OBJECTIVES

1. To determine the relation between friction head loss and velocity for flow of water through smooth bore pipes.
2. To compare the head loss predicted by a pipe friction equation with direct measure head loss.

LEARNING OUTCOME

At the end of this lab session, students should be able to

1. Investigate and draw the relationship between head loss and velocity at different type of flow

THEORY

Professor Osborne Reynolds demonstrated that two types of flow may exist in a pipe: -

1. Laminar flow at low velocities, where $h \propto u$.
2. Turbulent flow at higher velocities , where $h \propto u^n$

In laminar flow, head loss, h is directly proportional to flow velocity, u. While in turbulent flow, h is directly proportional to u^n. These two types of flow are separated by transition phase where (in this phase) no definite relationship between h and u exists. Graphs of h versus u and log h versus log u show these zones: -

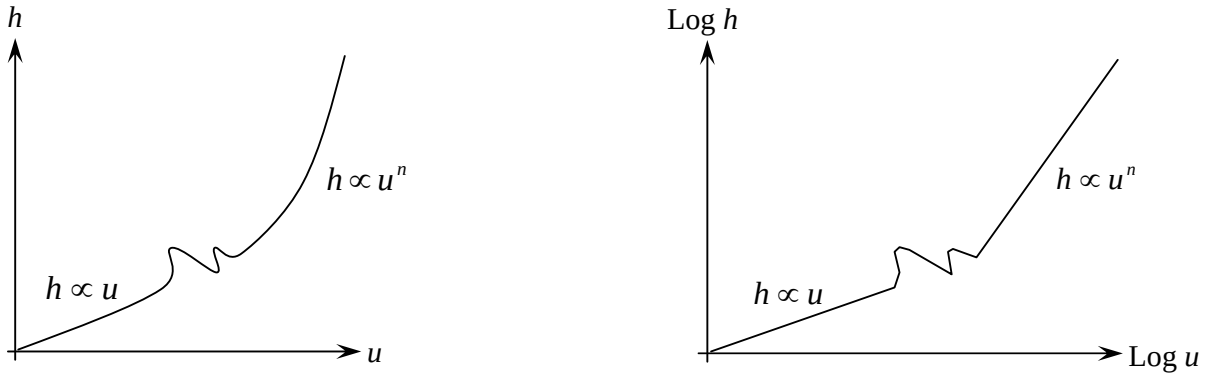

Figure 1 Graphs of h versus u and Log h versus Log u

For a circular pipe flowing full, the head loss due to friction may be calculated from the formula:

$$h = \frac{fLu^2}{d2g} \qquad (1)$$

where L = length of the pipe between tappings

d = internal diameter of the pipe

u = mean velocity of water in m/s

g = acceleration due to gravity in m/s^2

f = friction coefficient.

The Reynolds' number, Re, can be found using the following equation:

$$\text{Re} = \frac{\rho u d}{\mu} \qquad (2)$$

where μ = dynamic viscosity

ρ = mass density

Having established the value of Reynolds' number for flow in the pipe, the value of f may be determined using a Moody diagram.

APPARATUS

C6-MKII-10 Fluid friction apparatus, H12-8 Hand held digital pressure meter, internal vernier calliper, stop watch and thermometer.

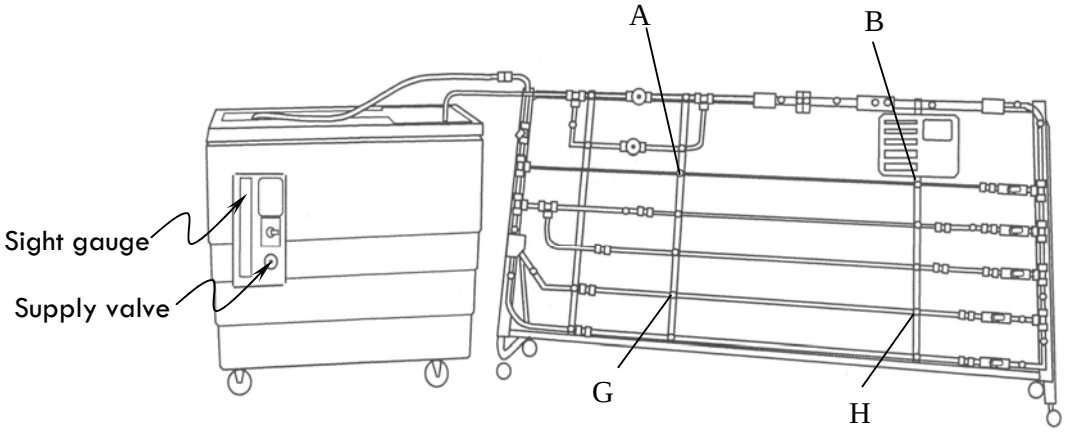

Figure 2 Fluid Friction Apparatus

PROCEDURES

1. Switch on the pump and open the supply valve fully. Set the pressure digital meter by plugging into pipe tapping. Make sure there were no air bubbles present in the rubber hose.

2. Switch on the equipment to allow water flowing in the pipe assembly. The flowing water will push the air bubbles out of the rubber hose. Make sure no air bubbles present in the rubber hose.

3. If the air bubbles were not present in the rubber hose, quickly connect the rubber hose to the pressure digital meter.

4. Before making any measurement, make sure the condition of the C6-MKII-10 Fluid Friction Apparatus is as follow: -
    a. Gate valve and Globe valve are fully open.
    b. Ball valve 2 is fully open, while ball valves 1, 3, 4 and 5 are fully close.
    c. The supply valve is fully close now.

5. Open the supply valve by ¼ turn (quarter turn).

6. Record (into Table 1) the time taken for 5 liters of water to fill in the volumetric tank. To do this, stop the water from flowing into the sump with the ball in the armfield, so that water is retaining in the volumetric tank. Its level will start to rise as may be seen at the sight gauge. Remember to lift the ball to allow water flowing back into the sump after the time is recorded.

7. Record the pressure difference reading from the hand held pressure digital meter into Table 1.

8. Take pressure different reading at several different flow rates by altering the flow using the supply valve in sequence of quarter turn. It is suggested that ten readings are sufficient to produce a good head-flow curve.

9. Measure the internal diameter of the test pipe sample using an internal vernier calliper.

10. Repeat procedures 2 to 8 for pipes between tapping EF and GH.

11. Measure the water temperature using thermometer and check the mass density as well as the dynamic viscosity of water using a given **Table of Approximate Physical Properties of Water**. Apply interpolation technique if the water temperature values are not in the given Table.

FLUID FRICTION

Name: _____ Metric Number: _____

Section / Group: _____ Date of experiment: _____

EXPERIMENTAL DATA

Density of water, ρ (from table) = _____kg/m^3

Dynamic viscosity of water, μ (from table) = _____kg/ms

Length of pipes, *L* = _____m

Internal diameter of pipe, *d* = _____m

Table 1 Fluid Friction Experimental Data

Volume *V* (litres)	Time *T* (s)	**Flowrate Q (m3/s)**	Diameter *d* (m)	**Velocity *u* (m/s)**	**Re**	***f* From Moody Diagram**	**Calculate Head Loss (m H2O)**	Measure Head Loss (m H2O)

Note: Attach samples of calculation in different sheet.

Flow rate = $\frac{V\ X\ 10^{-3}}{T}$

Velocity = $\frac{4Q}{\pi d^2}$

Reynolds' number = $\frac{\rho u d}{\mu}$

Head loss = $\frac{fLu^2}{2gd}$

QUESTION

1. **Plot a graph of log *h* versus log *u*.** Confirm that the graph is a straight line for the zone of turbulent flow $h \propto u^n$. Determine the slope of the straight line to find n.

2. Discuss the relationship of head loss and velocity based on Graph *h* versus *u*

3. Compare and discuss the values of head loss obtained from calculation and measurement (using the digital manometer)

4. Conclusion

APPENDIX A - Moody diagram

To find f , first locate the respective ε/D curve at the right vertical axis; In your case of smooth pipes, use the curve labeled smooth. After that, locate the respective Re at the bottom horizontal axis. At the intersection point, move horizontally to the left is the corresponding friction factor.