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Book Review

Yarin, L.P., Mosyak, A., Hetsroni, G. Fluid Flow, Heat Transfer and Boiling in Micro-Channels, 2009, XIV, 481 pp., 262 illus., hard-cover, ISBN: 978-3-540-78754-9, $ 209.

The distinguished authors of this monograph discuss many aspects of flow and heat transfer in single channels and networks of channels. The focus is on experimental systems where the channel size is a few millimeters or smaller and the authors draw together many aspects of the recent literature. The book opens with a chapter surveying high-power electronics, which motivates much of the interest in heat transfer in small channels. Subsequent chapters in Part I of the book are organized around distinct themes, and include discussion of single-phase flow and heat transfer, two-phase flow, and boiling. The majority of the presentation consists of brief summaries of many different research papers in the open literature, which is then followed by a summary of the main ideas. A final chapter in Part I gives some guidelines for design. Part II, which consists of four chapters, treats several topics, with focus on configurations with a single distinct meniscus or interface, and where a combined flow and energy analysis is possible.

A significant feature of the book is the large number of references, which number about 700. The references will be a significant resource for researchers interested in the topics covered by the book. In addition, the organization of each chapter makes it relatively easy to locate a topic of interest. Many figures from papers in the literature are reproduced in the book, which is useful for sharing observations, measurements, the progression of ideas, etc. The specifics are sometimes marred by the unevenness of clarity of some of these figures, which may simply be a consequence of printing the figures too small and not re-typesetting the lettering.

As a strategy for presenting much of the recent literature that focuses on flow and heat transfer in micron-scale channels, the authors made a choice to systematically present results in the literature, with regular commentary comparing one study with another. Generally, an overview is given afterwards. This kind of survey has value of course, but makes it difficult sometimes to see the "forest from the trees". For example, in Chapter 3 there are long sections detailing measurements reported in the literature on the friction factor as a function of Reynolds number and the laminar to turbulent flow transition in small channels. The reader has to wait until the end of the chapter summary to learn that the basic facts reported on these topics in our present undergraduate and graduate textbooks are still valid and applicable. A similar comment applies to the presentation of the heat transfer results. I would have preferred a strong and clear statement on the universal applicability of the basic results, basically on the grounds of dimensional analysis, and independent of the channel dimensions, unless a separate physical effect interferes with the flow. The fact that there has been some variability introduced in the literature on laminar flow in channels, which has generated some confusion, is at least in part due to the strong dependence of the geometric dimensions (e.g. the fourth power of radius for a circular tube) in the pressure drop versus flow rate relation; thus small geometric uncertainties, flow blockages, etc., which are likely more probable as the scale of the flow is reduced, lead to large deviations from classical results. Nevertheless, the authors generally make clear how to think about the problem and they clarify much of the confusion that has entered the field through the use of channel size, rather than dimensionless numbers characteristic of the transport process, for characterizing the flow and heat transfer.

In some places the book makes effective use of dimensional analysis, while in other it does not. In part, the uneven use of dimensional analysis in the book is likely due to the large number of dimensionless parameters needed to properly characterize heat transfer in two-phase flows, and the fact that so many papers in the literature do not report results in this manner. On the other hand, extracting useful information from specific experimental arrangements (e.g. the extensive literature summarized in the book), and using such results in design, demand nondimensional characterization of the flow and heat transfer.

In summary, this book is a valuable contribution to the literature on heat transfer and single and two-phase flow in small channels. The book is nicely put together and largely free of typographical errors. In some parts of the presentation a synthesis has been achieved, while in all cases a very useful list of relevant publications has been provided. All readers will gain something from spending time with this book. In addition, the authors have succeeded in producing a monograph that should motivate new research in the field.

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