Bolkan Y, Ph.D., “Modeling Circulating Fluidized Bed Riser and Downer Reactors and their Application to Fluid Catalytic Cracking”, University of Calgary, April 2002.

Abstract

Circulating Fluidized Beds (CFB) are highly effective reactors for fast gas-solid reaction systems. In spite of extensive research in this area, the degree of understanding of these types of reactors are far from complete. The importance of further improving the CFB operation becomes especially evident when applied to Fluid Catalytic Cracking (FCC). Due to the large throughput rates in FCC, any betterment in the CFB technology leans to significant economic and environmental impacts for this process.

In this work, hydrodynamic models are presented describing each of the conventional CFB riser and the relatively new CFB downer. These two models predict flow parameters along the reactor axis based on fundamental fluid mechanics, which is supplemented with empirical correlations when necessary. Simulation results of the riser and downer hydrodynamic models compare favourably with extensive data collected on a state-of-the-art experimental unit having a riser and a downer of equal dimensions, each operated under similar conditions. The fact that both models match this data very well indicates that the computer programs depict the up-flow and down-flow CFB fluid dynamics realistically, and the riser and downer models are used to conduct a comparative study of riser and downer hydrodynamics.

The FCC reaction kinetics is incorporated in both the riser and downer hydrodynamics models for prediction purposes. Resulting riser and downer FCC models calculate flow and reaction parameters, including conversion rates, product yields and selectivity. Predictions for both riser and downer FCC operation match available data well, which verifies both reactor models. A comparative study of downer vs. riser FCC performance is carried out for conditions that prevail in industry in order to discern the circumstances under which either reactor may supply more desirable results such as higher conversion rates and improved product yields. A sensitivity analysis is conducted that encompasses the effect of reactor temperature, catalyst-to-oil ratio, the attainable suspension density within the reactors, the various types of catalysts and the degree of backmixing, on reactor performance. These findings may be useful for optimal operation of industrial units as well as for suggesting when it may be worthwhile to switch from riser to downer operation.