HONOR CODE

I pledge to follow the Honor Code and to obey all rules for taking exams and performing homework assignments as specified by the course instructor.

I understand that when asked to follow the Honor Code on exams or homework assignments I must follow the rules below.

1. When following the Honor Code a student must work entirely alone on exams.

2. When following the Honor Code a student may not share information about any aspect of the exam with other members of the class, other faculty members, or other people who has not already taken the exam this year, or its equivalent in future years.

3. When following the Honor Code a student must direct all questions concerning the exam or homework assignment to the course instructor or teaching assistant.

4. When following the Honor Code it is the student's responsibility to obtain clarification from the instructor if there are questions concerning the requirements of the Honor Code.

5. When following the Honor Code a student can only access websites related to ODU (such as Blackboard, etc.) while taking the test.

6. When following the Honor Code a student cannot access, neither ask for help, from websites such as coursehero, chegg, and any other similar website, while taking the test.

I understand that failure to follow this Honor Code imply that the professor will immediately report my case for academic dishonesty to the ODU Office of Student Conduct & Academic Integrity.

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Student Signature: Dario Bax

Date: 7/21/2023

Q1

Purpose

To Determine Flow of the system if the valve is half open
Determine the pressure at the Exit of the T

Design Considerations

- Incompressible Fluid
- Isothermal process
- Steady state
- Do not neglect minor losses
- Elevation is measure with respect to ground level

Date and Variable

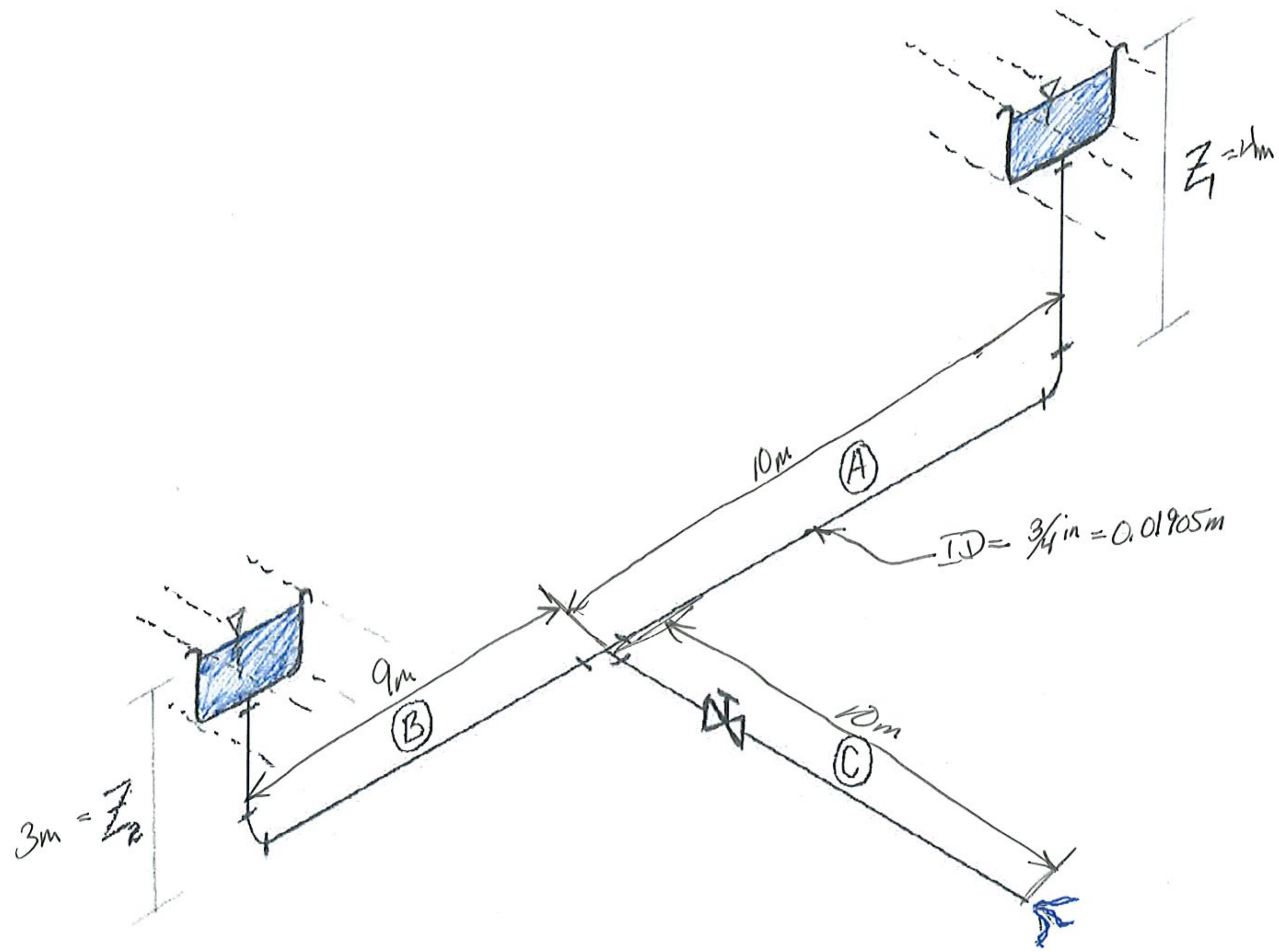
See Calculations

Procedure

I first started by finding the variables I would need to move forward in solving the problem. Variables such as Area, D/ε, Reynolds number, and the friction factor. After that I proceeded to account for all major and minor losses H_L. Then I used this information along with known variables such as Z_1 & Z_2 to find the velocity of B-C and A-C. Then I used the volume flow rate and continuity equation to find the total flow rate of the system.

Calculations

1. In a house there are two elevated gutters along 2 of its sides. Each gutter drains the water through pipes that get connected together to bring the rainwater to ground floor, as shown in the figure (please be aware that this is just a scketch, no real dimensions were intended). The gutters were designed for the worst case scenario: heavy rain. For this case, the whole system gutter-pipes is filled with running water. For some unknown reason, the engineer who designed the system decided to put a valve in the ground level pipe C (this is a bad decision but it is what was found). The lengths of the ¾ inch (inner diameter) commercial steel pipes are: L_A=10 m, L_B=9 m, L_C=10 m (this lengths include vertical and horizontal portions of the pipes). The water surfaces in the gutters are elevated at Z_1=4 m, Z_2=3 m. The elevation is measured with respect to the ground level horizontal pipe 3. Determine the flow out of the system if the gate valve is <u>half open</u>. Assume that the friction factor is only a function of the relative roughness. Do not neglect the minor losses. Check the velocity criterion (Vmax = 3 m/s). Is it violated? If so, provide some suggestions to avoid it. Finally, compute the pressure at the exit of the tee.



Purpose

To Determine flow at all the system if the gate Valve is half open.

Design considerations

- incompressible fluid
- isothermal process
- steady state
- Do not neglect minor losses
- elevation is measured with respect to ground level

Data and Variables

$L_A = 10m$ $Z_1 = 4m$

$L_B = 9m$ $Z_2 = 3m$

$L_C = 10m$ $ID = 3/4 in = 0.01905 m$

$V_{max} = 3 m/s$ steel pipe $\epsilon = 4.6 \times 10^{-5} m$

Water at 25°C from Appendix A

$\gamma = 9.78 \ kN/m^3$

$\rho = 997 \ kN/m^3$

$\eta = 8.91 \times 10^{-4} \ Pa \cdot S$

$\nu = 8.94 \times 10^{-7} \ m^2/s$

$K_{elbow} = 30 \times 0.025 = 0.75$

$K_{T \ Branch} = 60 \times 0.025 = 1.5$

$K_{valve \ half \ open} = 160 \times 0.025 = 4$

- General information needed to solve the problem

$$A = \frac{\pi D^2}{4} = \frac{\pi (0.01905)^2}{4} = 2.85 \times 10^{-4}$$

$$\frac{D}{\epsilon} = \frac{0.01905}{4.6 \times 10^{-5}} = 414.13$$

$$R_e = \frac{VD}{\nu} = \frac{3 m/s (0.01904)}{8.94 \times 10^{-7}} = 63,926.17$$

$$f = \frac{0.25}{\left(\log\left(\frac{1}{3.7(D/\epsilon)} + \frac{5.74}{R_e^{0.9}}\right)\right)^2} = \frac{0.25}{\left(\log\left(\frac{1}{3.7(414.13)} + \frac{5.74}{(63,926.17)^{0.9}}\right)\right)^2} = 0.027$$

$$f = \frac{0.25}{\left(\log\left(\frac{1}{3.7(D/\epsilon)}\right)\right)^2} = \frac{0.25}{\left(\log\left(\frac{1}{3.7(414.13)}\right)\right)^2} = 0.025$$

- for major and minor losses

$$h_L = \underbrace{f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right)}_{A+B+C} + \underbrace{K_{elbow}\left(\frac{V^2}{2g}\right)}_{A+B} + \underbrace{K_T\left(\frac{V^2}{2g}\right)}_{A+B} + \underbrace{K_{valve \ half \ open}\left(\frac{V^2}{2g}\right)}_{C}$$

$$h_L = 0.027\left(\frac{9}{0.01905}\right)\left(\frac{V^2}{2g}\right) + 0.027\left(\frac{10}{0.01905}\right)\left(\frac{V^2}{2g}\right) + 0.027\left(\frac{10}{0.01905}\right)\left(\frac{V^2}{2g}\right) + 2 \times 0.75\left(\frac{V^2}{2g}\right) + 2 \times 1.5\left(\frac{V^2}{2g}\right) + 4\left(\frac{V^2}{2g}\right)$$

$$= 0.650V^2 + 0.722V^2 + 0.722V^2 + 0.076V^2 + 0.153V^2 + 0.204V^2$$

$$= 2.527 V^2$$

$$\overset{0}{\frac{P_1}{\gamma}} + \frac{V_1^2}{2g} + Z_1 = \overset{0}{\frac{P_2}{\gamma}} + \frac{V_2^2}{2g} + Z_2 + h_L$$

$$\frac{V_1^2}{2g} + Z_1 = h_L \qquad \frac{V_2^2}{2g} + Z_2 = h_L$$

$$V_1 = \sqrt{\frac{Z_1}{h_L - \frac{1}{2g}}} = \sqrt{\frac{4}{2.527 - \frac{1}{2.981}}} = 1.271 m/s$$

$$V_2 = \sqrt{\frac{Z_2}{h_L - \frac{1}{2g}}} = \sqrt{\frac{3}{2.527 - \frac{1}{2.981}}} = 1.101 m/s$$

- after reading through Ch. 12 and looking at Module 7.2 examples I realized I should treat these as a systems first then add them together since this kind of mimics a branch system.

$$h_{L_{A\text{-}C}} = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) + K_{elbow}\left(\frac{V^2}{2g}\right) + K_T\left(\frac{V^2}{2g}\right) + K_{valve\ half\ open}\left(\frac{V^2}{2g}\right)$$

$$= 0.027\left(\frac{20}{0.01905}\right)\left(\frac{V^2}{2\cdot 9.81}\right) + 0.75\left(\frac{V^2}{2\cdot 9.81}\right) + 1.5\left(\frac{V^2}{2\cdot 9.81}\right) + 4\left(\frac{V^2}{2\cdot 9.81}\right)$$

$$= 1.445V^2 + 0.038V^2 + 0.076V^2 + 0.204V^2$$

$$= 1.763V^2$$

$$h_{L_{B\text{-}C}} = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) + K_{elbow}\left(\frac{V^2}{2g}\right) + K_T\left(\frac{V^2}{2g}\right) + K_{valve\ half\ open}\left(\frac{V^2}{2g}\right)$$

$$= 0.027\left(\frac{19}{0.01905}\right)\left(\frac{V^2}{2\cdot 9.81}\right) + 0.75\left(\frac{V^2}{2\cdot 9.81}\right) + 1.5\left(\frac{V^2}{2\cdot 9.81}\right) + 4\left(\frac{V^2}{2\cdot 9.81}\right)$$

$$= 1.373V^2 + 0.038V^2 + 0.076V^2 + 0.204V^2$$

$$= 1.691V^2$$

$$\cancel{\frac{P_1}{\gamma}}^{0} + \frac{V_1^2}{2g} + z_1 = \cancel{\frac{P_B}{\gamma}}^{0} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$\frac{V_1^2}{2g} + z_1 = h_{L_{A\text{-}C}}$$

$$\frac{1}{2\cdot 9.81}V^2 + 4m = 1.763V^2$$

$$4m = 1.763V^2 - \frac{1}{19.62}V^2$$

$$\sqrt{\frac{4m}{1.712}} = \sqrt{\frac{1.712V^2}{1.712}}$$

$$V = \sqrt{\frac{4m}{1.712}}$$

$$= 1.529 m/s$$

$$\frac{V_2^2}{2g} + z_2 = h_{L_{B\text{-}C}}$$

$$3m = 1.691V^2 - \frac{1}{19.62}V^2$$

$$3m = 1.640V^2$$

$$V_2 = \sqrt{\frac{3m}{1.640}}$$

$$= 1.353 m/s$$

$$Q = A_1V_1 + A_2V_2$$

$$\cancel{A_3}V_3 = \cancel{A_1}V_1 + \cancel{A_2}V_2$$

$$V_3 = 1.529 m^3/s + 1.353 m^3/s$$

$$= 2.882 m^3/s$$

- This does not violate the max velocity criterion of 3m/s.

To find Pressure at T exit

$$h_{L_A} + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_B}{\gamma} + \frac{V^2}{2g} + Z_2 + h_{L_B}$$

$$h_{L_A} = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) + K_{elbow}\left(\frac{V^2}{2g}\right) + K_{T\,Branc}\left(\frac{V^2}{2 \cdot g}\right)$$

$$= 0.027\left(\frac{10m}{0.01905}\right)\left(\frac{1.529 m/s^2}{2 \cdot 9.81 m/s}\right) + 0.75\left(\frac{1.529 m^2/s}{2 \cdot 9.81 (m/s)}\right) + 1.5\left(\frac{1.529\ m^2/s}{2 \cdot 9.81 m/s}\right)$$

$$= 1.957\ m$$

$$h_{L_B} = 0.027\left(\frac{9}{0.01905}\right)\left(\frac{1.353^2 m/s}{2 \cdot 9.81}\right) + 0.75\left(\frac{1.353}{2 \cdot 9.81}\right) + 1.5\left(\frac{1.352\ m^2/s}{2 \cdot 9.81 m/s}\right)$$

$$= 1.400 m.$$

$$P_A = \gamma\left(z_1 - \frac{V^2}{2g} + h_{L_A}\right)$$

$$= 9.78\ kN/m^3\left(4m - \frac{1.529^2}{2 \cdot 9.81} + 1.957m\right)$$

$$\cong 47.314\ kpa$$

$$P_B = 9.78\ kN/m^3\left(3m - \frac{1.353^2}{2 \cdot 9.81} + 1.400m\right)$$

$$= 42.119\ kpa$$

$$P_A + P_B = P_{at\,T}$$

$$\underline{\underline{P_{at\,T\,exit} = 89.433\ kpa}}$$

Q2

Purpose

To Determine pump power required for the fountain configuration
If efficiency is 92% determine electrical power required.

Design Considerations

- Incompressible Fluid
- Isothermal process
- Steady state
- Consider all minor losses
- Neglect loss at exit annulus

Date and Variable

See Calculations

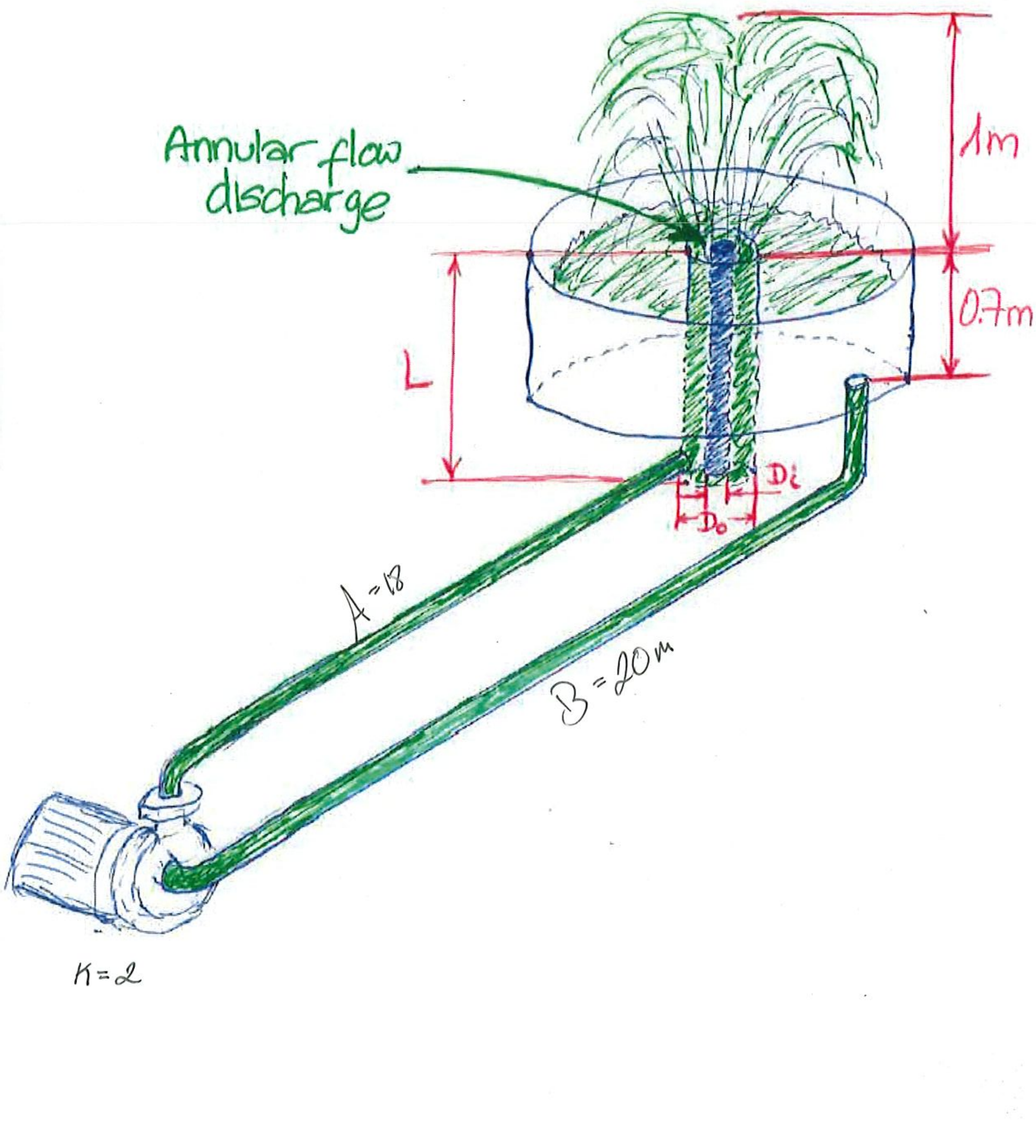
Procedure

I first started by finding the variables I would need to move forward in solving the problem. Variables such as Area, D/ε, Reynolds number, and the friction factor. To find D/ε I started with the Hydraulic radius equation. Then I used Torricelli's Theorem to find the velocities. I then used this information to find the diameter of PVC pipe needed to meet the required conditions. Finally I input all the data to find H_L and used the Power Added equation to determine the power needed to make the fountain perform as shown.

Calculations

2. You are in charge of designing a new decorative water fountain at ODU. It consists of a water reservoir and piping to and from a pump as shown in the figure (please be aware that this is just a scketch, no real dimensions were intended). You are asked to used only PVC pipes (see Table G3). The outlet line from the pump is 18 m and the inlet line to the pump is 20 m. The outlet line leads to the bottom of an annular flow line. The expansion there has a loss of K=2 based on the kinetic energy before the expansion. The annular flow passage has a length L = 1.80 m and is bounded by D_o=10 cm and D_i=7cm (use hydraulic radius for the energy loss calculations of such annular flow passage. Check Chapter 9 and lecture notes). It is also made of PVC. There is negligible loss at the exit of the annulus, which is exposed to the atmosphere. Consider all other minor losses following what is on the sketch. What is the pump power required for the flow configuration shown? If the pump-motor combination has an efficiency of 92%, determine the electrical power requirements.

HINTS: (1) The flow rate should be enough so the water reaches 1 m as sketched. (2) Use the velocity criteria discussed in class to select the PVC pipe diameters.



Purpose

Determine pump power required for configuration
If efficiency is 92% determine electrical power required.

Design Considerations

- incompressible fluid
- isothermal process
- steady state
- Conside all minor losses
- negligible loss at exit annulus

Data and Variables

$A_{outlet} = 18m$ $\quad K=2$ $\quad$ Water at 25°C

$B_{inlet} = 20m$ $\quad$ Water hight = 1m $\quad \gamma = 9.78 kN/m^3$

$L = 1.80m$ $\quad \rho = 997 kN/m^3$

$D_o = 10cm = .1m$ $\quad \eta = 8.91 \times 10^{-4} Pa \cdot s$

$D_i = 7cm = .07m$ $\quad \nu = 8.94 \times 10^{-7} m^2/s$

- General information I may need to solve this problem

$R = \frac{A}{WP}$

$A = \frac{\pi}{4}(D^2 - d^2)$

$= \frac{\pi}{4}(.1m^2 - .07m^2)$

$= 0.0040^2$

$Wp = \pi(D+d)$

$= \pi(.1 + .07)$

$= 0.5341m$

$R = \frac{0.040m^2}{0.5341m}$

$= 0.0075m$

$\frac{D}{\varepsilon} = \frac{4R}{\varepsilon}$

$= \frac{4 \times 0.0075}{3 \times 10^{-7}}$

$= 100{,}000$

$f = \frac{0.25}{\left(\log\left(\frac{1}{3.7(D/\varepsilon)}\right)\right)^2}$

$= \frac{0.25}{\left(\log\left(\frac{1}{3.7(100{,}000)}\right)\right)^2}$

$= 0.0008$

Torricelli's theorem

$V_2 = \sqrt{2gh}$

$= \sqrt{2 \cdot 9.81 \cdot 2.8m}$

$= 7.412 m/s$

$V_1 = \sqrt{2gh}$

$= \sqrt{2 \cdot 9.81 \cdot 1m}$

$= 4.429 m/s$

$Q = AV$

$= 0.0040 \times 4.429 m/s$

$= 0.018 m^3/s$

- To find dia of pipe

$V_I = \frac{4Q}{\pi D_I^2}$

$7.412 = \frac{4(0.018)}{\pi D^2}$

$D_I = \sqrt{\frac{4(0.0018) m^3/s}{7.412 \pi}}$

$= 0.0556m$

$ID = 0.057m$ pvc

- Major losses and minor losses

$$h_L = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right) + K\left(\frac{V^2}{2g}\right)$$

$$= 0.008\left(\frac{.38}{0.057}\right)\left(\frac{7.412^2 - 4.429^2}{2 \times 9.81}\right) + 2\left(\frac{7.412^2 - 4.429^2}{2 \times 9.81}\right)$$

$$= 13.20\,m$$

$$P_A = h_A \gamma Q$$

$$= 13.20\,m \times 9.78\,KN/m^3 \times 0.018\,m^3/s$$

$$= 2.33\,\frac{KN \cdot m}{S}$$

$$= 2.33\,KW \times .92$$

$$\underline{\underline{= 2.14\,KW}}$$