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CONCLUSION

The results of this study show that the logarithmic mean of the difference between average bulk temperature and wall temperature can be used in the calculations of average Nusselt number or average heat transfer coefficient. The average bulk temperature at the exit is given in Equation (1.44). When $a = 0.5$, the average bulk temperature can be calculated by Equation (4.5).

Figure 5 shows the relationship between the Nusselt number and Graetz number. From both theoretical and approximate solutions the following equation was derived:

$$\frac{h_M D}{\lambda} = 1.75\left\{\left(\frac{WC_p}{\lambda l}\right)\left(\frac{1-a}{4a\alpha}\right)\right\}$$

when

$$\{(WC_p/\lambda l)\cdot(1-a)/(4a\alpha)\} > 100$$

When wall temperature changes linearly along the y axis and velocity distribution is rodlike flow, the logarithmic mean can be used as the average-temperature difference. It is assumed that the logarithmic mean can be used even in the case of laminar flow, where the velocity distribution is not the same as it is in rodlike flow.

BOOKS

Viscous Flow Theory I, Laminar Flow, Shih-I Pai, D. Van Nostrand Company, Inc. 384 pages.

The development of aircraft and missiles which travel at velocities in excess of the velocity of sound has necessitated much new research in the hydrodynamics of compressible fluids. For though it is possible to neglect the compressibility of air at low speeds (circa 200 miles per hour), this is not possible at higher speeds. The book under review is concerned with the laminar flow of viscous, compressible fluids with special attention to aerodynamics. Three major topics are discussed: (a) the classical hydrodynamic theory of fluids, including some elementary kinetic theory of gases; (b) generalizations derivable from the theory without explicit solution of the differential equations, such as similarity and dimensional analysis and general properties of the Navier-Stokes equation; and (c) boundary layer theory. The latter is by far the largest section, occupying some 216 pages. Considerable detail is given, and numerous tables of useful data are included in the text. Turbulent flow is treated in part II of this work.

This reviewer feels that the major omission from the text is a discussion of the properties of gases at extremely low pressures. Under circumstances prevailing in the upper atmosphere the mean free path of a molecule may easily be of the order of magnitude of the dimensions of the flying object. Under these conditions the relative

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variation of macroscopic quantities over a mean free path is not negligible. For the limiting case of the Knudsen gas there are striking differences with phenomena under moderate pressures. For instance in Couette flow the force does not depend upon the velocity gradient but rather on the velocity difference; the force depends linearly on the pressure, etc. The transition region between ordinary gas pressures and those for which Knudsen behaviour subsists has been the subject of several studies recently. As anticipated the results differ from those of classical hydrodynamics.

Despite this omission *Viscous Flow Theory* by Shih-I Pai is to be recommended to engineers and advanced students interested in the hydrodynamics of viscous compressible flow.

STUART A. RICE

Ion Exchange Resins, by Robert Kunin, John Wiley & Sons, Inc. 466 pages.

One of the first books on ion exchange, *Ion Exchange Resins* by Kunin and Myers, has been revised and doubled in length by Dr. Kunin. In the years since the first edition appeared, other books have been published which cover some portions of its subject more intensively. Still this volume is unique in its comprehensiveness.

The title of this book is not indicative of the range of its contents. A few chapters are devoted to the characteristics of anion and cation exchange resins and the synthesis of resins. A greater portion of the work deals with the technological aspects of specific applications of ion exchange.

Because the book is so broad in its coverage one cannot expect to find depth in all areas. Engineers interested in ion exchange rate theory or the principles of fixed bed will be disappointed by the treatment of these topics. On the other hand those concerned with the operation of commercial ion-exchange equipment will find one of the new chapters, "Stability of ion exchange resins," especially valuable because it brings together much information which hitherto was available only piece-meal in service literature from the manufacturers of resins.

Some of the topics treated are highly specialized, so it is unlikely that any one reader will be interested in the entire book. This applies particularly to some of the new chapters on the treatment of sugar and glycerine, hydrometallurgic applications, water softening, and catalysis with ion exchange resins. There is also a chapter covering the subject of permselective membranes from electrochemical theory to the economics of the treatment of waste pickle liquor which uses membrane cells.

There are unfortunately a number of incorrectly listed references, and in one case there is discussion of a figure which does not appear. When one considers that over a thousand references are listed, these few mistakes do not seriously impair its usefulness.

This book will be a well-used reference in the library of any company in the process industries. It provides an excellent starting point for any reading on ion exchange.

W. A. SELKE