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LETTERS TO THE EDITORS

Comments on 'The possibility of determining and using a new local heat transfer coefficient' by G. Danko

THE NOVEMBER 1983 issue of the Journal contained an article entitled 'The possibility of determining and using a new local heat transfer coefficient' by G. Dankó, summarized in the statement:

"The present study introduces the concept of a local heat transport parameter, h_{ph}, defined by equation (2):

$$h_{ph} = \frac{dq_w}{dT_w} \tag{2}$$

this parameter might be called the local physical heat transfer coefficient."

With regard to this article, I would like to make the following points:

(1) The importance of the right side of equation (2) was recognized in 1964, ref. [1], in which (dq_w/dT_w) was used to appraise thermal stability based on

$$\frac{dq_{in}}{dT_w} - \frac{dq_{out}}{dT_w} \langle_s \; 0 \tag{a}$$

where the subscript 'out' is synonymous with the subscript 'w' in equation (2). (The symbol $\langle_s$ indicates stability if the criterion is satisfied.)

(2) The concept of a heat transfer coefficient defined by equation (2) was considered in 1974, ref. [2], pp. 5–13:

"I want to make it very clear that I am *not* promoting the concept of dynamic thermal resistance which of course would be defined by

$$h_{dynamic} = \frac{dq}{d\,\Delta T}. \tag{24}$$

This dynamic thermal resistance is a linear concept which would augment but not replace the static thermal resistance given by

$$h_{static} = \frac{q}{\Delta T}. \tag{25}$$

It is quite true that the addition of dynamic thermal resistance would bring about a great improvement in the old science of heat transfer. But it would not provide the nonlinear vehicle toward which we are striving—and which is represented by eq. 12."

(3) The relationship between the conventional h and h_{ph} in equation (2) is best revealed by noting that

$$q_w = h(T_w - T_\infty) = h\,\Delta T \tag{b}$$

$$\frac{dq_w}{dT_w} = h + \Delta T \frac{dh}{dT_w} = h_{ph}. \tag{c}$$

Note from equation (c) that the two hs are closely related, and in fact differ only in the event that h is a function of ΔT. Graphically, the two hs are related as shown in Fig. 1.

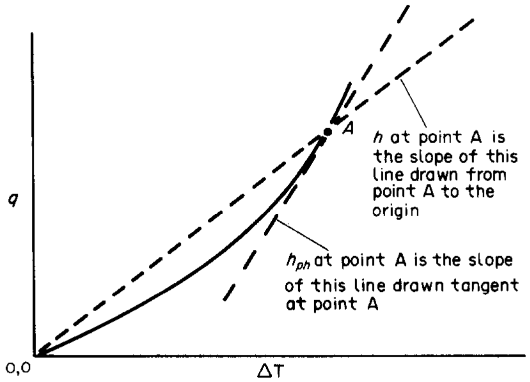

FIG. 1.

(4) If the concept of two hs is to be adopted, it would seem preferable to use the nomenclature suggested in ref. [2]:

$$h_{static} = \frac{q}{\Delta T} \tag{d}$$

$$h_{dynamic} = \frac{dq}{d\,\Delta T} = \frac{dq}{dT_w}. \tag{e}$$

This nomenclature is advantageous because it is descriptive and also because it continues the electrical analog:

$$R_{static} = \frac{E}{I} \tag{f}$$

$$R_{dynamic} = \frac{dq}{dT_w}. \tag{g}$$

where R refers to electrical resistance.

(5) It is important to note that $h_{dynamic}$ can be negative, and in fact is negative in the so-called transition region of the pool boiling curve.

The addition of the dynamic heat transfer coefficient would indeed bring about a considerable advance in the science of heat transfer. However, a much greater advance would be accomplished by abandoning all heat transfer coefficients and instead dealing directly with q and ΔT as described in ref. [2].

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REFERENCES

1. E. Adiutori, New theory of thermal stability in boiling systems, *Nucleonics* **22** (5), 92–101 (1964).
2. E. Adiutori, *The New Heat Transfer*, Ventuno Press (1974).

NOMENCLATURE

E	volts
h	conventional heat transfer coefficient
h_{ph}	heat transfer coefficient defined by equation (2)
I	amps
q	heat flux
q_{in}	heat flux from a source into an interface
q_{out}, q_w	heat flux from an interface into a sink
R	ohms
T_w	wall temperature
ΔT	temperature difference across a boundary layer

Comments on E. F. Adiutori's contribution

I WAS GLAD to be informed about the contribution of Mr. Adiutori, author of the *New Heat Transfer*. I myself respect his book very much, which is the art of the precise, purposeful and data-based model building. Of course, the 'new heat transfer coefficient' indicated in the title of [1] has not been found out for the purpose of Mr. Adiutori's *New Heat Transfer*, since the latter entirely eliminates the heat transfer coefficient. The new heat transfer coefficient has been made for the purposes of the 'old' type calculations. This is a new efficient means of heat transfer measurement and model building, and it can be well integrated into the conventional handling of heat transport. However, even in the most simple linear cases, a conversion is needed to turn to the usual boundary conditions. In addition to the definition and interpretation, this has been discussed by [1].

(1) In his contribution, Adiutori has made a summary which is insufficient regarding some important questions. The brief summary of statement [1] might be given, for example, in the following way:

The local heat transfer coefficient is a parameter, which is defined by equation 2, where dq_w and dT_w fulfil two postulates:

(a) they tend to zero in a way that, in limit value, the disturbed process is identical to the undisturbed one;
(b) they are of local difference relating to a single point of the heat transferring surface, while elsewhere T_w and q_w are undisturbed.

The following comments are supposed to explain that the above summary can be derived from [1].

(2) The Introduction of [1] defines a parameter by equation (2), which assigns a differential quotient to the heat transport in each point of the surface:

$$h_{ph} = \frac{dq_w}{dT_w} \tag{2}$$

where dq_w and $dT_w \to 0$, and dq_w is parallel to q_w.

However, all these are not sufficient to have equation (2) properly express the local physical heat transfer coefficient. For the purpose of interpreting the differential quotient in equation (2) the preliminary equation (12) has been made. Through this equation postulates (a) and (b) can be fulfilled simultaneously:

ad (a) the Prandtl–Taylor analogy used refers to equilibrium state, and consequently (a) is satisfied,
ad (b) the penetration of local disturbance can be expressed by the differential quotient dT/dT_w of equation (12).

It means that though equation (12) offers a formal differential quotient only, it allows the expression of the physical heat transfer coefficient. It is important to emphasize that if the surface extension of the thermal disturbance is not local, but refers to the whole surface, then the disturbance penetrates the entire thermal boundary layer, and therefore dq_w/dT_w equals to the h_t technical heat transfer coefficient. Now, however, the problem is not that. The disturbance is local, and either the value or the meaning of the dq_w/dT_w differential quotient is quite different. According to definition (13) by the value of δ^+, which is declared as the penetration depth of the local heat transfer, equation (12) really gives h_{ph}.

The estimate of the penetration depth of the local heat transfer in [1] was studied in the case of a fully developed turbulent flow, and finally the result (21) was obtained. Since the upper limit of δ^+ was 30, no doubt, in the case presented, the local heat transport cannot take place in one step through the entire heat transferring boundary layer with δ^+ of around 1000.

As a summary, equation (2) of [1] itself, picked out of the relevant conditions, cannot be reviewed. Together with the postulates a particular parameter was given, which supposedly had not appeared in the literature previously. Consequently $h_{ph} = dq_w/dT_w$ defined as above does not correspond to dq_w/dT_w in equations (a), (24), (e) and (c) of Mr. Adiutori's contribution.

(3) It can be disputed whether the notation of h_{ph} is proper or not. If we started from the aspect of h_{ph} measurement, it could be called 'local heat transfer coefficient determined by local perturbation'. However, the adjective 'physical' is shorter, and it tends to express, that the point in question is an objective characteristic determined unambiguously by the physical process of the local heat transport generated by the temperature gradient. Namely, the thermal boundary layer gives an unambiguous and free-from-engineers' preconditions answer to the question raised in the form of thermal disturbance. The h_{ph} depends on the physical reality, and not on the technical aspect—and within this frame on an enforced (e.g. linearized, etc) model—of the phenomenon. In this respect only, there is a close connection with the text on page 6.34 of [2], since the physical heat transfer coefficient does not require an *a priori* deduction either, over and above the simple model conception.

The notation 'dynamic' for the $h = dq_w/dT_w$ differential quotient advised in [2] and in the contribution—even in general—seems to be easily misunderstandable. Dynamics is connected with changes in time, though either in [2] or in the case of the physical heat transfer coefficient, the dq_w and dT_w changes are emphatically of stationary nature.

(4) Newton's famous cooling law, in which the heat transfer coefficient, as a proportion factor appeared at the first time, was related actually to the average heat transfer coefficient obtainable from the ratio of finite changes: $h = \Delta q_w/\Delta T_w$. Since then the cooling process of the surface has many times been used for the measurement of the heat transfer coefficient. A separate chapter of [3] deals with the measurement technique of dynamic Δq_w (changing effectively in time), obviously for the purposes of heat transfer measurement. Even in this Journal an article was presented definitely about the measurement of the heat transfer coefficient based on the