راهنمای نرم افزار اندازه گیری ونتوری متر، اوریفیس متر، پیتومتر و اندازه گیری افت اتصالات (اوریفیس متر)

Orifice meter

The object of this experiment will be to:

1. Find the coefficient of discharge (Cd) of an orifice meter and to demonstrate how it can be used to measure fluid discharge through a pipeline.

2. Show how the head lost as the fluid passes through the meter varies with the the velocity head.

instraction

This page shows a diagrammatic representation of the main equipment needed to undertake the investigation. You will require

the following items:

- Fluid Friction Apparatus

- Stop Watch

This investigation is concerned with the Orifice Meter, which is illustrated above. It will be useful if you obtain a printout of this diagram, by accessing the above PRINT rectangle. After you have studied this diagram 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 piezometric height

Hd = downstream piezometric height

Ho = orifice piezometric height

Hl = head loss through meter (Hu - Hd)

H = Hu - Ho

Ha = difference between upstream and orifice manometer heights in mm of mercury or mm of water depending on the manometer

Hb = difference between upstream and downstream manometer heights in mm of mercury or mm of water depending on the manometer used.

u = upstream suffix

o = orifice suffix

d = downstream suffix

V = fluid velocity in pipe

P = fluid pressure

p = density

Qa = actual flow rate

Qt = theoretical flow rate

Qincpt = apparent flow rate from graph when H=0

A = cross sectional area

Cd = coefficient of discharge

K = meter constant

$$Cd = \frac{\text{actual measured discharge}}{\text{theoretical discharge}}$$

Bernoulli's equation:

$$Zu + \frac{Vu^2}{2g} + \frac{Pu}{pg} = Zo + \frac{Vo^2}{2g} + \frac{Po}{pg}$$

Zu = Zo hence:

$\frac{Pu-Po}{pg} = \frac{Vo^2-Vu^2}{2g}$ 1

because P = p g h and H = Hu - Ho :

Hu - Ho = $\frac{Pu-Po}{pg}$

H = $\frac{Pu-Po}{pg}$ and from 1 H = $\frac{Vo^2-Vu^2}{2g}$

Continuity:- Qt = Au.Vu = Ao.Vo

Vo = $\frac{Au.Vu}{Ao}$

substitute:

$$H = \frac{\frac{Au^2.Vu^2}{Ao^2} - Vu^2}{2g}$$

rearranging:-

$$H = \frac{Vu^2\left((Au^2/Ao^2) - 1\right)}{2g}$$

rearranging:-

Vu = SQRT[2gH / ((Au^2 / Ao^2) - 1)]   (SQRT = ^0.5)

substituting in continuity

Qt = Au SQRT[2gH / ((Au^2 / Ao^2) - 1)]   (SQRT = ^0.5)

Let:- K = Au SQRT[2g / ((Au^2 / Ao^2) - 1)]

Qt = K SQRT(H)

This is the theoretical flow rate. Introducing the coefficient of discharge (Cd) takes account of friction and the assumption that the area of the jet is equal to the area of the orifice (ie neglecting Vena Contracta):

ACTUAL FLOW RATE (Qa) = Cd. K. SQRT(H)

If Cd as well as K is constant a graph of Qa against SQRT(H) will be a straight line having a slope equal to Cd.K .

Qa and H are found by experiment, K can be calculated from Au and At. Hence the best value of the coefficient of discharge (Cd) may be found.

HEAD LOSS

The overall losses (Hl = Hu - Hd) increase as the flow rate increases and should be proportional to the velocity head (V^2/2g). This can be confirmed by plotting a graph of Hl against V^2/2g.

ASSUMPTIONS

If the Cd graph appears to be a straight line, for practical purposes it is reasonable to assume that the relationship is linear and hence Cd is constant. However it can be seen that this assumption results in an apparent discharge Qincpt when H=0.

Once Cd has been determined experimentally the meter may be used to measure any flow rate by observing the manometer readings and using the formula:

Q = Cd K SQRT(H)

However to be really accurate Qincpt should be taken into account

Q = Cd K SQRT(H) + Qincpt

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

Use the Armfield Orifice Meter on the Fluid Friction equipment to carry out the following procedure:

Prime the pipe network with water. Open the appropriate valves to obtain flow of water through the flow meters 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 the height of the fluid in the manometer tubes and the types of manometers used. The computer will then be able to calculate:

Hl , Q, V^2 / 2g, SQRT(H), Cd for each set of readings.

A graph of Q against SQRT(H) is then drawn to find the accurate Cd for the meter, and a graph of Hl against V^2 / 2g is also drawn to show their relationship.

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

This is the Readings Page. As the readings are entered the appropriate graphs are drawn.The graph scales have been preset, however you may alter the graph axes to suit your readings. Note that the units used on the graph are more appropriate to the calculations, whereas the units used for entering the readings are more appropriate for the equipment.

Move the cursor to appropriate rectangles and enter the sets of experimental readings in the following order:

1. Select the water/mercury manometer used for measuring the difference in head between the upstream and orifice tapping positions by toggling.

2. Ha (mm) The difference between the upstream and orifice manometer reading in mm of manometer fluid.

3. Select the water/mercury manometer used for measuring the difference in head between the upstrea and downstream tapping positions by toggling.

4. Hb (mm) The difference between the upstream and downstream manometer readings in mm of manometer fluid.

5. Vol (l) The volume of water collected in litres.

6. t (s) The time taken to collect that volume of water.

After each set of readings have been entered the following will be calculated and displayed:

1. Hl (mm) The head loss through the meter in mm of water.

2. H^.5 (m^0.5) The square root of Ha

3. Q (m^3/s x 10^-3) or (l/s) The flow rate.

4. V^2 /2g (mm) The velocity head

5. Cd The apparent coefficient of discharge calculated for that unique set of readings only.

This is the Conclusion Page. The coefficient of discharge and the intercept on the Q axis has been calculated from graph1. The constant of proportionality relationship between the head loss and velocity head has been calculated from graph2.

QUESTION 1

For a Venturi Meter the Cd is approximately 0.95, but for an Orifice Meter it is much less. Increased friction has the effect of:

a) increasing the value of Cd

b) reducing the value of Cd

c) not altering the value of Cd

The correct answer is (b). There is more friction in the Orifice Meter, hence the Cd is lower.

QUESTION 2

Which is the correct explanation for energy distribution as the fluid approaches the orifice ?

a) Pressure energy increases, K.E. increases, P.E. increases

b) Pressure energy decreases, K.E. increases, P.E. unaltered

c) Pressure energy increases, K.E. decreases, P.E. unaltered

The correct staement is (b). The velocity hence K.E. has increased. This increase can only be at the expense of the pressure energy.

QUESTION 3

Which statement is WRONG ?

a) An Orifice Meter produces a greater energy loss than a comparative Venturi meter.

b) An Orifice Meter is less expensive to manufacture than a Venturi Meter.

c) If an Orifice Meter were installed in a pumping main, the electricity used by the pump would be less than if a Venturi Meter had been installed.

The incorrect staement is (c). An Orifice Meter causes more friction in the water and hence more energy is lost, hence a greater amount of energy is required by the pump.

QUESTION 4

The Orifice Meter would conveniently be used as a flow measuring device:

a) when energy losses are critical

b) when the cost of the instrument is not important

c) when installed in a pipe for dissipating energy

The correct answer is (c), because the Orifice Meter causes turbulence , resulting in a loss of energy within the fluid. The orifice meter is an inexpensive device to manufacture.

QUESTION 5

Why is the Cd for an Orifice Meter so very much less than the Cd for a Venturi Meter?

a) Because of the turbulence

b) Because of the friction against the pipe walls

c) Because of the effect of the curvature of the streamlines

d) Because of the friction within the fluid

(c) is correct, because although (a) & (d) are factors, the curvature of the streamlines have the most significant effect. See the next question for the explanation.

QUESTION 6

The downstream tapping measures the pressure in the vicinity of the Vena Contracta. The theory assumes that:

a) the velocity does not change

b) downstream area is the area of the orifice

c) downstream area is the area of the Vena Contracta

The correct answer is (b). The area of the Vena Contracta at the downstream pressure tapping point should be used, but it cannot easily be measured.