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2 (i) $\cancel{\frac{\Delta P}{\rho}}^{0} + g\Delta z + \cancel{\frac{1}{2}\Delta v^2}^{0} + \cancel{W_s}^{0} + F = 0$

we don't know V, so use the ϕRe^2 and Re plot

$$F = 9.8 \times 5$$

$$= 49 \text{ J/kg}$$

$$\phi Re^2 = \frac{F D^3 \rho^2}{4 L \mu}$$

$$= \frac{49 \times (0.0254)^3 (990)^2}{4 \times 10 \times (0.00495)^2}$$

$$= 802966$$

→ smooth pipe

$$Re = 1.5 \times 10^4$$

$$\frac{Re\,\mu}{\rho d} = V$$

$$V = \frac{1.5 \times 10^4 \times 0.00495}{990 \times 0.0254}$$

$$= 2.95 \text{ m/s}$$

$$Q = VA$$

$$= 2.95 \text{ m/s} \times \pi \times \frac{(0.0254\text{m})^2}{4}$$

$$= 1.50 \times 10^{-3} \text{ m}^3/\text{s}$$

(ii) $\frac{(P_2 - 101.3)10^3}{1000} + 9.8 \times 1.5 + \frac{1}{2}(2.95^2 - 0) + \frac{2 \times 0.007 \times 4}{0.0254} \times (2.95^2)$

$$P_2 = 139538 \text{ Pa}$$

$$\simeq 139.5 \text{ kPa}$$

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3) (i) finding hsystem

$$h_s = \frac{\Delta P}{\rho} + g\Delta z + \frac{1}{2}\Delta v^2 + F$$

$$= 0 + \frac{9.8 \times 3}{9.8} + \frac{1}{2} \times 0 + \left[\frac{2 \times (165 + 35 \times 0.1) \times 0.015}{0.1 \times 9.8} + \frac{1}{2 \times 9.8}(1.5)\right]\left(\frac{Q}{\frac{\pi \times 0.1^2}{4}}\right)^2$$

$$= 3 + 84861 Q^2$$

$$h_s = h_p$$

$$12 - 70Q - 4300Q^2 = 3 + 84861 Q^2$$

$$\Rightarrow 89162 Q^2 + 70Q - 9 = 0$$

$$Q = \frac{-70 + \sqrt{70^2 + 4 \times 89162 \times 9}}{2 \times 89162}$$

$$= \underline{0.01 \, m^3/s}$$ //

(ii) $P_F = h_p g \rho Q$

$$= (12 - 70(0.01) - 4300(0.01)^2)(9.8)(1000)(0.01)$$

$$= 1065.26 \, J/s$$

$$P_B = \frac{P_F}{0.7} = \frac{1065.26}{0.7} = 1521.8 \, J/s$$

(iii) $$Re = \frac{1000 \times \left(\frac{0.01}{\pi \times 0.1^2/4}\right) \times 0.1}{0.09}$$

$$= 127324$$ //

with $f = 0.015$ gives relative roughness of 0.03

$$\frac{e}{D} = 0.03$$

$$e = 0.003 \, m$$ //

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(iv) $NPSH_A = \frac{(101.3-3)\times10^3}{10^3 \times 9.8} - 1 + \frac{2\times0.015\times5}{9.8\times0.1} \times \left(\frac{0.01}{\pi\times0.1^2/4}\right)^2$

$= 9.279\ m.$

(v) NO cavitation as $NPSH_A > NPSH_R$ of 3m,,

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5 (i) Branch from entry = 40 km

ignore.

$$\frac{P_J^2 - P_{entry}^2}{2 \times \frac{RT}{M}} + \left(\frac{G}{A}\right)^2 \left[\cancel{\ln\left(\frac{P_{entry}}{P_J}\right)} + \frac{2fL}{D}\right] = 0$$

$$\frac{P_J^2 - (1000 \times 10^3)^2}{2 \times 8.314 \times \frac{(303)}{16 \times 10^{-3}}} + \left(\frac{1.125}{\frac{\pi \times 0.2^2}{4}}\right)^2 \times \frac{2 \times 0.005 \times 40 \times 10^3}{0.2} = 0$$

$$P_J^2 = 1.924 \times 10^{11}\ Pa^2$$

$$P_J = 438\,631\ Pa$$

(ii) Find G toward A

$$\frac{(400 \times 10^3)^2 - 438631^2}{2 \times 8.314 \times \frac{303}{16 \times 10^{-3}}} + \left(\frac{G}{A}\right)^2 \left[\ln\left(\frac{438631}{400000}\right) + \frac{2 \times 0.005 \times 10 \times 10^3}{0.2}\right] = 0$$

$$\left(\frac{G}{A}\right)^2 = 205.726$$

$$\frac{G}{A} = 14.34\ kg\ m/s^2$$

$$G = 14.34 \times \frac{\pi \times 0.2^2}{4}$$

$$= 0.451\ kg/s$$

$$G_{main} = G_A + G_B$$

$$G_B = 1.125 - 0.451$$

$$= 0.674\ kg/s.$$

(iii) $$\frac{P_B^2 - P_J^2}{2 \times \frac{RT}{M}} + \frac{2 \times 5 \times 10^3 \times 0.005}{0.2} \times \left(\frac{0.674}{\pi \times 0.2^2/4}\right)^2 = 0$$

$$P_B^2 = 1.56 \times 10^{11}\ Pa.$$

$$P_B = 395174\ Pa.$$

$$\rho_B = \frac{P_B}{\frac{RT}{M}}$$

$$= \frac{395174}{8.314 \times \frac{303}{16 \times 10^{-3}}} = 2.51\ kg/m^3$$

$$V_B = \frac{G}{A \rho_B}$$

$$= \frac{0.674}{\frac{\pi \times 0.2^2}{4} \times 2.51}$$

$$= 8.55\ m/s$$

(iii) momentum balance in x
+ (iv)

$$\rho\left(\cancelto{0}{\frac{\partial V_x}{\partial t}} + V_x \cancelto{0}{\frac{\partial V_x}{\partial x}} + \cancelto{0}{V_y}\frac{\partial V_x}{\partial y} + V_z \cancelto{0}{\frac{\partial V_x}{\partial z}}\right) = -\frac{\partial P}{\partial x} + \mu\left(\cancelto{0}{\frac{\partial^2 V_x}{\partial x^2}} + \frac{\partial^2 V_x}{\partial y^2}\right.$$

$$\frac{\partial P}{\partial x} = \mu \frac{\partial^2 V_x}{\partial y^2}$$

$$\frac{\partial P}{\partial x} = \frac{P_2 - P_1}{L}$$

$$\frac{\partial V_x}{\partial y} = \frac{\Delta P}{\mu L} y + C_1$$

$$V_x = \frac{\Delta P}{2L\mu} y^2 + C_1 y + C_2$$

$$V_x(y=h) = V_x(y=-h) = 0$$

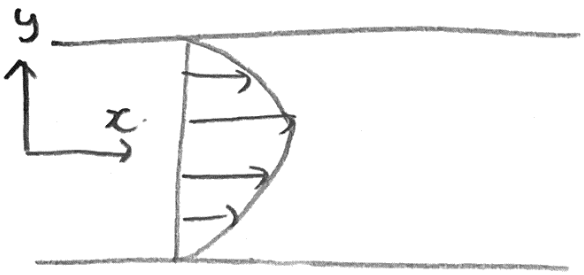
$$\frac{\Delta P}{2L\mu} h^2 - C_1 h + C_2 = \frac{\Delta P}{2L\mu} h^2 + C_1 h + C_2$$

$$\therefore C_1 = 0$$

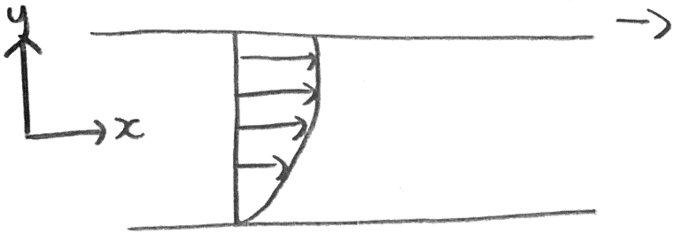
$$C_2 = -\frac{\Delta P}{2L\mu} h^2$$

$$V_x = \frac{\Delta P}{2L\mu}(y^2 - h^2)$$

(v)



(vii)



(vii)