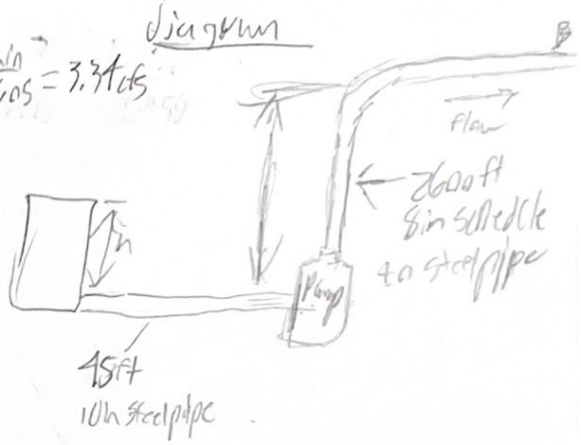
Kenny MET 330

(8-33) problem: shows a portion of a fire protection system in which a pump draws water at 60°F from a reservoir and delivers it a point B at the flow rate of 1500 gal/min

Given: $T_w = 60°F$, $F_r = 1500$ gal/min/$L_p = 45$, $D_p = 10in$, $P_{Br} = 25ft$, $P_{BL} = 2600ft$
$P_{BD} = 8in$

Diagram



Solution: Flow rate: $Q = 1500 gal/min \times \frac{1 ft^3}{7.48 gal} \times \frac{1 min}{60s} = 3.34 cfs$

$A_1 = \frac{\pi}{4} \times (10/12 ft)^2 = 0.545 ft^2$

$A_2 = \frac{\pi}{4} \times (8/12 ft)^2 = 0.349 ft^2$

$D_1 = 10/12 ft = 0.833 ft$

$D_2 = 8/12 ft = 0.667 ft$

Determine the velocities

$V_1 = \frac{Q}{A_1} = \frac{3.34}{0.545} = 6.13 ft/s$

$V_2 = \frac{Q}{A_2} = \frac{3.34}{0.349} = 9.57 ft/s$

Head loss

$HL = f \frac{L}{D} \frac{V^2}{2g}$, $f = 0.02$

(For 10in)

$h_{f1} = 0.02 \frac{45}{0.833} \frac{(6.13)^2}{2 \times 32.2} = 0.63 ft$

(For 8in)

$h_{f2} = 0.02 \frac{2600}{0.667} \frac{(9.57)^2}{2 \times 32.2} = 111.06 ft$

Total Dynamic head

$TDH = 25 + 0.63 + 111.06 = 136.63 ft$

Pump power

$P = \frac{\gamma_a Q \, TDH}{\eta \times 550} \Rightarrow \frac{62.4 \times 32.2 \times 3.34 \times 136.63}{0.7 \times 550} = \boxed{236.35 HP}$

8-38 problem: For the pipeline described in 8:37 consider that the oil is to be heated to 100°C to decrease its viscosity. How does this affect the pump power requirement.

b. At what distance apart could the pumps be placed with the same pressure drop as that from problem 8.37

Given: sg = 0.93, $\dot{V}$ = 1200 L/min, Pipe = DN150, Sch steel pipe, pump efficiency = 3.2km

Solution: $Q = 1200\ L/min \times \frac{1m^3}{1000L} \times \frac{1min}{60s} = 0.02 m^3/s$

Calculate velocity

$A = \frac{\pi}{4} D^2 = \frac{\pi}{4}(0.129)^2 = 0.0131 m^2$

$V = \frac{Q}{A} = \frac{0.02}{0.0131} = 1.53\ m/s$

Head loss

$h_f = f \frac{L}{D} \frac{V^2}{2g}$

$L = 3.2 km = 3200 m$

$g = 0.9 m/s$

$h_f = f \frac{L}{D} \frac{V^2}{2g} = 0.02 \frac{3200}{0.129} \frac{(1.53)^2}{2 \times 9.81} = 59.01$

Pump power

$P = \frac{\rho g Q h_p}{\eta} \Rightarrow \frac{930 \times 9.81 \times 0.02 \times 59.01}{0.7} = 1525.57 = \boxed{15.25 kW}$

b. Distance apart from pumps

$h_f \propto f \frac{1}{D}$

$L_{new} = 2 L_{old} \Rightarrow 2 \times 3200 = \boxed{6400 m}$

(10.20) problem: Determine the energy loss for a sudden contraction from a DN 125 schedule 80 steel pipe to a DN 50 schedule 80 pipe for a flow rate of 500 L/min

Given: $F_r = 500$ (L/min), I_p = DN125 St pipe, F_p = DN50 schedule80steel

Solution: $Q = 500\ L/min \times \frac{1m^3}{1000L} \times \frac{1min}{60} = 0.00833 m^3/s$

Pipe Areas

- DN125 schedule 80
  - Nominal diameter: 125mm
  - Inside diameter: 114.3mm = 0.1143m
- DN50 schedule 80
  - Nominal diameter: 50mm
  - Inside diameter: 44.26mm = 0.04426m

Velocities

$V_1 = \frac{Q}{A_1} = \frac{0.00833}{0.01026} = 0.812 m/s$

$V_2 = \frac{Q}{A_2} = \frac{0.00833}{0.00153} = 4.55 m/s$

Energy loss

$h_L = K_L \frac{V_2^2}{2g}$

$K_L = (1 - \frac{A_2}{A_1})^2 = 7\ (1 - \frac{0.00153}{0.01026})^2 = 0.676$

$h_L = 0.676 \frac{(4.55)^2}{2 \times 9.81} = 0.713 m$

10.48 problem: compute the energy loss in a 90° bend in a steel tube used for a fluid power system. The tube has a 11 1/2 in OD and a wall thickness of 0.083in. The mean bend radius is 3.25 in. The flow rate of hydraulic oil is 27.5 gal/min

Given: OD = 11.5in, WT = 0.083in, bend radius = 3.25in, Flow rate = 27.5

solution: Inside Diameter

ID = OD − 2x wall thickness = 11.5 − 2 × 0.083in = 11.334in

$ID = \frac{11.334 ft}{12} = 0.9445 ft$

Flow rate

$Q = 27.5 \text{ gal/min} \times \frac{1 ft^3}{7.45 gal} \times \frac{1 min}{60 s} = 0.0614 cfs$

cross sectional area

$A = \frac{\pi}{4} D^2 = \frac{\pi}{4}(0.9445)^2 = 0.700 ft^2$

Velocity

$V = \frac{Q}{A} = \frac{0.0614}{0.700} = 0.0877 ft/s$

Determine Energy loss in 90 bend

$K_B = 0.9 + \frac{0.35R}{D} = 0.9 + \frac{0.0485}{0.1445} = 1.004$

$h_L = 1.004 \frac{(0.0877)^2}{64.4} = 0.000120 ft$