MET 330	HW 2.3	John Butler

Chapter 15.

4) Given

$d_1 = 10in \Rightarrow 0.833ft$ $\quad Q = 25 gal/min \Rightarrow 0.0557 ft^3/s$

$Sg = 0.83$ $\quad \nu = 2.5E-6\ lb/ft$

a) $d_2 = 1in = 0.0833ft$

$A_1 = \pi/4 (0.833)^2 = 0.545 ft$

$A_2 = \pi/4 (0.0833)^2 = 0.00545 ft$

$\frac{A_2}{A_1} = \frac{0.00545}{0.545} = 0.01$

Solve for 'h'

$Q = A_2 \sqrt{\frac{2(P_1 - P_2)}{\rho\left(1 - \left(\frac{A_2}{A_1}\right)^2\right)}} \Rightarrow \frac{P_1 - P_2}{\rho} = gh \Rightarrow \frac{\left(\frac{Q}{A_2}\right)^2\left(1 - \left(\frac{A_2}{A_1}\right)^2\right)}{2g} = h$

$h = \frac{\left(\frac{0.0557 ft^3/s}{0.00545 ft}\right)^2\left(1 - (0.01)^2\right)}{2 \times 9.81} = 0.52 ft$

$h = 0.52 \times 0.83 = \underline{0.431 ft}$

b) $A_2 = \pi/4 (0.583)^2$

$= 0.2670 ft$

$\frac{A_2}{A_1} = 0.489$

$h = \frac{\left(\frac{Q}{A_2}\right)^2\left(1 - \left(\frac{A_2}{A_1}\right)^2\right)}{2g} = \frac{\left(\frac{0.0557}{0.267}\right)^2\left(1 - (0.489)^2\right)}{2 \times 9.81} = 0.0081 ft$

$h = 0.0081 ft \times 0.83 = \underline{0.0067 ft}$

15) Given

$T = 50°C$ $\quad x = 0.24 in \Rightarrow 6.09E-3 m$ $\quad g = 9.81 m/sec$

$\rho_w = 1000 kg/m^3$ $\quad P = 101.325 kPa$

$V = \sqrt{2gh}$ $\quad h = x\left(\frac{\rho_m}{\rho} - 1\right)$

*From Table
$R = 287.05 J/kg \cdot K$

$\rho_{air} = \frac{P}{RT} \Rightarrow \frac{(101.325E3\ Pa)}{(287.05)(50°C)}$

$\rho_{air} = 7.06\ kg/m$

$h = x\left(\frac{\rho_w}{\rho_a} - 1\right) = 6.09E-3m\left(\frac{1000 kg/m^3}{7.06 kg/m}\right)$

$h = 0.863 m$

$V = \sqrt{2(9.81)(0.863m)}$

$\underline{V = 4.115 m/s}$

Q: 16.9

Daniel Erdogan

$\gamma_{merc} = 844.9$ lb/ft³
$\gamma_{oil} = 58$ lb/ft³
$\nu = 3.84 \times 10^{-4}$ ft²/sec

Copper tube = 5 in ⇒ ID: 4.805 in ⇒ 0.40 ft
oil T = 77°F   A: 18.133 in² → 0.12593 ft²
flowrate = 700 → 1000 gal/min
mano range: 0 → 8.0 in

$1 \text{ gal/min} = \dfrac{0.13368056 \text{ ft}^3}{60 \text{ sec}}$

so:

700 gal/min = 1.56 ft³/sec
1000 gal/min = 2.23 ft³/sec

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find V_{max}:

$$V = \frac{Q}{A} = V_{max} = \frac{Q_{max}}{A} = \frac{2.23 \text{ ft}^3/\text{sec}}{0.12593 \text{ ft}^2} = 17.71 \text{ ft/sec}$$

find Reynolds

$$R_e = \frac{\rho V D}{\mu} = \frac{VD}{\nu}$$

velocity, diameter (Agreeing), viscosity

$$R_e = \frac{17.71 \text{ ft/sec} \cdot 0.40 \text{ ft}}{3.84 \times 10^{-4} \text{ ft}^2/\text{sec}} = 18{,}447.92$$

Use orifice plate flow meter! (nozzle)

$C_{max} = 0.961$ $h = 8 \text{ in} = 0.67 \text{ ft}$

$$v_1 = C \cdot \sqrt{\frac{2gh\left(\frac{\gamma_{m}}{\gamma_{oil}} - 1\right)}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$$ solve for A_1 ⇒ $$17.71 = 0.961 \cdot \sqrt{\frac{2 \cdot 32.174 \cdot 0.67\left(\frac{844}{68} - 1\right)}{\left(\frac{A_1}{0.12593}\right)^2 - 1}}$$

used online calculator

$A_1 = 0.12699 \text{ ft}^2$

$$A_{circle\,(orifice)} = \left(\tfrac{1}{4}\right) \cdot \pi \cdot d^2$$

$$d = \frac{2\sqrt{\pi \cdot A}}{\pi} = \frac{2 \cdot \sqrt{\pi \cdot 0.12699}}{\pi} = 0.402 \text{ ft}$$

plug area