Practice Session No. 2

Fluid Mechanics

Analysis of Pressure Drops in Pipes

Name	
ID Number	
Professor	
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Presentation	5%	
Quiz	10%	
Format	10%	
Numerical Analysis	20%	
Results	20%	
Discussion of the Results	15%	
Conclusions	20%	
TOTAL	100%	

Introduction

All valves, pipes and accessories which constitute a series of flows present certain resistance to the fluid that travels through them. This resistance is caused by friction and it will reduce the fluid energy. The lost of energy should be taken in account in order to design hydraulic systems; this will help the designer to reduce the losses of the fluid and it will permit the fluid to arrive wherever the designer wants.

Objective

Determine the volumetric flow of water that is located inside the pipe measured by the Venturi and compare this value with the volumetric flow obtained in the equations.

Theory

When we want to move the fluid through a pipe, we can observe that it will always be a lost of energy due to the friction between the fluid and the pipe. This lost of energy will represent a reduction of pressure of the fluid. The pressure drop in a horizontal pipe, without accessories can be calculated with the equation 1.1:

$$-\frac{\Delta P}{\rho} = \left[\frac{1}{2}\overline{V}^2\right]\left(\frac{L}{D}\right)f \qquad (1.1)$$

The flow of the section of the pipe that we want to measure can be calculated with equation 1.2:

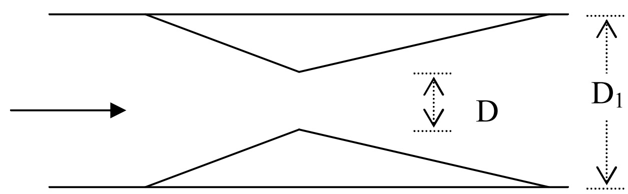
$$Q_{tube} = \sqrt{\frac{\pi^2 D^4 \left(-\Delta P\right)}{8\rho\left(\frac{L}{D}\right)f}} \qquad (1.2)$$

Where
ΔP Pressure Drop that we want to measure
ρ Density that we are measuring
f Friction Factor
L Length of the Pipe we are using
D Pipe Diameter
v Average velocity of the fluid inside the pipe

The pressure drop that takes place in a section of the pipe can be determined with the help of a differential manometer which is connected to the ends of the pipe. The differential manometer is formed by two hoses which are connected to a pair of tubes, where water is rise until a certain level (this will help us finding the height difference). In order to calculate the height difference and the pressure drop you can use equation 1.3.

$$\Delta P = \rho_{water} \cdot g \cdot \Delta h \tag{1.3}$$

To determine the average velocity of the fluid inside the pipe it is necessary to use the Venturi tube, which is form by a gradual reduction in the diameter of the pipe, just as you can see in the next figure:



Applying the Bernoulli equation for this section, we can find the next approximation for velocity, which is given by equation 1.4.

$$Q = Cd_{Venturi} A_t \sqrt{\frac{2(P_1 - P_2)}{\rho(1-\beta^4)}} \tag{1.4}$$

Where:

$$Cd_{Venturi} \approx 0.9858 - 0.196(\beta)^{4.5}$$

$$\beta = \frac{D_0}{D_1}$$

$$A_t = \frac{\pi D_0{}^2}{4}$$

The pressure drop through the Venturi tube can be measured with the help of the tubes that are in the system. Another important thing is the calculation of the friction factor f. This factor depends of the physics properties of the fluid (such as viscosity and density), and the flow. It also depends on the properties of the pipe, such as the diameter and the roughness. We can find the value of the friction factor by using the Moody diagram or we can apply the Colebrook equation which is shown in equation 1.5.

Colebrook equation:

$$\frac{1}{\sqrt{f}} = -2\log\left[\frac{\varepsilon/D}{3.7} + \frac{2.51}{\mathrm{Re}\sqrt{f}}\right] \tag{1.5}$$

System to Analyze

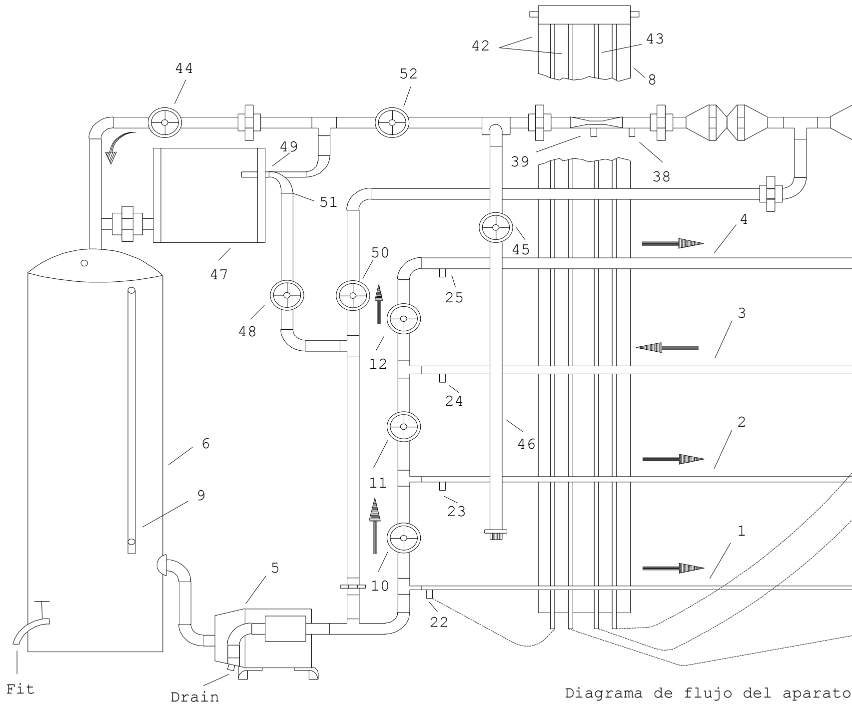


Diagram of the Water System

Water System

The system of the fluid should include several pipes (different diameters) in order to study the flow as an incompressible fluid. The systems should contain:

1. 4 resistant tubes of different diameters and same experimental length, having each tube different ways to measure the pressure; and connected to different accessories (Elbows) and valves that taken together can form different arrangements of pipes.
2. A ¼ hp motor, a centrifugal pump and a turn on control (S.P.S.T).
3. A water tank that contains the fluid made of fiber glass (to prevent corrosion) with a capacity of 14 gallons, and a glass tube to measure the flow.
4. A cylindrical tank with transparent walls to facilitate the observation of the laminar or turbulent flow of the system or tube.
5. Two devices to measure flows: a transparent Venturi tube and a transparent orifice design to be changeable.
6. Two differential manometers or 4 individual manometers and pressure devices in the entire system.

System Details
Experimental Standard Length of Pipes (L-type, drawn-copper, water pipe);

Tube # 4
Nominal Size (in) 1
Exterior Diameter (in) 1.125
Interior Diameter (in) 1.025

Tube # 3
Nominal Size (in) 3/4
Exterior Diameter(in) 0.875
Interior Diameter (in)............ 0.785

Tube # 2
Nominal Size (in) 1/2
Exterior Diameter(in) 0.625
Interior Diameter (in) 0.545

Tube # 1
Nominal Size (in) 3/8
Exterior Diameter (in) 0.500
Interior Diameter (in)............ 0.430

Orifices:
Orifice (edge); Diameter (in) 0.625
Optional Orifice (edge); Diameter (in) 0.562
Optional Orifice(edge); Diameter (in) 0.562

Venturi:
Inlet Diameter (in)... 1.025
Throttling Diameter (in) 0.625

Storing Tank:
External Diameter (in) 12 3/8
Internal Diameter (in) 12
Capacity (gal) 14

Motor:
Volts y Amps .... 115 y 5.2
Cycles per second.............. 60
Horse Power 1/4
Velocity, max (rpm) 1725

Pump (centrifugal):
Inlet NPT (in) 1
Outlet NPT (in)....................... 1
Capacity, 10 ft. head (gph) 300
Capacity, 2 ft. head (gph) 1320

Dimensions:
Length (in) 109
Width (in) 23
Height, without manometers (in) 52
Height, with manometers (in) 81
Weight, without fluid (lbs) 230
Boarding Weight (lbs) 315

Fluid Mechanics

Group: ______________________________ Date ______________________
Name:_____________________________ ID Number _________________

Experimental Results and Procedure:

	Venturi Tube		Pipe – 1 in (diameter)	
No. of Valve Openings (1-6)	Δh (in)	Δh (m)	Δh (in)	Δh (m)

Procedure

1. Open and close the valves that are necessary to ensure that the circuit is including the pipe of the bigger diameter (1in) where we will determine the pressure drop, and verify that the fluid travels through the Venturi tube.
2. Connect the hoses of the differential manometer to the pipe of 1 in.
3. Connect the hoses of the other differential manometer to the Venturi tube.
4. Turn on the pump of the water circuit.
5. Regulate the flow using the valve (number 52 in the diagram shown before) and let the flow become stable.
6. Watch and write the measures (manometer) in a graduate scale and verify that there is no air in the pipes.
7. Modify the volumetric flow by moving valve (52), letting have 6 different openings.
8. For each opening watch and write the measures in a graduate scale. Write them in the table of the experimental results.

Numerical Analysis

1. Calculate the volumetric flow taking the measure from the Venturi tube.
2. Calculate the volumetric flow with the measure taken from the 1 in. tube.
3. Fill in the results table that is shown below and write down your conclusions.

Results Table:

Flow	$Q_{venturi}$ [m^3/s]	Q_{tube} [m^3/s]	Error %

Conclusions:

1. With your own knowledge ¿What results were you expecting to obtain from measuring the volumetric flow in the 1 in tube and the Venturi tube?
2. ¿What percentage of error did you fin after measuring the flow in the 1 in tube and the Venturi tube? ¿Which method of measure of flow will you recommend? ¿Why?
3. Write down 3 concepts that you learned during this practice.

Bibliography

[1] White, Frank M. Fluid Mechanics; 3rd Edition, Mc Graw – Hill; 1994