Redefining Catalyst and Process Development in Fluidized Bed Reactors for Chemical Recycling and Renewable Feedstock Integration

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Abstract

Fluid Catalytic Cracking (FCC) continuous to be the most important process in current refineries to upgrade the bottoms of the barrel to valuable gasoline and C2-C4 olefins for petrochemical processes. In addition to classical FCC feedstocks (VGO + Resid), alternatives such as (biogenic) oils, fats, and waste plastic melts and pyrolysis condensates can be co-processed. These direct drop-in solutions for renewable feedstocks and chemical recycling are very promising and allow utilizing existing FCC assets in refineries. The commercial FCC process uses entrained flow reactors for cracking diverse feedstocks at short contact times (0.5-5 sec), high reaction temperatures > 500°C and reactor pressures < 4 barg. The FCC reaction kinetics and catalyst deactivation strongly depend on the hydrodynamics at reactor inlet and the plug flow of catalyst and product vapors. To simulate the commercial reaction conditions, continuous pilot Circulating Riser Unit (CRU) testing has been developed. More recently, a novel, more affordable FCC catalyst testing procedure based on the Micro Downflow Unit (MDU) is available, which provides realistic cracking conditions on the lab-scale, closely simulating the gradients in temperature, partial pressure and contact time of commercial operations. The entrained flow reactor is operated with a typical (integral) experimental time of 60 sec and all liquid and gaseous products as well as coke on catalyst are quantified. Additionally, the MDU can be operated in an unprecedented broad parameter space of catalyst temperatures between 200-900°C, reaction pressure of 0.5-3.5 barg and, by dilution, variable hydrocarbon partial pressures, catalyst to oil ratio of 4-20+, and contact time of 0.5-5 sec [1-3]. The control and measurement of these descriptors for reaction kinetics in combination with the generation of mass balanced yield distributions allow to calibrate models for thermal as well as catalytic cracking. In our presentation, we will discuss examples of different case studies such as [4] and compare the results of the MDU with those from CRU and commercial FCCU. Furthermore, we will focus on the relevance of the MDU technology for process development in the context of current shifts to integrated, petrochemical refineries and a circular economy.

References:

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