Skin Friction Drag

In many practical high Reynolds number circumstances (such as in ship drag assessments), the skin friction drag is evaluated by using expressions for the *skin friction coefficients* taken from laminar and/or turbulent boundary layer analyses (see sections (Bjf) and (Bkk)) for which $\tau_w/\rho U^2$ is proportional to either $Re_s^{-\frac{1}{2}}$ or $Re_s^{-\frac{1}{5}}$ respectively with s being the surface distance from the front stagnation point. (Of course, adjustment factors of proportionality are used based on experimental measurement or flow computations.)

Whatever means are used to perform the integral in equation (Dab6), it can be seen that there is an additional factor that did not appear in the equivalent form drag equation, namely the factor A^{**}/A^{*}, which effects the outcome. This factor is roughly proportional to the ratio of the length of the object, ℓ, to the breadth of the object, h. Consequently, even when the shear stresses are much smaller than the pressures, the skin friction drag may be comparable to the form drag when the object has an A^{**}/A^{*} value much greater than unity. Such can be the case for streamlined objects with $\ell/h \gg 1$. Figure 1 is an example of the comparison between the form drag and the skin friction drag, specifically for the case of a

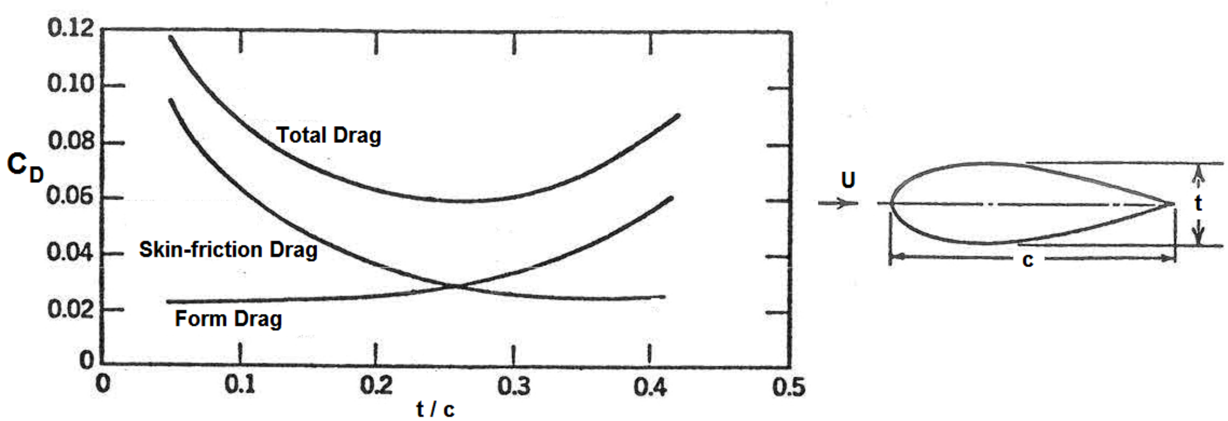

Figure 1: Coefficients of drag (based on frontal projected area) of a streamlined, symmetric strut (thickness, t, and chord, c) as a function of the ratio, t/c. Shown are the C_D values for the form drag and the skin-friction drag as well as the total.

streamlined, symmetric strut of thickness, t, and chord, c. The drag coefficients are plotted as a function of the ratio, t/c, and the demonstrate that while the form drag increases with t/c, the skin friction drag decreases. In this example they are equal at a ratio, t/c, of about 0.26. The total drag is also a minimum for this thickness to chord ratio. Though this drag minimum will not necessarily always correspond with the thickness to chord ratio at which the drag contributions are equal, it is probable that the two optimum values of t/c are not far apart. Since the structural strength and rigidity of struts is often an important design consideration and since these structural features will improve as the thickness is increased it seems likely that the choice of $t/c \approx 0.26$ (or some comparable value that might depend on other geometric features of the strut such as the roundness of the leading edge) will provide the best design choice.