Shell Global Solutions gathers knowledge about the dynamics of gas/solid flow patterns in FCC-crackers

Understanding really the dynamics of gas/solid flow patterns of FCC-crackers is essential to optimize flows in many processes (e.g. through higher conversion rates or increased throughput).

Shell Global Solutions tried to find a stable and solid solution to characterise such highly loaded flows. They carried out tests in a cold-flow pilot-plant (Fig. 1) in which FCC-catalyst was circulated with air at ambient pressure and temperature.

Labasys 100® the measuring system for simultaneous determination of local concentrations and velocities in multiphase flows helped successfully to obtain reliable results.

Measuring Task

Overview

- Task: **Flow characterisation in FCC-cracking**
- Target Sizes: **Local Concentration, Velocity**
- Motivation: **Optimization, Modelling**
- Solids Conc.: **0-60 Vol.-%**
- Temperature: **0-30°C**
- Particle Size: **50 µm**

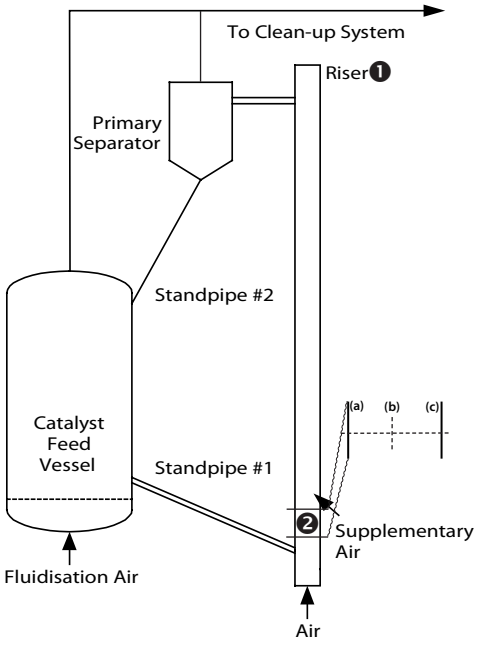

Fig. 1: Schematic drawing of the pilot plant for FCC dense flow measurements. (Shell Global Solutions)

The knowledge about dense flows is insufficient so far and measurements with results under realistic conditions are rare. Shell Global Solutions tried to reach these objectives over certain years, but felt the need for additional detailed information. The main interest lay on the local concentrations and velocities profiles at different levels.

MSE Meili a swiss instrumentation company specialized since more than 15 years in stable measuring systems had been engaged to help understanding the local dynamics in the riser (Fig. 1, ❶).

The riser had an ID of 30 cm and was 15 m high. The standpipe feeding catalyst to the riser was a 30 cm ID pipe. The flow rate of the catalyst was regulated by a slide valve. The particle size distribution and density of the catalyst was typical for FCC-catalyst.

The superficial gas velocity in the lower part of the riser below the supplementary air supply was 1 m/s and several m/s above; the flow rate of the catalyst was 15 kg/s. Measurements were taken across the riser cross-section at an elevation between the standpipe inlet and the locus of supplementary air injection (❷) and at three different positions (a, b, c) along the riser traverse (see enlargement Fig. 1).

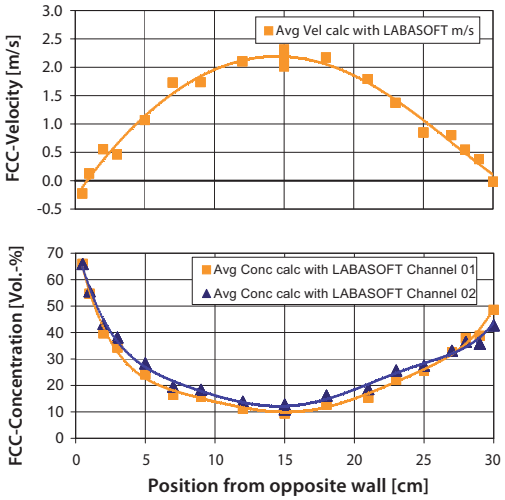

Fig. 2: Profiles of solids velocities (above) and solids volume fraction (below) measured over the riser cross-section ❷. (Shell Global Solutions)

Realisation

Key Success Factors

- Handle the strong abrasivity of the FCC-particles at high velocities.
- To accurately characterise the highly loaded flows in FCC-processes stable and robust optics with a high signal-to-noise ratio are essential.

The measuring principle of Labasys 100® is Laser backscattering: The light of Laser diodes is guided to a specially designed optic which defines a from the application depending measuring volume and allows

an unambiguous calibration for high concentrations too. The by solid particles backscattered light is directed to photodiodes by additional fibres and converted into a voltage signal, from which the local solids concentration can be determined. During the first tests it could be stated that FCC-particles at higher velocities are strongly abrasive. This abrasivity infected the used anti-reflection coating on the front window which lead to instable results first. Due to these phenomenon the initially very high signal-to-noise ratio decreased.

After intense research for several months MSE Meili presented enhanced windows featuring different front window materials (eg. special hardened anti-reflection coating on Quartz or Sapphire) matching the particulars of a specific flow.

Results

Products and Services used

- **Labasys 100®** – 2 channel-instrument for 1 dimensional velocity determination
- **Labasoft** – Windows™ based (98/NT/2000/XP) data acquisition and analysis Software
- Dense flow optics – Quartz, Sapphire
- Dense flow Calibration Service
- Competent engineering, development and test services
- Personal training at MSE Meili Laboratories (Switzerland)

To really understand the dynamics of gas/solid flow patterns for optimizing conversion rates and/or increased throughput it was essential for MSE Meili to handle the strong abrasivity of the FCC-catalyst. Thereafter stable and reliable data allowed Shell Global Solutions to characterize the fluid dynamics in the cold flow model. The figures 2 to 3 show exemplary results of the taken measurements.

Fig. 2 shows concentration results for both of the channels of the optical probe. «The correspondence between the two channels is quite satisfactory. This fact is not trivial in view of the different volt-characteristics of both channels», states Dr. René Samson, Senior Researcher at Shell Global Solutions. Channel 1 has a voltage span between 0.6 and 1.5 V; channel 2 between 0.7 and 2.2 V. In consequence of this, also the calibration characteristics of the two are totally different: Fig. 4 shows the calibration data determined in MSE Meili's specially designed dens flow calibration unit with the FCC-sample supplied. Note the wide concentration range covered of 0.6 to 47 FCC-Vol.-%.

Fig. 3 shows the temporal fluctuations of the catalyst density at three different positions along the risers traverse. Plotted are raw (i.e. unconverted) Volt-signals measured at a certain position with a sampling frequency of 4 kHz. «We could elaborate that the characteristics of the density fluctuations near the wall are quite different from the center. Near the wall, a large fraction of the time the density is close to its maximum value about 2.2 V, with relatively infrequent dips to lower values corresponding to an infrequent passage of bubbles», notes Dr. René Samson. «In the center on the other hand, the Volt-signal is much noisier. In other words: the frequency of change from lower to higher density is much higher than near the walls. These reliable results really helped us to gather more knowledge about our processes», explains Dr. René Samson.

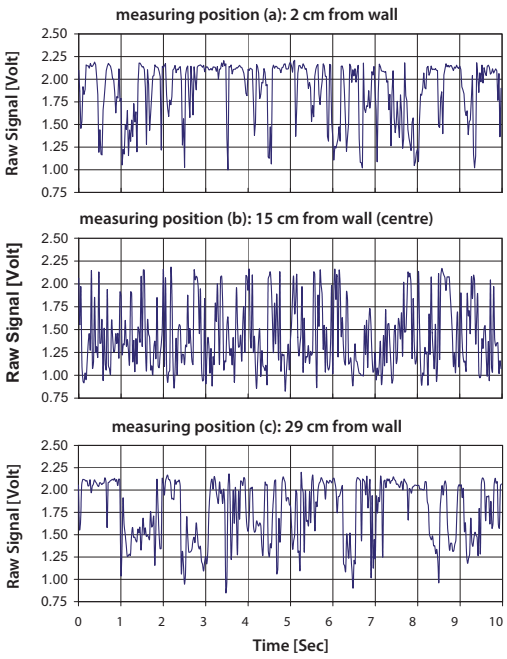

Fig. 3: Temporal fluctuations measured as shown in enlargement of Fig. 1; data of channel 2 sampled at 4 kHz (Shell Global Solutions)

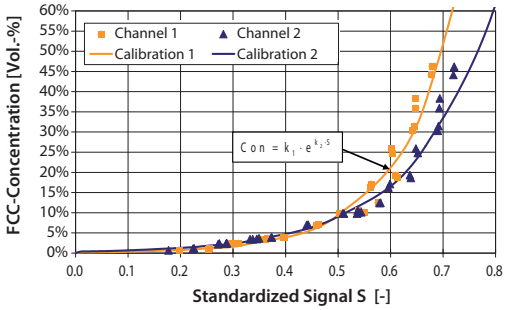

Fig. 4: Calibration data for FCC-particles (MSE Meili for Shell Global Solutions)

«With Labasys 100® we made a step forward in understanding gas/solid flow patterns. MSE Meili as an experienced partner with high engineering competence brought what we needed: a reliable measuring instrument with high sensitivity and accuracy.»

Dr. René Samson, Shell Global Solutions