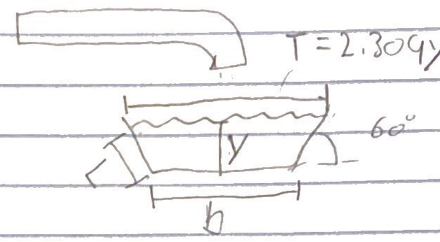
MET 330 Test - 2 Hunter Young

1 A Purpose - To determine the depth of the water based on specific flow rate and dimensions

Dimensions and Diagrams -



Sources - "Applied Fluid Mechanics" 7th ed

Design Considerations -
- In U.S units
- Constant properties
- Steady flow

Data and Variables
Channel slope = 0.1 % $\theta = 60°$ $Q = 75$ GPm
material → unfinished concrete $T = 2.309 \cdot y$
↳ $n = 0.017$

Procedure -
- First I gathered all the equations that relate the height (y) to the other given dimensions
- Using Manning's equation for english units, I related the flow rate (Q), the n of unfinished concrete, and the slope of the open channel to the substituted equation with (y)
- Solving for y gives the depth of the water in the open channel at 75 gpm, with a 1% slope, and being made of unfinished concrete.

MET 330 Test 2 continued

Calculations -

$K = (\frac{1.49}{n}) A R^{2/3}$ $T = 2.309y$

$b = 1.155y$ $L = b$

$WP = 3.46y$ $A = 1.73y^2$

$R = y/2$ $AR^{2/3} = \frac{nQ}{1.49 S^{1/2}}$

$Q = 75\ GPm = 0.1671\ ft^3/s$

$AR = \frac{nQ}{1.49 S^{1/2}}$

$ft^2 \cdot ft = \frac{ft^3/s}{}$

$1.73y^2 \cdot (\frac{y}{2}) = \frac{nQ}{1.49 S^{1/2}}$

$1.73y^2 (\frac{y}{2}) = \frac{0.017 \cdot 0.1671}{1.49 \cdot 0.001} = 1.9065$

$\frac{1.73y^3}{2} = 1.9065$

$\frac{3.46y^3}{2} = 3.813$

$\frac{\frac{3.46y^3}{2}}{1.73} = \frac{3.813}{1.73}$

$y^3 = \frac{3.813}{1.73} = 2.204$

$y = \sqrt[3]{2.204}$

$y = \boxed{1.301}\ ft$

Summary - The design reflects 1.301 ft deep at 25gpm. It would be deeper if the flow rate increased

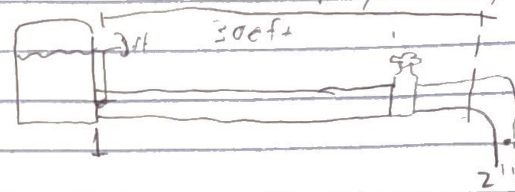
Materials - water, unfinished concrete,

Analysis - If the design did not stick to typical trapezoidal ratios, this would have been more difficult

MET330 Test 2 Continued

Hunter Young

Purpose - To determine the value of relevant forces on the pipe system caused by the moving water and the effects of the pipe, elbow, and valve



Drawings and Diagrams

Sources - "Applied Mechanics" 7th ed

Design considerations

- Constant properties
- Constant α
- Incompressible
- Pipe friction based on roughness

Data and variables

$L = 30\ ft$ Pipe roughness $= 4.5 \cdot 10^{-5}$ $\rho_w = 62.4\ lbs/ft^3$

$ID = 1.61\ in$ $OD = 1.9\ in$ $1\frac{1}{2}$ in pipe $f_T = 0.020$

Procedure -

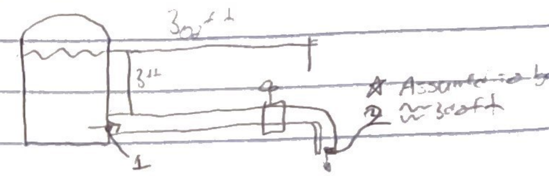
- First using head loss equations, I calculated first the coefficient K, then the minor losses from the valve and the pipe bend
- Using bernoullis and the minor losses, I calculated the pressure at Point 1
- With the pressure, flow rate, and calculated velocity, I was able to calculate the reactionary forces

Calculations

$\gamma_v = 61.329\ lb/ft^3$, $\gamma_w = 62.364\ lb/ft^3$

$F_x = \rho_w\ Q(V_{2x} - V_{1x})$

$F_y = \rho_w\ Q(V_{2y} - V_{1y})$



$Q = 75\ GPM = 0.1671\ ft^3/s$

$h_L = K(V^2/2g)$, $Le/D_{valve} = 340$, $Le/D_{bend} = 13$, $f_T = 0.020$

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

$K_{bend} = (Le/D)_{bend} f_T$

$K_{bend} = 13 \cdot 0.020 = 0.26$

$A = \frac{\pi}{4} \cdot \left(\frac{1.61}{12}\right)^2 = 0.0141\ ft^2$

$Q = V \cdot A$

$0.1671\ ft^3/s = V \cdot 0.0141\ ft^2$

$V = 11.85\ ft/s$

$K_{valve} = (Le/D)_{valve} \cdot f_T$

$K = 340 \cdot 0.020 = 6.80$

$$\frac{P_1}{\gamma_v} = \frac{P_2}{\gamma_v} + h_{L_{valve}} + h_{L_{bend}}$$

$h_{L_{bend}} = K(V^2/2g) = 0.26 \cdot \left(\frac{11.85^2}{2 \cdot 32.2}\right)$

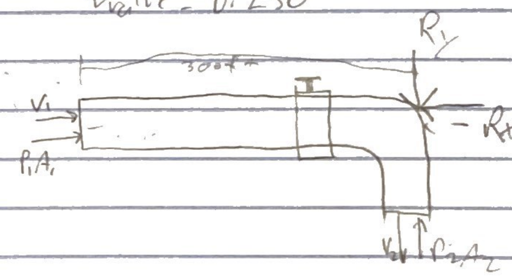
$h_{L_{bend}} = .567$

$h_{L_{valve}} = K(V^2/2g) = 6.8 \cdot \left(\frac{11.85}{2 \cdot 32.2}\right)^2$

$h_{L_{valve}} = 0.230$

$$\frac{P_1}{61.329} = \frac{0}{61.329} + 0.230 + .567$$

$P_1 = (0.230 + .567) \cdot 61.329 = 48.919$



$F_x = \rho Q(V_{2x} - V_{1x})$

$F_x = R_x - P_1A_1$ $\quad V_{2x} = 0,\ V_{1x} = 11.85$

$R_x = \rho Q V_1 + P_1 A_1$

$R_x = 48.919 \cdot .1671 \cdot 11.85 + 48.919 \cdot .0141$

$\underline{R_x = 97.55\ lb\text{-}f}$

$F_y = \rho Q(V_{2x} - V_{1x})$

$F_y = R_y - P_2A_2$

$R_y = \rho Q V_2 + P_2 A_2$

$R_y = 0 \cdot .1671 \cdot 11.85 + 0 \cdot .0141$

$R_y = 0$

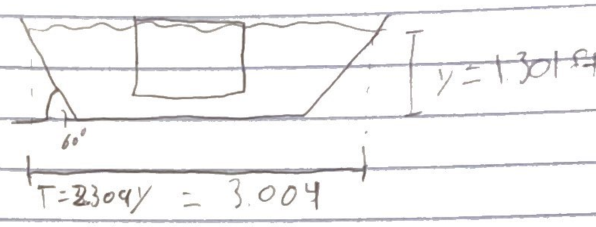
Summary - The force of the running water minus the losses was still a good amount of force

Materials - Water, 1 1/2 steel pipe, water tank, open channel

Analysis - Adding more things onto the pipe would increase the reactional force in both x and y directions

C Purpose - To determine the largest possible log with restrictions on water height and width, as well as log buoyancy

Drawings and Diagrams -



Sources - "Applied Fluid Mechanics" 7^{th} ed

Design Considerations

- Constant properties
- log only needs to barely float
- Logs length = width

Data and Variables:-

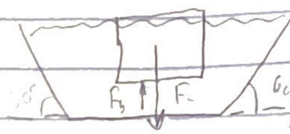
$y = 1.301$ ft $T = 3.004$ ft $\rho_{log} = 830\ kg/m^3$ $\rho_w = 62.364$ $\gamma_w = 61.374$

Procedure

Calculations

$F_b = \gamma_f V$ $\quad$ $F_w = Mg$ $\quad$ $m = V_d \cdot \rho$

$w = V \cdot \gamma$



$830\ kg/m^3 = 51.81\ lb/ft^3$

$\gamma_{log} = 1.610\ slugs/ft^3$

To keep equilibrium/float without sinking - $F_b \geq F_w$

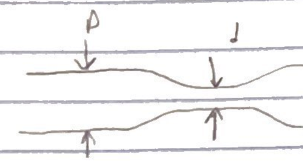
$F_b = F_w$

$\gamma_w \cdot V = V \cdot \gamma_{log}$

$1.907\ slugs/ft^3 \cdot V_{sub} = 1.610\ slugs/ft^3 \cdot V_{log}$

D Purpose - To determine the difference in Pressure after a flow nozzle

Drawings and Diagrams



$\frac{d}{D} = .5$

Sources - "Applied Fluid Mechanics" 7th ed

Design Considerations -

• Constant Properties • Incompressible • Constant flow rate

Data and Variables

ID = 161 in   Q = 75 GPM = .1671 ft^3/s V_1 = 11.85 ft/s

Procedure -

• First Reynolds number was calculated and used with the given β ratio to determine C

• Then using the equation for velocity through a flow nozzle I was able to solve for the change in pressure

Calculations - $V_1 = C\sqrt{\frac{2g(P_1-P_2)/\gamma_w}{(A_1/A_2)^2-1}}$

$\gamma_w = 1.9077\ Sl/ft^3$

$A_1/A_2 = \frac{\pi}{4}\cdot\left(\frac{1.61}{12}\right)^2 / \frac{\pi}{4}\left(\frac{.805}{12}\right)^2$

$= .01413/.003533$

$A_1/A_2 = 4.003$

$C = 0.9975 - 6.53\sqrt{B/N_R}$

$Re = \frac{V\cdot D\cdot\rho}{\eta} = \frac{11.85\cdot\left(\frac{1.61}{12}\right)\cdot 62.36}{1.129}$

$Re = 87.816$

$B = 0.5$

$C = 0.9975 - 6.53\sqrt{0.5/87.816}$

$C = 0.504$

$11.85 = 0.504\sqrt{\frac{2(32.2)(\Delta P)/1.9077}{(4.003)^2-1}}$

$\underline{\Delta P = 246.02\ PSI}$

Summary - The flow nozzle only restricted / changed the pressure by a little,

Materials - 1 1/2 inch steel pipe, flow nozzle, water

Analysis - the Nozzle would have changed the pressure more if it were tighter or the water was faster

E Purpose - To determine the pressure change caused by closing the valve too quickly

Drawings and Diagrams

Sources - "Applied Fluid Mechanics" 7th ed

Design Considerations -

- Constant properties
- No cavitation
- Incompressible fluid

Data and Variables -

MOD of Steel = 200 GPa   ID = 1.61 in   OD = 1.9 in   Q = 75 GPM

δ = .29 in   V = 11.85

Procedure:

- Using the equation in the book, I was able to determine C, based on the given variables and the values in the book
- Using the known velocity, C value, and water density, pressure change was calculated

Calculations -

$$\Delta P = \rho \cdot C \cdot V$$

$$C = \frac{\sqrt{E_0/\rho}}{\sqrt{1 + \frac{E_0 D}{E\delta}}}$$

$\delta = .24in$

$E_0 = 3.12\ lbf/in^2$

$E = 200GPA = 2.901 \cdot 10^7\ lbf/in^2$

$V = 11.81$

$\rho_v = 61.379\ lbs/ft^3 = 0.0355\ lb/in^2$

$D = 1.61in$

$$C = \frac{\sqrt{3.12 / 0.0355}}{\sqrt{1 + \frac{3.12 \cdot 1.61}{2.901 \cdot 10^7}}} = 9.374 in/s$$

$$\Delta P = 0.0355\ lb/in^2 \cdot 9.384 \cdot 11.85$$

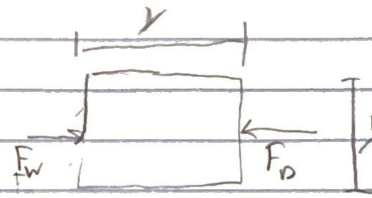
$$\Delta P = \underline{3.943\ KPSI}$$

Summary - The water hammer effect drastically effected the pressure, but there aren't any low enough pressure spots for cavitation

Materials - $1\frac{1}{2}$ in steel pipe, valve, water

Analysis - If the fluid velocity was higher or there was more stuff in the pipe, there would be a chance for low pressure cavitation f **Purpose** - To determine the drag force created by water flowing into a log flowing down an open channel

Drawings and Diagrams



Sources - "Applied Fluid Mechanics" 7th ed

Design Characteristics -

- Constant properties
- assumptions are made
- Velocity in channel not pipe

Data and Variables

$Q = 75$ GPM $= 0.1671\ ft^3/s$ Assuming $y = \frac{1}{2}$ ft $n = 0.012$ $C_D = 1.16$

Procedure -

- Using mannings equation, and the other dimensions I had already solved, I solved for velocity
- Using velocity in the drag equation gave me the drag force

Calculations - $F_D = C_D(\rho V^2/2)A$ $V = \frac{1.49}{n} R^{2/3} S^{1/2}$

$1/400 = 1.301$ ft

$R = 1/2 = 1.301/2 = .6505$ ft

$S = 0.001$ $n = 0.012$

$\rho = 61.379$

$V = \frac{1.49}{n} R^{2/3} \cdot S^{1/2} = \frac{1.49}{0.012} \cdot 0.6505^{2/3} \cdot 0.001^{1/2}$

$V = 2.947$ ft/s

$A = y \cdot y = .5^2 = .25 ft^2$

$F_D = C_D(\rho V^2/2)A$ $C_D = 1.16$

$F_D = 1.16(61.379 \cdot 2.947^2/2) \cdot .25$

$\underline{F_D = 77.29 \text{ lbf}}$

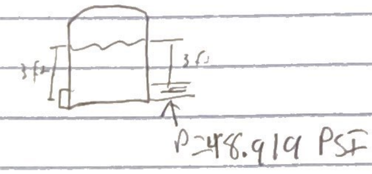
Summary - The force on the assumed size of the log is proportional with the flow in the open channel

Materials - Hickory logs, water, open channel

Analysis - The log drag force doesn't take into account if the log were to accidentally turn off center

G Purpose - To determine the force acting on the blind flange and where it is located

Drawings and Diagrams



Sources - "Applied Fluid Mechanics" 7th ed

Design Considerations -

• Constant properties • liquid is water • Pressure doesn't change

Data and Variables -

P = 48.919 PSF D = 1.90 in

Procedure

• Using the Diameter from the pipe area was calculated

• Because pressure at point 1 is the same as the flange it is used as P_{avg} and multiplied by the area to determine the force

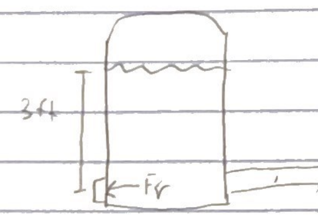
Calculations - $h = 3\ ft = 36\ in$ $A = \frac{\pi}{4}(1.9in)^2$

$A = 2.835\ in$

$F_R = P_{Avg} \cdot A$ $P_{avg} = \gamma(h/2)$

$P_{avg} \approx 48.919\ psi$

$F_R = 138.68\ lbf$



Summary - The flange only felt the pressure from the water in the tank and the pressurized air in it

Materials - Flange, water, water tank (pressurized)

Analysis - because the flange is at the same height of the pipe, the force is easily computed after quickly finding the area