			y	Q	A
Q	0.167	ft^3/s	1	3.020625	1.73
S	0.001		0.5	0.475719	0.4325
n	0.017		0.25	0.074921	0.108125
A	1.73	ft^2	0.3	0.12183	0.1557
R	0.5		0.4	0.262376	0.2768
			0.35	0.183772	0.211925
			0.34	0.170101	0.199988

R	% diff
0.5	1708.757
0.25	184.8614
0.125	-55.1371
0.15	-27.048
0.2	57.11113
0.175	10.04283
0.17	1.856972

1

Zachary Zum Brunnen MET 330 Test 2 03/21/22

Purpose: a) Determine the water debth (Y) in the open channel. The angle of lateral walls is 60°, The Top of water T = 2.309 y (table 14.3 in book), channel slope is 0.1% and is unfinished concrete.

b) The pipe connected to the tank must be supported, determine the total horizontal and vertical forces in the whole system pipe elbow.

c) Determine the largest hickory log the open channel can carry, the log should barely float. Log has a square cross-section. Prove if Log is stable also.

d) using a flow nozzle with a nozzel diamiter to pipe diamiter ratio of 0.5, what is pressure drop across nozzle?

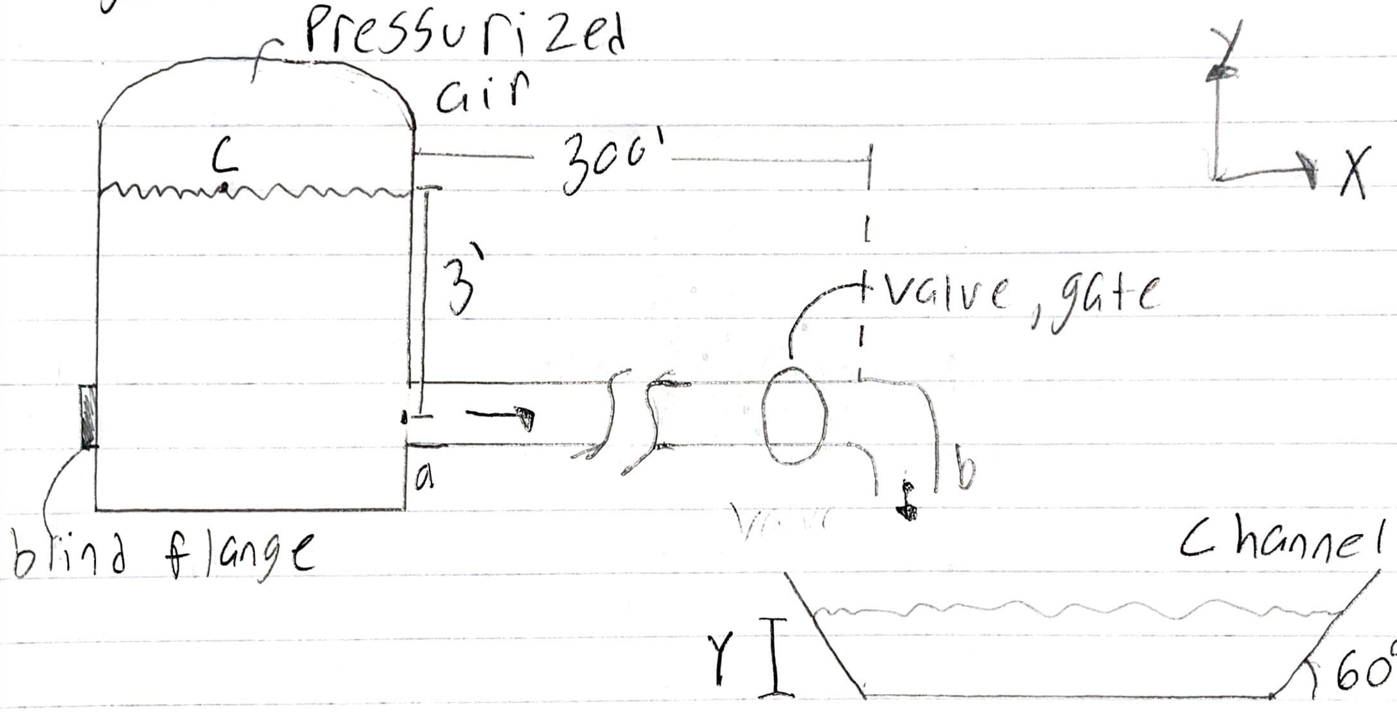
e) If the valve in the pipe were to close suddenly, what pressure increment after the sudden closing? is there any change in cavitation in the system? why?

f) Assuming there is a Log half the maximum size the channel can carry, what is the Largest drag force that Log were to experiance if it got stuck at the bottem of the channel?

②

Purpose: g) compute the force acting on the blind flange at the bottom Left side of the tank, diamiter of the flange is the same as the Pipe. where is the force Located?

Diagram:



Sources: Applied fluid mechanics by Robert L matt, and Joseph A Untener
Thermodynamics: An Engeneering approach by Yunus Cengel

Design Considerations: Constant properties, 60°F constant temperature, steady state, Incompressable fluid's.

3

Data & variables: $Q = 75\,gpm = 0.167\ ft^3/s$

$\rho_{Log} = 830\ kg/m^3 = 1.61\ slug/ft^3$

$\rho_{water} = 1.94\ slug/ft^3$ $\quad A_{pipe} = 0.014\ ft^2$ (inner dia)

Pipe is made from Schedvel 40 steel 1½ in

$D_{outer\ pipe} = 0.158\ ft$ $\quad d_{inner\ pipe} = 0.1342\ ft$

$E_{steel} = 200\ GPa = 4.17 \times 10^9\ lb/ft^2$

$\gamma_{Log} = 51.84\ lb/ft^3$ $\quad \gamma_{water} = 62.47\ lb/ft^3$

Trapezoidal channel, Slope $(S) = 0.001$

$A = 1.73\ y^2$ $\quad T = 2.309\ y$ $\quad \eta_{water} = 2.35 \times 10^{-5}\ lb\text{-}s/ft^2$

$R = y/2$ $\quad$ Table 14.3

$n = 0.017$

flow nozzel $\beta = 0.5 = d/D$

$E_0 = 45504000\ lb/ft^2$ for water

$\delta = 0.0238\ ft$ Pipe thickness

Procedure: a) To determine height of water Y I will use the known Q and mannin's equation (English version) to calculate Y.

b) To determine the force's acting on the pipe elbow I will use point's A, and B to compute the pressure at A. Then using the external force equation using pressure, volumetric flow rate and velocity to calculate the forces.

c) To find the Largest size Log the channel can carry, force due to boyancy and the weight of the Log will be assumed to be equal. And the draft of the

(4)

Procedure: c) Log will be basically the same as Y (height water) so Y ≈ draft. This will allow me to solve for MB and determine stability.

d) To determine the ΔP across the nozzle The velocity equation for flow nozzle's will be used. Calculating for N_r and substituting Q into the equation for V will allow for ΔP to be calculated.

e) To determine the pressure increment (ΔP) the Length (of Pipe) and velocity are known and I can calculate C to then Calculate ΔP can be done.

f) To determine the force due to drag on the Log a C_d will be assumed to be 1.16 (from table 17.1 for rectangular plate), velocity will be calculated using the Channel as Area, then F_d can be found

g) To determine the force acting on the flange The pressure of the air must be calculated by using bernoulli's equation. Once that is found using the equation of forces due to stagnant fluids can be calculated. The Location of the force is at the centroid of the area.

5

Calculations: a) $T = 2.309Y$ $A = 1.73Y^2$

$R = Y/2$ $S = 0.001$ $n = 0.017$

$V = \left(\frac{1.49}{n}\right) S^{1/2} R^{2/3}$ Substitute $Q = AV$

$Q = \left(\frac{1.49}{n}\right) A S^{1/2} R^{2/3} = \left(\frac{1.49}{n}\right) \cdot 1.73Y^2 \cdot S^{1/2} \cdot \left(\frac{Y}{2}\right)^{2/3}$

using excel to guess values of Y untill the correct $Q = 0.167 ft^3/s$ is found

when $\underline{Y = 0.345 \text{ ft}}$ the % differance is 1.8%.

b) $\frac{P_A}{\gamma} + \cancel{\frac{V_A^2}{2g}} + \cancel{z_a} = \cancel{\frac{P_B}{\gamma}} + \cancel{\frac{V_B^2}{2g}} + \cancel{z_B} + h_L$

$V_A = V_B$ (Just different direction

$z_a \approx z_B$ so niglect this

$P_B = 0$ since open to atmosphere

so $\frac{P_A}{\gamma_{water}} = h_L$ $h_L = h_{friction} + h_{valve} + h_{bend}$

$h_L = f_T\left(\frac{L}{D} \cdot \frac{V^2}{2g}\right) + 8f_T\left(\frac{V^2}{2g}\right) + 30f_T\left(\frac{V^2}{2g}\right)$

$f_T = 0.02$ for 1½ in schedule 40

6

Calculations: b) $V = Q/A = 0.167\,ft^3/s / 0.014\,ft^2$

$V = 11.93\,ft/s$

$$h_L = 0.02\left(\frac{300ft}{0.1342ft}\cdot\frac{11.93^2\,ft/s}{2(32.2\,ft/s^2)}\right) + 8\cdot 0.02\left(\frac{11.93^2\,ft/s}{2\cdot 32.2\,ft/s^2}\right)$$
$$+\ 30\cdot 0.02\left(\frac{11.93^2\,ft/s}{2\cdot 32.2\,ft/s^2}\right)$$

$h_L = 100.48\,ft$

$P_A = h_L \cdot \gamma_w = 100.48\,ft \cdot 62.47\,lb/ft^3$

$P_A = 6276.74\,lb/ft^2$

neg V_2 direction $\quad P_B = 0$

$R_x = \rho \cdot Q \cdot V_1 - P_A A_A \qquad R_y = \rho Q V_2 + \cancel{P_B A_B}$

$R_x = 1.94\,slug/ft^3 \cdot 0.167\,ft^3/s\,(-11.93\,ft/s)$
$+\ 6276.74\,lb/ft^2 \cdot 0.014\,ft^2$

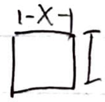
$R_x = 91.74\,lb$ acting in negative X direction.

$R_y = 1.94\,slug/ft^3 \cdot 0.167\,ft^3/s \cdot -11.93\,ft/s + 0$

$R_y = 0.39\,lb$

c) $F_B = F_{W,log} \qquad F_B = \gamma_{wood}\cdot V_{wood} \qquad F_B = \gamma_{water}\cdot V_d$

$V_{wood} = X \cdot X \cdot L \qquad V_d = Y \cdot X \cdot L \qquad Y \approx$ draft



Log cross section

so $\gamma_{wood}(X\cdot X\cdot L) = \gamma_{water}(Y\cdot X\cdot L)$

$$X = \frac{\gamma_{water}\cdot Y \cdot \cancel{X}\cdot \cancel{L}}{\gamma_{wood}\cdot \cancel{X}\cdot \cancel{L}} = \frac{62.47\,lb/ft^3 \cdot 0.34\,ft}{51.84\,lb/ft^3}$$

7

Calculations : c) $X = 0.41\ ft$

If stable $Y_{mc} > Y_{cg}$

$Y_{c.g} \approx 0.205 ft$ $\quad$ $Y_{c.b} \approx 0.1675\ ft$

$Y_{mc} = Y_{c.b} + MB$ $\quad$ $MB = I / V_d$

$I = \frac{L \cdot X^3}{12}$ $\quad$ $V_d = L \cdot Y \cdot X$

$MB = \frac{\cancel{L} \cdot X^{\cancel{3}\,2}}{12} \cdot \frac{1}{\cancel{L} \cdot Y \cdot \cancel{X}} = \frac{X^2}{12 \cdot Y} = \frac{0.4ft^2}{12 \cdot 0.335 ft}$

$MB = 0.04\ ft$

$Y_{mc} \approx 0.1675\ ft + 0.04ft \approx 0.2075\ ft$

$Y_{cg} > Y_{mc}$ so not stable

d) $\beta = 0.5 = d/D$ $\quad$ $V_1 = C\sqrt{\frac{2g(P_1 - P_2)/\gamma_{water}}{(A_1/A_2)^2 - 1}}$

$Q = AC\sqrt{\frac{2g(P_1 - P_2)/\gamma_{water}}{(A_1/A_2)^2 - 1}}$ $\quad$ $A = A_1 = 0.014\ ft^2$

$d = 0.5 \cdot 0.1342\ ft$ $\quad$ $d = 0.0671$ $\quad$ $\frac{A_1}{A_2} = 3.95$

$A_2 = 0.00354\ ft^2$

$N_R = \frac{VD\rho}{\eta} = 134189.5$ $\quad$ $C = 0.9975 - 6.53\sqrt{\beta / N_R}$

$C = 0.985$

8

Calculations: d) $Q = A C \sqrt{\dfrac{2g(P_1 - P_2)/\gamma_{water}}{\left(\frac{A_1}{A_2}\right)^2 - 1}}$

$$\left(\frac{Q}{AC}\right)^2 = \frac{2g(P_1 - P_2)}{\gamma_{wat}} \cdot \frac{1}{\left(\frac{A_1}{A_2}\right)^2 - 1}$$

$$\frac{\left(\left(\frac{A_1}{A_2}\right)^2 - 1\right) \cdot \left(\frac{Q}{AC}\right)^2 \cdot \gamma_{wat}}{2g} = P_1 - P_2$$

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

$$P_1 - P_2 = \frac{\left((3.95)^2 - 1\right) \cdot \left(\frac{0.167\ ft^3/s}{0.014\ ft^2 \cdot 0.985}\right)^2 \cdot 62.47\ lb/ft^3}{2 \cdot 32.2\ ft/s^2}$$

$$\Delta P = 2077.39 \ \frac{lb}{s^2 ft} \cdot \frac{s^2}{ft} = \underline{2077.39\ lb/ft^2}$$

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

$V = 11.93\ ft/s$

$\rho_{water} = 1.94\ slug/ft^3$

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

$$1\ slug/ft^2 = 1\ \frac{lb \cdot s^2}{ft^4}$$

$$C = \frac{\sqrt{45504000\ \frac{\cancel{lb}}{\cancel{ft^2}} \cdot \frac{1\ ft^4}{1.94\ \cancel{lb} \cdot s^2}}}{\sqrt{1 + \frac{45504000\ \frac{\cancel{lb}}{\cancel{ft^2}} \cdot 0.1342\ \cancel{ft}}{4.17 \times 10^9\ \frac{\cancel{lb}}{\cancel{ft^2}} \cdot 0.0233\ \cancel{ft}}}}$$

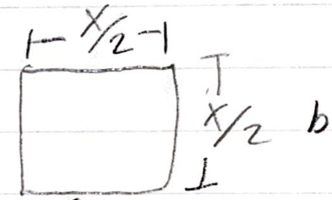
(9) e)

Calculations: $c = \frac{4843.1 \frac{ft}{s}}{1.03}$

$c = 4702$ ft/s

$\Delta P = 1.94 \frac{lb \cdot s^2}{ft^4} \cdot 4702 \frac{ft}{s} \cdot 11.93 \frac{ft}{s}$

$\Delta P = 108824.93$ lb/ft^2



f) $X/2 = 0.41/2 = 0.205$ ft

$F_d = C_D \left(\rho_w \frac{V^2}{2} \right) A_{Log}$ $\quad A_{Chanel} = 1.73\, y^2$

$A_{chanel} = 1.73\,(0.34)^2 = 0.2$ ft^2

$A_{Log} = 0.042$ ft^2

$V = \frac{Q}{A} = \frac{0.167\, ft^3/s}{0.2\, ft^2} = 0.84$ ft/s

C_D for rectangular plate with $a/b = 1$
$C_D = 1.16$

$F_d = 1.16 \cdot \left(1.94 \frac{lb \cdot s^2}{ft^4} \cdot \frac{0.84^2 ft/s}{2} \right) \cdot 0.041 ft^2$

$F_d = 0.033$ lb

10

Calculations: g) using points C & A

$$\frac{P_C}{\gamma_w} + \frac{\cancel{V_C^2}}{2} + Z_C = \frac{P_A}{\gamma_w} + \frac{V_A^2}{2} + \cancel{Z_A} + h_L$$

$Z_A = 0$, at refferance $\quad V_C = 0$, in tank

$Z_C = 3\,ft \quad V_A = 11.93\,ft/s$

$$h_L = h_{L\,exit\,Loss} = K\frac{v^2}{2g} \qquad K = 0.5$$

$$h_L = 0.5\left(\frac{11.93^2\,ft/s}{2 \cdot 32.2\,ft^2/s}\right) = 1.1\,ft$$

$$\frac{P_C}{\gamma_w} = \frac{P_A}{\gamma_w} + \frac{V_A^2}{2} + h_L - Z_C$$

$$\frac{P_C}{\gamma} = \frac{6276.74\,lb/ft^2}{62.47\,lb/ft^3} + \frac{11.93^2\,ft/s}{2} + 1.1\,ft - 3\,ft$$

$$\frac{P_C}{\gamma} = 169.7\,ft$$

$$h_{total} = 3\,ft + 169.7\,ft = 172.74\,ft$$

$$F = \gamma_w h_{total} A_{flange} = 62.47\,lb/ft^3 \cdot 172.74\,ft \cdot 0.014\,ft^2$$

$F = 151.07\,lb$, acting at the centroid of the flange area, facing outward of the tank.

(11)

Summary: a) The calculated Y has a 1.8% differance between the known Q and calculated Q. This is within 5% so it is valid.

b) The calculated pressure at point H is 6101, but this will mean the air is pressurized to a high valve, The force in the -X direction (horizontal) uses that pressure and is why the valve is so high. The Y (vertical) force is only due to the ΔV. This is niglecting the weight of pipe, and water in pipe which would both add to the forces in the Y direction,

c) The maximum size log having a square cross section would be 0.41 ft X 0.41ft. This Log would not be stable, but it is close to being stable.

d) The pressure drop across a flow nozzle with a $\beta = 0.5$ would be 2077.39 lb/ft^2.

e) The pressure increment or ΔP that would occure if the valve closed suddenly is 108824.93 lb/ft^3, the lowest pressure in the system is atmospheric so there is no cavitation occuring.

12)
Summary: f) A log that is half the max size would have a drag force of 0.033 lb. This is with a assumed C_D of 1.16 for a rectangular plate where $a/b = 1$.

g) The force that is acting on the flange is due to the pressurized air and the stagnate fluid in the tank. This force is acting horizontally to the centroid of the circular area (acting -x direction) and its value is 151.07 lb

Materials: · water · flow nozzle

Analysis: - The height of the channel walls should be greater than 0.34 ft.
- The pipe will need more support along the x-axis (not accounting for weight).
- There is a 2077 lb/ft² pressure drop across flow nozzle, so if a manomiter is used make sure it is properly sized.
- If valve suddenly closes there will be a very large pressure build up.
- flange must be able to sustane a force of 151.07 lb.