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EFFECT OF THE INCIDENT SURFACE PRESSURE FIELD ON NOISE DUE TO TURBULENT FLOW PAST A TRAILING EDGE

In a recent paper [1], the expression for $\mathscr{L}$, the "generalized lift", given by equation (5) of the paper, was evaluated by using only the induced surface pressure g, given by equation (2). The effect of the incident surface pressure field given by equation (1), which should be added to that of the induced field, is thereby neglected. However, equation (1) as written should not be directly substituted into equation (4b) to find the contribution of the incident pressure to $\mathscr{L}$ since this would result in modelling the pressure field as one which suddenly appeared at the leading edge, convected downstream and disappeared at the trailing edge. Thus, in addition to the trailing edge contribution there would be a leading edge contribution due to the sudden appearance of the pressure at the leading edge. A preferable model would be one in which the incident pressure gradually increased from a zero value at the leading edge, to reach its maximum value at the trailing edge and which was identically zero downstream. Thus, a convergence factor ε can be introduced into equation (1) so that

$$g_0 = \exp(\bar{x}\bar{K}_x(-\mathrm{i} + \varepsilon)). \tag{1}$$

Introducing this into equation (4b) gives

$$\mathscr{L}_0 = \frac{\mathrm{i}}{\Theta + \mathrm{i}\varepsilon\bar{K}_x}[1 - \exp(2(\mathrm{i}\Theta - \varepsilon\bar{K}_x))]. \tag{2}$$

For $\omega \to \infty$ followed by $\varepsilon \to 0$ the effect of the leading edge drops out and

$$\mathscr{L}_0 \to \mathrm{i}/\Theta. \tag{3}$$

If this is added to equation (5), the last term in equation (5), $\exp(-\mathrm{i}2\Theta)$, is cancelled. (Note that equation (5) was multiplied by $-\mathrm{i}\exp(-\mathrm{i}2\Theta)$ before the absolute value was taken.)

The result of this correction is to raise the calculated level of the trailing edge noise in Figure 1 of reference [1] by an average of about 6 dB while at the same time giving a much smoother curve. The corrected figure is given here as Figure 1.

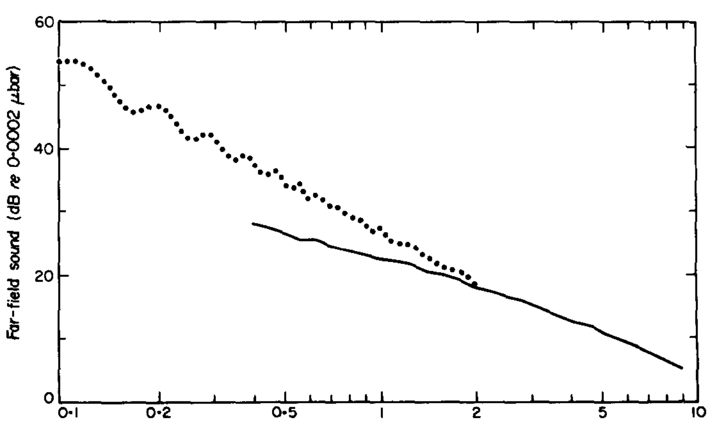

Figure 1. Trailing edge noise compared with incident turbulence noise. Span = 40 meters, chord = 5 meters, $M = 0{\cdot}3$, observer position = 200 meters directly above airfoil retarded position. ——, Trailing edge noise; ····, incidence fluctuation noise with integral scale = 1 meter and intensity = 1 %.

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Another result of the correction is that for the high frequency limit the directivity expression contains the factor $\cos^2(\theta_e/2)$ which often appears in half plane problems. Here θ_e represents the angle to the retarded source position as measured from the upstream axis. In terms of retarded co-ordinates

$$\sigma = r_e(1 - M\cos\theta_e), \qquad x = r_e(M - \cos\theta_e), \tag{4}$$

where r_e is the distance from the observer to the retarded source position. Thus, in the high frequency limit the directivity factor in equation (4a) of reference [1] becomes

$$\begin{aligned}\frac{z^2}{\sigma^4}|\mathscr{L}_c|^2 &\to \frac{z^2}{\sigma^4\,\Theta^2}\frac{1 + M + \bar{K}_x/\mu}{1 + x/\sigma} \\ &= \frac{2}{M_c r_e^2 \bar{K}_x^2[1 - (M - M_c)\cos\theta_e]^2}\frac{1 + M_c - M}{1 - M\cos\theta_e}\cos^2\frac{\theta_e}{2},\end{aligned} \tag{5}$$

where $\mathscr{L}_c = \mathscr{L}_0 + \mathscr{L}$ represents the corrected value for $\mathscr{L}$. If the uncorrected expression for $\mathscr{L}$ were used to calculate the directivity in this high frequency limit, in addition to the above term there would be a term containing the factor $\sin\theta_e$.

United Technologies Research Center,
East Hartford,
Connecticut 06108, *U.S.A.*

R. K. AMIET

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REFERENCE

1. R. K. AMIET 1976 *Journal of Sound and Vibration* **47**, 387–393. Noise due to turbulent flow past a trailing edge.