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AN INTERNATIONAL JOURNAL IN THE FIELD OF HEAT AND MASS TRANSFER

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IT is appropriate for a new journal to introduce itself in its first issue to the reader and to the interested public, to explain the reasons for its origination, and to outline the width of the segment of physical sciences that it hopes to cover.

Looking back in time one finds that it took fairly long before heat transfer had established itself as a coherent body of knowledge. That was undoubtedly due to the complexity of the physical processes involved in heat transfer. These processes are relatively simplest in heat conduction and, correspondingly, the basic laws, their mathematical formulation, and the methods for obtaining solutions were achieved at first in this field [1]. A similar process in the field of heat convection had to await the establishment of a basic understanding of viscous flow phenomena which was started by O. Reynolds' studies on turbulence (1883) and by L. Prandtl's paper on boundary layer theory (1904). A systematic approach to radiative heat transfer finally could be developed only after the laws for black body radiation had been conclusively formulated by M. Planck in 1900. Engineering needs, on the other hand, made the establishment of relations from which heat transfer could be predicted imperative. Such relations were very restricted in their applicability, and the corresponding investigations were reported in the journals which dealt with the respective engineering activity. This situation, that heat transfer papers are dispersed in a large number of magazines, still exists today and makes it extremely difficult for anybody to keep informed, especially since the number of papers has grown in recent years almost at an exponential rate. This fact alone makes it very desirable to have a journal in which essential progress in our understanding of heat transfer processes is continuously recorded.

There is, however, a still more important reason that suggests a heat transfer journal. Through the developments which have been sketched above, a well-grounded and fairly complete basic understanding of the various heat transfer processes has been obtained in recent years. In this situation, a magazine covering the complete field of heat transfer can do much to stimulate progress by demonstrating the basic unity and interrelation of the various heat transfer processes. This interrelation is very clear between heat conduction and convection, since many processes which we term "heat convection" consist essentially in the superposition of heat conduction on the transport of energy by a moving fluid. The similarity is less obvious, but nevertheless existent, between radiative heat exchange and conduction or flow processes. According to modern physics, the following model can be accepted for a radiative process: Photons are released from atoms by thermal agitation. They travel on straight paths until they are intercepted by other atoms. Those again may release new photons and in this way energy is transported from higher to lower energy levels. Such a process has a strong similarity with the model of conductive energy transport in a gas that kinetic theory provides. Here the molecules move on straight paths until they come sufficiently close to other molecules for interactions to take place. Energy transport is here provided by the molecules. In particular, the character of such an energy transport process, either by photons or by molecules, depends on the "mean free path length" of the carriers of energy. In radiation heat transfer processes that have been studied in connection with engineering applications, the mean free path length is by several orders of magnitude greater than in normal heat conduction. Recent developments—like space flight—have, however, advanced interest in heat transfer at very low densities where mean molecular path lengths are of the same order as those encountered in radiation. Counterparts of the free molecular regime, where mean path lengths are large compared to any other dimension involved, and of the mixed regime, where both dimensions are of the same order of magnitude, exist in radiative exchange among solids with a non-absorbing medium in between and in radiative exchange between solids and absorbing gases. As a consequence of this analogy, analytic methods as well as experimental procedures are very similar for radiative heat exchange and for investigations under rarefied gas conditions. Fig. 1 demonstrates

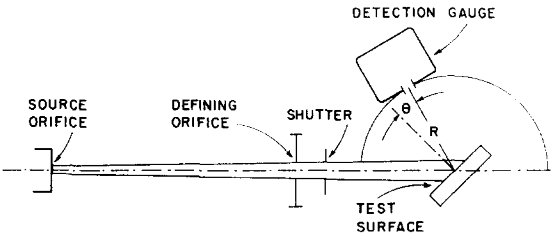

FIG. 1. Apparatus to measure the space distribution of the scattering for molecules impinging on a solid surface (from Hurlbut [3]).

this. The illustrated device might easily be taken as an apparatus to measure the angular distribution of the reflectivity of surfaces for impinging radiation, whereas actually it measures angular distribution of the scattering of molecules impinging on a solid surface.*

Considerable attention has recently been directed toward combined processes in which conduction, convection and radiation are jointly and relatedly active in transferring heat, as well as processes in which heat transfer is connected with some other physical phenomena like mass transfer, reaction kinetics, electric or magnetic interactions, and a heat transfer journal should be a good place to publish the results of such studies.

There is also a very real economic reason suggesting a basic approach to engineering heat exchange problems, an approach as it can be undertaken when a coherent science of heat transfer has been established. Experimental investigations under conditions as they are actually expected become more and more involved and expensive in many new engineering developments. One can mention in this connection cooling problems in nuclear power plants and in rockets, where elaborate safety precautions are required, or in missiles and satellites, where conditions with temperatures of several hundred thousand degrees or close to absolute zero occur on objects with considerable dimensions. It is fortunate, indeed, when analytic procedures are available to predict heat transfer under such conditions and when experiments can be restricted to selected check runs. An example which indicates how well heat transfer coefficients under new conditions can today be predicted from the available basic stock of knowledge is demonstrated in Fig. 2. Local Nusselt numbers as a dimensionless presentation of heat transfer coefficients, measured in gas flow through a tube at

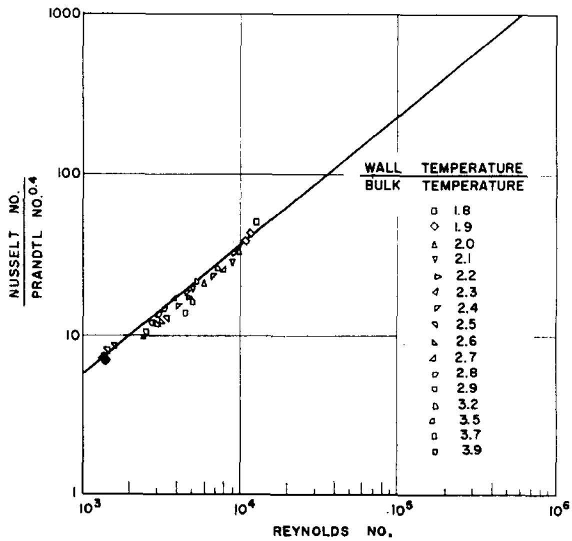

FIG. 2. Heat transfer coefficients for helium flowing in a tube with surface temperatures up to 5900°R (from a paper by Taylor and Kirchgessner [4]).

* The similarity between radiation and conduction processes has been pointed out very clearly in the book by R. C. L. Bosworth [2].

temperatures up to 5900°R, are presented as experimental points and compared with the line which is the result of low temperature measurements and theory. Experiments under such high temperatures have to be considered as a real achievement and it is satisfying to observe how well they confirm the prediction.

The title of the journal includes also mass transfer. The close similarity between Fick's diffusion law and Fourier's heat conduction equation, as well as the fact that turbulent mass and heat exchange are caused, according to our present understanding, by the same mechanism, suggests a common consideration of both processes very strongly. Differences in the boundary conditions and in the dependence of properties on the state parameters have, of course, to be considered.

It is hoped that the papers in the new magazine will also be of direct value to engineers engaged in the design of heat transfer appliances. Engineers in all parts of the wide field of applied heat transfer are finding more and more in common in their problems and each can help his colleagues toward a better understanding of them. To give only a few examples, the industrial furnace designer and the rocket engineer are concerned with the same basic problem of radiant gas heat exchange; the electrical engineer depends very largely on improved convection or conduction for increasing the output of electric equipment; the use of liquid metals for heat exchange, pioneered by nuclear power engineers, is not without interest in more conventional engineering; developments of the regenerator, at present of particular interest to the gas turbine engineer, might find many new applications elsewhere.

The international character of the journal, finally, should be very helpful in furthering the science under consideration, because science by its very nature has an international character and thrives best when the exchange of ideas is furthered on a world-wide basis. It is our wish that beyond this goal the journal, in its way, contributes also to a general improvement of understanding between the nations.

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