# Processing Waste with Microchannel Reactors

*A Pacific Northwest National Lab spinoff is looking to commercialize smaller-footprint chemical processors*

**By LAURA SILVA**

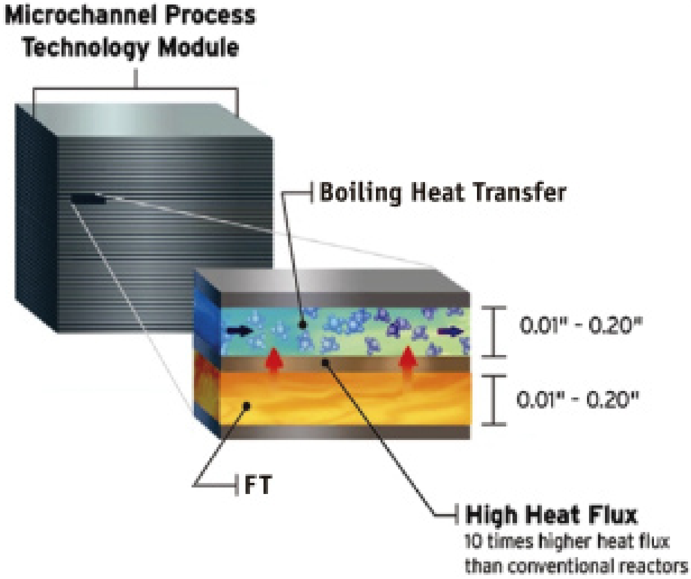
**BACK IN THE EARLY 1990S** when scientists and engineers at Pacific Northwest National Laboratory were considering ways to process nuclear waste left over from the Manhattan Project during World War II and stored in underground tanks sites scattered around Washington state, they came up with a big new concept for tackling the problem: distributed small-scale processing.

The idea made a lot of sense, says Ed Baker, director of the energy and efficiency division at PNNL. "Rather than transporting the waste to a large centralized facility, the idea was to develop small-scale machines that could be placed in tanks to process the waste *in situ*." Initial calculations coupled with proof-of-concept work funded by the Department of Energy suggested that the idea of using small-scale distributed processing to treat the nuclear waste was a good one. And work being carried out at the same time in the U.S. and Europe to develop ways to etch microchannels—small channels with gaps in the range of 0.1 to 10 mm—onto silicon chips suggested a promising way forward: the development of microchannel reactors to carry out advanced chemical processing.

Unfortunately, says Baker, "the idea of developing microchannel reactors to use for the distributed processing of nuclear waste never got any real traction. Instead, a multibillion dollar centralized facility to vitrify the waste in the tanks is currently under construction at Hanford, which is not very far from our labs at Richland." Win some, lose some. But the work on the microchannel reactors and the small-scale distributed processing concept was far from wasted.

Once the focus switched to chemical processing, the idea of microchannel reactors really began to take off. It soon caught the attention of a number of government and industrial clients, who, along with PNNL researchers, identified a wide range of applications where microchannel reactors could be potentially useful. To carry on with development, a new company, Velocys, based in Plain City near Columbus, Ohio, was spun out of PNNL and staffed with researchers from the lab along with specialists recruited from a variety of chemical, oil and manufacturing companies.

Now eight years on, Velocys continues to benefit from PNNL support to help it tackle the many challenges that still remain before microchannel reactor technology can be commercialized. An initial hurdle was to publish enough data and patent enough ideas to convince the skeptics in the chemical engineering community of the feasibility of such a radical new technology approach. Like the microelectronics technology that revolutionized the computer industry, microchannel technology shrinks processing hard-



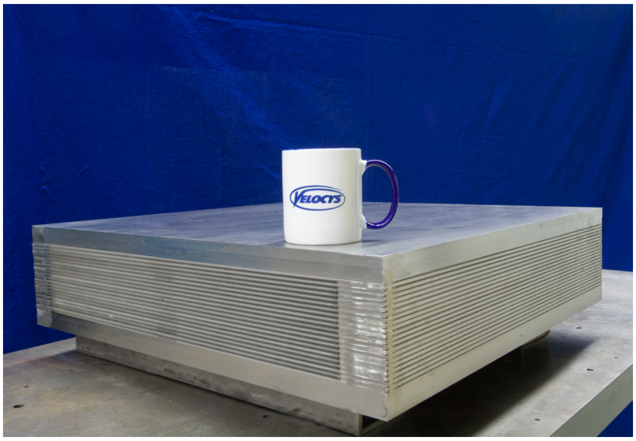


**Diagram (left) of a microchannel reactor. It consists of many hundreds of rows of microchannels each containing large numbers of parallel microchannels. The reactor (about 24x24x6 inches) is capable of producing 10 barrels per day of liquid biofuel.**

ware, while at the same time improving its performance. The secret of microchannel reactor success is down to the fact that it offers a way to reduce the size and cost of the chemical processing hardware while still enabling efficient and precise temperature control. This leads to higher throughput and conversion.

The basic building blocks of microchannel reactors consist of components with parallel microchannels. “The small size means that the capital costs associated with microchannel reactors are relatively low compared to conventional equipment,” says Terry Mazanec, chief scientist at Velocys. “There are other benefits, too. The smaller footprint of a microchannel reactor allows it to be sited where space is at a premium, on offshore oil platforms or in crowded refiners, for example. Their modular construction leads to lots of flexibility when designing plants.

Maintenance and catalyst replacement can be carried out by replacing individual modules, rather than requiring the prolonged shutdown of the entire system. And chemical plants based on microchannel reactors can be constructed in smaller increments to more closely match capacity to demand. This not only smoothes out the business cycle and saves on transport costs. It also makes it easier, cheaper and quicker to install additional capacity as needed.”

Because each reactor block has thousands of thin process channels filled with catalysts, which are interleaved with heat input or coolant channels, microchannel reactors are better able to overcome heat transfer and mass transfer barriers in chemical processes. Overcoming mass transfer barriers essentially makes it possible to speed up the time it takes for the product to emerge from the reactor, while the heat transfer capabilities mean that the reactors are able to handle heat issues more efficiently than conventional systems. As a result microchannel reactors are ideally suited for carrying out both highly exothermic—or heat generating—catalytic reactions in which the heat from the reaction must be dissipated, as well as highly endothermic, or heat-requiring, reactions.

Now that the microchannel reactor concept is more widely accepted, Velocys is continuing to address other issues. “One is the need to find and adapt the right catalysts for use in microchannels,” says Lee Tonkovich, vice president of technology and manufacturing development at Velocys. “Since Velocys became part of the United Kingdom-based Oxford Catalyst Group in 2008, we have been making great progress and are moving more quickly toward achieving this goal.”

Potential applications for microchannel reactors range from the production of commodity chemicals such as vinyl acetate, ethylene oxide, acrylic acid and acrylonitrile via selective partial oxidation reactions to steam methane reforming to produce hydrogen for use in fuel cells. However, the first application likely to come on stream is the distributed production of second generation biofuels from waste (BTL) via the FT reaction using microchannel reactors based in small scale plants located near sources of the waste feedstocks. “With the right catalyst optimized for use,” says Tonkovich, “small microchannel FT reactors can operate efficiently and economically when processing just 500 to 2,000 tons of waste per day.”

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