$$\mathrm{Nu}=\frac{h_{\mathrm{bath}}D}{k_{\mathrm{b}}}=0.87\,\mathrm{Re}_{\mathrm{N}}^{2/3}\,\mathrm{Pr}^{1/3}\left(\frac{\mu_{\mathrm{c,b}}}{\mu_{\mathrm{w,b}}}\right)^{0.14} \tag{5.34}$$

where D is the inside diameter of the agitated vessel, k_{b} is the thermal conductivity of the bath fluid (typically water), the last term is the ratio of dynamic viscosities for the bath fluid, and the Reynolds number Re_{N} for an agitated vessel is given by

$$\mathrm{Re}_{\mathrm{N}}=\frac{N\rho_{\mathrm{b}}L_{\mathrm{a}}^{\;2}}{\mu_{\mathrm{c,b}}} \tag{5.35}$$

where N is the agitator speed, L_{a} is the agitator diameter, and ρ_{b} and $\mu_{\mathrm{c,b}}$ are the density and dynamic viscosity of the bath fluid.

For an example of multi-bath system design, an optimal choice for the bath temperatures and tube lengths could be based on the objective of low maximum supersaturation level within the metastable zone, to maintain purity and avoid secondary nucleation within the liquid slugs passing through the tube. In the case of a four-bath system, the optimization is given by

$$\min_{\substack{T_1,T_2,T_3\\ \ell_1,\ell_2,\ell_3,\ell_4}} w_1\max\{0,[C_{\mathrm{f}}-C_{\mathrm{sat}}(T_4)]\}+w_2S_{\max}+w_3\sum_i \ell_i \tag{5.36}$$

where the first term compares the final concentration C_{f} in the system to $C_{\mathrm{sat}}(T_4)$, the saturation concentration at the final temperature, to force high yield. In the second term, $S_{\max}$ is the maximum supersaturation within the system. The third term is the total length of tubing. The values of weights, w_i, are dependent upon the experimental system.

5.4.2 Heat Exchangers for T Zones

An alternative system replaces the constant-temperature baths with counterflow single-pass double-pipe heat exchangers (Figure 5.14). With the shell-side temperature for each heat exchanger held constant, $T_{c,i}$, the length of tubing, ℓ_i, and cooling water flowrate, $\dot{m}_{\mathrm{c},i}$, can differ, offering degrees of freedom for design and control.[32]

The outlet temperatures of a double pipe heat exchanger can be calculated using the effectiveness defined as[38]

$$\eta=\frac{1-\mathrm{e}^{-\alpha}}{1-\frac{W_{\mathrm{c}}}{W_{\mathrm{s}}}\mathrm{e}^{-\alpha}}, \tag{5.37}$$

for $W_{\mathrm{c}}\neq W_{\mathrm{s}}$, where W_{s} and W_{c} are the heat capacity rates of slugs and cooling water ($W=\dot{m}\hat{C}_{\mathrm{p}}$), and the exponent α is defined by