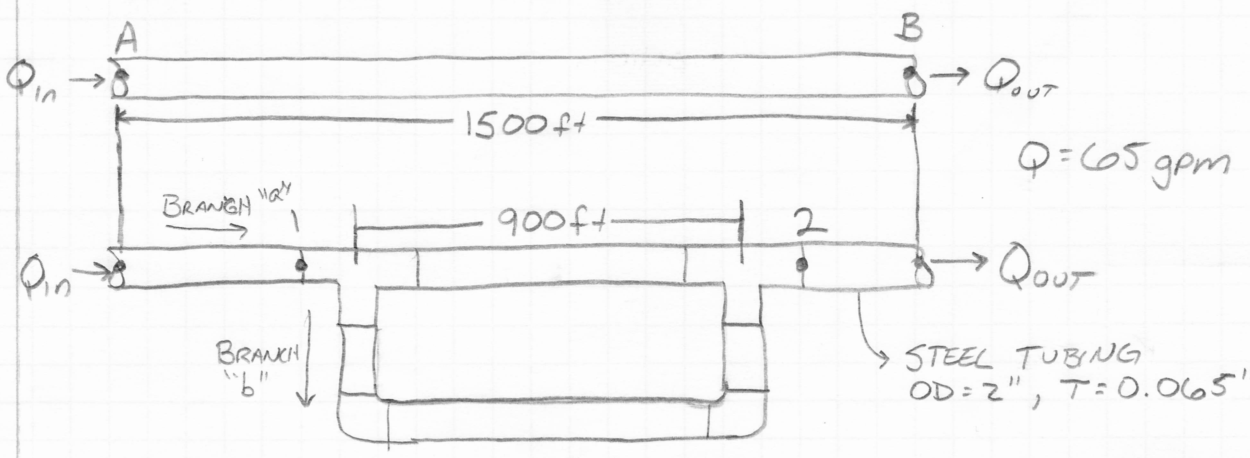
TEST 2, PROBLEM #2 | MET 330, SPR '18 | STEVEN Blea

PROBLEM #2

PURPOSE: AFTER DETERMINING INITIAL PRESSURE DROP THROUGH A PIPE, WE WILL DETERMINE THE EXPECTED INCREASE IN FLOW RATE AFTER ADDING AN ADDITIONAL LOOP OF PIPE 900 FT LONG.

DRAWINGS & DIAGRAMS:



SOURCES: MOTT, R., UNTENER, J.A., "APPLIED FLUID MECHANICS", 7th EDITION, PEARSON EDUCATION INC. (2015)

DESIGN CONSIDERATIONS:
- CONSTANT PROPERTIES
- INCOMPRESSIBLE FLUID
- FLUID IS 60° F
- FLOW IS STEADY
- CONSTANT TEMPERATURE
- SCH 40 PIPE
- PIPE FRICTION DEPENDS ONLY ON PIPE ROUGHNESS $f = f_T$

DATA & VARIABLES:

$\eta = 2.35 \times 10^{-5}$ [lb-s/ft²]
$\nu = 1.21 \times 10^{-5}$ [ft²/s]
$\rho = 1.94$ [slugs/ft³]
$\gamma = 62.4$ [lb/ft³]
(APPENDIX A.2)

$V = \frac{Q}{A} = \frac{65[gpm]}{(1.87[in])^2} = 7.591$ [ft/s]

- $D = \overset{1.87[in]}{0.1558}$ [ft]
- $A = 0.01907$ [ft²]
(APPENDIX G.1)

$N_R = \frac{(7.591)(0.1558)}{(1.21 \times 10^{-5})} = 97{,}742$

- $\varepsilon = 5.0 \times 10^{-6}$ [ft]
(TABLE 8.2)
- $f_T = 0.018 = f$

$\left(\frac{D}{\varepsilon} = 31{,}160\right)$

$K_{elbow} = 0.36$

$K_{\underset{Branch}{tee}} = 1.08$

$K_{\underset{run}{tee}} = 0.36$

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PROCEDURE: USING DARCY'S EQUATION WE CAN CALCULATE the PRESSURE DROP IN THE 1500 ft PIPE FROM POINT A TO POINT B. MULTIPLYING THE RESULT BY GAMMA(γ) WILL GIVE PRESSURE DROP FROM (A) to (B). WE WILL THEN APPLY BERNOULLI PRINCIPLE FROM POINT (1) TO POINT (2), THIS WILL GIVE ME TWO EQUATIONS, ONE FOR EACH BRANCH. THE EQUATION FOR THE UPPER BRANCH. I WILL NEED TO FIND FLOW RATE THROUGH THE NEW BRANCH. USING VALUES FROM SOURCE TEXT WILL ALLOW ME TO SOLVE FOR VELOCITIES AND FLOW THROUGH ADDED BRANCH. BY MANIPULATING BERNOULLI EQUATION AND SUBSTITUTING FOR KNOWN VALUE I CAN DETERMINE THE EXPECTED INCREASE IN TOTAL FLOW RATE.

CALCULATIONS:

DARCY'S EQUATION: $h_L = f \times \frac{L}{D} \times \frac{v^2}{2g} \Rightarrow 0.018 \times \frac{1500[ft]}{0.1558[ft]} \times \frac{7.591[ft/s]^2}{2\times(32.2[ft/s^2])}$

$$h_{L_{A-B}} = 155.063 \text{ ft}$$

$$P_A - P_B = \gamma\left(h_{L_{A-B}}\right) = 62.4[lb/ft^3] * 155.063[ft] = 9675.937\left[\frac{lb}{ft^2}\right]$$

$$P_A - P_B = 9675.937\left[\frac{lb}{ft^2}\right] * \left[\frac{1ft^2}{144\,in^2}\right] = \underline{67.194\ \frac{lb}{in^2} \text{ or psi}}$$

APPLY BERNOULLI'S EQ. FOR STRAIGHT RUN (BRANCH "a"):

$$\frac{P_1 - P_2}{\gamma} = \left(f_a \frac{L_a}{D_a} + 2K_{\substack{Tee\\run}}\right)\frac{V_a^2}{2g} \qquad \text{I}$$

for branch "b":

$$\frac{P_1 - P_2}{\gamma} = \left(f_b \frac{L_b}{D_b} + 2K_{\substack{tee\\Branch}} + 2K_{ELBOW}\right)\frac{V_b^2}{2g} \qquad \text{II}$$

OBTAIN P_1 & P_2, I CAN USE II to get V_b & Q_b. I ALREADY KNOW D_B = 1.5" steel Pipe which is 1.37" ID.

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I NEED TO FIND ADDITIONAL FLOW RATE

SUMMARY: THE INCREASED FLOW RATE EXPECTED WHEN ADDING AN ADDITIONAL LOOP OF 1.5" STEEL PIPE 900 ft LONG IS

MATERIALS:

- WATER
- 1.5" & 2" STEEL TUBING

ANALYSIS: SINCE FLUID TAKES THE PATH OF LEAST RESISTANCE, THE INCREASE IN FLOW RATE DOES NOT INCREASE BY A LARGE AMOUNT.

THE TOTAL FLOW RATE OF THE NEW SYSTEM IS NOT VERY MUCH HIGHER THAN THE ORIGINAL FLOW RATE OF 65 gpm