HOMEPROBLEM SET THREE | TRANSPORT PHENOMENA II | KEITH, JASON M.

DUE 19 NOVEMBER 1993 | 4200:322 | I worked with B, Stevenson

30

☆ ↑ List collaborators

13,B Heat Transfer in Laminar Tube Flow

One hundred pounds per hour of oil at 100°F are flowing through a 1-in.id. copper tube, 20 ft long. The inside surface of the tube is maintained at 215°F by condensing steam on the outside surface. Fully developed flow may be considered constant at the following values: $C_p = .49$ Btu $lb_m^{-1} F^{-1}$ $\rho = 55\ lb_m\ ft^{-3}$ $\mu = 1.42\ lb_m\ hr^{-1}\ ft^{-1}$, $k = 0.0825$ Btu $hr^{-1}\ ft^{-1}\ F^{-1}$ a) Calc Re b) Calc Pr c) Calc exit temp °F oil.

Number pages

Write out problem statement

a) $Re = \frac{\rho \langle v_z \rangle D}{\mu}$ but $\langle v_z \rangle = \frac{Q}{S} = \frac{4Q}{\pi D^2}$

$Re = \frac{4 Q \rho D}{\pi \mu D^2}$ but $Q = \dot{m}/\rho$

$Re = \frac{4\dot{m}}{\pi \mu D} = \frac{4(100\ lb_m/hr)}{\pi (1.42\ lb_m/(hr\ ft))(1/12\ ft)}$

$\boxed{Re = 1075}$ ← box in answers ☆

b) $Pr = \frac{C_p \mu}{k} = \frac{(.49\ Btu/lb_m\ °F)(1.42\ lb_m/ft\ hr)}{.0825\ Btu/hr\ ft\ °F}$

$\boxed{Pr = 8.44}$

tell us what you are doing (assumptions, etc.)

c) Since $Re < 2100$, laminar flow

If $Re\ Pr\ D/L > 10$, we may use the Graetz correlation.

$Re\ Pr\ D/L = (1075)(8.44)(\frac{1}{12})(\frac{1}{20}) = 37.8$

$h_{lm} = \frac{k}{D}(1.86)(Re\ Pr\ D/L)^{1/3}(\mu_b/\mu_a)^{0.14}$

Assume μ = constant

$h_{lm} = \frac{.0825\ Btu/hr\ ft\ °F\ (1.86)(37.8)^{1/3}(1)^{0.14}}{\frac{1}{12}\ ft}$

$h_{lm} = 6.18$ Btu/hr ft² °F

use engineering paper

From macroscale enthalpy balance (see ex. 9.6-1 solved earlier)

☆ SHOW all work

$$\dot{W}_s^A \hat{C}_p^A (T_b^A(L) - T_b^A(0)) = h_{lm} (\pi D L) \left[\frac{(T_{K_0 R} - T_b^A(0)) - (T_{K_0 L} - T_b^A(L))}{\ln \left((T_{K_0 R} - T_b^A(0)) / (T_{K_0 L} - T_b^A(L)) \right)} \right]$$

$$100\ lb_m/hr\ (.49\ Btu/lb_m\ °F)(T_b^A(L) - 100) = (6.18\ Btu/hr\ ft^2\ °F)(\pi \tfrac{1}{12}\ ft)(20\ ft) \left[\frac{(215-100) - (215 - T_b^A(L))}{\ln((215-100)/(215-T_b^A(L)))} \right]$$

$$49(T_b^A(L) - 100) = \frac{32.857(T_b^A(L) - 100)}{\ln[115/(215 - T_b^A(L))]}$$

$\boxed{T_b^A(L) = 155\ °F}$ and $Q = 49\ Btu/lb_m\ °F\ (155 - 100\ °F) = \boxed{2724\ Btu/hr}$

See 9.6-1 on Notebook for more information