Int. J. Heat Mass Transfer. Vol. 25, No. 5, p. 953, 1981
Printed in Great Britain

0017-9310/81/050953-01 $02.00/0
Pergamon Press Ltd

LETTER TO THE EDITORS

COMMENT ON "TURBULENT CONVECTIVE HEAT TRANSFER FROM ROUGH SURFACES" AND THE DISCUSSION OF HALL'S METHOD

(*Received* 21 *October* 1980)

THIS pertains directly to heat transfer from a rough rod of radius r_1, located coaxially in a circular smooth tube of radius r_2, to a gas flowing in the inner region, zone 1, of the annulus—between the rod and the surface of radius r_m, where $\tau = 0$. Heat flux from the rod is given as q_{w1} = const and at $r = r_2$, $q_{w2} = 0$.

If the surface of zero shear and the surface of zero heat flux were coincident, i.e. $q = \tau = 0$ at $r = r_m$, then the boundary conditions in region 1 of the annulus would be similar to those in the cells of an infinite three-angular array of equally roughened rods with q_w = const, and the experimental correlations obtained for heat transfer in zone 1 of the annular passage could be suitable for calculation of heat transfer in the bundles. But the actual temperature distribution in the annulus at the prescribed conditions is such that at $r = r_m$, $q \neq 0$. In order to overcome this difficulty, Hall [1] has developed an analytical method of transformation of the actual profile of temperatures $T(r)$ into that of $T_1(r)$ to obtain $\partial T_1/\partial r = 0$ at $r = r_m$ with nonvariable q_{w1} (the method has been described in detail in [1, 5]). He has obtained an equation for the radial gradients $\partial T_1/\partial r$ of the transformed temperatures (equation (15) in [1]), which is to be integrated with respect to r in order to arrive at the new temperature profile itself and especially at the new wall temperature. This allows calculation of the transformed Stanton number if the temperature and velocity distributions as well as the heat flux q_{w1} and radius of no shear surface are known from the experiment (Hall and later Wilkie [6] assumed that $r = r_m$ at $\partial u/\partial r = 0$). The question now is how to determine the integration constant for the problem to be solved completely. It is precisely this point which is considered below.

According to Hall [1] "the constant of integration may be chosen so that the new bulk mean fluid temperature is identical with the experimental value". This statement is obscure since it is not clear what is the "experimental value". If it is the bulk mean nontransformed temperature in zone 1, then Dalle Donne and Meyer [2, 4] are correct in stating that Hall's transformation data, as far as heat transfer is concerned, "are simply referred to the average gas temperature of a region of the annulus which is not delimited by a well defined boundary condition such as $q = 0$". Lyall [3], attempting to clarify the question, has complicated it still further. Referring to Fig. 2 of Hall's paper, Lyall states that "the constant of integration has been chosen to give the same surface temperature in the experimental and transformed situations" (the same mistake is present in [6], see Fig. 3.46 and formulae (3,11)). Hall [5] disagrees with this statement by writing: "the wall temperature derived from the transformed temperature profile will not coincide with the measured wall temperature (my use of identical wall temperatures in Fig. 2 was for the purpose of illustrating the change in profile *shape* only)". However, here again no precise formulation of the so-called "experimental value" of the bulk mean fluid temperature is given.

Wilkie [7] used Hall's method to calculate the transformed Stanton numbers in his numerous experiments with single rough rods in smooth circular tubes, but no mention was made as to the way the integration constant had been calculated.

Thus, in the works cited, the question as to determination of the integration constant and, hence, complete solution of the problem has remained far from being settled.

Meanwhile, it is clear that a correct solution of the problem can be obtained only if the integration constant is chosen as follows: the new mean bulk temperature T_{b1} must exceed the experimental value of the mean bulk temperature T_b of the fluid throughout the entire annulus by a factor of G/G_1.

In fact, with a nonvariable heat flux q_{w1}, the whole heat transferred from the rod should, in the transformed situation, be absorbed entirely by the mass flux G_1 in region 1 only, while in the actual (experimental) situation the same amount of heat is taken up by the mass flux G throughout the whole annular space. From this it follows that $T_{b1}/T_b = G/G_1$.

REFERENCES

1. W. B. Hall, Heat transfer in channels having rough and smooth surfaces, *J. Mech. Engng Sci.* **4**(3), 287–291 (1962).
2. M. Dalle Donne and L. Meyer, Turbulent convective heat transfer from rough surfaces with two-dimensional rectangular ribs, *Int. J. Heat Mass Transfer* **20**(6), 583–625 (1977).
3. H. G. Lyall, Comments on "Turbulent convective heat transfer from rough surfaces", *Int. J. Heat Mass Transfer* **21**(4), 523 (1978).
4. M. Dalle Donne and L. Meyer, Rejoinder, *Int. J. Heat Mass Transfer* **21**(4), 523 (1978).
5. W. B. Hall, Comments on "Turbulent convective heat transfer from rough surfaces", *Int. J. Heat Mass Transfer* **21**(12), 1627 (1978).
6. D. Wilkie, Forced convection heat transfer from surfaces roughened by transverse ribs, *3rd Int. Heat Transfer Conference*, vol. 1, pp. 1–19. Chicago (1966).
7. E. K. Kalinin, G. A. Dreitzer and S. A. Yarkho, *The Enhancement of Heat Transfer in Chemicals*, Mashinostroenie, Moscow (1972).

All-Union Heat Engineering Institute,
Moscow, U.S.S.R.

V. L. LELCHUK