

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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#### REFERENCES

1. M. F. KAZANSKY, P. P. LUTSICK and V. N. OLEYNIKOV. Non-stationary temperature and moisture content fields of porous bodies in the

convection heat transfer process. *Int. J. Heat Mass Transfer*, **2**, 231–239 (1961).

2. A. H. NISSAN. Mechanism of drying of thick porous bodies during the falling-rate period. *Nature*, **180**, 142–143, (1957); A. H. NISSAN, W. G. KAYE, and J. R. BELL. Mechanism of drying thick porous bodies during the falling-rate period. Part I. The pseudo-wet-bulb-temperature. *J. Amer. Inst. Chem. Engrs*, **5**, 103–110 (1959); J. R. BELL and A. H. NISSAN. Part II. A hygroscopic material, *ibid.*, **5**, 344–347, (1959); A. H. NISSAN, H. H. GEORGE, JR. and T. V. BOLLES. Part III. Analytical treatment of macroporous systems, *ibid.*, **6**, 406–410 (1960).

### 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
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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 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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