FM S1 2018

3) $V_1 = \frac{Q}{A_1}$

$= \frac{0.025}{\pi \times 0.2^2 / 4}$

$= 0.796 m/s$

$V_2 = \frac{Q}{A_2}$

$= \frac{0.025}{\pi \times 0.15^2 / 4}$

$= 1.41 m/s$

$\frac{\Delta P}{\rho} + g\Delta z + \frac{1}{2}\Delta V^2 + W_s + F = 0$

$\frac{\Delta P}{\rho} + 0 + \frac{1}{2}(1.41^2 - 0.796^2) + W_s + \frac{2 \times 0.004 \times 5}{0.15} \times 1.41^2 + \frac{1}{2} \times 0.21875 \times 1.41^2$

$+ 2 \times \frac{0.0038 \times 5}{0.2} \times 0.796^2 = 0$

$Re_1 = \frac{0.796 \times 0.2}{1 \times 10^{-6}}$

$= 159200$

$f_F = 0.004$

$Re_2 = \frac{1.41 \times 0.15}{1 \times 10^{-6}}$

$= 212207$

$f_F = \frac{0.004}{0.0038}$

$K_{con} = 0.5\left(1 - \left(\frac{0.15}{0.2}\right)^2\right)$

$= 0.21875$

$\frac{\Delta P}{\rho} = -1.545$

$h = \frac{|\Delta P|}{\rho g}$

$= 0.158 m$

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5(a) $\frac{\partial P}{\partial x} = \mu \frac{\partial^2 V_x}{dz^2}$

$= B.$

$\frac{B}{\mu} = \frac{\partial^2 Vx}{\partial z^2}$

$\frac{\partial Vx}{\partial z} = \frac{Bz}{\mu} + C_1$

$Vx(z) = \frac{Bz^2}{2\mu} + C_1 z + C_2$

$Vx(z=0) = 0.$

$C_2 = 0.$

$Vx(z=d) = U$

$U = \frac{Bd^2}{2\mu} + C_1 d$

$\frac{U}{d} - \frac{Bd}{2\mu} = C_1$

$Vx(z) = \frac{Bz^2}{2\mu} + \left[\frac{U}{d} - \frac{Bd}{2\mu}\right] z$

$= \frac{B}{2\mu}\left[z^2 - dz\right] + \frac{Uz}{d}$

(b) $\left.\frac{\partial Vx}{\partial z}\right|_{z=d} = 0.$

$B/2\mu.$

$0 = \cancel{0} + C_1$

$C_1 = 0.$

$\frac{U}{d} = -\frac{Bd}{2\mu}$

$B = \frac{2\mu U}{d^2}.$

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5) $Q = \int_0^y \int_0^d v_x(z)\, dz\, dy$

$$v_x(z) = -\frac{2\mu u}{d^2}[z^2 - dz] + \frac{uz}{d}$$

$$= u\left[\left(\frac{z}{d}\right)^2 - \frac{z}{d}\right] + \frac{uz}{d}$$

$$= u\left(\frac{z}{d}\right)^2$$

$$Q = Y \int_0^d -u\frac{z^2}{d^2}\, dz$$

$$= Y\left[-\frac{uz^3}{3d^2}\right]_0^d + \left[\frac{uz^2}{d}\right]_0^d$$

$$= -\frac{Yud}{3} + Yud$$

$\frac{2}{3}u$

in couette flow = $\frac{u}{2}$

ratio = $\frac{y}{3}$ flow in couette flow

FM S1 2018

6) (a) $K_{exp} = \left(1 - \frac{1}{4}\right)^2$

$= 0.5625$

Elbow = 0.8

Valve = 0.15

$V_2 = \frac{Q}{A} = \frac{1.5\ kg/s}{1157\ kg/m^3} \times \frac{1}{\frac{\pi \times 0.1^2}{4}}$

$= 0.165\ m/s$

$V_1 = 0.66\ m/s$

$\frac{\Delta p}{\rho} + g\Delta z + \frac{1}{2}V_2^2 + W_s + F = 0$

$\frac{0.1 \times 10^3}{1157} + 9.8 \times 0.3 + \frac{1}{2}(0.165^2) + W_s + \frac{2 \times 0.007 \times 4}{0.05}(0.66^2) + \frac{1}{2}(1.6 + 0.5625)\,0.66^2 + 2 \times \frac{0.007 \times 8}{0.1}(0.165^2) = 0$

$Re_1 = \frac{0.66 \times 1157 \times 0.05}{0.019}$

$= 2009.5$

$Re_2 = \frac{0.165 \times 1157 \times 0.1}{0.0019}$

$= 10047$

$\frac{e}{D} = \frac{0.01}{5} = 0.002$

$\frac{e}{D} = \frac{0.01}{10} = 0.001$

$f_{F1} = 0.0076$

$f_{F2} = 0.007 - 0.008$

$-W_s = 4.03\ J/kg$

pump power $= -W_s G$

$= 6.04\ J/s$ //

(b) $\frac{\Delta p}{\rho} + 9.8 \times 1.8 + \frac{1}{2}(0.165^2 - 0.66^2) + F = 0$

$P_d - P_2 = 1157\,(18.425)$

$= 21.3\ kPa$