Int. J. Heat Mass Transfer. Vol. 6, pp. 931–932. Pergamon Press 1963. Printed in Great Britain.

BOOK REVIEWS

The Use of Secondary Surfaces for Heat Transfer with Clean Cases: Institution of Mechanical Engineers, Symposium, 1961, 157 pp., 70*s*.

THIS book contains the proceedings of a symposium held in November 1960 and "arranged by the Institution of Mechanical Engineers under the aegis of the British Nuclear Energy Conference." It consists of twelve independent papers dealing with the heat-transfer and pressure-loss performance of the external surfaces of the various types of finned tubes used in nuclear power-plants with gas-cooled reactors. Finned tubes are used both in the reactor itself and in the boiler. In the reactor, the tubes or "cans" enclose the fuel element and the fins or "secondary surfaces" are required to improve the heat transfer to the gas coolant which flows axially in the annulus between the tube and the surrounding graphite; the fins also serve to stiffen the fuel can. In the boiler, the water and steam flow inside the tubes and again it is the heat transfer between the gas and the external surface of the tubes that needs to be improved so that once again fins are required, though in this case the gas flows at right-angles to the tube axes. In both cases, not only is good heat transfer required, that is high heat-transfer coefficient, large surface area and high fin effectiveness, but the pressure drop in the gas needs to be low to ensure low pumping power. These two requirements are of course broadly incompatible, but without a satisfactory combination of heat-transfer and pressure-drop performance, the power plant will be uneconomic, hence the detailed attention paid to the design and performance of finned tubes.

Most of the papers deal with the fuel cans, mostly of the "polyzonal" type in which helical (or axial) splitters divide the annulus into about four channels in order to encourage a type of flow in which cool gas from the outer region of the annulus is made to replace the hot gas in the region of the fins which are axial (or helical) and of considerably smaller outside diameter than the splitters. One paper deals with the case of three or four such cans inside a single circular channel. There are two French contributions, one dealing with a type of passage in which inclined triangular vanes are attached to the splitters, the fins being circular; the other dealing with a "herring-bone" type of can in which the periphery of the can is divided into an even number of zones having helical fins of opposite turn. There is also a survey paper which discusses the factors influencing the design of fuel cans for gas-cooled power reactors.

Of the four of the papers dealing with the performance of finned tubes in nuclear boilers, one is concerned with "studded" tubes, the studs actually being thin rectangular pieces set around the tube at right-angles to its axis and parallel to the flow. Another deals with helical fins and a third with circular fins. The fourth deals with the case when the tubes themselves are coiled into helices of differing diameters and arranged concentrically, the flow being parallel to the axis of the helices and substantially at right-angles to the tube axes.

Most of the papers present both heat-transfer and pressure-drop data for various geometrical variations of a basic type. Unfortunately, there is no uniformity of approach in presentation, the results appearing both as Stanton and Nusselt numbers, sometimes in combination with the Prandtl number, and also in other forms. There is variation too in the form of presentation of the friction data. Consequently, tedious calculations would be needed before useful comparisons could be made. When comparing the heat-transfer performances of passages of such diverse shapes, there seems no good reason for using either the Stanton number or the Nusselt number, since we are not particularly interested in the heat-transfer coefficient on its own but rather in combination with the surface area. A better basis of presentation would therefore be the Number of Transfer Units, in combination with the Prandtl number where necessary.

Indeed, it must be said that the general impact of this volume is one of disorder. Several authors use notation which conflicts with the notation recommended for the symposium; in one case, the author uses his own notation extensively in his summary. The title itself is somewhat misleading since it is not the fact that the gases are clean that characterizes the papers so much as the fact that the surfaces have been specially designed to meet the requirements of nuclear power-plants. Units vary from paper to paper and the dimensional constant in Newton's second law is editorially stated to be dimensionless! Several of the photographs ought to have been rejected since they are quite unhelpful. And it is not a little surprising to find that several of the papers are without summaries.

One or two of the authors have made brave attempts to provide some sort of law to cover their range of variables. However, it seems doubtful whether the data presented can find any application in their present form outside the field in which they have arisen, since, although many geometric and other variables have been considered, the laws remain highly empirical and particular and the theoretical basis for extrapolation does not exist.

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Physicochemical Hydrodynamics. V. G. LEVICH, Prentice-Hall, 1962, 700 pp.

THE publication of this translation from the Russian of the second edition of Professor V. G. Levich's monograph is a most important event. That the author's achievements have hitherto been almost unknown to heat-transfer workers in English-speaking countries has been due not to the language barrier alone; for Professor Levich has approached heat and mass transfer by way of the seemingly remote field of electrochemistry. The apt title of his book shows that the remoteness was illusory: a proper understanding of electrochemical processes demands knowledge of just those phenomena of diffusion and heat conduction in fluids moving near solid surfaces which are the perpetual concern of readers of this journal; moreover the electrochemist possesses techniques which are particularly well-suited to the investigation of these phenomena, as the author has superlatively shown, particularly by his work on the rotating-disc electrode.

Although it will take some months of study to explore the full profusion of this highly original book, the reviewer has already gained much pleasure and profit from its study. Some of the material is familiar, for example the discussion of transport processes in turbulent flows; yet, again and again, the well-trodden path which the author seems to be following leads to new insights or to results which Western scientists have only recently become aware of. One example is his theory for the influence of surface roughness on mass transfer to a turbulent stream; similar theories, with experimental confirmation, have only been published in English in the last few months.* Moreover the author discusses many topics which lie just outside the field of most specialists in heat transfer, for example the coagulation of dispersions motion induced by capillarity, and other interactions between a pair of fluid phases. Such processes have not before been treated so comprehensively or clearly in the form of a book.

One omission is surprising: the author invariably neglects, without apparently realising its existence, the contribution of the transverse velocity to the mass transfer at a solid boundary. Thus he writes the boundary condition there as:

$$j = D\left(\frac{\partial c}{\partial n}\right)_{y=0} \qquad \text{equation (9.2)}$$

where j is the mass-transfer rate, D is the diffusion coefficient, c is the concentration of the diffusing substance, n is the distance normal to the wall, and $y = 0$ denotes a surface just on the fluid side of the interface. Yet, as is by now well known, there is an additional convective term, such that, if only one substance is being transferred, the boundary condition becomes

$$j = D\left(\frac{(\partial c/\partial n)}{1 - c/\rho}\right)_{y=0}$$

where ρ is the fluid density. His solutions of the differential equation are therefore valid only for small concentrations of the diffusing substance. It is surprising that the effect of the convection term has not been forced on the author's attention by experimental data; for processes with large values of $(c/\rho)_{y=0}$ are by no means uncommon. Possibly the reason is that Professor Levich has mostly been concerned with liquids, for which the dependence of diffusion coefficient on concentration is a quite separate source of non-linearity between transfer rate and concentration difference; it will have been easy to ascribe *every* observed non-linear relation to the variation of diffusion coefficient, and so to overlook the part played by the convection term.

There are other instances, less serious than the above, which suggest that the author has nodded. Thus, where Levich reproves Kruzhilin (on page 91) for "incorrect conclusions", this reviewer finds himself on Kruzhilin's side. But freedom from error is a negative virtue, lower in the scale of values than abundance of merit; and it is the latter which the present book outstandingly possesses. All who are concerned with developing the science of heat and mass transfer should read it; they will be rewarded by a deepened understanding of their subject and a better appreciation of how it interacts with other important branches of physics and chemistry.

In addition to its quality as a work of scholarship, the monograph is a good example of how technical translations should be published. The translation has been edited, with evident care, by a distinguished team of American scientists. These have succeeded in smoothing out many of the difficulties which would beset the reader of a "straight" translation, and have done much to make the author's communication successful. Let us hope that other publishers of translated books will adopt the same practice.

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* P. R. Owen and W. R. Thomson, *J. Fluid Mech.* **15**, 3, 321–334 (1963). D. F. Dipprey and R. H. Sabersky, *Int. J. Heat Mass Transfer*, **6**, 329 (1963).