Heat balanced simulation in Short Contact Time Riser Test

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Introduction

Laboratory simulation of the Fluid Catalytic Cracking (FCC) process is essential for evaluating new catalyst developments and making adequate forecasts on catalytic performance. A continuous improvement in catalyst assembly and manufacturing technology requires also permanent innovation in catalyst performance evaluation.

Albemarle, known for its outstanding reputation in laboratory evaluation of catalysts, presents their latest development in the Short Contact Time Riser Test (SCT-RT). This paper presents the simulation of heat balanced operation using the SCT-RT in comparison with real life FCCU.

Laboratory performance testing of FCC catalysts

Bench-scale and pilot-scale performance tests are widely applied at several research institutes world-wide, each test features its own characteristics. One of the first developments was the Fixed-Bed performance tests, the MAT and the MST [1-2]). The Fluidized Bed Test is an improvement over the Fixed-Bed Test [3], both performance tests have in common that they apply injection times of minimal 12 seconds. For the fluidized bed test a more uniform coke layer is formed during cracking. Another typical feature of these tests is that they are operated at a fixed typical riser outlet temperature (isothermal mode), and often apply preheating devices to evaporate the feed before it contacts the catalyst [4]. The contact of hot regenerated catalyst with relatively cold feed is not simulated in these tests; neither is there a temperature gradient during the reaction cycle. A more recent development now is the Albemarle's Short Contact Time Riser Test (SCTRT). This bench-scale performance test is unique in its kind as oil is injected directly into a hot fluidized bed at a typical commercial catalyst return temperature, and at a typical injection time of one single second. On top of this the SCT-RT allows a wide variety of feeds to be processed from VGO up to residual feed with a Conradson Carbon up to 10 wt% [5]. In figure 1 the concept of SCT-RT is illustrated.

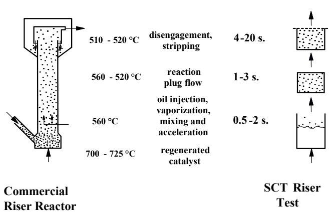

Figure 1: The SCT-RT simulates the process that takes place in a commercial riser

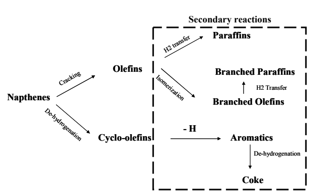

Figure 2: Catalytic cracking sequence

The reason for short contact time testing

In the early days, FCC operation was performed in bed crackers at long contact times as the available catalysts featured low activity. In figure 2 a simplified cracking mechanism is given. Hydrogen transfer reduces olefins which are important for alkylation and petrochemical feeds. Secondary reactions increase with vapor contact times and lead to excessive olefins saturation and too much coke and dry gas production. With the emergence of more active catalysts, contact times could be reduced and the FCC process became more selective. Simulating commercial short contact times is therefore essential for proper catalyst evaluation.

Simulation of Heat balance effects in SCT-RT

Most of the laboratory scale performance tests lack a proper simulation of the heat balance effects that are observed in commercial operation. In figure 3, the average temperature difference between regenerator and riser-outlet of a few commercial units versus Cat-To-Oil (CTO) ratio is shown. The catalyst bed temperature is not constant with catalyst circulation rate in a commercial unit. A higher catalyst circulation rate corresponds with on average a 20 °C lower regenerator temperature per cat-to-oil. The heat balance effects can directly be observed in the yield performance. For example, the dry gas yield will go down when catalyst circulation increases at constant riser outlet temperature. It is possible to adjust the operating conditions of the SCT-RT to replicate the heat balance effects of a commercial unit to obtain a more realistic simulation of yields. In figure 4 the effect of CTO on dry gas selectivity is illustrated for the SCT-RT operating in a heat balanced mode.

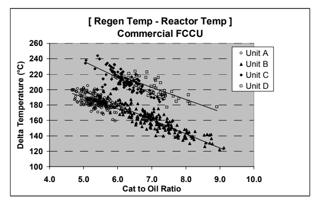

Figure 3: Heat balanced FCC Response

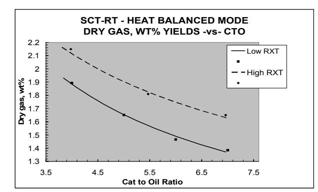

Figure 4: Dry gas reduces with CTO in heat balanced testing in SCT-RT

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