidization (FF) flow regimes. Since the cross-sectional solids concentration is also low (<10%-vol) in the upper portion of industrial FCC risers, another aim is to provide a detailed image of the radial solids concentration profiles and their development toward the top of a high-flux riser. Since there is confusion of how and why DSU flow regime would occupy a riser, some fundamental reasons are discussed in detail. It is shown that to realize a high-density circulating fluidized-bed operation (HDCFB), a high-flux circulating fluidized-bed (HFCFB) operation is essential but not sufficient.

For having some experience enclosed from a low-flux riser, paper I is discussing the low-flux riser hydrodynamics concerning especially the flow structure near to the column wall. Papers II and III present the solids concentration and particle velocity profiles and flow development in a long and high-flux riser. Paper IV goes on to define a novel concept of four longitudinal sections in an HFCFB riser (but not in an HDCFB riser). This concept may be a very useful fundamental aid for industrial modeling of HFCFB risers. Paper V presents some operating experiences of a high-flux riser with a novel design in the solids feeding inlet. Paper VI is discussing the particle aggregation in an HFCFB riser. The collected data in papers II and III are believed to be useful for several industrial applications since not much measured data existed under high-solids fluxes.