Book Review

Studies in Heat Transfer: A Festschrift for E. R. G. Eckert. Edited by J. P. Hartnett, T. F. Irvine, Jr., E. Pfender, and E. M. Sparrow. McGraw-Hill Book Company, New York (1979). 516 pp. $45.00.

This volume is a collection of invited papers assembled in recognition of Professor E. R. G. Eckert's seventy-fifth birthday. There are 30 papers, whose subjects can be divided into the following broad categories:

1. boundary layers and external flows
2. natural convection
3. internal flows
4. solar energy
5. conduction
6. boiling and two-phase flow.

At first glance, one is struck by the broad scope of subject matter that is presented, and questions whether there is a unifying thread that pervades the material. The answer lies not in the topics covered, but rather in the quality of the contributions. Clearly these international authors are eminent researchers in the field of heat transfer, even though the list is by no means complete. Each paper is understandably narrow in scope because it reports on a specific area of heat transfer research. However, many of the papers are broadened by addressing the fundamentals of the subject and hence contribute a sense of permanence. These contributions give the volume a textbook flavor.

The first 12 papers are concerned with boundary layers and external flows. The first paper presents experimental and analytical results for several turbine blade cooling configurations; however, the real value of this paper is contained in the author's recommendations for future research in this area. In particular, improved fabrication techniques make possible more complex shaped cooling passages providing design flexibility. Advancements in aeroengines can be incorporated into stationary gas turbine designs since high-temperature gas turbines make Brayton cycles more attractive than Rankine cycle systems for electric power generation. It was appropriate to begin this volume with this subject, to which Eckert has devoted much effort.

The next two papers are concerned with flow in the vicinity of a wall with mass injection. One of the papers is experimental and characterizes the flow under various gas dynamic and thermophysical conditions. It contains both previously reported and new results. The other paper presents a mathematical model for lateral injection through a single hole on the premise that this is a fundamental building block for analysis of more complex configurations.

There are two notable papers in this group. One discusses discrepancies in the heat, mass, and momentum transfer analogy for evaporating flows. When the mechanisms are coupled, corrections are required that account for interdiffusion. The Ackermann correction and others are discussed. An excellent discussion of the stability of laminar boundary layers is contained in the other paper, where the stability of wedge flows with power law surface temperature distributions are presented.

Also in this first group are two papers describing experimental techniques. One paper describes measurements of streamwise vortex patterns around cones by inducing striations in fresh paint applied to the conical surface. The second paper studies large eddy structures in turbulent shear flow using smoke-wire and hydrogen bubble techniques. In addition, thin wafers of liquid crystals attached to the wall record the temperature distribution. Since flow visualization techniques utilize the Lagrangian reference frame, they are useful in studying the basic structures of turbulent flows.

Other papers in this group discuss heat transfer in an axisymmetric, confined jet, in the anode region of high-intensity arcs, and in the compressible turbulent boundary layer. The latter is at high free-stream-to-wall temperature ratios and uses integral techniques. Papers on rotating flows and turbulence in the atmospheric boundary layer are also included in this group.

There are five papers dealing with natural convection. Two of the papers are concerned with phase change. In one the potential difference is temperature; in the second it is concentration. The convection in a rotating annulus is analyzed in a third paper, where the device being analyzed is actually a rotating heat pipe and is a welcome addition to this field. An excellent piece of experimental work on free convection heat transfer in the subcritical region is the subject of a fourth paper. Since the behavior of physical properties near the critical point presents difficulties in heat transfer correlations, which are traditionally based on the film temperature, this paper addresses an often neglected topic. The final paper in this group is an experimental investigation of natural convection from vertical plates with a semicircular leading edge.

The first of four papers on internal flows organizes in a clear and concise manner heat transfer data on internally roughened tubes for comparison with smooth tube data. Fabrication costs are low and specific performance is increased. An outstanding paper in this group is contributed by E. M. Sparrow, reporting on heat transfer in complex duct flows. It describes recent experiments at the heat transfer laboratory of the University of Minnesota, and is a good survey article. The last two papers in this group are concerned with viscoelastic fluids. By adding small quantities of certain long-chain polymers, the pressure drop of the bulk fluid in pipe flow can be reduced. Degradation of the fluid properties in these systems is a problem, and is the subject of one of the papers. The other is an experimental investigation of the pressure drop in triangular ducts, where advantage is taken of the enhancement of the laminar sublayer.

Of the three papers on the topic of solar energy, one is a comprehensive discussion of the thermodynamics of solar collection. This is one of the best discussions of the topic I have seen, and is of general interest in view of the recent stimulus for effective energy utilization. A thermal analysis of a solar tower receiver is the topic of a second paper, and a hybrid system composed of a solar collector and heat pump is discussed in the third.

The subject of conduction is discussed in three papers. One reports on the conductivity of lunar soil from Apollo 15 data, while another discusses the role of radiation in the conductivity of fibrous insulations. The third paper is an outstanding contribution. The author exploits the similarity between duct flows and unsteady heat conduction. He applies this technique to unsteady conduction in slabs, cylinders, and spheres, and indicates how existing duct flow solutions can be applied to other geometries.

Three papers on boiling and two-phase flow conclude the volume. A Russian contribution discusses augmentation of heat transfer coefficients in single and two-phase flow heat exchangers, in boilers, and in condensers. Specific recommendations are made and the paper is a good review of Russian research in this area. A systematic study of heat transfer between horizontal layers of boiling water and floating hydrocarbons is discussed in a second paper. These results have application to cryogenic hydrocarbon spills on water, loss-of-coolant accidents in nuclear reactors, and in salt water conversion systems. The final paper is the most novel in the collection. It describes the operation of a heat pipe or reflux boiler with a condensation trap. The operation of this system is analogous to that of a triode. Whereas the variable conductance heat pipe controls the thermal conductance, this system allows proportional temperature control. A major disadvantage of this system, however, is a nonuniform source temperature caused by the partial dryout of the evaporator.

This festschrift is a powerful collection of treatises covering a broad range of topics in heat transfer research and a fitting tribute to a man who himself has contributed much to this science. Because of its broad scope, only a few of the papers will be directly applicable to any one area of research, however, the large number of in-depth contributions spread throughout the volume increases its utility making it a valuable addition to any heat transfer specialists' library.

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About the Reviewer: Coyne Prenger is a staff member in the advanced heat transfer and reactor safety group at the Los Alamos Scientific Laboratory, where he is engaged in basic heat pipe research. Before joining the staff at Los Alamos, he spent ten years working in the aerospace industry at Martin Marietta, McDonnell Douglas, and the Applied Physics Laboratory. Dr. Prenger received his education at Colorado State University, where he did research on natural convection and chemical thermal storage systems.