Reaction Engineering Group constructs a 180" flat screen

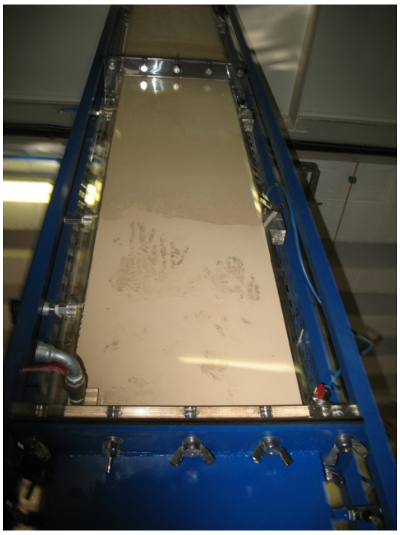
by Prof Willie Nicol, Elizbé du Toit and Jean Saayman

Many people think that large flatscreens are meant for World Cup soccer matches, but the 180" flat screen in the Department of Chemical Engineering delivers even more action than the most exciting football match. Students can now view a chemical reaction in a fluidised bed reactor using a flat screen reactor that is taller than the world's largest flatscreen television.

The complexity of the interaction between fast-flowing gas over a bed of fine particles is hard to capture in a textbook, but unfortunately most chemical engineering students have nothing more than that to grasp the principles of this type of catalytic reactor. The fluidised bed reactor is extensively used in industry, but, due to the tall steel containers used, the internal happenings (where gas and solid meet in intricate contacting patterns) occur in darkness and the engineers can only work with the difference between the gas inlet and the outlet.

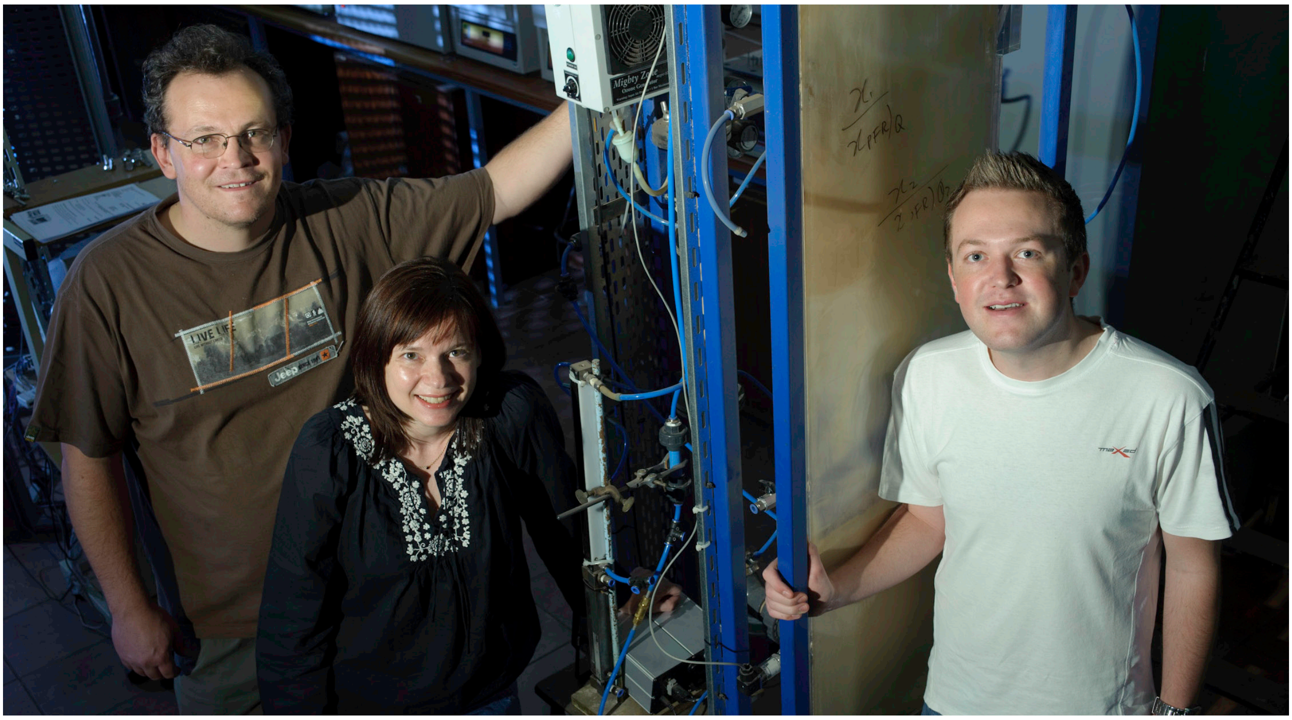
To address this shortcoming, a 4.5 m (180'') x 0.4 m x 0.025 m transparent perspex column was constructed to host a chemical reaction at ambient conditions where gaseous ozone gets decomposed over a commercial solid catalyst. This not only enables the solid gas interactions (hydrodynamics) to be viewed, but also allows for simultaneous monitoring of the extent of the reaction in the column via an online ozone concentration display. The link between the hydrodynamics and the extent of the reaction (conversion) provides the opportunity for the "a-ha" moment, where all the textbook theory and models suddenly come to life. If a picture is worth more than a thousand words, then a real-life movie is worth more than a thousand words and fifty equations!

Apart from the display for postgraduate and undergraduate students, the column is also used for research. The column is designed to operate at very high gas velocities, where a significant amount of the catalyst becomes entrained (removed from the dense bed at the bottom). In order to keep all the catalyst in the system, two parallel cyclones are used to separate the solids from the outlet steam and to return the catalyst to the bed. The wider range of possible gas flow rates allows the investigation of the effect of catalyst productivity as a function of the superficial velocity. Governing phenomena like interphase mass transfer and axial dispersion can be explored by using the reaction outcome as measurement.



→ Dense section of the catalyst bed at intermediate gas velocities.

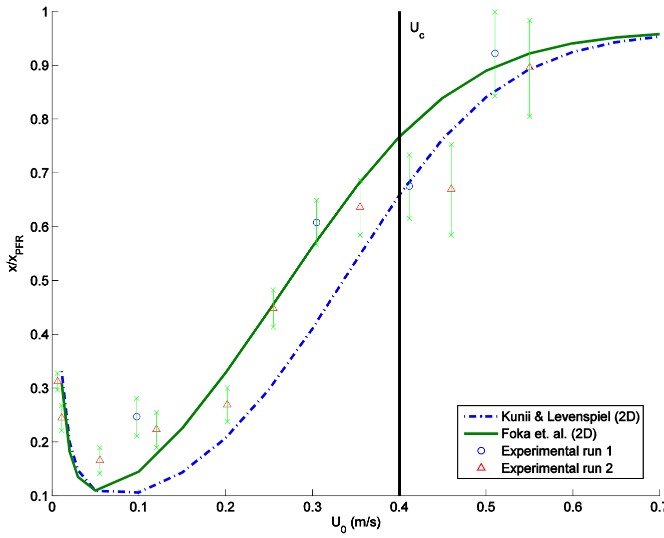
→ Catalyst circulation above the dense bed section.



→ *Members of the Reaction Engineering Group in the Department of Chemical Engineering (from left): Prof Willie Nicol, senior lecturer Elizbé du Toit and PhD student Jean Saayman.*

Figure 1 shows the ratio of the measured conversion to the optimum conversion as a function of superficial velocity. From the graph, it is clear that the low-velocity bubble-flow regime exhibits poor productivity characteristics, while the effect diminishes at higher velocities (turbulent regime). This effect can be mimicked by using two-phase models to describe the effect of the hydrodynamics on the reaction.

All in all, the flat sceen reactor is an invaluable tool for chemical reaction engineering, teaching and research.



→ *1. Ozone conversion measurements (as a function of the optimum conversion) with model comparisons.*

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