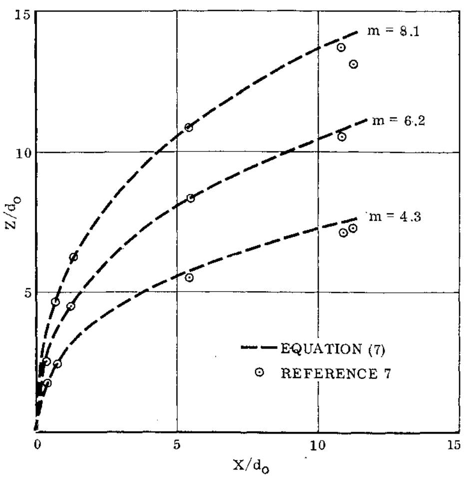

Fig. 2 Jet centerlines.

is any function of m. Equation (8) is seen to be of this form.

Figure 2 shows calculated jet centerlines using Eq. (7). Shown in the same figure are data from Ref. 7, and it is seen that Eq. (7) fits these experimental data quite well. Analysis of other experimental data[8,9] has shown the same functional relationship, although for each set of test data better correlation can be obtained by using slightly different values for the coefficient and exponent of Eq. (7).

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Skin-Friction Formula for Tapered and Delta Wings

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When determining the skin-friction drag for a tapered or delta-shaped wing, it is necessary to take into consideration the variation of the skin-friction coefficient over the whole surface and the dependence on the Reynolds' number spanwise variation with chord length. In principle this can be done in two ways. One method is to choose some equivalent reference chord on the wing for the calculation of the skin-friction coefficient. This method can however give considerable errors. The other method of analysis is to integrate the skin-friction coefficient along the span of the wing, the so-called strip integration method. If the skin-friction formula used is simple enough for the integral to be developed into an explicit expression, the analysis is quite straightforward. Unfortunately, this is not always the case. For the skin friction in turbulent boundary layer, the formulas commonly used will require numerical integration. This can be very time consuming. Much time could be saved if there existed a formula which made the numerical integration unnecessary. The following is such a formula for a tapered surface (one side of the wing) with fully turbulent boundary layer:

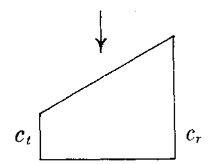
$$c_f = \frac{0.472}{\left({}^{10}\log Re \; \dfrac{1+\lambda}{2}\right)^{2.58}} \cdot \left[1 - \frac{(1-\lambda)^4(4.55 - 0.27 \cdot {}^{10}\log Re)}{100}\right]$$

where Re = Reynolds number based on c_r ($c_r > c_t$)

$$\lambda = \frac{c_t}{c_r}$$

c_r = root chord

c_t = tip chord



The formula has been developed by correlating the λ and Re dependence against values calculated by complete integration, using the Prandtl flat-plate turbulent skin-friction formula

$$c_f = 0.472/({}^{10}\log Re)^{2.58}$$

For the Reynolds number range $10^5 - 10^9$, the formula agrees within 0.2% with strip-integrated values.

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