BOOK REVIEWS

Flow Visualization V
Edited by R. Řezníček
Hemisphere Publishing, New York, © 1990, 1052 pp., $9.95 (US and Canada)

The International Symposium on Flow Visualization has been one of the most popular conference series within the international fluid mechanics community since it was founded in 1977. The Fifth in this series was held in Prague, Czechoslovakia in August 1989 and the proceedings are published in *Flow Visualization V*. This volume was edited by R. Řezníček and is similar to the previous four proceedings, Flow Visualization I–IV, because it chronicles the advances in techniques and computer aided methods and presents a considerable collection of flow visualization applications.

Of the approximately 150 papers included in the volume, about one third specifically discuss visualization methods and computer techniques, and the remaining papers elaborate on the broad spectrum of applications of flow visualization. In the methods section, contributions from Soviet researchers abound and primarily exploit the effects of streaming fluid on passing radiation/field. Over half of the computer aided flow visualization section is from Japanese authors who detail several microcomputer based digital image processing systems. The main body of the Flow Visualization V volume consists of papers describing applications of flow visualization techniques in the extensive array of fluid mechanics interests, including aerodynamics, external and internal flows, engines, heat and mass transfer, and atmospheric, oceanographic and chemical engineering. The variety of contributions from Japan, the United States, the Soviet Union, Czechoslovakia, Germany, France, the United Kingdom and others make the publication a relatively well balanced selection of applications.

The book presents a wealth of recent information on what people are doing and which techniques are continuing to evolve. The trend toward qualitative results generated by computer based imaging systems is evident and it appears that the Japanese are spear-heading this effort with several promising approaches. The book is highly recommended for libraries and researchers who frequently make use of visualization methods.

Mark C. Schmidt

The Kinetics of Mixing: Stretching, Chaos and Transport
J. M. Ottino
Cambridge University Press, 1989, 364 pp.

This book is one of the series Cambridge Texts in Applied Mathematics. The series mainly aims to provide textbooks at the advanced undergraduate and beginning graduate level for students of applied mathematics, engineering science, engineering or physics. Authors are encouraged to provide plenty of worked examples and exercises and to give as a high priority a clear and careful exposition and a sound pedagogic presentation of the mathematical techniques and theories relevant to the topic in question. To me, it appears that this book on the kinetics of mixing sets out to achieve those aims and in most respects clearly does so. However, the level of mathematics involved appears to be significantly higher than suggested, judging by my knowledge of undergraduate and postgraduate students of chemical engineering that I have acquainted over many years. Indeed it appears that for most industrial engineers, the mathematical level is beyond them.

A detailed analysis of the contents of the book clearly shows these aims. Whilst Chapter 1 sets the scene as an introduction, Chapter 2 gives the basic kinematical foundation of fluid mechanics and is entitled "Flow, Trajectories and Deformation." Chapter 3 extends this basic material and covers conservation equations, change of frame and vorticity whilst Chapter 4 starts to relate this foundation material to mixing. It is entitled "Computation of Stretching and Elongation" and essentially defines mixing in these terms alongside folding of material elements. Certain idealized, mainly two-dimensional flows, e.g., constant stretch history motions and steady curvilineal flows are analyzed in terms of the rigorously defined mathematical definitions of mixing based on stretching and elongation. The importance of material reorientation during the mixing process, if mixing is to be efficient, is also brought out. The chapter also shows that whilst steady two-dimensional flows are good for understanding and developing ideas, they do not give a good indication of what happens in three-dimensional and unsteady flows as found in real mixers.

Chapter 5 is another background chapter, introducing the reader to the fashionable concept of chaos in dynamical systems. This introduction covers fixed and periodic points, invariant manifolds associated with hyperbolic points and various signatures of chaos, such as homoclinic points and horseshoe maps. This chapter contains many difficult, and for me rather new, features. It does not explain them as well as I hoped, in spite of recently having read the best seller, *Chaos*, by James Gleick.

Chapter 6 continues the exploration and analysis of chaos, covering chaos in Hamiltonian systems. As with all chapters up to this point except Chapter 1, this chapter is essentially a further mathematical development to enable mixing itself to be analyzed. These developments occupy the first 150 pages and to this should be added the 20-page appendix on Cartesian vectors and tensors to properly appreciate the care taken in setting the sound pedagogic presentation that is the aim of the series.

Chapter 7 is entitled "Mixing and Chaos in Two-Dimensional Time-Periodic Flows." Making use of Chapters 2 through 6, it considers two idealized flows that admit analytical treatment, namely the tendril-whorl flow and the blinking vortex flow and two flows capable of experimental simulation, namely the journal-bearing flow and cavity flow. The latter somewhat simulates flow inside a screw extruder and although extremely idealized experimentally, there is stated to be no analytical solution of the velocity field. For the journal-bearing flow, some excellent pictures of Poincaré map sections from color-coded computer printouts can be compared with experimental photographs obtained by visualization of the flow using glycerine and fluorescent dye.

Chapters 8 and 9 consider the most realistic problems. Chapter 8 is entitled "Mixing and Chaos in Three-Dimensional and Open Flow" and Chapter 9 is entitled "Epilogue: Diffusion and Reaction in Lamellar Structures and Microstructures in Chaotic Flows." By Chapter 8, two three-dimensional flows are treated under creeping flow conditions. Of these, one, the partitioned pipe-mixer, is periodic in space and is compared to the Kenics static mixer; the other is the eccentric helical annular mixer (or the journal-bearing flow with a superimposed throughflow), which is time-periodic. This superposition of periodicity greatly enhances mixing (stretching and area generation). Finally, three