International Journal of Heat and Mass Transfer 51 (2008) 5475–5476

Contents lists available at ScienceDirect

International Journal of Heat and Mass Transfer

journal homepage: www.elsevier.com/locate/ijhmt

Book Review

Handbook of Experimental Fluid Mechanics, C. Tropea, A.L. Yarin, J.F. Foss (Eds.), Springer (2007). XXVIII, 1557 pp., 1240 illustrations, in color, DVD-ROM with full contents, ISBN: 978-3-540-25141-5.

In 2007, the *Handbook of Experimental Fluid Mechanics* has appeared as a new volume in the Springer Handbook Series, which so far has addressed nanotechnology, speech processing and communication, robotics, automation, and numerous other fields. This new handbook with a total of 1585 pages (including all indices) at the first look already promises a large quantity of substance and information, similar to the other volumes of the series. In a sense it could be seen as a complement to the *Handbook of Computational Fluid Mechanics*, edited by Roger Peyret and first published 1996 by Academic Press in London. Browsing the book, we see that the reality of this milestone in the literature of fluid mechanics is even far more than what one would expect from its title and size.

The editors Cam Tropea, Alex Yarin, and John Foss have undertaken the enormous effort to bring together and coordinate 94 expert authors (including themselves) from numerous fields in fluid mechanics (and transport phenomena in general), as well as from computer science, yielding one of the largest knowledge bases in the field that has ever been compiled into one volume. The aim was to produce a handbook. What is a handbook? Handbooks are reference works for daily use by two main groups of people: on the one hand by experienced scientists, and by engineers or physicists working in research and development, both in academia and industries. And, on the other hand, by students who are performing their first laboratory studies in the field of fluid mechanics. It is safe to say that, due to the breadth and depth, this book serves both groups excellently.

The fields of fluid mechanics covered by the book are restricted to single-phase flows of pure fluids – with the exception of everything said about surface tension and contact angles, and except for the section about diffusion, which inherently involve at least two phases or mixtures, respectively. Everybody familiar with the field will understand that this can be considered restrictive, or perhaps also not. The first is true, since the field of multiphase flows adds numerous further subjects not found in single-phase flows, but the second is also true, since the fields covered by the book reveal the large body of material pertinent to single-phase flows alone.

The book as a whole consists of four parts – A through D – which treat experiments in fluid mechanics, the measurement of primary quantities, specific experimental environments and techniques, and analysis and post-processing of data. A walk through this structure readily reveals that it is a perfect image of what we usually do when turning to work on an experimental problem in fluid mechanics: we design an experiment, considering the theoretical basics of the process, select proper techniques for measuring the relevant properties of fluids and/or flow fields, with accounting especially for the peculiarities of the flow type (e.g., geophysical, aerodynamic, non-Newtonian, or combustion), and then analyze the measurement data acquired – before possibly repeating some of the experiments. So what the book does, apart from presenting detailed and broad information about the various aspects of experimental work, is to also guide the user along the path of the experiment (and to lead the beginner through the jungle of experimental and data analysis techniques).

In this review I would like to attempt to convey some impression about the book to the reader and inspect selected sections from chapters of all four parts of the book. The section in Part A about the non-dimensional representation of the boundary-value problem of an experiment is a direct link to the experiment under the aspect of similarity with characteristic numbers. We look into the section about self-similarity of flows and heat transfer processes. The section first names causes of self-similarity in fluid mechanics and heat transfer, presents implications in experimental studies, and then goes through particular examples of self-similar Navier–Stokes flows, boundary-layer flows, strong explosions in gas dynamics, and free-surface flows. What is remarkable here is that, in contrast to many textbooks on fluid mechanics, clear criteria for the potential of a flow problem to exhibit self-similarity are given, rather than just calling it "convenient" to introduce a similarity coordinate to reduce the PDE governing the problem to an ODE. The text presented in this section may even readily serve as a guideline for a lecture in the related field – just as the entire Part A of the book, which may be taken as a very good introductory lecture in transport phenomena. Further, it may be the first time that such a large base of solutions of self-similar ODEs of selected flow and heat transfer problems were compiled, as it was done in the tables of this section. The collection of these solutions will help the experienced user to avoid repeating theoretical work that has already been done by others. This section is an excellent example of the condensed and well-written presentations of this book, providing a wide overview together with in-depth views on the various subjects.

Part B is dedicated to the measurement of primary quantities. We look into the section about viscometry, which discusses techniques for measuring the dynamic viscosity of Newtonian fluids. The section discusses five different classes of viscometers, oscillating-body, vibrating, torsional-crystal, capillary, and falling-body viscometers. Each part describes the working principles of the instruments and the essential equations determining the measured quantity. What is of particular value is the evaluation of characteristics of the instruments, such as accuracy of the measurements, fields of application (e.g., suitability of the instrument for measuring gas or liquid viscosities) and convenience in use. This section, such as others discussing measurements of primary quantities, is of high value for considerations at the beginning of an experimental study to select the proper measurement technique. Instrument costs, which may also play a role, are not addressed in the handbook, which is reasonable, since prices are not absolute nor invariable quantities. The end of the section consists of a series of tables of dynamic viscosities of some organic liq-

doi:10.1016/j.ijheatmasstransfer.2008.05.008

uids and some gases, which complement the information presented in this section in a very handbook-like manner.

In Part C we find a rich and relevant selection of experimental situations, and of techniques for their investigation. The situations presented and discussed range from non-Newtonian and turbulent flows to aerodynamic and geophysical flows. The techniques covered range from flow visualization and measurements of turbulent flows to combustion diagnostics. We look into the section about ground vehicle aerodynamics in the chapter on aerodynamics. Aerodynamic development in engineering may be considered as a strongly empiricism-driven field of experimental fluid mechanics. Consequently, this section contains practically no equations, but describes all aspects of experimental investigations on vehicle aerodynamics with wind tunnels. The discussion starts from the basics of experimentally simulating the physical situation of a car moving through air on a road or track, addresses details of wind tunnels for ground vehicle (i.e., car and train) testing, and details aspects of the wind tunnel design and their relevance, among many others, for the costs of a measuring campaign. Equipment for automotive wind tunnels is discussed as well as limitations in simulating the real flow around a moving vehicle by a wind tunnel test with the vehicle standing still in the test section. Measurement techniques to be applied depend on the purposes of the test (e.g., HVAC, performance, or soiling tests). Ending with a short discussion about accompanying wind tunnel tests by CFD simulations, the authors have covered the entire set of questions posed when setting up a wind-tunnel experiment – exactly what one expects from a handbook.

The final Part D of the book about data analysis and post-processing is usually also the final step of the experimental work, which the experienced experimenter considers already when designing the experiment. Here we find discussions about the most important techniques of data processing as well as data analysis from image processing. We inspect the section about motion analysis. This section presents important techniques used to obtain velocity information from images of the flow field. Techniques like PIV and PTV are discussed in the context of the image processing techniques typically in use, which are correlation and least-squares matching techniques. Tracking techniques are set into contrast with standard PIV in terms of achievable accuracy of individual velocities. Optical-flow-based velocity analysis is presented as based on the movement of brightness patterns in the images and laid out in terms of techniques for improvements of determining optical flow.

The material presented in this handbook is accompanied by lists of in total over 4300 references to up-to-date literature and suggestions for further reading. Given the depth of the discussions in the book, a beginner in a field of experimental fluid mechanics may find the text itself to be sufficient, but the references offer further details for the more experienced reader. All this is accompanied by a DVD-ROM with the full contents of the book and a large set of reference data tables, which may be regarded as an indispensable and particularly valuable part of any handbook.

In their foreword, the editors assume that there may be misprints in the book. The editors are right, but their number found by this reviewer so far is remarkably low. The book is in a very good state already in this first edition. Certainly there is potential for improvements further to the pure editorial misprints: perhaps these will find their way into future editions. In summary, the community of fluid mechanics today has in their hands a highly valuable and important new book, which is a major reference in our science and will soon become a standard reference.

Günter Brenn
Graz University of Technology,
Institute of Fluid Mechanics and Heat Transfer,
Inffeldgasse 25/F,
8010 Graz,
Austria
Tel.: +43 316 873 7341; fax: +43 316 873 7356.
E-mail address: brenn@fluidmech.tu-graz.ac.at