Turbulent Flow

$$Nu_D = 0.023\, Re_D^{4/5}\, Pr^n$$

$0.6 < Pr < 160$

$Re_D > 10{,}000$

$\frac{L}{D} > 10$

heating

$T_s > T_m$

$n = 0.4$

cooling

$T_s < T_m$

$n = 0.3$

For larger temperature difference

$$Nu_D = 0.027\, Re_D^{4/5}\, Pr^{1/3} \left(\frac{\mu}{\mu_s}\right)^{0.14}$$

$0.7 < Pr < 16{,}700$

$Re_D > 10{,}000$

$\frac{L}{D} > 10$

All properties at T_m except μ_s

For smooth tubes

$$Nu_D = \frac{(f/8)(Re_D - 1000)\,Pr}{1 + 12.7(f/8)^{1/2}(Pr^{2/3} - 1)}$$

$0.5 < Pr < 2000$

$3000 < Re_D < 5 \times 10^6$

Entry region short $10 < \frac{x_{fd}}{D} < 60$

$$\overline{Nu_D} = Nu_{D,fd}$$

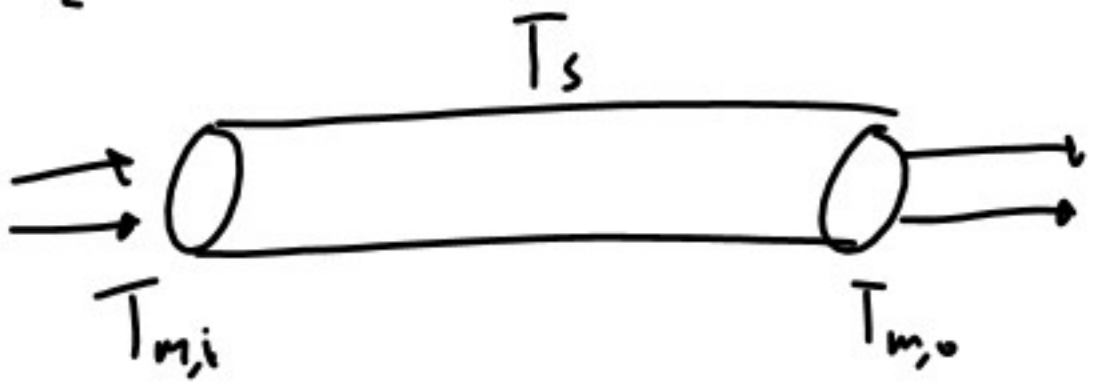
For short tubes

$$\frac{\overline{Nu_D}}{Nu_{D,fd}} = 1 + \frac{C}{(x/D)^m}$$

C and m depend on inlet geometry

Properties at

$$\bar{T}_m = \frac{T_{m,i} + T_{m,o}}{2}$$



8.20 Engine oil flows through a 25-mm-diameter tube at a rate of 0.5 kg/s. The oil enters the tube at a temperature of 25°C, while the tube surface temperature is maintained at 100°C.

(a) Determine the oil outlet temperature for a 5-m and for a 100-m long tube. For each case, compare the log mean temperature difference to the arithmetic mean temperature difference.

$$Re_D = \frac{4\dot{m}}{\pi D \mu} = \frac{4 \cdot 0.5\ \mathrm{kg/s}}{\pi \cdot 0.025\,\mathrm{m} \cdot 48.6\times10^{-2}\ \mathrm{Ns/m^2}}$$

$$\bar{h} = \frac{k}{D}\overline{Nu_D} = \frac{k}{D}\left(3.66 + \frac{0.0688\ \frac{D}{L} Re_D Pr}{1+0.04\left(\frac{D}{L} Re_D Pr\right)^{2/3}}\right)$$