راهنمای نرم افزار اندازه گیری افت فشار در خطوط لوله

The object of this experiment is to investigate the loss of energy when water flows through pipes of varying diameter and roughness The different relationships of laminar, smooth turbulent and rough turbulent flow will be studied. The Darcy Friction Factor (f) will be determined for different flow rates.

For the purpose of the theory this page shows a diagrammatic representation of the main equipment needed to undertake the investigation. You will require the following items:-

- Fluid Friction Equipment
- Stop Watch
- Measuring cylinder
- Thermometer

It will be useful if you obtain a printout of this diagram, by accessing the above PRINT rectangle. After you have studied this diagram you may scroll this window to move onto the Theory Page.

T H E O R Y

Nomenclature:

g = acceleration due to gravity (9.81 m/s^2)

Z = height from horizontal datum

Hu = Height in upstream piezometer above the centre line

Hd = Height in downstream piezometer above the centre line

H = Hu - Hd

Hf = head loss due to friction in metres of water

u = upstream suffix

d = downstream suffix

V = fluid velocity

P = fluid pressure

p = density

Q = flow rate

A = cross sectional area

D = diameter of pipe

Vis = kinematic viscosity (= dynamic viscosity / density)

L = length of pipe

f = Darcy coefficient (British)

Re = Reynolds Number

T = Boundary shear stress due to moving fluid

Ph = Difference in piezometric head.

(Piezometric head = Pressure Head + Position Head)

theta = angle of pipe (to horizontal)

Pi = 3.142

Three types of flow can be distinguished:

LAMINAR - This occurs when Re < 2000

SMOOTH TURBULENT - This occurs at higher values of Re, but when the pipe roughness projections lie within the laminar sub-layer and the pipe roughness has no effect on the value of f or on the discharge.

ROUGH TURBULENT - This occurs in rough pipes. The pipe roughness now significantly affects the flow and the value of f. The laminar sub-layer is now thinner than the height of the roughness projections.

Re is the ratio between the viscous forces and the inertia forces. It can be shown that:

Re =

At a certain Re value (approx 2000) the viscous shear forces are no longer powerful enough to maintain the orderly laminar type of flow. The forces produced by the momentum of the faster moving particles then take over resulting in turbulent eddies throughout the flow.

Considering the equilibrium of the control volume of fluid of length L :

Piezometric head u = Pu/pg + Zu

Piezometric head d = Pd/pg + Zd

Ph = + Zu - Zd 1

Downward force on upstream end = Pu x A

Upward force on downstream end = Pd x A

Gravity force component due to weight of water:

= ALpg SIN(theta) = ALpg(Zu - Zd)/L

= Apg(Zu - Zd)

Summing these three force components in the direction of the flow gives:

Total Force = (Pu A)-(Pd A)+(Apg(Zu - Zd))

This force is balanced by the shear stress T acting over area Pi.D.L, so the opposing total force is T.Pi.D.L. Equating the two balancing forces and dividing both sides by (pg) :

(Pi/4)D^2 [+ (Zu - Zd)] =

substituting 1 gives:-

Ph - =

Ph/L is the rate at which total energy is lost. Since there is no change of K.E., this is equal to:-

= i = hydraulic gradient and therefore:-

=

Experiments in the fully (rough) turbulent flow region by Froude and others indicated that the drag resistance and hence T is approximately proportional to V^2. This led to the assumption that:

T=K.V^2 where K is a constant of proportionality. (For the laminar flow region T=K.V which indicates that K needs to be modified for differing flow rates.) Therefore:

=

However 2gK/pg is also a constant and is known as the DARCY FRICTION FACTOR. Its symbol is f. (In fact f is only constant for rough turbulent flow). Rearranging gives the DARCY FORMULA:

4fL V^2

Hf = --- --

D 2g

Since many practical flow rates in commercial pipes are fully turbulent, the Darcy formula is universally used. It is however equally valid for all other types (smooth turbulent and laminar) provided the appropriate value of f is used. (Dimensional analysis shows that f is a function of Re). This investigation is concerned with flows varying from laminar to rough turbulent.

VARIATION OF Hf WITH VELOCITY

If a graph of Log(Hf) against Log(V) is drawn, the result should be a straight line indicating that the relationship is of then form

Hf = CV {since Log(Hf) = Log(C) + n.Log(V) }

Results should show that for laminar flow n=1, for smooth

turbulent flow n=1.75 (approx) and for rough turbulent flow n=2.0

(approx)

VARIATION OF f WITH Re

If a graph of Log(f) against Log(Re) is drawn, the result should be a straight line, indicating that the relationship is of the

form: n

f = C Re

Results should show that for laminar flow n=-1 and C=16 (Log(C) is the intercept). For smooth turbulent flow n=-0.25 and C is 0.079. For rough turbulent flow n=0.0 (graph horizontal) and f depends only on the roughness of the pipe

Hence:- LAMINAR SMOOTH TURBULENT ROUGH TURBULENT

f = f = f=

MANOMETERS:- Differential manometers only record the difference in pressure head when the tapping points are at the same level.If the tapping points are at different levels the manometer will record the difference in PIEZOMETRIC HEAD (sum of pressure and potential head)

For the Inverted WATER Manometer:

DIFFERENCE IN PIEZOMETRIC HEAD = DIFFERENCE IN MANOMETER WATER

LEVEL READINGS

For the MERCURY U Tube Manometer:-

DIFFERENCE IN PIEZOMETRIC HEAD = DIFFERENCE IN MERCURY LEVEL

READINGS x 12.6

Use Fluid Friction Equipment to carry out the following procedure:

Prime the pipe network with water. Open and close the appropiate valves to obtain flow of water through the required test pipe.

Measure flow rates using the volumentric tank in conjunction with flow control valve V6. For small flow rates use the measuring cylinder in conjunction with flow control valve V5 (V6 closed). For each measured flow rate record type of manometer, Hu, Hd the heights of fluid in the manometer tubes. The computer will then be able to calculate:

Re, Log(Re), Hf, Log(Hf), V, Log(V), f, Log(f) for each set of readings.

Graphs of Log(Hf) against Log(V) and Log(f) against Log(Re) are then drawn to ascertain the different relationships of laminar and turbulent flow.

You should ensure that you calculate one set of results for the first set of readings. These results should agree with the computed results and be included in your report.

QUESTION 1

The reason why pipe friction can occur is because:-

a) the water rubs against the pipe sides

b) water has viscosity

c) of the high pressure

d) of the effects of gravity

Answer a,b,c or d

The correct answer is (b). If the fluid had no viscosity (an ideal fluid) there could be no friction. The fluid in contact with the pipe walls is stationary. (A fluid having no viscosity is often called an inviscid fluid.)

QUESTION 2

For laminar flow the friction is proportional to:-

a) velocity squared

b) velocity

c) Reynolds Number raised to the power 0.25

d) Reynold Number squared

Answer a,b,c or d

The correct answer is (b). See theory. (Note for fully turbulent flow the friction is proportional to the velocity squared)

QUESTION 3

It is important to know how much energy is lost through pipe friction for many reasons. Which of the following reasons is INcorrect ?

a) to choose a suitable pump for a piping system

b) to establish the power consumption of the pump

c) to calculate the size of pipe suitable for a piping system

d) to estimate the life of the pipes in a piping system

Answer a,b,c or d

The incorrect statement is (d). The friction does not cause any wear of the pipe. The friction occurs within the fluid.

QUESTION 4

The piezometric head for water flowing through a pipe is:

a) the sum of the pressure and velocity heads.

b) the sum of the pressure and potential heads.

c) the total available head of the fluid.

Answer a,b or c

The correct answer is (b). In a uniform pipe the difference in piezometric head between two points is equal to the head loss due to friction, because there is no change in velocity head.