Microchannels—Short History and Bright Future
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editorial

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It gives me great pleasure in presenting this special issue of Heat Transfer Engineering on Microchannels in our continued efforts to keep abreast of new technologies.

Increasing heat transfer rates for a given heat exchanger volume has long been a quest of thermal designers. Some of the approaches developed over the past several decades include the incorporation of high-density fins, compact plate fin surfaces, and microfin tubes in single phase and two-phase applications. Recent developments in electronic and integrated circuit technology created a need for higher heat dissipation rates in small component sizes, such as today’s high-performance IC chips.

Reducing passage hydraulic diameters provides a larger surface area per unit volume of heat exchangers for a given mass flux of fluid flowing through the channel. However, making dimensions on the order of micrometers, as in microchannels, introduces a number of challenging issues—increased pressure drop, fouling, complexity in manifold design, and flow instabilities. At the same time, the manufacturing issues also pose some serious challenges.

As a thermal researcher, many of us are pursuing studies to establish the thermohydraulic performance of microchannels under single phase, flow boiling, and flow condensation conditions. The proliferation of microchannels into commercial products, however, faces an uncertain future. The basic issues that need to be addressed are cost-effective manufacturing processes, reliable operation, and availability of accurate thermal and hydraulic performance characteristics for given fluid flow conditions. With the need to operate under an extremely clean, nonfouling environment, microchannel usage is restricted to closed loop systems employing clean fluids, such as nonreacting gases, or liquids, such as refrigerants.

The start of microchannel history may be linked to the pioneering work of Tuckerman and Pease [1] over two decades ago—a very short time from a historical perspective. It is exciting to realize that we are actively shaping history through the research being conducted at almost every major thermal research center in universities and industries. The technological movement toward micro- and nano-dimensions leaves no doubt in our minds on the important role microchannels will play in tomorrow’s products of innovative technology. Additional new application frontiers include fuel cells—individual cells, stacks, reformers and auxiliary heat exchangers, and biomedical applications.
This issue of Heat Transfer Engineering journal is dedicated to microchannel-related papers from authors who have extensive experience working in this field. The first paper, authored by Kandlikar and Grande, is intended to serve as a historical roadmap of thermo-hydraulic performance and fabrication technology. A comprehensive coverage of our current understanding of thermal performance, especially in single-phase and flow boiling applications, is featured. It is also believed to be the first article of its kind covering the fabrication processes for producing microchannels. The channel size classification has also been looked at from a molecular perspective.

The second paper, by Bergles, Lienhard, Kendall, and Griffith, provides an excellent overview of different thermal issues associated with microchannels, including a discussion on critical heat flux. With its broad and in-depth coverage, it should serve as a must-read article for all researchers, particularly the new researchers entering the field.

The phase change application is being looked at very seriously in a number of research laboratories. The third article in this issue, by Nino, Hrnjak, and Newell, provides an excellent coverage of the pressure drop aspects of two-phase flow in microchannels. Finally, the article by Murakami and Mikic clearly brings out the design and optimization issues associated with microchannels.

There are a number of issues related to microchannels that still need to be addressed, including single-phase gas flow under noncontinuum flow conditions, two-phase flow structure modeling, local heat transfer and pressure drop data under boiling and condensing conditions, and flow visualization. It is hoped that these topics will be covered in the second special issue of Heat Transfer Engineering focusing on microchannels. In an effort to improve our offering, I would like to personally encourage the readers to provide me with any feedback to make this endeavor more useful to the heat transfer community.

REFERENCE


Satish Kandlikar has been a professor in the Mechanical Engineering Department at RIT for the last twenty-two years. He received his Ph.D. from the Indian Institute of Technology in Bombay in 1975 and has been a faculty member there before coming to RIT in 1980. His research is mainly focused in the area of flow boiling. After investigating the flow boiling phenomenon from an empirical standpoint, which resulted in widely accepted correlations for different geometries, he started to look at the problem from a fundamental perspective. Using high-speed photography techniques, he demonstrated that small bubbles are released at a high frequency under flow conditions. He is also working in the areas of binary flow boiling and bubble formation in inkjet printing application. He has given a number of invited and keynote talks nationally and internationally.