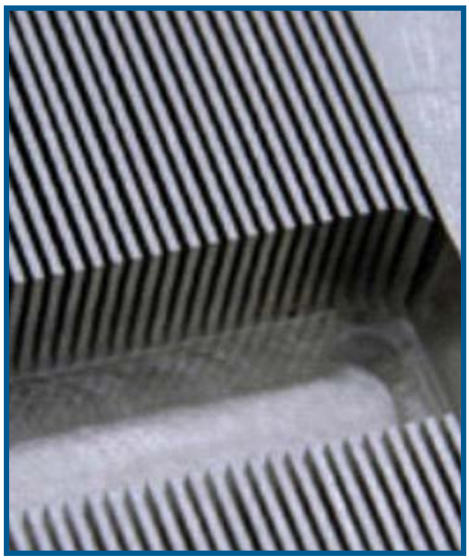
Heat Integrated Distillation through Use of Microchannel Technology

Microchannel Technology Enables Advanced Distillation Processes

Distillation consumes over ten percent of the entire manufacturing sector's energy use. The energy efficiency of a commercial distillation column is low with a typical thermal efficiency of less than ten percent. Distillation efficiency can be improved by using reboilers (heat exchangers) at multiple stages to improve heat transfer. However, the cost of adding such capital-intensive heat exchangers to conventional distillation towers typically outweighs any energy efficiency benefit. Microchannel process technology (MPT) promises an economical alternative to efficient distillation.



Microchannels reduce heat and mass transport distances, enabling reduced equilibrium stage height and integrated heat transfer for Velocys advanced distillation technology

MPT integrates heat transfer with fractionation, eliminating the need for external heat exchange equipment. Microchannels create precise heat loads, which can be tailored to individual distillation stage requirements. Heat load tailoring reduces wasted energy to improve overall distillation efficiency. Integrating heat transfer and fractionation requirements into a single device also reduces the distillation equipment size and costs for capital and operation.

Velocys, Inc., and ABB Lummus Global, Inc. (LGI) seek to design and develop MPT for advanced distillation in an ethylene plant. Ethylene is a building block for the chemical, plastic, and petrochemical industries. Heat exchangers and distillation columns comprise the majority of high energy-consuming equipment in ethylene manufacture. Integrating heat transfer and distillation systems in ethylene manufacture promises energy savings of 13 trillion Btu per year by 2020.

Benefits for Our Industry and Our Nation

Successful commercialization of advanced distillation with MPT technology will result in energy savings of 13 trillion Btu per year by 2020 in ethylene production alone. Emissions reductions for ethylene production will reach 3.2 million pounds per year NO_x, 1.7 million pounds per year SO_x, 0.7 million pounds per year CO, 70,000 pounds per year VOCs, and 33,400 pounds per year particulates. The technology will also yield significant capital and operating cost reductions.

Applications in Our Nation's Industry

Advanced distillation with MPT technology will find immediate application in the ethylene industry, specifically in the fractionation sections of ethylene plants.

Project Description

The goal of this project is to develop a breakthrough distillation process using Microchannel Process Technology (MPT) to integrate heat transfer and separation into a single unit operation. The project focuses on the application of MPT in a fractionation section of an ethylene plant, the C2 splitter. This advanced separation process is expected to provide both capital and operating cost savings compared to conventional distillation technology.

Barriers

Major barriers to be overcome include:

- Demonstrating liquid removal structures in single microchannels with integral heat transfer at varied and specified temperatures and loads to approach reversible distillation
- Designing a conceptual commercial-scale distillation MPT module that meets all product specifications
- Demonstrating commercial-scale MPT elements in a multi-channel test device

Pathways

The objectives of this project will be achieved through (1) selecting the demonstration process conditions that support flowsheets with reduced energy requirements, decreased compressor work, and high heat integration; (2) designing microchannel geometry and evaluating hardware performance with integrated heat management; (3) designing, building, and testing single-microchannel MPT devices that demonstrate the performance needed for a commercial-scale system; and (4) comparing the expected capital and operating costs of the high-intensity MPT ethylene fractionation process to conventional processes.

Progress and Milestones

- Design, fabricate, and test a microchannel experimental device (completed)
- Design and demonstrate a bench-scale microchannel separator
- Complete capital and operating cost estimate

Commercialization

The project team's combined experience and capability with ethylene plant design and construction, technology licensing, technology development, and MPT provides a foundation for development and commercialization. In the technology development phase of this project, Velocys will manage the project, perform computational modeling, design, build, and test the microhannel devices, and evaluate experimental results. LGI will perform material and energy balance simulations and process flowsheet studies, incorporate the Velocys MPT technology within the fractionation sections of an olefins plant, generate capital and operating cost estimates for a typical large-scale olefins plant, analyze MPT performance in the ethylene splitter, and determine if other fractionators will be impacted by implementing MPT. For commercialization, LGI will provide access to the ethylene market through its leading position in ethylene technology. Velocys' MPT systems, operational know-how, and process licenses will be offered through LGI to ethylene producers as part of ethylene plant engineering and construction contracts for new plants, as well as expansion and debottlenecking projects. The project team's commercialization strategy will also build on previous successes in other MPT commercialization programs, as well as LGI's history in commercially implementing first-of-a-kind process technologies.

Project Partners

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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