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MET 330

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HW #3.1

Devon Moore: Looking the solved series pipeline solutions I learned that Bernoulli's equation and the minor loss equations can be combined to determine what the required size of a pipe is to produce a particular flow rate. The same principal can be used to find things like flow rate, velocity, or pressure depending on the given variables. For some applications it can be easier to rearrange the equation derived from Bernoulli's and the minor losses to directly solve for the missing variable. Other applications may require the equation to be split into two halves and solve for the missing variable using an iteration process on excel. This way of solving series pipeline systems is very useful when dealing with gravity fed systems because there is no given fluid velocity.

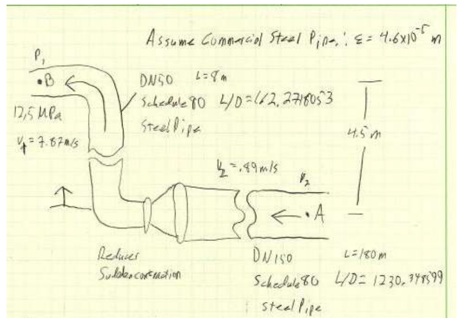
Dave Buonconsiglio: This week we worked on iterations. I have been trying to do this for some time. This is what excel spreadsheets are made for. Once you can get the equation figured out, the solution is actually pretty easy. The tough part is figuring out where to put what. Once you have that data, then it just becomes plug and chug in a table in excel.

This weeks problems will also help greatly with our groups design for the project, as we are using gravity fed pipes for most of the system.

Richard Harrell: We learned there are there classifications of piping system analysis and design. Class 1 are completely defend with size of pipes, what loses are present and Flow rate. Used to find pressure at a point. While class 2 completely defends the location and equipment, leaving you to look for the flow rate Then finally we have class 3 is just a general design and know volumetric flow rate allowing you to size the pipes as need. We also worked with iteration "repetition of a mathematical" which is ideal for use in programs/ excel**.**

Traveon Williams:

11.5



HW 3.1 Problem 11.5.1

$Q = 0.015\ m^2/s$

$$\frac{P_A}{\rho g} + \frac{V_A^2}{2g} - Z_1 = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_2 + h_A$$

$$\frac{P_A}{\rho g} = \frac{P_B}{\rho g} + \frac{V_B^2 - V_A^2}{2g} + Z_2 + h_A + Z_1$$

Pipe A = $\varepsilon/d = 4.6\times10^{-5}/.15 = 3\times10^{-4}$, Re = 6x4

$f = 0.016$

Pipe B = $\varepsilon/d = 4.6\times10^{-4}/0.05 = 9.2\times10^{-4}$

$f = .0019$

$$h_{L_A} = \frac{f l v^2}{2dg} = \frac{.016 \times (180)(.89)^2}{2(0.15)9.81} = 0.7m$$

$$h_{L_B} = \frac{f l v^2}{2dg} = \frac{.019 \times 8 \times (7.64)^2}{2(0.05)(9.81)} = 9.04\ m$$

$$h_{L\,sudden} = \frac{.5V^2}{2g} = \frac{.5(7.64)^2}{2\cdot 9.81} = 1.48$$

$h_A = .7 + 9.04 + 1.487 = 11.22\ m$

$$\frac{P_A}{\rho g} = \frac{P_B}{\rho g} + \frac{V_B^2 - V_A^2}{2g} + 2 + h_A$$

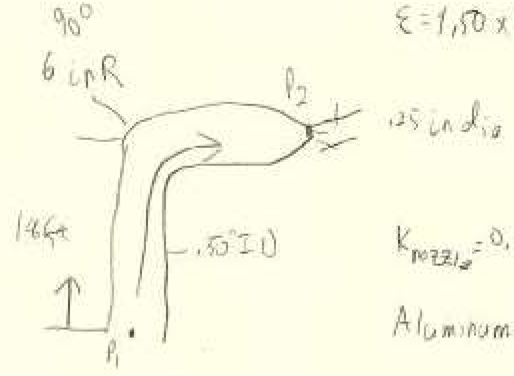
$$\frac{P_A}{\rho g} = \frac{12.5\times10^6}{8.8\times10^3} + \frac{7.64^2 - .88^2}{2\times9.81} + 4.5 + 11.22$$

$$\frac{P_A}{\rho g} = \frac{14.39}{8.8\times10^{-3}}$$

$P_A = 12.7\ MPA$

$Loss = .2\ MPA$

11.13



$\varepsilon = 1.50 \times 10^{-3}$ mm ÷ 305 =

(pressure-drop.com)

$K_{nozzle} = 0.15$

$A = \frac{\pi D^2}{4} = \frac{\pi (.5^2)}{4} = 0.1963495408$ in^2

Aluminum

.001363538 ft^2

P_{1a} 20 psig

$L = 20$ ft + elbow

P_{1b} 80 psig

Water @ 100°F

elbow $K = 30 f_T$

Pipe $K = f\left(\frac{L}{D}\right)$

f, f_T } for formula see Excel Spreadsheet

$$\frac{P_1}{\gamma} + \overset{0}{\cancel{z_1}} + \frac{V_1^2}{2g} - h_L = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g}$$

Assume Water @ Atm pressure

$R_e = \frac{VD}{\nu}$

100°F

$D/\varepsilon = \frac{.5 \text{ in}}{4.92E\text{-}6} \cdot \frac{1}{12 \text{ in}}$

$\gamma = 62 \frac{lb}{ft^3}$

$\nu = 7.37 \times 10^{-6} \frac{ft^2}{s}$

$L/D = \frac{20 \text{ ft}}{.5 \text{ in}} \cdot \frac{12 \text{ in}}{1 \text{ ft}}$

~~$V = \frac{Q}{A} = \frac{4Q}{\pi D^2}$ $\frac{V^2}{2g}$ $\frac{\left(\frac{4Q}{\pi D^2}\right)^2}{2g}$ $\frac{\frac{16Q^2}{\pi^2 D^4}}{2g}$ $\cdot \frac{1}{2g}$~~

$h_{L\,pipe} = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right)$

~~$\frac{8}{g\pi^2 D^4} Q^2$~~

$h_{L\,elbow} = 30 f_T\left(\frac{V^2}{2g}\right)$

~~$\frac{P_1}{\gamma} + \frac{8}{g\pi^2 D^4} Q^2 = \frac{P_2}{\gamma} + z_2 + \frac{8}{g\pi^2 D^4} Q^2$~~

Aluminiur	new	1.50E-03	mm	4.92E-06	ft

20	psi	2880	psf
80	psi	11520	psf

hL 20 psi	28.15384615	ft
hL 80 psi	167.8064516	ft

g	32.2	ft/s^2		
D pipe	0.5	in	0.041667	ft
L	20	ft		
v	7.37E-06	ft^2/s		
ϵ	1.50E-04	ft		
γ	62	lb/ft^3		
K n	0.15			
D n	0.25	in	0.020833	ft
A pipe	0.001363538	ft^2		
A nozzle	0.000340885	ft^2		
z2	18	ft		
fT	2.75E-02			
K elbow	5.50E-01			
1/(3.7De)	9.73E-04			
D^2	0.001736111			
√gDhL/L	1.37428303	√gDhL/L	3.355148	
1.784v	1.31E-05			
D√gDhL/L	0.057261793		0.139798	
1.784v/D	2.30E-04		9.41E-05	
log	-2.91988369		-2.97183	
D2√	0.002385908		0.005825	
Q	0.015465794		0.03843	
V	45.36958642		112.7348	
De	2.78E+02			

$$Q = -2.22 * D^2 \sqrt{\frac{gDh_L}{L}} \log\left(\frac{1}{3.7\left(\frac{D}{\varepsilon}\right)} + \frac{1.784v}{D\sqrt{\frac{gDh_L}{L}}}\right)$$

Va	45.36958642	ft/s
Vb	112.7348262	ft/s

Formulae:

$$V = \frac{Q}{A}$$

$$\frac{p_1}{\gamma} + z_1 + \frac{v_1^2}{2g} - h_L = \frac{p_2}{\gamma} + z_2 + \frac{v_2^2}{2g}$$

$$\frac{p_1}{\gamma} + z_1 + \frac{v_1^2}{2g} = \frac{p_2}{\gamma} + h_L + \frac{v_2^2}{2g}$$

$$LHS = \frac{p_1 - p_2}{\gamma} - z_2$$

455.2258065	20 psi
2684.903226	80 psi

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(D/\varepsilon)} + \frac{5.74}{Re^{0.9}}\right)\right]^2}$$

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

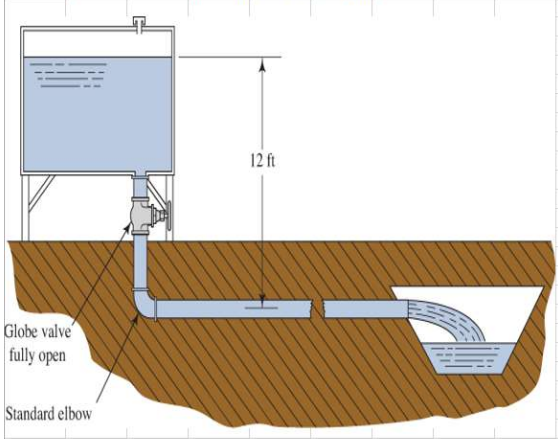
$$K_{pipe} = f\left(\frac{L}{D}\right)$$

$$K_{elbow} = 20f_T$$

$$Re = \frac{VD}{v}$$

11.20

The tank shown in the figure is to be drained to a sewer. Determine the size of new Schedule 40 steel pipe that will carry at least 400 gal/min of water @ 80°F through the system shown. The total length of pipe is 75 ft.



Formulae:

$$V = \frac{Q}{A}$$

$$\frac{p_1}{\gamma} + z_1 + \frac{v_1^2}{2g} - h_L = \frac{p_2}{\gamma} + z_2 + \frac{v_2^2}{2g}$$

$$\frac{p_1}{\gamma} + z_1 + \frac{v_1^2}{2g} = \frac{p_2}{\gamma} + h_L + \frac{v_2^2}{2g}$$

$$LHS = \frac{p_1}{\gamma} + z_1 + \frac{v_1^2}{2g}$$

$$RHS = \frac{p_2}{\gamma} + h_L + \frac{v_2^2}{2g}$$

$$h_{L\,pipe} = f\left(\frac{L}{D}\right) * \left(\frac{v^2}{2g}\right)$$

$$h_{L\,valve} = K\left(\frac{v_2^2}{2g}\right)$$

$$h_{L\,elbow} = 20 f_T * \frac{v_1^2}{2g}$$

$$f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(D/\varepsilon)} + \frac{5.74}{Re^{0.9}}\right)\right]^2}$$

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

$$K_{pipe} = f\left(\frac{L}{D}\right)$$

$$K_{elbow} = 20 f_T$$

$$Re = \frac{VD}{v}$$

g	32.2	ft/s		
L	75	ft		
γ	62.2	lb/ft^2		
v	9.15E-06	ft^2/s		
p1	0	psi		
Q	400	gpm	0.8912	ft^3/2
e	1.50E-04	ft		
LHS	12	ft		

Iteration	D (ft)	V (ft/s)	Re	D/e	fT	f	K v	K e	K p	RHS	%diff
1	0.3	12.6079	4.13E+05	2.00E+03	0.0167	0.0180	5.677661	0.500970075	4.489606	11.23316584	-6.4%
2	0.4	7.091944	3.10E+05	2.67E+03	0.0157	0.0175	5.328019	0.470119292	3.284959	2.705426639	-77.5%
3	0.2	28.36778	6.20E+05	1.33E+03	0.0183	0.0190	6.231998	0.549882138	7.139397	89.38288631	644.9%
4	0.25	18.15538	4.96E+05	1.67E+03	0.0174	0.0184	5.917373	0.522121138	5.514121	28.38234525	136.5%
5	0.275	15.00444	4.51E+05	1.83E+03	0.0170	0.0181	5.790208	0.51090069	4.949013	17.45624697	45.5%
6	0.29	13.4924	4.28E+05	1.93E+03	0.0168	0.0180	5.721118	0.504804545	4.662593	13.33302498	11.1%
7	0.295	13.03891	4.20E+05	1.97E+03	0.0168	0.0180	5.699143	0.50286558	4.574437	12.22845458	1.9%
8	0.297	12.86389	4.18E+05	1.98E+03	0.0167	0.0180	5.690492	0.50210226	4.540115	11.81795874	-1.5%
9	0.296	12.95096	4.19E+05	1.97E+03	0.0167	0.0180	5.694808	0.502483058	4.55721	12.02107631	0.2%

0.296 nearest size up is 1/4 in Schedule 40 pipe