Automating catalyst evaluation

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Accurate evaluation of catalysts performance is an important step in optimising catalytic refinery processes with respect to product yields, run length, energy efficiency, and overall product quality. Utilising high throughput multiple parallel reactors is key to success in developing better catalysts that shorten the innovation cycle and speed up the time to market. For this, it is essential to have an accurate distribution of the liquid feed across all parallel reactors, so that the reactors operate at the exact same space velocity.

Avantium has developed a microfluidic distribution technology to overcome the practical limitations of the cumbersome capillary technology conventionally used for distributing the feed over parallel testing systems. The restrictor channels in our microfluidic glass chips allow for a very accurate distribution of feed to the parallel reactors. Still, for heavy feed applications, an active liquid feed control for each reactor is required to ensure an equal distribution; any restriction in the reactors can affect the pressure drop per channel and therefore the liquid flow rate. To overcome this major challenge, Avantium has developed a fully automated Active Liquid Distribution (ALD) system suitable for a wide range of liquids such as naphtha, SRGO, LCO, VGO, HVGO, and DAO (see **Figure 1**).

This system actively controls the liquid flow distribution by regularly measuring the flow rate to each reactor using a single flow sensor without interrupting the flow to the reactors. The real time, accurate and individual flow control of the liquid feed distribution and the overall flow control by a coriolis mass flow controller greatly improves the precision of such parallel reactors systems. With a liquid distribution error <0.4% RSD, this makes it a highly accurate liquid flow control device for 16-parallel reactors. Another advantage is its auto-calibrating function enabled by the use of a single flow sensor.

Figure 2 shows the significance of controlling the flow to each reactor over time. Two modes are shown: capillary equivalent mode, without active control of the flow, followed by the active mode where the ALD is enabled to demonstrate the efficient liquid distribution. Note the difference in RSD from ±2% to <±0.5% for all 16 reactors which directly improves the mass balance.

A good feed distribution for gases and liquids is directly reflected in the accuracy of the overall mass balance; 1% deviation in feed is equal to 1% absolute deviation in mass balance across all reactors.

The capability to measure fine differences in catalyst performance accurately is of greater

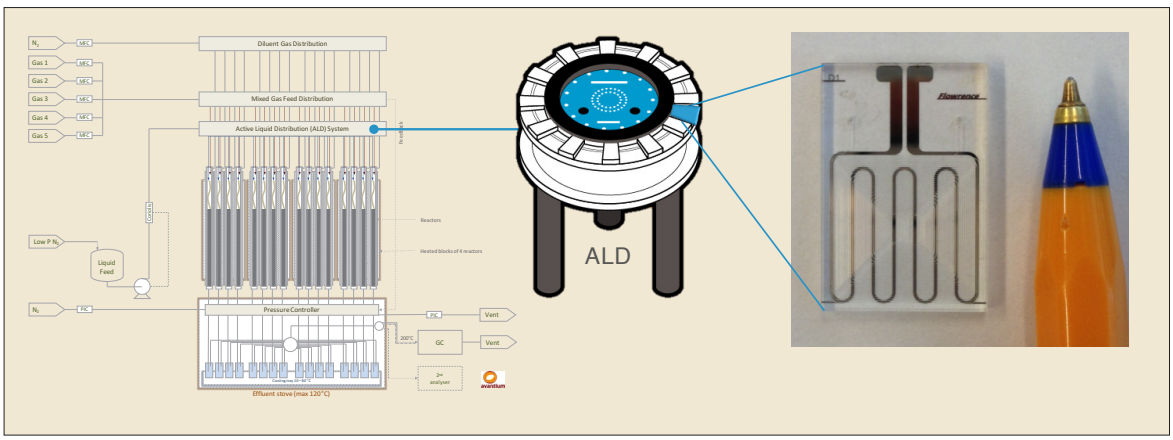

Figure 1 (left to right) Schematic of a 16-parallel reactors system, the ALD and the active microfluidic glass chip

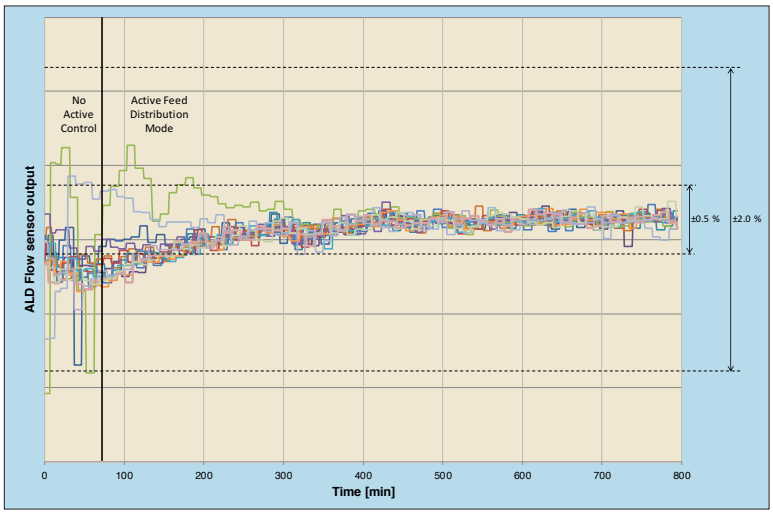

Figure 2 Two modes of flow control to reactors: capillary equivalent mode, without active control of the flow, followed by active mode

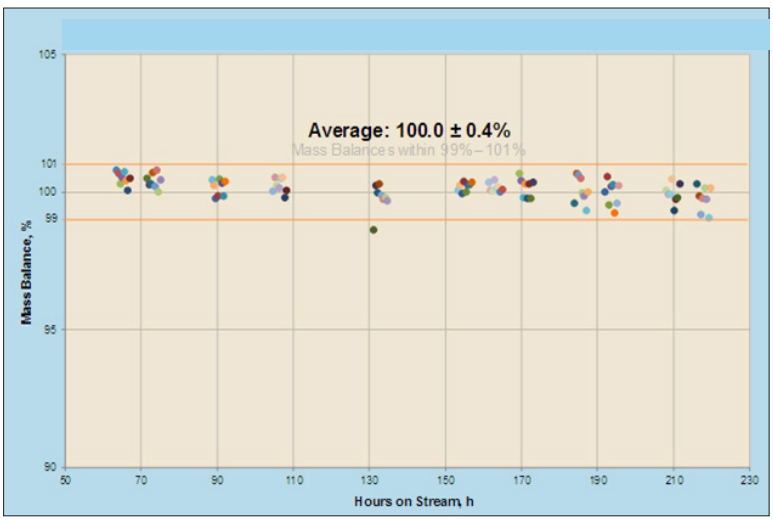

Figure 3 Mass balance closure is well below 1% RSD between reactors, at naphtha selective hydrocracking conditions and more than 75% net conversion at 190°C+ (with each colour point representing one of the 16 reactors)

importance when evaluating hydrocracking catalysts. Small differences in catalyst performance result in considerable economic gain. Avantium's micro-pilot plant allows for the efficient testing of catalysts for fixed bed processes, producing the highest data quality (repeatability, reproducibility and scalability) with low amounts of feed (less waste generated). The technology enables confident discrimination of a 1°C difference in catalyst activity, and 0.5 wt% in middle distillates yields.

With the ALD technology, the feed flow rate variation in the 16-reactors systems is less than 0.4% RSD among the reactors. Combined with the individual reactor pressure control and other Avantium Flowrence proprietary technologies, this enables the most precise and accurate mass balances closures for the most challenging applications. **Figure 3** shows the highly accurate mass balance closure well below 1% RSD between reactors, at naphtha selective hydrocracking conditions and more than 75% net conversion at 190°C+.

This offers the possibility to compare catalysts with similar performance where differences between catalysts are precisely and accurately determined.

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