Great Technology Comes in Small Packages

Microchannel Reactors Make Winning Liquid Fuels from Waste a Reality

Challenge – The management of waste is a worldwide challenge, and so is the growing need for renewable energy supplies. The use of microchannel reactors to enable the distributed production of biofuels from biomass waste via the biomass to liquids process (BTL) offers one option for solving both problems at once. Derek Atkinson of the Oxford Catalysts Group explains how.

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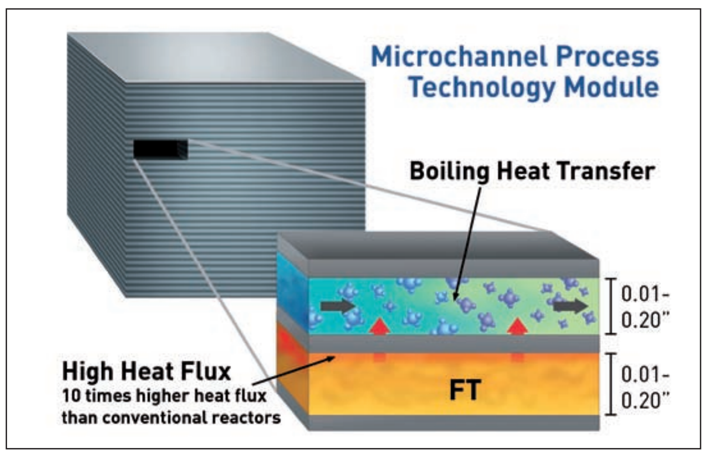
The FT microchannel demonstration plant at Güssing, Austria



The microchannel reactor

Microchannel technology offers enhanced heat and mass transfer

	Microchannel	Conventional
Heat transfer (W/cm^2)		
Convective	1–20	< 1
Boiling	1–20	< 1
Mass transfer (contact time in seconds)	0.001–0.3	1–10
Selectivity, % C5+	78–82	81–94
Selectivity, % CH_4	< 10	no information available
Alpha ratio	0.89–0.92	> 0.9
Contact time, ms	< 250	no information available
Catalyst life, years	not yet determined	2

(Data sources: Velocys test data and estimates from Nexant, Inc.)

Back in the early 1990s, when scientists and engineers at Pacific Northwest National Laboratory in Washington were considering ways to process nuclear waste leftover from the Manhattan Project (1939–1946) and stored in underground tanks sites scattered around the state, they came up with a big new concept for tackling the problem: distributed small-scale processing using microchannel reactors. The aim was to develop a way to process the waste in situ rather than transporting it to a large centralized facility. Velocys, Inc., now part of the Oxford Catalysts Group, was set up in 2001 in Ohio to further the development of microchannel reactor technology.

Although the idea of developing microchannel reactors to use for the distributed processing of nuclear waste didn't take off, the concept of using small-scale distributed processing concept using microchannel reactors has. The Oxford Catalysts Group have gone on to develop microchannel reactors for two applications: small-scale gas to liquids (GTL) plants for capturing associated and stranded gas both offshore and onshore, and small-scale biomass to liquids (BTL) plants for the distributed production of biofuels from feedstocks such as municipal, forestry and agricultural waste.

The Fischer-Tropsch (FT) process, in which synthesis gas (syngas), a mixture of CO and H_2 is converted into various liquid hydrocarbons using a catalyst at elevated temperatures, plays a key role in both. Because they don't contain aromatics or sulfur-containing contaminants, the liquid fuels produced via FT are typically of higher quality and burn cleaner than petroleum-based diesel and jet fuels, resulting in lower emissions of NO_x and harmful particulates. Distributed production systems, which make it possible to produce biofuels in small plants located near the source of the feedstocks and potential markets for the fuel, also reduce carbon emissions by avoiding the need to transport large volumes of waste to central processing facilities.

After winning a number of awards, the technology is now being put to test in the real world. The first practical demonstration of the use of FT microchannel reactors for BTL – jointly operated by the Oxford Catalysts Group and the Portuguese incorporated company SGC Energia (SGCE) – for the small scale distributed production of biofuels is now mechanically complete and undergoing start up at the biomass gasification facility in Güssing, Austria. The plant, which will use gasified woodchips from the existing Güssing gasifier, includes an FT microchannel reactor developed by Velocys, combined with a new highly active catalyst developed by the Oxford Catalysts Group.

Small Size – Big Performance

Microchannel process technology is a developing field of chemical processing that enables rapid reaction rates by minimizing heat and mass transport limitations, particularly in highly exothermic reactions, such as FT, or highly endothermic reactions, such as steam methane reforming (SMR).

This improved performance is achieved by reducing the dimensions of the reactor systems. In the FT microchannel reactors that lie at the heart of distributed BTL production systems, the key process steps are carried out reactor blocks that contain arrays of thousands of microchannels, each with diameters in the range of just 0.1–5 mm. In the reactors process channels filled with a highly active FT catalyst developed by Oxford Catalysts are interleaved with water-filled coolant channels.

The small channel diameter enables chemical reactions to be greatly intensified – the reactions occur at 10 to 1,000 times faster than in conventional systems – while still maintaining efficient and precise temperature control. This leads to higher throughput and conversion efficiencies. In contrast to conventional FT plants, where conversion rates of 60 % or less are common, FT microchannel reactors achieve conversion rates on the order of 70 %. The catalyst enables the reactors to achieve productivities that are orders of magnitude higher (defined as $kg/m^3/h$) for more conventional systems.

BTL Building Blocks

In contrast to conventional FT plants, which only work economically at capacities of 30,000 barrels per day (bpd) or higher, plants using small scale FT microchannel reactors are designed to produce 500–2,000 bpd of liquid fuels efficiently and cost-effectively. This is just one of the features that makes microchannel reactors particularly useful for distributed production systems.

Another is their small size–reactor assemblies are roughly 1.5 m in diameter – and modular construction. The entire FT microchannel demonstration plant for the Güssing demonstration is contained on a skid with a footprint just 20 feet long by 10 feet wide. The modular construction allows for greater flexibility in plant design and means that plant size can be increased by "numbering up," or simply adding more reactors. It also makes the plants more durable and easier to service because maintenance and catalyst replacement can be carried out by replacing individual modules, rather than requiring prolonged shutdown of the entire system.

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New Dimensions

Modern 3D Designs for Blister Packaging

Cutting Edge – The seemingly humble blister pack is the standard unit of primary pharmaceutical packaging in both Europe and most of the world. It is the critical means of ensuring the pharma dosage is protected against all potential degradents and is presented to the patient in the correct manner in compliance with their medication regime. It is, in fact, a sophisticated drug delivery system in its own right and has a number of critical functions to fulfil. Yet, even today the conventional standard in the blister packaging industry for the presentation of blister designs and drawings is a two-dimensional black and white format.

A number of years ago, Prodieco Pharmaceutical Components (PPC) challenged this standard by becoming the first company to introduce three-dimensional drawings and computer modelling to our customers to allow for greater detail and information to be conveyed to produce more consistent and sophisticated packs and to open up the design process to other often excluded key stakeholders in the package design process.

PPC chose the SolidWorks design system to bring the blister pack design into the 3D world, a standard design platform in many high tech and engineering based industries, yet almost unused in blister design.

The company initially used just one seat of this software for more complex pack designs but rapidly found that the advantages were just as strong for the conventional designs. Now all packs in PPC – irrespective of the product, company, machine and perceived level of complexity – are designed on a 3D platform as standard.

The company has followed up this change to a 3D format to its logical conclusion; now the blister tool design, machine programming and final tool verification are all carried out in full 3D as well, thus allowing for a closed loop, full 3D process.

PPC recently carried out an in-depth global voice of customer exercise to find out how the 3D blister designs were being received. Here is some of the feedback:

"We get an immediate understanding of how the finalized blister will look and more importantly how it will function."

"Less technical or even non-technical people are now able to input as appropriate to the design process. Marketing and supply chain often previously only inputted after the first blister was actually produced on the blister machine, which of course is too late."

"It speeds up communication both internally and between us and the tool manufacturer."

"We especially like the 3D animations of the packs, which allow us to explore functionally that was impossible before: child resistance, senior friendly, perforations, scoring, etc."

"Getting fully validated pocket geometry in 3D with our tooling is a huge help with our internal validation and verification procedures."

Rapid Prototyping

3D design was the first step in allowing the company to communicate with its clients in a 3D way. The next step was the introduction of a rapid prototyping service to allow PPC to further enhance the blister design for its customers. These prototype blisters have been a huge success ever since the very first meeting with a pharma company, where we actually brought rapid prototypes of their finished pack to the design discussion.

PPC now boasts its own rapid prototype machine in-house. Rapid prototyping can be defined as a group of techniques used to rapidly fabricate a scale model of a part or assembly using three dimensional computer aided design data. The company can now generate a rapid and fully colored prototype of a customer's finalized blister design using the 3D blister pack design. The use of rapid prototypes in the pack design process reduces the development time taken to get a new or modified pack to market; it also allows for multiple stakeholders to input. The list of advantages here is long: better overall design; optimized package functionality; increased operational efficiency; and increased product sales potential.

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