Question 90: What determines the minimum feedrate for a fixed bed reformer? What process indicators would tell you that the feedrate is too low?

Rick Grubb (Chevron USA)

Besides mechanical limitations, such as pump capacities, flowmeter ranges, control valve sizes, etc., the process factors that determine the minimum feed rate of a fixed-bed reformer are:

- Flow distribution in the reactors
- Heat of reaction dissipation in reactors
- Flow distribution in furnaces
- Phase separation in exchangers

Most refineries set the feed rate minimum at 40% of design (liquid hourly space velocity of 0.6 volumes of feed per volume of catalyst per hour). The minimum space velocity for continuous operation is 0.8 v/v/hr.

At low feed rates, the most critical issue is free radical cracking. When flow through a catalyst bed is low, the heat is generated by hydrocracking faster than it can be carried away. At a certain temperature, the hydrocracking changes from normal hydrocracking to free radical cracking, also called demethylation. Free radical cracking is essentially thermal hydrocracking in which feed molecules are totally cracked to methane with a huge heat release. This is the most important effect of low feed rate to watch for, because at such high temperatures, catalyst can fuse and destroy reactor internals in internally insulated (cold wall) reactors. In a hot wall reactor, such an excursion could result in a reactor outlet piping rupture if not caught soon enough.

The first signs of free radical cracking in one or more reactors (usually not the first one) are:

- Recycle specific gravity starts to rise
- Reactor DT’s start to drop and may go positive in the last and next to last reactors
- C1/C2 ratio in the recycle gas starts to rise above the normal 1.2-1.4:1
- Reformate color turns to a darker yellow
- Net hydrogen yield per barrel of feed starts to drop off

For normal hydrocracking, the total DT is 200-250°F. For demethylation the DT can be as high as 1200-1400°F. So, a significant drop in individual reactor DT’s can be an indication of free radical cracking.

Russ Weinhammer/Joe Zmich (UOP LLC)

UOP has traditionally used a minimum liquid hourly space velocity (LHSV) of 0.75 hr-1 or 50% design feedrate whichever is greater. For units with lower design LHSV UOP advises maintaining the combined

feed mass flow above 50% of the design value. The main process implication with low LHSV is an increase in cracking reactions. The increase in cracking leads to decreased reformate and hydrogen production, lower reactor delta T's, lower recycle gas H2 purity, increased stabilizer off gas and LPG flow, and increased C1-C4 yield.

Javier Quintana (Valero Energy)

Valero has experience operating as low as 0.6 LHSV in a fixed bed reformer, although such operation was accompanied by an elevated H2/HC ratio in order to ensure good flow distribution through the catalyst beds.

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