journal of heat transfer

# discussion

## Hot-Wire Anemometer Calibration for Measurements at Very Low Velocity[1]

GOPAL K. GUPTA.[2] In the discussed paper the authors have presented an excellent way of hot wire anemometer calibration for measurements at very low velocities. The calibration setup is relatively simple and quite accurate.

The authors of the discussed paper have presented the calibration curves using the parameter $(V - V_0)$ versus $U$. To investigate the nature of these curves, the equation for the heat loss from the hot-wire probe can be written as[3]:

$$I^2R_w = (A + B\sqrt{U})(T_w - T_g) \qquad (1)$$

The term $A(T_w - T_g)$ represents heat loss due to free convection and radiation and $B\sqrt{U}(T_w - T_g)$ represents forced convection. $A$ and $B$ are constants dependent on the probe dimensions and its film temperature. $R_w$ is the hot-wire probe operating resistance, $T_w$ its operating temperature, and $T_g$ the fluid temperature. Equation (1) can be rewritten as:

$$V^2 = R_w(A + B\sqrt{U})(T_w - T_g) \qquad (2)$$

Now if the operating temperature of the hot-wire probe and the fluid temperature are constant, $R_w$ and $(T_w - T_g)$ are constant and equation (2) can be written as:

$$V^2 = A_1 + B_1\sqrt{U} \qquad (3)$$

$A_1$ and $B_1$ are new constants. $A_1$ and $B_1\sqrt{U}$ are of the same order of magnitude because neither the forced nor the natural mode of convection is truly dominant as can be seen from Fig. 1 of the discussed paper. $(V - V_0)$ is now given by:

$$V - V_0 = (A_1 + B_1\sqrt{U})^{1/2} - A_1^{1/2} \qquad (4)$$

This shows that the variation of $(V - V_0)$ with $U$ is not linear. It also shows that the use of $V - V_0$ versus $U$ or log $(V - V_0)$ versus log $(U)$ is not very convenient. The author recommends $V^2 - V_0^2$ or $V^2$ versus $\sqrt{U}$ calibration curves because these curves will be straight lines. Fewer measurements will be required for such calibration curves and the hot-wire probe does not have to be calibrated for the whole range of velocity in which it is being used.

In the discussed work, $(T_w - T_g)$ is about 76 deg F for $Rr = 1.2$. Considering equation (1), the fluid temperature variation of about 5 deg F will change $(T_w - T_g)$ by over 6.5 percent, thus changing $(V^2 - V_0^2)$ by over 3 percent if the average value of $V_0$ is used. This variation will be larger in the case of $Rr = 1.1$ and smaller for $Rr = 1.3$. An experimental study[4] carried out by the author confirms this. Authors of the discussed paper indicate that no noticeable effect of the fluid temperature variation on the calibration curves was found; it is thus doubtful that the proposed technique of velocity measurement is capable of one part in $10^4$ accuracy as the authors claim.

[1] By R. P. Dring and B. Gebhart, published in the May, 1969, issue, of the JOURNAL OF HEAT TRANSFER, TRANS. ASME, Series C, Vol. 91, No. 2, p. 241.

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[3] Hinze, J. O., "Turbulence," McGraw-Hill, New York, 1959, pp. 75–119.

[4] Gupta, G. K., "Experimental Investigation of Electric Baseboard Heaters," MSc thesis, Department of Mechanical Engineering, University of Manitoba, Winnipeg, Canada, Aug. 1968.

## Flow and Heat Transfer in Ducts of Arbitrary Shape With Arbitrary Thermal Boundary Conditions[1]

CARLTON F. NEVILLE.[2] The authors have presented a practical method for engineers to use in solving fluid flow and heat transfer problems; however, certain features of the method could easily mislead a casual reader of this work.

First, the method presented does not give "closed-form solutions" as stated in both the paper and the abstract. A closed-form solution to a problem is normally considered to be an exact solution which consists of a finite number of terms. The method presented does not give exact solutions, rather it gives approximate solutions which consist of a finite number of terms.

Second, no mention is made of the requirement that a set of functions must be linearly independent before the Gram-Schmidt orthogonalization procedure can be applied to generate an orthonormal set.

Third, the use of orthonormal functions is said to be an essential feature of the method. Actually, the method is simply a least squares approximation of a given function by a linear combination of linearly independent functions. While it is true that the computer programs which are used do employ the Gram-Schmidt procedure to generate orthonormal functions, this is done simply to minimize error in the numerical computations in the computer.

Fourth, the statement is made that equation (7) is *the* solution for $u^*$. Actually, equation (7) is only *a* solution for $u^*$; many other solutions made up of other combinations of the $g_i$'s are also solutions.

[1] By E. M. Sparrow and A. Haji-Sheikh, published in the Nov., 1966, issue of the JOURNAL OF HEAT TRANSFER, TRANS. ASME, Series C, Vol. 88, No. 4, pp. 351–358.

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