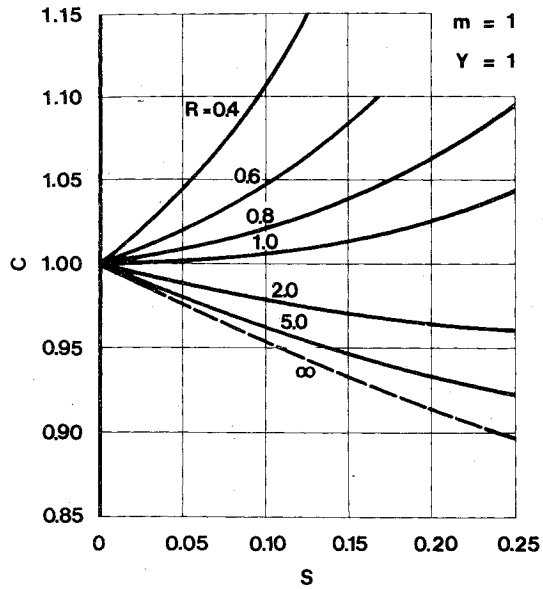

Fig. 2 Effect of nozzle geometry on correction factor.

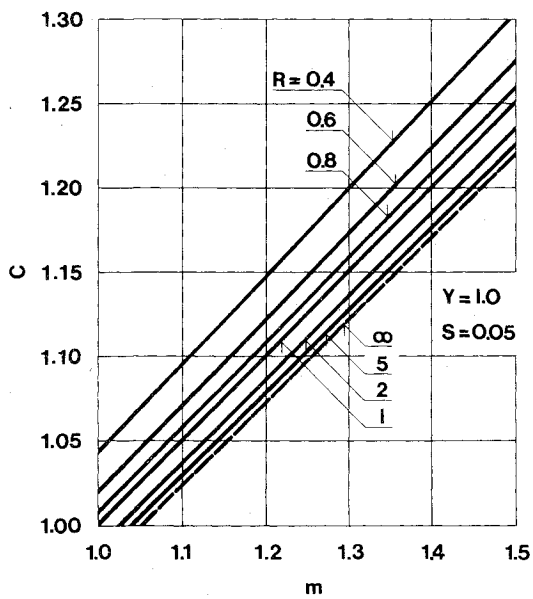

Fig. 3 Effect of temperature dependence of thermal conductivity on the correction factor.

and (9) are applied, the correction factor takes the form

$$C=\frac{S(m+1)\,(Y+R\cos\psi)}{2(R-S)\,(Y+S\cos\psi)}\left[\ln\frac{R\,(Y+S\cos\psi)}{Y(R-S)}\right]^{-1} \tag{10}$$

Geometrically similar expansion nozzles have identical correction factors if their temperature at corresponding points does not differ.

Discussion

As an example, the results for the particularly interesting nozzle throat ($Y=1$) are presented. In Fig. 2, C is plotted as a function of S with R as a parameter for $m=1$. It can be seen that for growing S the correction factor C deviates increasingly from the limiting case $C=1$. For expansion nozzles of rocket engines, $1\leq R\leq 2$ and $S\leq 0.05$ is generally recommended.[4] In this range there is apparently no need for correcting Eq. (4) because the error is $f<1\%$. Recently, however, nozzle geometries approaching $R\geq 0.5$ have been discussed.[5] The dashed line for $R\to\infty$ as a limiting case provides the correction factor for a tube.

Figure 3 shows correction factor C as a function of m for different values of R for $Y=1$ and $S=0.05$. This shows that frequently a correction of Eq. (4) becomes indispensable because the error reaches a percentage that cannot be tolerated even in approximate calculation.

References

[1] Huzel, D.K. and Huang, D.H., "Design of Liquid Propellant Rocket Engines," NASA SP-125, 1971.

[2] Sutton, G.P., *Rocket Propulsion Elements,* 3rd ed., Wiley, New York, 1963.

[3] Back, L.H., Massier, P.F., and Gier, H.L., "Convective Heat Transfer in a Convergent-Divergent Nozzle," *International Journal of Heat Mass Transfer,* Vol. 7, May 1964, pp. 549-568.

[4] Barrere, M., Jaumotte, A., Veubeke, B.F., and Vandenkerckhove, J., *Rocket Propulsion,* Elsevier Publ. Co., Amsterdam, 1960.

[5] Back, L.H., Cuffle, R.F., and Massier, P.F., "Influence of Contraction Section Shape and Inlet Flow Direction on Supersonic Nozzle Flow and Performance," *Journal of Spacecraft and Rockets,* Vol. 6, June 1972, pp. 420-427.

Errata

Economical Scheme for Estimating Orbital Lifetimes

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ON page 324, Fig. 2 the curves labeled $e_0=0.7$ should be labeled $e_0=0.6$ and the curve labeled $e_0=0.60$ should be labeled $e_0=0.40$.

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