The static and dynamic response of a hot-wire anemometer

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In a recent article, Bullock *et al*[1] presented some predictions of the static and dynamic responses of a hot-wire anemometer. Their predictions were claimed to substantiate the validity of King's law:

$$E^2 = a + bU^n \quad (1)$$

where E is the wire voltage corresponding to the effective cooling velocity U, and a, b and n are constants. A model of the dynamic behaviour of a hot-wire anemometer was then developed using Eq (1), leading to the conclusion that a more sophisticated anemometer control system was needed for measurements of large amplitude, high frequency turbulence.

It has been demonstrated by Siddall and Davies[2] and by Fand and Keswani[3] that the static response of a hot-wire anemometer is well represented by an equation of the form:

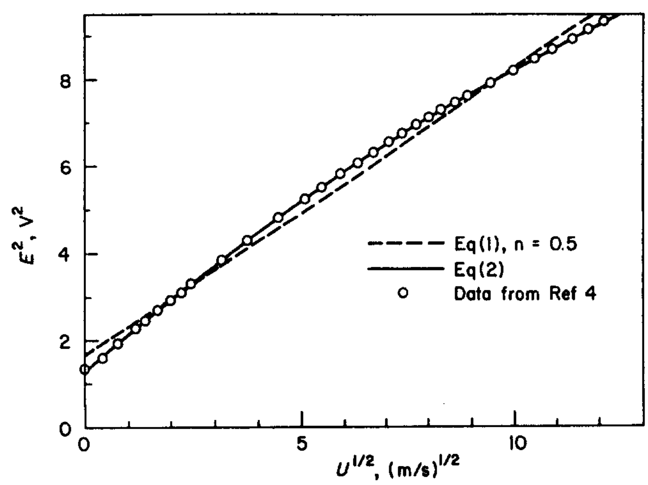

Fig 1 Static response of a hot-wire anemometer

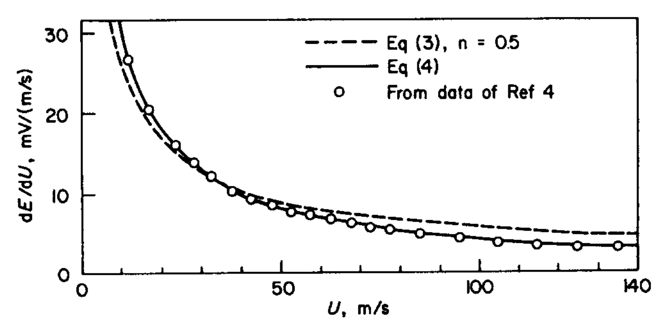

Fig 2 Dynamic response of a hot-wire anemometer

$$E^2 = A + BU^{1/2} + CU \quad (2)$$

Fig 1 shows the comparison of a least-squares fit of Eqs (1) and (2) to the hot-wire calibration data of Davies and Bruun[4]. These data were obtained using a 5 μm diameter wire and cover the entire Reynolds number range of interest in anemometry. Fig 1 demonstrates the superiority of Eq (2) over Eq (1). Correlations of the form of Eq (1) may only be used over limited ranges of Reynolds number, ie for low amplitude turbulence measurements.

Perry and Morrison[5] demonstrated that the dynamic response of a hot-wire anemometer calculated from Eq (1) for any value of n gives poor agreement with the measured dynamic response.

The method of calculating dynamic flow parameters, such as turbulence intensity, described by Schubauer and Klebanoff[6], involves the use of wire sensitivity, dE/dU, obtained by differentiation of the wire static response equation. Thus the sensitivity of wire based on Eq (1) is:

$$\frac{dE}{dU} = \frac{nbU^{n-1}}{2E} \quad (3)$$

and that based on Eq (2) is:

$$\frac{dE}{dU} = \frac{2C + BU^{-1/2}}{4E} \quad (4)$$

Fig 2 shows the dynamic response of the wire used by Davies and Bruun[4], calculated by numerical differentiation of their calibration data, compared with Eqs (3) and (4).

The conclusion to be drawn from Figs 1 and 2 is that the use of Eq (2) leads to more accurate mean flow velocity and turbulence intensity measurements, especially when large amplitude turbulence fluctuations are involved.

References

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