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Conical Flarings in Uniform Supersonic Flow at Zero Angle of Attack

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Numerical calculations were carried out on the Illiac,† based on the method of characteristics for axially symmetric supersonic flow and the oblique-shock relations, disregarding the effects of vorticity behind the (slightly) curved shock fronts. In Ref. 1 surface-pressure coefficients, drag coefficients, and shock-front configurations were presented in graphical form as functions of a dimensionless length coordinate for half-cone angles of 5°, 10°, 15°, and 20° and approaching Mach numbers of 1.5, 2.0, 2.5, 3.0, and 3.5 (see Fig. 1 for geometry and nomenclature).

Hypersonic-similarity concepts[2] can be used to achieve a more generalized interpretation of these data and at the same time to illustrate the accuracy in their use for the whole range of cone angles and Mach numbers covered by the original computations.

Figure 2 provides information on the surface-pressure coefficient

$$C_{ps} = (p_s - p_\infty)/\tfrac{1}{2}\rho_\infty V_\infty^2 = C_{ps}(R/R_0, M_\infty, \theta_s)$$

by representing, in graphical form, $C_{ps}/\sin\theta_s^2$ as a function of the modified hypersonic-similarity parameter $K = (M_\infty^2 - 1)^{1/2} \tan\theta_s$ for various values of R/R_0.

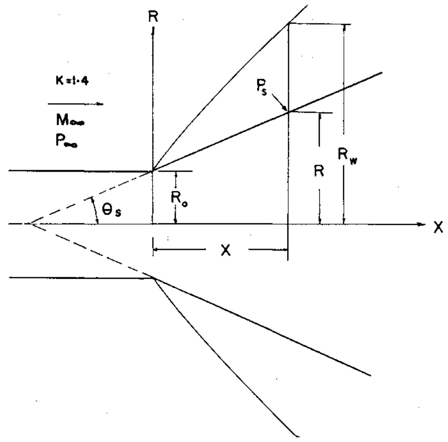

Fig. 1 Conical flaring in supersonic flow

Figure 3 yields information in a similar fashion on the drag coefficient, established on the basis of the maximum cross-sectional area of the flaring,

$$C_{DR} = \frac{1}{(R/R_0)^2} \int_1^{R/R_0} C_{ps} d\left(\frac{R}{R_0}\right)^2$$

The shock-front geometry also can be presented conveniently in a form suggested by supersonic-hypersonic similarity concepts, as shown in Fig. 4, where R_W/R_0 is plotted against $x/R_0 \tan\theta_s$ for values of $0.1 < K < 0.6$.

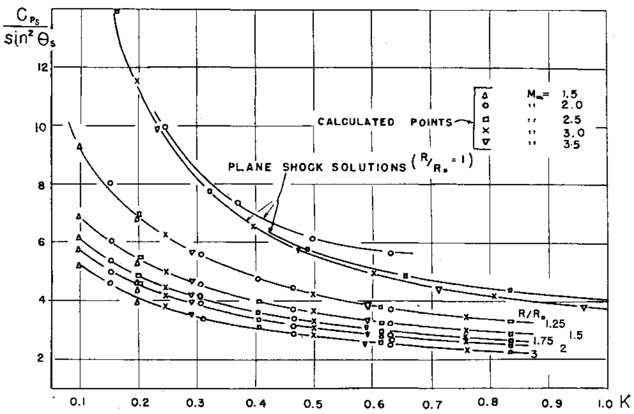

Fig. 2 Pressure coefficient for conical flarings in supersonic-hypersonic similarity presentation

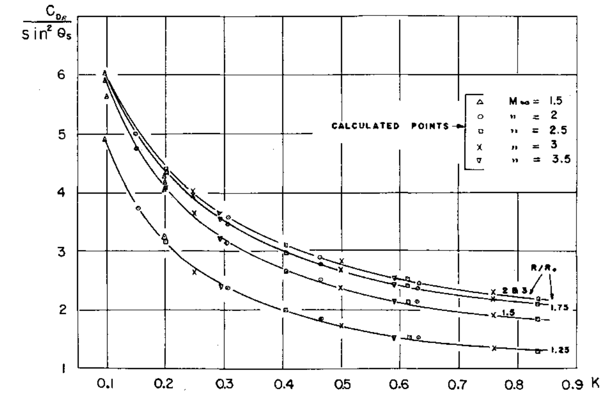

Fig. 3 Drag coefficient for conical flarings in supersonic-hypersonic similarity presentation

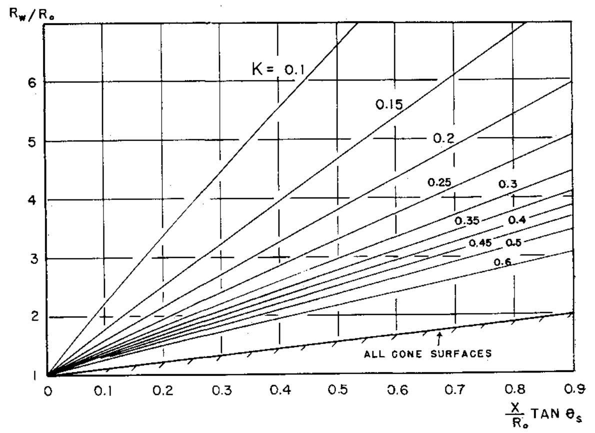

Fig. 4 Shock-front configuration for conical flarings in supersonic flow at various similarity parameter values

Correlation obtained by presenting the original data of Ref. 1 in terms of the similarity concepts is indicated by showing the individually calculated points in addition to the faired curves. The latter are based predominantly on those cases in which the small-disturbance aspects of the similarity concepts were satisfied best.

The asymptotic tendency of drag coefficients toward that for cones obtained by Newton's impact theory is well born out in Fig. 3, where, for large values of K and R/R_0, the coefficient $C_{DR}/\sin^2\theta_s$ approaches the value 2.

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