$''$ = unmixed dispersed phase
$-$ = time-smoothed value

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The Reduction in Heat Exchanger Effectiveness Caused by Dilute Quantities of Drag Reducing Substances

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In a recent communication (*1*) K. A. Smith and others have published further data on heat transfer to drag-reducing polymer systems. These systems have received considerable study because there is clearly some practical advantage in using additives to cut down pumping requirements. In a recent study (*2*) I have pointed out the possibility that use of these additives in tube heat exchangers may have no beneficial effect whatsoever. It is gratifying to see that Smith's results also confirm this trend.

Their turbulent flow heat transfer data for dilute polymer solutions has been correlated in a form easily amenable for design purposes. Rearranging their equation (5) one obtains

$$h = \frac{\tau}{U} \cdot \frac{c_p^{0.4} k^{0.6}}{\mu^{0.6}} \tag{1}$$

or, assuming that physical properties are unaffected by addition of small amounts of polymer

$$h = \text{const.} \times \frac{\tau}{U} \tag{2}$$

For the effect of drag reduction to have practical application the addition of polymer must ensure that the heat transfer coefficient divided by pumping power is increased. Pumping power is proportional to $\tau\, U$. Hence the important ratio is $h/\tau\, U$. From Equation (2), we may write

$$\frac{h}{\tau\, U} \sim \frac{1}{U^2}$$

for a given τ, U is increased by addition of polymer so $h/\tau U$ is decreased. Again the Toms effect appears to offer no practical benefit in high Reynolds number heat transfer in a smooth pipe. In retrospect this is not surprising since turbulence promoters are often used in process heat exchangers. Here a higher wall shear stress is accepted as necessary to cut down the thickness of the laminar sublayer, it being of the greater importance to cut down the thickness of this layer than to decrease wall shear stress. In contrast the laminar sublayer is thickened by dilute polymer solutions under drag reducing conditions.

It should also be pointed out that reasonable correlations have been obtained by several workers (*1*, *3* to *5*) using straightforward modifications of turbulent flow heat transfer analogies (*6*). All this type of work requires *a priori* knowledge of turbulent flow friction factor data for the given system. In so far as very little satisfactory work has been done on the friction correlation problem the calculation of heat transfer data for turbulent flow of dilute polymer solutions remains unsolved. For this reason the latter problem is probably a more important area of research.

NOTATION

c_p = heat capacity of solution, $(L^2T^{-2}\theta^{-1})$
h = heat transfer coefficient for the pipe, $(M\ T^{-3}\theta^{-1})$
k = thermal conductivity of solution, $(MLT^{-3}\theta^{-1})$
U = mean velocity, (LT^{-1})
μ = solution viscosity, $(ML^{-1}T^{-1})$
τ = pipe wall shear stress, $(ML^{-1}T^{-2})$
(M = mass, L = length, T = time and θ = temperature units)

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