Shaping the Future of Refineries Through Hydrodynamically Innovative Reactors

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In fluid catalytic cracking (FCC) of crude oil, traditional riser reactors suffer from hydrodynamic inefficiencies that severely reduce product selectivity and promote excessive coke formation. While co-current downer reactors improve selectivity, they are limited by low solid holdups and require high capital investment due to the size requirement of the reactor. The counter-current downer reactor presents a promising, yet under-explored alternative, introducing gas upward against falling catalyst particles to optimize contact. This study utilized an optical fiber probe to quantify local solid holdups and particle velocity profiles across the reactor's cross-section. During initial trials, FCC particles exhibited electrostatic agglomeration. Consequently, sand (Geldart Type B) was utilized to establish preliminary baseline results before the FCC particles (Geldart Type A) were treated to minimize these forces. Crucially, across varying gas velocities, the counter-current downer maintained highly uniform radial profiles. The setup achieved a core-to-wall particle velocity drop of ~30% with FCC particles and ~31% with sand, confirming a minimized core–annulus flow structure that directly narrows residence time distributions compared to traditional reactor configurations. Furthermore, the counter-current downer achieved solid holdups of ~5.0 using the FCC particles and ~2.0 using the sand; a significant improvement over the low holdup limits characteristic of co-current downers. Ultimately, these results promote FCC product selectivity, reaction severity, and mitigation of coke formation and subsequent carbon emissions. This study shows potential in advancing energy-efficient petroleum refining, with highly promising applications for biomass pyrolysis as well.

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