Colby Watts

Professor Ayala

3/15/24

330 Test 2

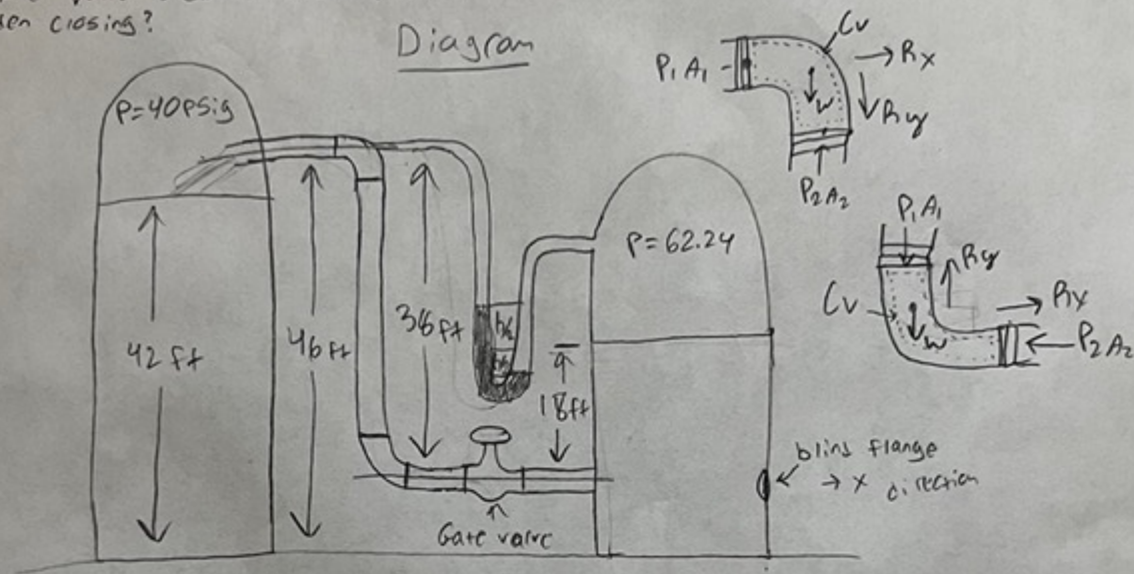
Colby watts fluids test 2

PART A

Purpose

What is the force magnitude and location on a blind flange?
Calculate total horizontal and vertical forces in the whole pipe - elbows valve system.
What is the pressure drop accross the nozzle?
If the valve is closed suddenly, what is the pressure increment after the sudden closing?

Diagram



Sources

- Applied Fluid mechanics Book
- Professor Ayala solved problems
- Notes in Class

Design Considerations

The design is safe, to me it does not look like it will blow up. Adding a flange proves some risk because if you do not calculate the force on the flange correcty it could bust out of the side.

Data & Variables

Diameter 2 in

Diameter = 0.166 ft

$Q = 150$ gpm $= 0.334\ ft^3/s$ $\quad P_2 = 40$ psi

$\rho = 1.53\ \frac{slugs}{ft^3}$ or $1.53\ \frac{lb \cdot s^2}{ft^4}$ $\quad P_1 = 64.2$ psi $\quad \beta = 0.5$

Area of pipe $= 0.02333\ ft^2$

$V = 14.3\ ft/s$ $\quad W = 32.2\ ft/s^2$ $\quad \gamma = 49.01\ lb/ft^3$

Diameter of flange

Area of flange $= \frac{\pi (.166ft)^2}{4}$ $\quad h = 18\ ft$ $\quad 64.25\ psi = 9252\ lb/ft^2$

$A = 0.0216\ ft^2$ $\quad 40\ psi = 5760\ lb/ft^2$

Procedure Part A ①

$$P_B = \gamma h + P_2 = (49.01\ lb/ft^3)(18\ ft) + 9252\ lb/ft^2$$

$$P_B = 10134.18\ lb/ft^2$$

Then to calculate for the force magnitude I use

$$F = P_B \cdot A = 10134.18\ lb/ft^2 \cdot 0.0216\ ft^2$$

$$F = 218\ lbf$$

Part A ②

To find Horizontal and vertical forces of the system we use the x-direction and y-direction

So first I am going to do the x-direction

$$R_x = \rho Q V + P_1 A_1 \qquad A_1 = A_2$$

and then the y direction

$$R_y = \rho Q v + P_2 A_2$$

So for R_x

$$R_x = \left(1.53 \frac{lb \cdot s^2}{ft^4}\right)\left(.334 \frac{ft^3}{s}\right)(14.3\ ft/s) + \left(5760 \frac{lb}{ft^2}\right)(0.0233\ ft^2)$$

$$R_x = \underline{134.5\ lbf}$$

for R_y forces that are vertical

$$R_y = (1.53\ \frac{lb \cdot s^2}{ft^4})(.334\frac{ft^3}{s})(14.3 ft/s) + (9252\ lb/ft^2)(0.02333 ft^2)$$

$$R_y = \underline{216\ lbf}$$

Part A ③

To calculate for pressure drop we use the equations for flow rate.

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

to calculate for C we need Reynolds number

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

$$N_R = \frac{V\rho D}{\eta} = \frac{14.3 \cdot 1.53 \cdot .1723}{2.10 \cdot 10^{-5}} = 1.7 \cdot 10^5$$

Then plug that into the C equation

Also β is given to us that is the 0.5 ratio.

Now for C I got 0.994. I also need both Areas but we already have. $A_1 = 0.02333\ ft^2$, $A_2 = d/D$

$A_2 : d/D = .5$ D = the pipe inner diameter 0.1723 ft
Table F.1

$$D = 0.08615\ ft$$

$$A_2 = \frac{(\pi)(0.08615\ ft)^2}{4} = 0.0058\ ft^2$$

So now I can solve for flow nozzle and plug in all variables. Then solve for the change in pressure.

$$14.3\ ft/s = 0.994\sqrt{\frac{\frac{2(32.2\ ft/s^2)(\Delta P)}{49.01\ lb/ft^3}}{\left(\frac{0.02333ft^2}{0.0058ft^2}\right)^2 - 1}}$$

$$\Delta P = 2362.54\ psi$$

<u>Materials</u>

- Blind Flange
- Orifice plate
- ethyl alcohol

<u>Analysis</u>

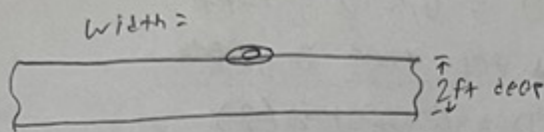
I am 100% positive that everything is incorrect besides the force magnitude and the location of the flange being 18ft from the surface of the tank. I did not do Question 4 because I did not have time. Overall the piping system for horizontal and vertical forces seem to be correct.

PArt B Design a lazy River.

Purpose

- What is the water flow rate required
- What would drag force be in a 4 year old?
- How deep into the water the tube would go?

Diagram



Sources

- Applied Fluid mechanics Book
- Professor Ayala solved problems
- Notes in class
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Design Considerations

Lazy River width should be designed for two tubes to go Side-by-Side with a little bit of wiggle room.
It should also be safe for a 4 year old.

Data and Variables

Tube diameter = 0.96m or 96cm

$n = 0.013$ = Smooth Asphalt

Slope $= 0.001$

$C_D = 1.12$

$\rho = 1.93 \frac{slugs}{ft^3}$

$1.93 \frac{lb \cdot s^2}{ft^4}$

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

$F_D = C_D \left(\frac{\rho v^2}{2}\right) A$

$W = 220$ lbs

Procedure

Part B ①

To calculate for flow rate we need depth of lazy river and width as well as other numerous variables and numbers. My depth for the lazy river is 2 ft and the width is 6.5 ft. I calculated the width by multiplying the tube diameter by 2. $2(0.96) = 1.92\,m = 6.3$ feet.

Then to find Area I used

$$A = W \cdot D = 6.5 \cdot 2 = 13ft^2$$

Then for the wetted perimeter I used

$$WP = W + 2D = 6.5ft + 2(2)$$

D = Depth

W = width

$$WP = 10.5\ ft$$

So then I used the Hydraulic radius equation

$$R = \frac{A}{WP} = \frac{13ft}{10.5ft} = 1.238\ ft$$

Then I used the open channel flow equation to get flow rate.

$$Q = \left(\frac{1.49}{0.013}\right)(13ft^2)(0.001^{1/2})(1.238^{2/3}) = 54.3\ ft^3/s$$

Then to find the velocity of the lazy river I did

$$V = \frac{Q}{A} = \frac{54.3\ ft^3/s}{13\ ft^2} = 4.17\ ft/s$$

Part B ②

Then to calculate for Drag force I used the

$$F_D = C_D\left(\frac{\rho V^2}{2}\right)A$$

$$(1.12)\left(\frac{(1.93\ lb \cdot s^2/ft^4)(4.17^2)}{2}\right)(13) = 244\ lb$$

This can not be true due to it being unsafe for a 4 year old kid to stand in the lazy River. Which means my calculations for the Drag fore are incorrect.

Part B ③

Now to find how deep into the water the lazy river tube would go with a 220 lb person I used

$$\text{Depth} = \frac{W}{(V_d)(g)(\gamma_f)}$$

$$\frac{220 \text{ lb}}{(.463m)(32.2 ft/s^2)(62.4 lb/f^3} = .236 \text{ ft or } 2.832 \text{ in}$$

So the depth is 2.832 in into the water.

Materials

- The tube diameter
- The material for what my lazy river surface was.
- Cylinder was used as the kid.

Analysis

Overall my lazy river is good other than my drag force. That much of a drag force could drown a 4 year old kid. I also could not find anything in the book about a bouyant force how far it would be submerged. But I probably was looking in the wrong place. I also made my equation up from a different equation in the book.