Technical Comments

Comment on "Free-Flight Investigations of Subliming Ablators and Transpiration Cooling at Hypersonic Velocities"

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SINCE there has been some success in analysis with the Hatch-Papell model[2] of gaseous *film cooling*, the possible extension of its use to describe the *downstream cooling* results presented in Fig. 6 of Ref. 1 where the coolant was injected through a porous material, is of interest. A possible comparison between the two cooling systems can then be made. The Hatch-Papell equation, in the nomenclature of Ref. 1, for tangential slot injection of coolant is

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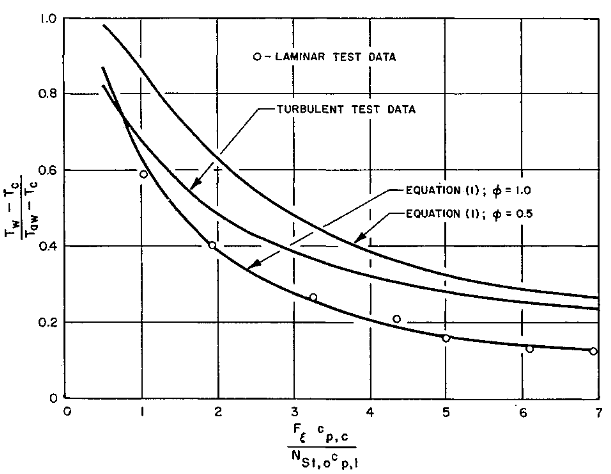

Fig. 1 Comparison of Eq. (1) with downstream cooling test data.

$$\frac{T_w - T_c}{T_{aw} - T_c} = 1 - \exp\left(-\frac{1/\varphi}{F_\xi c_{p,c}/N_{St,0}c_{p,1}}\right) \qquad (1)$$

where φ is an efficiency factor, and, for flat-plate or rocket-motor film cooling with slot-type film coolant injectors, φ is normally between 0.1 and 0.3 when the mainstream flow is turbulent.

Equation (1) is shown in Fig. 1 with $\varphi = 1.0$ and $\varphi = 0.5$. Also included are the experimental curves of Fig. 6 of Ref. 1. It can be seen that the $\varphi = 1.0$ curve agrees very well with the laminar data, but the turbulent data at the high end of the abscissa scale are closer to the $\varphi = 0.5$ curve. On the basis of these high φ values, the downstream cooling described in Ref. 1 would appear to be relatively efficient as compared with slot-type film cooling, probably because of small losses of the coolant when it is injected through a porous material. This comment is made because, in most applications, the efficiency of film cooling is important, and of special concern is the method of injection of the coolant and its effect on the efficiency.

References

[1] Walton, T. E., Jr., Rashis, B., and Winters, G. W., "Free-flight investigations of subliming ablators and transpiration cooling at hypersonic velocities," J. Spacecraft Rockets **1**, 498–501 (1964).

[2] Hatch, E. and Papell, S. S., "Use of a theoretical flow model to correlate data for film cooling or heating on adiabatic wall by tangential injection of gases of different fluid properties," NASA TND-130 (November 1959).

Erratum: "Simplified Equations for Determining Propulsion System Specific Impulse"

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IN the reference paper,[1] equations are presented which can be used to compute an effectiveness system specific impulse, $I_{ss} \equiv I_T/W_i$, where I_T = total impulse, and W_i = weight of the loaded propulsion system. However, this definition of effectiveness is not consistent with the effectiveness space system specific impulse derived by Ross.[2] Therefore, to be consistent with the foregoing definition, the corrected form of Eq. (1) of Ref. 1 is

$$\Delta V = I_{ss}g \ln\left(\frac{M_G}{M_P}\right) + I_{sp}g \ln\frac{(M_P/M_G)^\lambda}{[1 + \lambda\,(M_P/M_G - 1)]}$$

where M_P is the mass of payload, M_G is the gross mass of vehicle or stage in question, I_{sp} is the propellant specific impulse, and $\lambda = I_{ss}/I_{sp}$.

Reference

[1] Ross, F. W., "Space system specific impulse," J. Aerospace Sci. **28**, 838–843 (1961).

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