Class :2nd stage

Subject: Fluid Flow

Ministry of Higher Education and Scientific Research
Al-Mustaqbal University College

Chemical engineering and petroleum industries

(Fluid Flow Lab)

Experiment No. 9
FRICTION (MAJOR) LOSSES IN PIPES

اعداد:

م.م هدى عادل محمد

م .زينة قاسم علوان

Number of Experiment: 9

Name of Experiment: Friction Losses in Pipes

Purpose of Experiment:

To measure the friction factor for flow through a pipes over a wide range of Reynolds number and compare with corresponding theoretical value.

Introduction:

When a fluid is flowing through a pipe, it experiences some resistance due to which some of energy (head) of fluid is lost. Energy loss through friction in the length of pipeline is commonly termed the major loss (hf) which is the loss of head due to pipe friction and to viscous dissipation in flowing water.

In fluid flow, major head loss or friction loss is the loss of pressure or "head" in pipe flow due to the effect of the fluid's viscosity near the surface of the pipe or duct.

Major head losses are a function of: flow regime (i.e., Reynolds number), flow velocity, pipe diameter and its length, friction factor (flow regime (i.e., Reynolds number), relative roughness)

Friction head losses in straight pipes of different sizes can be investigated over a range of Reynolds' numbers from 10^3 to nearly 10^5, thereby covering the laminar, transitional, and turbulent flow regimes in smooth pipes. A further test pipe is artificially roughened and, at the higher Reynolds' numbers, shows a clear departure from typical smooth bore pipe characteristics.

Figure 1. Schematic of a bourdon tube device for mechanical measurement

Theory:

In Bernoulli's equation as shown below, h_f represents the head loss due to the friction between the fluid and the internal surface of the constant diameter pipe as well as the friction between the adjacent fluid layer (Figure 1)

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + h_f$$

Where $Z_1 = Z_2 = 0$, $d_1 = d_2$

$Q_1 = Q_2$, $V_1A_1 = V_2A_2 \rightarrow V_1 = V_2$

So:

$$\frac{P_1}{\rho g} = \frac{P_2}{\rho g} + h_f$$

$$h_f = h_1 - h_2$$

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

$$h_f = \frac{fLV^2}{2gd}$$

where L is the length of the pipe between tappings, d is the internal diameter of the pipe, u is the mean velocity of water through the pipe in m/s, g is the acceleration due to gravity in m/s^2 and f is pipe friction coefficient.

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

$$Re = \frac{\rho V d}{\mu} = \frac{V d}{v}$$

Where ρ: density, V: average velocity, d: Pipe inside diameter, µ: Viscosity, v: kinematic viscosity .

Based on the nature of the flow, friction factor (f) can be estimated using the following correlations

Laminar flow: $f_{theo} = 64/Re$ (Eq.1)

Turbulent Flow: $f_{theo} = 0.316 \times Re^{-0.25}$ (Eq.2)

Equation (2) is Blausius Equation and only valid for smooth pipe and $3000<Re<10^5$. The value of f for turbulent flow can be obtained from the Moody Chart. Moreover, for turbulent flow, the relationship between hf and V takes:

$$hf = K \cdot V^n$$

Where K is a loss coefficient and n ranges from 1.7 to 2.0 (depending on the value of Re and ks/D).This equation can be written as: $\text{Log } h_f = \text{Log } K + n \text{ Log } V$

In order to find K and n experimentally, using graph.

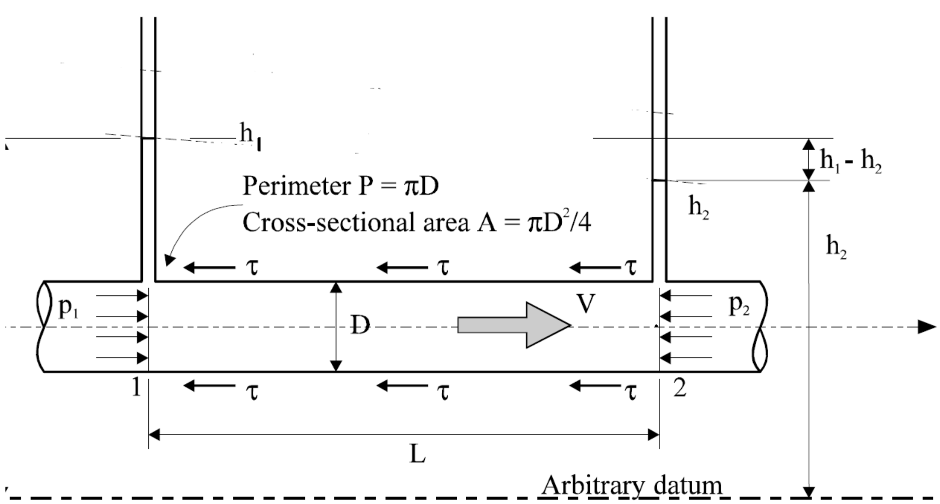


Fig.1 Illustration of fully developed flow along a pipe

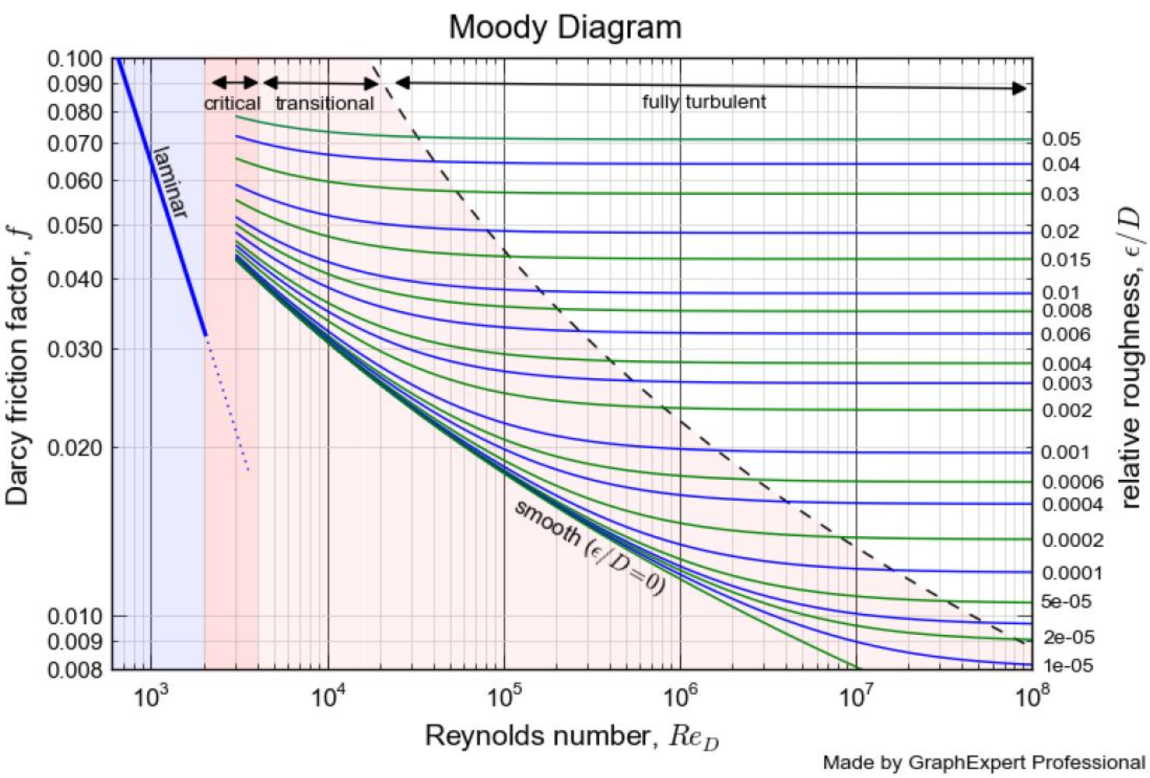


Fig. 2: Moody diagram

Apparatus:-

1. Fluid friction apparatus.

2. Hydraulics bench to supply water to the fluid friction apparatus (the flow of water can be measured by timed volume collection).

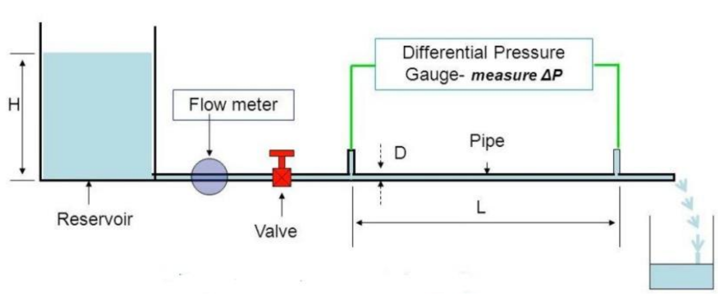


Fig.3 Schematic of experiment Apparatus

Procedure:-

1- Prime the pipe network with water. Open and close the appropriate valves to obtain flow of water through the required test pipe.
2- Take readings at several different flow rates, altering the flow using the control valve on the hydraulics bench (ten readings is sufficient to produce a good head-flow curve).
3- Measure flow rates using the volumetric tank. For small flow rates use the measuring cylinder. Measure head loss between the tappings using the portable pressure meter or pressurised water manometer as appropriate.
4- Obtain readings on all four smooth test pipes.
5- Measure the internal diameter of each test pipe sample using a Vernier calliper.
6- Record the results in table (1).

Reading:

Diameter of Pipe = 0.0235 m

Length of Pipe = 1.817 m

$v = 1.51 \times 10^{-6}\ m^2/s$

$g = 9.81 N/m^2$

No.	Manometer Reading (mm)		Q (m^3/s)
	h1	h2	
1	915	185	4.33×10^{-4}
2	780	245	3.67×10^{-4}
3	660	300	3×10^{-4}
4	570	350	2.33×10^{-4}

Calculation:

Results :

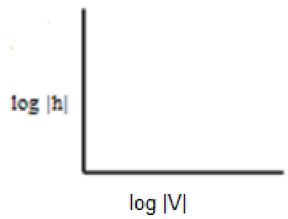
Case No.	Head loss $h_f = h_1 - h_2$ (mm)	Head loss h_f (m)	Discharge Q (m^3/s)	Velocity $V = \frac{Q}{A}$ (m/sec)	$f_{exp.}$ $f = \frac{2gdh_f}{LV^2}$	Reynolds No. $Re = \frac{V\,d}{v}$	$f_{theo.}$ From (Eq.1 or Eq.2 or Moody Diagram)
1							
2							
3							

Class :2nd stage

Subject: Fluid Flow

Discussion:

1. What is major head loss? And what is the function of major losses?
2. Plot a graph of pipe friction coefficient versus Reynolds' number (log scale).



2. Note the difference from the smooth pipe curve on the Moody diagram when the flow is turbulent.