Int. J. Heat Mass Transfer. Vol. 20, pp. 1429–1432. Pergamon Press 1977. Printed in Great Britain

BOOK REVIEWS

Selected Papers on Chemical Science, edited by D. W. Van Krevelens, Elsevier, Oxford (1976). 385 pp.

This valedictory volume, which derives from Dr D. W. Van Krevelen's long association with the Fuel and Polymer industries, marks the end of some forty years as an active researcher. It contains reprints of thirty papers in the field of Chemical Engineering Science covering Gas Absorption, the Drying of Solids, Bubble Formation in Liquids, Fluidization, Chemical Reaction Engineering and Specific Chemical Reaction Processes. Considerations of space make it possible here to mention only a few aspects of this wide range of subjects.

After graduating at Leiden and Delft Universities, Dr Van Krevelen began his industrial career as a research chemist in the Dutch State Mines, becoming Head of the Department of Chemical Engineering in 1943 and Director of Research in 1948. Later, in 1959, he was appointed Vice President of AKZO where polymeric substances played an important role in the extentsion of his interests.

It was during the early part of his career that he became one of a distinguished group of young chemical engineers who broke away from the original concept of Unit Operations which had long dominated chemical engineering teaching, and laid the foundations for a chemical engineering science based upon the fundamental principles of classical physics and physical chemistry. In this work he had the advantage of day-to-day contact with the problems of large scale operations; a circumstance which is evident by the link between theory and practice to be found in all his researches.

Gas absorption. Until recent years, in Europe, domestic and industrial gases were produced almost entirely from coal and coke; and one of the important stages in the manufacture was the removal of gaseous impurities such as ammonia, hydrogen sulphide, carbon dioxide and carbon monoxide by scrubbing with solvents of various kinds. To the improvement of the efficiency of industrial scrubbers, Dr Van Krevelen made many significant contributions. In a group of seven papers included in this volume he demonstrated *inter alia* that, when a gaseous component is absorbed by a liquid, with simultaneous reaction with a component of the liquid, the overall rate of reaction can be expressed as a dimensionless function of the maximum rate of diffusion of the liquid component through the liquid film, the limiting rate of reaction with the liquid film and the maximum rate of reaction with the main body of liquid. A graphical representation of the theoretical relationship enables a prediction to be made of the overall rate of interphase mass exchange as soon as reaction velocity and mass-transfer coefficients are available; this prediction was later verified by experimental data on the absorption of carbon dioxide in alkali and ammoniacal solutions.

Since mass transfer is the essential element in gas absorption processes combined in some instances with chemical reaction, a large contact area is necessary for efficiency. In practice this is achieved by films in wetted wall columns, by liquid drops in spray columns and by gas bubbles. In a summary of his work in this field the author points out that a number of other variables which effect the efficiency of absorption require further investigation, as for example the influence of Reynolds and Schmidt numbers and the kinetics of the more complicated reaction mechanisms.

Fluidization. The technique of fluidization first developed by the oil industry has many potential applications in other industries making use of exothermic reactions, and there is a rapidly growing body of literature on the characteristics of the fluidized state. Dr Van Krevelen's work in this field is described in a group of four papers dealing with the determination of the critical mass velocity and with the mechanism of heat transfer. He first demonstrated that the resistance to gas flow may be calculated from the kinematic viscosity, the number of particles per unit volume of the bed, the effective diameter of the particles and a generalized shape factor. In reviewing previous work on heat-transfer coefficients he drew attention to the large number of variables which are to be found in the various empirical correlations put forward by M. Leva, W. Dow and M. Jakob and others, leading to widely divergent results. He concluded that a better understanding of the mechanism by which high rates of heat transfer are achieved should provide a useful guide in the selection of the relevant correlating variables. One fact which has not always been taken into account by previous workers is that the heat capacity of the solid particles per unit volume of bed is about one hundred times greater than that of the interstitial gas whilst the mean particle velocity is only about ten times lower than the gas velocity. Thus the convective transport of heat by the moving particles largely outweighs all other means of heat transport.

The high transfer rates have been attributed by Leva and others to the scouring action of particles moving downwards along the wall, preventing the formation of a laminar boundary layer of gas and giving rise to high values of the eddy conductivity of the gas in close proximity to the heat transfer surface. Based upon a relation between the eddy conductivity and the mixing rate, proposed by Leva, van Krevelen shows by a simple calculation that the interstitial gas only provides the particle suspension with a thermal conductivity of the same order of magnitude as the effective thermal conductivity of granular material in stationary gas. The rapid heat exchange between different parts of the bed can be attributed to the turbulent motion of the particles which is equivalent to the high eddy diffusivity of a well stirred liquid. The gas flow is assumed to be everywhere virtually laminar and the interstitial gas only serves as a medium for heat transfer from particle to particle and from particle to wall exclusively by normal conduction in the steady state. This proposed mechanism finds support from measurements of heat and mass-transfer coefficients in fluidized beds of coke, iron oxide and carborundum in a variety of gases.

Specific Chemical Reaction Processes and Chemical Reaction Engineering

The fifteen papers included under these headings cover a range of disconnected topics which bear witness to the author's wide scientific interests. Amongst these mention may be made of process Optimization Principles and Methods, Oxidations carried out with Vanadium Oxide Catalysts and Selectivity in Consecutive Reactions.

A complete list of the authors publications is given in appendix.

D. M. Newitt

Turbulente Scherströmungen, Teil I, Grenzschichten. W. Szablewski, Akademie, Berlin, (1976), 196 pp.

This book, written in German, is the first part of a monograph on turbulent shear layers and deals with incompressible, constant-property wall boundary layers, including channel flows. Part 2 on free shear layers will be published later.

The book focuses on the mathematical treatment of boundary layers and begins by introducing the continuity and momentum equations and the velocity law of the wall for boundary layers both without and with streamwise pressure gradient (Chapters 1 and 2). Later (Chapters 11 and 12), equivalent equations are derived for thermal boundary layers. Chapters 3–5 deal with the turbulence structure; the equations governing the turbulent kinetic energy, E, and the Reynolds stresses are derived, and model assumptions are introduced for the diffusion, dissipation and pressure-strain terms, based mainly on dimensional arguments applied to the law of the wall region. The assumptions made are quite unorthodox: the diffusion flux of E is not, as usual, assumed proportional to $\partial E/\partial y$ but to $\sqrt{(|\partial E/\partial y)}(\partial E/\partial y)$ which yields a variation of E as $(\ln y^+)^5$ in agreement with Klebanoff's measurements; the dissipation terms in the individual stress equations are made proportional to the stresses, in conflict with the concept of local isotropy; and the pressure-strain term is assumed proportional to the production of turbulence energy, with different constants for the different components. Adjusting the constants gives agreement with measured stress distributions in the log-law region. Application to boundary layers near separation yields a variation of the energy components proportional to $y^{1/3}$, again in agreement with experiments. The model is also applied to homogeneous shear flow and to grid turbulence relaxing after a contraction; but now different constants are required for each case.

Chapter 6 introduces the mixing-length distribution used in all the analysis which follows, namely: $l = \kappa y e^{-y/(\delta m)}$, with $m = 0.6$ as empirical constant. This relation is close to the 'ramp' function used extensively by Spalding and his co-workers. Together with Van Driest's damping law, it covers the whole boundary layer. An equivalent relation for calculating the heat flux is introduced in Chapter 13. The consequences of Van Driest's law for the sublayer profiles and the kinetic-energy balance in the sublayer are discussed for boundary layers with zero and finite streamwise pressure gradient in Chapter 7. The above mixing-length distribution is used to derive velocity-defect and drag-coefficient laws for the flat boundary layer in Chapter 8, and equivalent laws for the temperature defect and Stanton number are given in Chapter 14. Approximate schemes for calculating nearly self-preserving boundary layers are presented in Chapter 9 for velocity and in Chapter 15 for thermal boundary layers: to evaluate the convection terms in the momentum and temperature equations, the law-of-the-wall distribution for velocity and temperature is assumed to hold over the whole fully turbulent layer. The closed-form solutions are compared with experiments of Clauser, Herring and Norbury, and Stratford and show fairly good agreement. Chapter 10 presents empirical eddy-viscosity formulae for developed pipe/channel and Couette flow (different for the two cases) and applies them to obtain velocity profiles and friction laws; the topics of roughness and thick sublayers are also discussed. The final chapter gives a short introduction to the subject of spectral distribution of turbulence energy and shear stress.

The literature references quoted in the book lack many of the more recent, important publications on the subject; for example the 1968 AFOSR-IFP Stanford Conference is not mentioned, and a comparison of the author's model suggestions with published models for the diffusion, dissipation and pressure-strain terms in the Reynolds-stress equations would have been appropriate. The author's view that the differences between the fluctuating velocity components in the log-law region can be explained via the pressure-diffusion term is, in the opinion of the reviewer, incorrect: these differences are due to the wall effect on the pressure-strain terms. The recommended use of mixing-length theory to calculate the heat flux is problematic; the author should have included a warning that this theory does not work when there is a finite heat flux at points of zero velocity gradient.

The purpose of the book and the audience for which the book is intended are not quite clear to the reviewer (and are not stated by the author). Unlike other books available in the German language, the present volume is not suitable as an introduction to turbulent boundary layers since it gives very little physical explanation. Also, the reading is in parts quite arduous because all the derivations are included in the main text; and they are sometimes fairly long-winded. The book is also of limited value to researchers or designers who have to solve boundary-layer problems; the author states correctly that boundary-layer calculations are usually carried out with the aid of finite difference methods; hence his rather cumbersome approximate schemes can hardly be in great demand. Further, the book is restricted to a few basic boundary-layer situations and does not discuss the effects of wall curvature, blowing or suction, or free-stream turbulence. The model for the turbulence structure in the law of the wall region is also of little interest because, due to the dimensional analysis used, it is geared to this region and cannot be extended to a general model. This book does however contain a great many useful basic relations; and it may come as a consolation to workers who do not have access to a computer.

W. RODI

D. J. TRITTEN, **Physical Fluid Dynamics.** Van Nostrand–Reinhold, New York (1977).

"PHYSICAL Fluid Dynamics" is written by a physicist who had 'final-year physics students particularly in mind'. This reviewer is in a mechanical engineering department and so has mechanical engineering students in mind.

Books on fluid mechanics by engineers in academic departments, written for undergraduates, rarely break new ground, though frequently their publishers if not the authors claim novelty of presentation. A claim to be oriented towards practical applications often means only the presentation of much arithmetic calculation; and a claim to present fundamentals often means only the laying out of a lot of algebraic manipulation associated with three-dimensional field theory. In both types of book skilled use of words, sentences, paragraphs (i.e. the content of discursive prose), is often at a disappointingly poor level; it is flat and dull as if only algebraic symbols or numerical magnitudes matter. (And yet academics are primarily talkers!) This present book makes handsome amends.

In his Preface the author quickly disposes of the need to classify his book as "pure or applied", "theoretical or experimental": he categorises it by treating fluid mechanics as a branch of physics. This offers him a unifying idea and allows him to be theoretical or experimental as needed and, most importantly, to weld the two approaches together, so displaying yet another example of how progress in the physical sciences is made. The author writes about his material in prose which, sentence by sentence is full of content; he can develop arguments in most illuminating ways; and he moves smoothly amongst a mixture of prose (mainly), algebra and numbers. He has also rediscovered the use and immense value of parenthetical comment. For too many authors, comment in parenthesis is merely comment which cannot be made to fit into the main sentence structure; here the author uses parenthetical comment most exactly: for, just when a nagging question arises in the reader's mind regarding perhaps the restrictions under which an argument is developing, the question is answered precisely and briefly, in parenthesis.

The author sets out to capture the reader's attention in Chapters 2–4 by describing what one can see, measure and hope to explain in Pipe and Channel Flow, Flow past cylinders, Convection in Horizontal Layers. In each case he finds a descriptive style which allows him to discuss the great variety of flow phenomena which occur in those situations without drawing on analytical knowledge that the student at this stage does not possess. His description of transition to turbulent flow within the context of his examples is one of the best I have read. An engineering student reading these chapters would realise what he is missing in his more conventional reading; and he would be keen to learn what can be done to explain this exciting variety of phonemena.