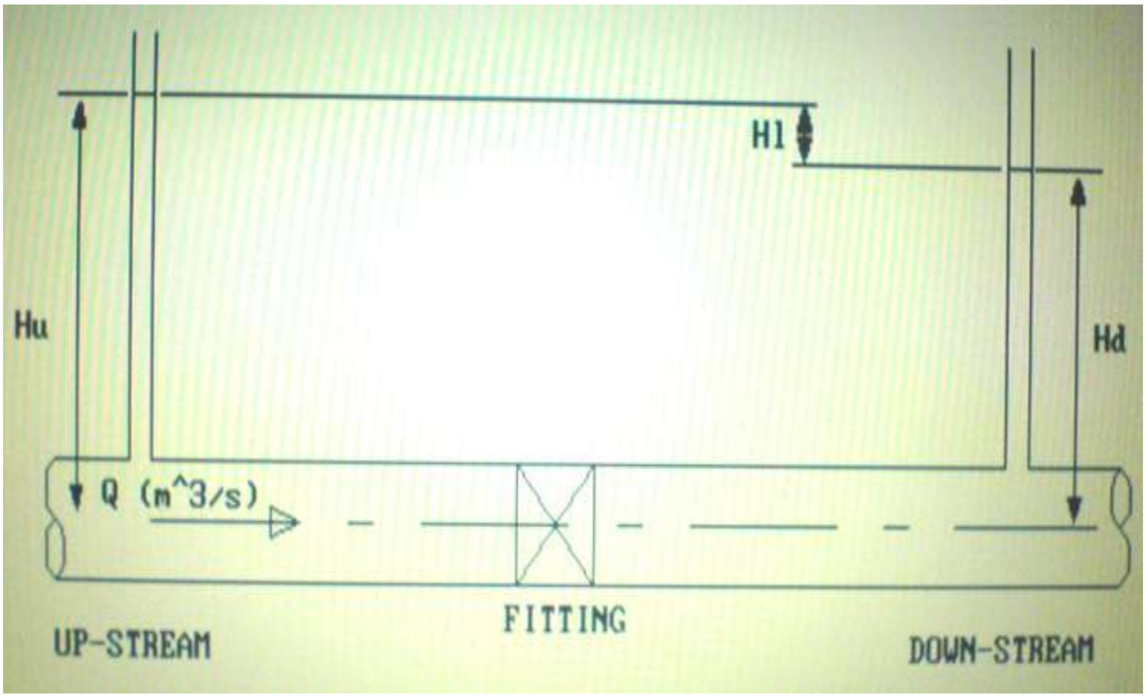
راهنمای نرم افزار افت فشار شیرها در خطوط لوله

Energy losses in fitting

The object of this investigation is to demonstrate that there is a loss of energy as fluid flows through a pipe fitting, to find this loss of energy in terms of head of fluid and to find the velocity pressure factor (K value) for a fitting.



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

It will be useful if you obtain a printout of this diagram, by accessing the above PRINT rectangle. After you have studied these diagrams and noted the abbreviations for the dimensions, 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 = upstream manometer height

Hd = downstream manometer height

Hl = head loss through fitting

u = upstream suffix

d = downstream suffix

V = fluid velocity

P = fluid pressure

p = density

Q = actual flow rate

Hl_incpt = apparent head loss from graph when V=0

A = cross sectional area

K = velocity pressure factor (K value)

Bernoulli's equation (modified for viscous flow):-

$$Zu + \frac{Vu^2}{2g} + \frac{Pu}{pg} = Zd + \frac{Vd^2}{2g} + \frac{Pd}{pg} + Hl$$

Rearranging:

$$Hl = \frac{Pu - Pd}{pg} + \frac{Vu^2 - Vd^2}{2g} + (Zu - Zd)$$

since P = p g h

therefore:- Hu - Hd = $\frac{Pu-Pd}{pg}$ (obtained from manometers)

$\frac{Vu^2-Vd^2}{2g}$ can be calculated from the CONTINUITY equation

(Q = Au Vu = Ad Vd)

Hence Hl can be calculated for each flow rate.

Since Hl is dependent on the velocity of the fluid, it is conventional to relate it to KINETIC ENERGY (expressed as metres head of fluid) :

$$Hl = K \frac{V^2}{2g}$$

where K is a constant for a fitting and is known as the VELOCITY PRESSURE FACTOR (or K value). The velocity V is the greater of the upstream and downstream velocities. The K value can now be calculated for each flow rate, however in order to obtain a better, more accurate K value for each fitting a graph of Hl against V^2 /2g can be drawn. If the graph is a straight line this would indicate that K is a constant over the flow range. The slope (gradient) of the graph will give the best K value for the fitting.

ASSUMPTIONS

If the graph appears to be a straight line , for practical purposes it is reasonable to assume that the relationship is linear and hence K is a constant. However it may be seen that this assumption results in an apparent Head loss (Hl_incpt) when the velocity is zero.

Once K has been determined experimentally, K may be used to obtain the head loss for any flow rate by using the formula:

$Hl = K (V^2 /2g)$

However to be really accurate and to be consistent with experimental observations Hl_incpt should be taken into account:

$Hl = K (V^2 /2g) + Hl\_incpt$

CAUTION: The above theory relates to practical turbulent flow and should not be used for laminar and small flows, and may account for "apparent" error resulting from the graph not passing through the origin.

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

Method

For several different flow rates ranging from a very small flow rate to the maximum for which readings can be obtained, measure the time taken to collect a known quantity of fluid in the measuring tank. For each measured flow rate record Hu and Hd ie the heights of fluid in the manometer tubes at the sides of the desired fitting. The computer will then be able to calculate:

Hl, $V^2 / 2g$ and the discrete K for each set of readings.

A graph of Hl against $V^2 / 2g$ is drawn to show the proportional relationship. The statistical best K factor for all flows is then calculated from the slope of the graph.

Repeat the above procedure for each fitting being investigated.

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

QUESTION 1

Is the pressure loss through a fitting with equal inlet and outlet diameters and with tapping points at the same level equivalent to the energy loss (m head) due to the fitting ?

a) Yes

b) No

The correct answer is (a). The pressure loss is equivalent to the energy loss due to the fitting because the K.E. and potential energy have not altered between the upstream and downstream tapping points.

QUESTION 2

Which of the following statements is the correct one for a pipe which is not horizontal:

a) With no flow there would be a pressure difference between the tapping points.

b) With no flow the difference in manometer levels is the same as the height between the tapping points.

c) With no flow there would NOT be a pressure difference between the tapping points.

d) With flow in the pipe the manometer readings indicate the pressure difference

The correct answer is (a). The differential manometer only records pressure difference when the pipe is horizontal. When the pipe is not horizontal some of the POTENTIAL energy in the pipe has been converted into PRESSURE energy (or vica versa).

QUESTION 3

In the experiment the tapping points are at different levels. The manometer used will record directly which of the following:

a)the difference in pressure

b)the head lost in friction

c)the difference in level of the tapping points when there is no flow

The correct answer is (b). The differential manometer only records pressure difference when the pipe is horizontal. When the tapping points are at different levels and there is zero flow, the manometer readings will be equal.

QUESTION 4

Why, for this investigation, is it not essential to know the difference in height between the manometer tappings in determining the head lost in friction.

a)Because the difference in height will not affect the pressure difference.

b)Because the difference in level of the liquid in the manometer records the difference in piezometric head (sum of pressure and position head), and not pressure difference.

c)Because the difference in level of the liquid in the manometer records the pressure difference and not pressure.

d)Because the air is compressed in the manometer

The correct answer is (b). It is however essential to know the height difference if we wish to determine the pressure difference between the tapping points.

QUESTION 5

Is the pressure loss through a fitting with unequal inlet and outlet diameters and with tapping points at the same level, equivalent to the energy loss (m head) ?

a) Yes

b) No

The correct answer is (b), because there is a change in the K.E. which affects the pressure.

QUESTION 6

In the experiment the tapping points are at different levels. The manometer used will record directly which of the following:

a)the difference in pressure

b)the head lost in friction

c)the difference in level of the tapping points when there is no flow

The correct answer is (b). The differential manometer only records pressure difference when the pipe is horizontal. When the pipe is vertical the readings will be equal for zero flow, although the lower tapping point will have a higher pressur.