TEST 2 - MET330 - KAYLA DAVIES

Ⓐ PURPOSE: USING THE SYSTEM BELOW FROM TEST 1,

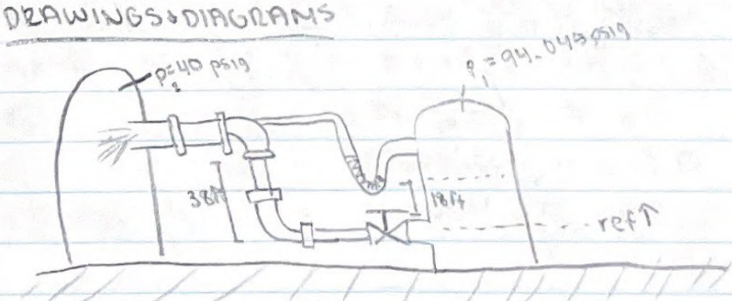
- Calculate THE FORCE MAGNITUDE & LOCATION ON A BLIND FLANGE
- Calculate THE TOTAL HORIZONTAL & VERTICAL FORCES IN THE SYSTEM
- FIND PRESSURE DROP ACROSS NOZZLE
- FIND PRESSURE INCREMENT AFTER A PIPE CLOSES SUDDENLY, IF THE PIPES WOULD FAIL, & VERIFY THAT THERE IS NO CAVITATION

SOURCES: MOTT, R, UNTENER, JA, "APPLIED FLUID MECHANICS", 7TH EDITION, PEARSON EDUCATION INC. (2015)
CANVAS NOTES & PROBLEMS & TEST 1

DESIGN CONSIDERATIONS:

- CONSTANT PROPERTIES
- INCOMPRESSIBLE FLUIDS
- ISOTHERMAL CONSIDERATIONS
- PRESSURIZED AIR CONTROLS

DRAWINGS & DIAGRAMS



MATERIALS

ETHYL ALCOHOL @ 77°F, AIR AT 77°F
2 in SCHEDULE 40 STEEL PIPE

DATA & VARIABLES

$Q = 150\ gpm = 0.334\ ft^3/s$ $\quad D_N/D_P = 0.5$ $\quad z_1 = 38\ ft,\ z_2 = 18\ ft$

$D_{flange} = 2\ in$ $\quad \varepsilon = 1.5E{-4}\ ft$ $\quad D/\varepsilon = 1148.67$ (test 1)

$P_2 = 40\ psig = 5760\ lb/ft^2$ $\quad D = 0.17 \rightarrow A = 0.023\ ft^2$

(A)

PROCEDURE & CALCULATIONS

(1) First, I have to

(2) I am calculating the energy losses, h_L & using N_R to find f.

$$v = \frac{Q}{A} = \frac{0.334}{0.023} = 14.5 \text{ ft/s}$$

$$N_r = \frac{vD}{\nu} = \frac{14.5 \times 0.17}{1.37E-4} = 1.7E4$$

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7 \times D/\epsilon} + \frac{5.74}{N_r^{0.9}}\right)\right]^2} = \frac{0.25}{\left[\log(5.73E-4)\right]^2} = 0.024$$

$$\left.\begin{array}{llll} \text{vert.(2)} & h_L = f\frac{L}{D}\frac{v^2}{2g} & = 0.024\left(\frac{36}{0.17}\right)\left(\frac{14.5^2}{19.62}\right) & = 54.46 \text{ ft} \\ \text{horiz.} & h_L = f\frac{L}{D}\frac{v^2}{2g} & = 0.024\left(\frac{38}{0.17}\right)\left(\frac{14.5^2}{19.62}\right) & = 57.49 \text{ ft} \\ \text{sci} & h_L = K\frac{v^2}{2g} & = 0.5\left(\frac{14.5^2}{19.62}\right) & = 5.36 \text{ ft} \\ \text{valve} & h_L = K\frac{v^2}{2g} & = 8(0.019)\left(\frac{14.5^2}{19.62}\right) & = 1.63 \text{ ft} \\ \text{elbows(2)} & h_L = \downarrow & = 30(0.019)\left(\frac{14.5^2}{19.62}\right) & = 0.61 \text{ ft} \end{array}\right] \quad \underline{h_L = 174.62 \text{ ft}}$$

Now using bernoullis, I can find P_1 & calculate first the individual forces and then the total in the system.

simplified. $P_1 = \gamma\left(\frac{P_2}{\gamma} + \frac{v_2^2}{2g} + (z_2 - z_1) + h_L\right)$

$$P_1 = \left(5760 + \frac{14.5^2}{19.62} + (38-18) + 174.62\right) = 5965.54 \text{ lb/ft}^2$$

(3) Using N_r to find C, we use velocity to find the pressure drop.

$N_r = \frac{VD}{\nu} = \frac{14.5 \times 0.17}{1.37E-5} = 1.8E5$ $\beta = 0.5$

$C = 0.99 - 6.53\sqrt{0.5/1.8E5} = 0.98$

$V = C\sqrt{\frac{19.62(P_1 - P_2)/\gamma}{(A_1/A_2)^2 - 1}} =$

4 yr old: h=40 in ,

adult: W=220 lb $n=0.013$

slope= 0.1%

SUMMARY

USING THE SYSTEM + PRESSURIZED TANKS WE WERE TO CALCULATE THE FORCE MAGNITUDE & LOCATION, TOTAL FORCES, PRESSURE DROP ACROSS THE NOZZLE, & IF CAVITATION OCCURS.

ANALYSIS

I WAS NOT ABLE TO FINISH, BUT I CAN ASSUME THAT WHEREVER THE NOZZLE IS PLACED, THE PRESSURE WILL DROP.

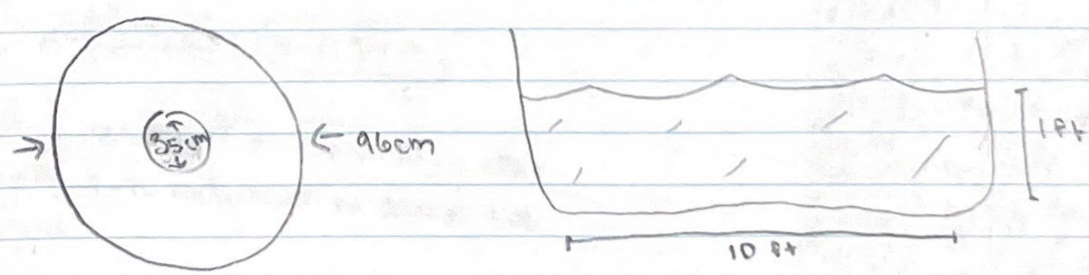
TEST 2 - KD

(B) PURPOSE: DESIGN A LAZY RIVER IN A WATER PARK, CALCULATING THE REQUIRED FLOW RATE, FINDING THE DRAG FORCE A 4-YR OLD WOULD EXPERIENCE, & HOW DEEP UNDERWATER THE TUBE WOULD BE IF 250 lb PERSON WAS ON IT. PROVE IF THE TUBE IS STABLE

SOURCES: MOTT, R, UNTENER, JA, "APPLIED FLUID MECHANICS", 7TH EDITION, PEARSON EDUCATION INC. (2015), CANVAS NOTES, TUBE WEBSITE (AQUATEC-EUROPE.COM)

DESIGN CONSIDERATIONS
- REQUIRED TO FIT 2 TUBES SIDE BY SIDE
- WATER DEPTH NEEDS TO BE SAFE FOR YOUNG CHILDREN
- OPEN CHANNEL FLOW

DRAWING



MATERIALS
4 yr old child, lazy river tube

DATA/VARIABLES

$D_{external} = 95$ cm $w = 2$ kg assume water: 60° F

$D_{internal} = 35$ cm $\gamma = 62.2$ lb/ft³, $\nu = 9.15E{-6}$, $\rho = 1.93$ slug/ft³

4 yr old: $h = 40$ in, $W = 40$ lb, $D = 20$ in? $\gamma_f = 62.4$ lb

adult: $W = 220$ lb $n = 0.013$

slope = 0.1%

(B)

PROCEDURE + CALCULATIONS

(5) First, I am finding the flow rate required using
$Q=\left(\frac{1.49}{n}\right)AR^{2/3}S^{1/2}$ for open channel flow.

$A=1\times10=10\ ft^2$ $\quad n=0.013$

$R=\frac{10\times1}{10+2(1)}=0.83\ ft$ $\quad S=0.1\%=0.001$

for rectangle
$A=by \quad WP=b+2y$
$R=\frac{by}{b+2y}$

$Q=\left(\frac{1.49}{0.013}\right)(10)(0.83)^{2/3}(0.001)^{1/2}=\boxed{32.01\ ft^3/s}$

(6) Next, I am finding the drag force on a 4yr old using Reynolds number, N_R, + assuming the kid is a cylander.

$D_{kid}=20\ in=1.67\ ft$ $\qquad C_D=1.12$ (TABLE 17.1)

$v=\frac{Q}{A}=\frac{32.01\ ft^3/s}{(\pi\times1.67^2)/4}=14.61\ ft/s$

$N_r=\frac{vD}{\nu}=\frac{14.61\times1.67}{9.15E-6}=2.66E6$

$F_D=C_D\left(\frac{\rho v^2}{2}\right)A=1.12\left(\frac{1.93\times2.19^2}{2}\right)(2.19)=\boxed{11.35\ lb}$

(7) I need to find the combined weight of the tube + person to calculate the displaced volume and then the V of a hollow cylinder to find h.

$220\ lb+2\ kg=224.4\ lb$

$V_D=\frac{w}{\gamma_f}=\frac{224.4\ lb}{62.4\ lb/ft^3}=3.59\ ft^3$

$V=\frac{\pi h(D_2^2-d_1^2)}{4}\ \therefore\ 3.59=\frac{\pi h(3.11^2-1.14^2)}{4}$ $\quad \boxed{h=0.55\ ft}$

Using the center of bouyancy + metacenter of bouyancy I can figure of if the adult is stable. If the metacenter is above the center of gravity its stable.

$CB=\frac{H}{2}=\frac{0.55}{2}=0.275\ ft$

$MB=\frac{I}{V_D}\rightarrow I=\frac{\pi(D_e^4-D_I^4)}{64}=\frac{\pi(3.11^4-1.14^4)}{64}=4.51\ ft^4$

$MB=\frac{4.51\ ft^4}{3.59\ ft^3}=1.26\ ft$

$MC=CB+MB=0.275+1.26=\boxed{1.485\ ft}$ STABLE!

SUMMARY

When designing the lazy river, flow rate, drag force of a child, how deep a tube would go underwater if a 220 lb-person was using it, and if the tube was stable with the heavier object. These were found using the properties of cylinders for the humans. The depth of the water needed to be such that the child can stand safely.

ANALYSIS

The flow rate was calculated using equations for a rectangle, the closest to a pool shape. If I changed the y to a smaller ft than 10, the flow rate is likely to decrease. Using C_D for a cylinder from table 17.1, I was able to calculate the drag force. The person in the tube will be stable, due to the calculated metacenter.