Experiment 8: Fluid Friction in a pipe



CE 272: Fluid Mechanics Sessional
Experiment No. 8
FLUID FRICTION IN A PIPE

General

Head loss in a pipe flow is mainly due to friction in pipes and again friction is due to roughness of pipes. It has been proved that friction is dependent not only upon the size and shape of the projection of roughness, but also upon their distribution or spacing.

Practical application

Flow through a single pipe line, pipes in series and parallel and also in pipe network system, the head loss has to be estimated. The head loss from source to the point of interest due to the friction along the pipe also provides the basis of pipe size (diameter) design. This experiment gives an estimate of head loss due to friction in the pipe per unit length of the pipe.

Theory

If the head loss in a given length of uniform pipe is measured at different values of the velocity, it will be found that, as long as the velocity is low enough to secure laminar flow. the head loss, due to friction, will be directly proportional to the velocity. But with increasing velocity, at some point where the visual observation in a transparent tube would show that the flow changes from laminar to turbulent, there will be an abrupt increase in the rate at which the head loss varies. If the logarithms of those two variables are plotted on linear scales or if the values are plotted directly on log-log paper, it will be found that, after a certain transition region has been passed, lines will be obtained with slopes ranging from about 1.75 to 2.00.

It is thus understood that for laminar flow the drop in energy due to friction varies as V, while for turbulent flow the friction varies as Vn, where n ranges from about 1.75 to 2.00. The lower value of 1.75 for turbulent flow is found for pipes with very smooth walls; as the wall roughness, the value of n increases up to its maximum value of 2.00

However, velocity is not the only factor that determines whether the flow is laminar or turbulent. The criterion is Reynolds number. For a circular pipe the significant linear dimension L is usually taken as the diameter D, and thus

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

Head loss, h_L can be generalized as proportional with the exponential power of velocity, V by

$h_L \alpha V^n$

where n is the exponent of velocity

Therefore, $h_L = KV^n$

where K is a constant.

Early experiment on the flow of water in long, straight, uniform circular pipes indicated that head loss varied (directly with velocity head and pipe length and inversely with pipe dia. Darcy Weisbach proposed the formula for the turbulent flow,

$$h_L = 4f \frac{L}{D} \frac{V^2}{2g}$$

Where, f=friction factor

$\varphi(R_e) = 0.079 R_e^{0.025}$

Friction factor also depends upon the relative roughness.

For laminar flow head loss (h_t) given by Hagen-Poiseuille is

$$h_L = \frac{32 \mu L V}{\rho g D^2}$$

as $f = \frac{64}{R_e}$

Therefore, friction factor (f) can be related empirically as

$f = \varphi(R_e)$

$= C R_e^{\ m}$

Where m is the exponent of Reynolds number and C is a constant.

The striking feature of the equation is that it involves no empirical coefficient or experimental factors of any kind, except for the physical properties of fluid such as, viscosity, and density.

From this it would appear that in laminar flow the friction is independent of the roughness of the pipe wall.

Apparatus

1. Pipe friction apparatus
2. Stop watch
3. Discharge measuring facility
4. Thermometer.

Procedure

1. Measure the diameter of the pipe and distance between the two tapings.
2. Prime the mercury manometer.
3. Connect the test section pipe to the main water supply pipe.
4. Open flow control valve, priming test section and pipe work.
5. Open clips on water manometer, allowing water to circulate through the system until all the air is expelled.
6. Close pipe clips.
7. Bleed mercury manometer via bleed screws in conjunction with the control valves.
8. Close flow control valve.
9. Observe datum level on manometer.
10. To achieve maximum flow fully open flow control valve. Note levels in manometer and measure flow rate. Repeat for different control valve position.
11. When the mercury level is below 35 mm, open pipe clips near water manometer and take readings on both manometers, The level in the water manometer can be adjusted by operating the air valve or the hand pump.
12. For flows the constant head tank should be used as follows. Close control valve, close supply valve, disconnect inlet pipe from the bench and connect to constant head tank. Connect tank inlet to bench supply. Carefully open bench valve, fill head tank and adjust until water discharges from outlet pipe with flow control valve open. Take readings as before and measure flow rate. Measure the water temperature.

Objective

1. To find the frictional loss
2. To plot h_L vs velocity in log-log paper and determine the empirical relationship of the form $h_L = KV^n$.
3. To plot f vs. R_e in a log-log paper and find the empirical relation of the form $f = CR_e^m$

Practice Questions

1. What are the factors upon which the frictional loss in a pipe depends?
2. What is meant by critical Reynolds number?
3. What is a higher and lower critical point? Explain.
4. Write down the different types of losses that may occur in pipe flow.
5. An oil (s= 0.85, $v=1.8x10^{-5}$ m^2/s) flows in a 10 cm diameter pipe at 0.50 l/s. Is the flow laminar or turbulent?

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Calculation and Data Sheet

Diameter of the pipe, D = ————————
Area of the pipe, A = ————————
Temperature of water, t = ————————
ρ = ———————— . μ = ———————— , υ = ————————

No of obs	Volume V_1	Time T	Discharge Q	Velocity V	Reynolds No R_e	h_L m of H_g	h_L m of H_2O	f

No. of observation					
Discharge Q					
Velocity V					
Reynolds No. R_e					
h_L (m of H_2O)					
f					

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Signature of the Teacher

Note: Suitable unit must be provided in the data sheet.