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LETTERS TO THE EDITOR

TEMPERATURE DISTRIBUTION IN A MACROPOROUS BODY DURING DRYING, COMMENTS ON PAPER BY KAZANSKY *et al.**

I WISH to draw attention to a possible source of error in interpreting the results of experiments by Kazansky *et al.* which were reported recently in your Journal [1]. Figs. 2, 3, 4 and 6 show temperature distributions within a macroporous body when it is subjected to drying conditions in a hot wind tunnel. In all these figures, a striking feature is the reversal of the temperature gradient with depth in the bed, during some period of drying.

Work on drying carried out by my students and myself at the University of Leeds, England, and at Rensselaer Polytechnic Institute, U.S.A., over the last few years [2] leads me to believe that this reversal is a misleading artifact. In our earlier work we, too, obtained such reversals. We traced it to heat leaks through the sides and bottom of the sample holder. By taking several precautionary steps, these leaks were eliminated and some important conclusions became clear.

To illustrate, I enclose a typical graph we obtained on the temperature distribution within a drying wool bobbin (Fig. 1). This picture was replicated with a bobbin of Terylene (a polyester) as well as with flat beds of sand, glass beads, paper pulp and other materials. Whenever leaks were plugged, temperature gradient reversal was eliminated.†

Comparing the enclosed figure with, say, Figs. 2 or 3 of the paper by Kazansky *et al.* two features become evident:

(1) Temperature reversals are completely absent.
(2) The temperature within the body tends to rise to two plateaux: (a) to the wet bulb temperature during the constant rate period; and (b) to what we called the "pseudo-wet-bulb temperature" during the falling-rate period.

This behavior is fully discussed in (2).

Finally it should be understood that temperature gradient reversals do occur in certain commercial driers and whenever heat is supplied through two sides—e.g., the twin agencies of air and a hot plate; these, however, are particular conditions.

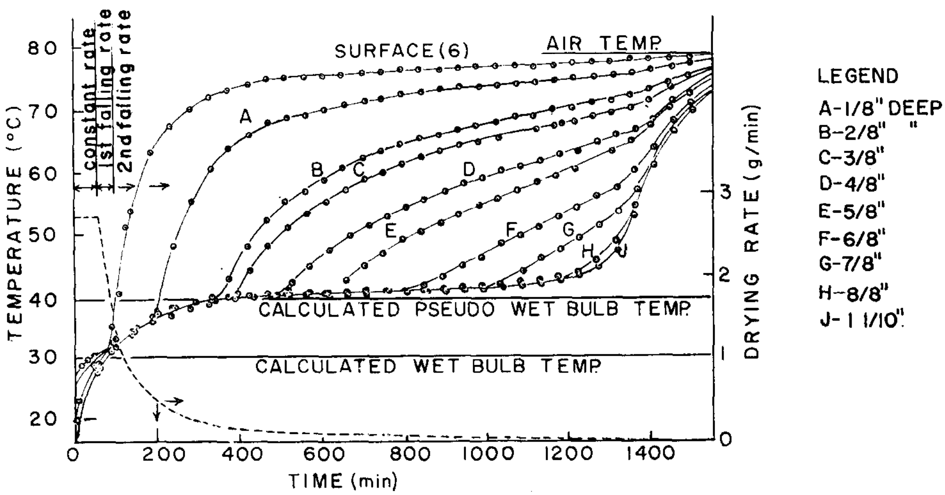

FIG. 1.

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† *Note added in proof.* After writing the above I noticed a similar curve in A. V. Luikov's book, *Heat and Mass Transfer in the Drying Process*, p. 241, Fig. 6–11. Gosenergoizdat, Moscow (1956).

Work is now proceeding on the further elucidation of these interesting features under a National Science Foundation Grant G10183 and to the N.S.F. I wish to make grateful acknowledgment.

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COMMENT ON SQUIRE'S SHORTER COMMUNICATION "APPLICATION OF THE DEFECT LAW TO THE DETERMINATION OF THE AVERAGE VELOCITY AND TEMPERATURE IN TURBULENT PIPE FLOW"*

WE READ with interest Squire's Shorter Communication in the September issue of the International Journal of Heat and Mass Transfer, entitled "Application of the defect law to the determination of the average velocity and temperature in turbulent pipe flow". In this Communication Squire refers to our earlier paper on the "Evaluation of bulk velocity and temperature for turbulent flow in tubes" which appeared in Vol. 1 of the same Journal.

With regard to the curves of u_{av}/u_c against Reynolds number, agreement is within 1 per cent, and this small discrepancy is explained entirely by the inadequacies of the universal velocity profile and the defect law to describe actual velocity profiles.

The differences between Squire's values and ours for T_{av}/T_c are more serious, and we cannot agree with Squire's statement that "It is believed that the difference between average and bulk average is not large enough to account for the difference between the two analyses." In our view the difference lies almost entirely in the fact that we were concerned with the bulk temperatures (T_{bulk}/T_c), while Squire calculated a simple mean value (T_{av}/T_c). To prove the point it would be necessary to go through lengthy numerical integrations, because Squire's defect law cannot be put into explicit form. The following argument, however, will support our contention at least at or near a Prandtl number of unity.

Our analysis at $P = 1$ gives

	$R = 10^4$	10^5	10^6
T_{av}/T_c	0·792	0·847	0·875
T_{bulk}/T_c	0·856	0·880	0·902
difference	0·064	0·033	0·027

Squire's curves at $P = 1$ give

T_{av}/T_c	0·785	0·825	0·855.

It is reasonable to assume that the difference between the two averages should be of the same order of magnitude when worked out according to either analysis. Hence it follows that Squire's results for the bulk average would be approximately

T_{bulk}/T_c	0·855	0·865	0·885

i.e. the agreement between the universal velocity profile and the defect law analyses is within 2 per cent at $P = 1$, and thus about 80 per cent of the discrepancy noted by Squire is accounted for by the difference between T_{bulk} and T_{av}.

With regard to liquid metals the discrepancy is more serious. It is obvious that at very low Prandtl numbers the family of curves of T_{av}/T_c (unlike that of T_{bulk}/T_c) should merge and and approach a value that can be deduced from a laminar-flow type analysis—since the temperature profile is determined predominantly by the conductivity and not by the eddy diffusivity. A few simple calculations suggest that the value of T_{av}/T_c at very low Prandtl numbers should be just below 0·5, and not at 0·72 as shown by Squire's curves. The values of T_{bulk}/T_c will be in the region of 0·54, depending on the Reynolds number, which is consistent with our original curves.

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