The 18th & 19th weeks

1. Pitot Tube:

is a pressure measurement instrument used to measure fluid flow velocity. The pitot tube was invented by the French engineer Henri Pitot in the early 18th century[1] and was modified to its modern form in the mid-19th century by French scientist Henry Darcy.

It is widely used to determine the airspeed of an aircraft, water speed of a boat, and to measure liquid, air and gas flow velocities in industrial applications. The pitot tube is used to measure the local flow velocity at a given point in the flow stream and not the average flow velocity in the pipe or conduit.

A slender tube aligned with the flow (Figs. 6.29*g* and 6.30) can Measure local velocity by means of a pressure difference. It has sidewall holes to measure the static pressure ***ps*** in the moving stream.

Hole in the front to measure the *stagnation* pressure ***p*0**, where the stream is decelerated to zero velocity.

Instead of measuring *p*0 or *ps* separately, it is customary to measure their difference with, say, a transducer, as in Fig. 6.30.

The flow around the probe is nearly frictionless and Bernoulli's relation, applies For incompressible flow:

$$\frac{P_s}{\gamma} + \left(\frac{v_s^{\,2}}{2g}\right) + z_s = \frac{P_o}{\gamma} + \left(\frac{v_o^{\,2}}{2g}\right) + z_o$$

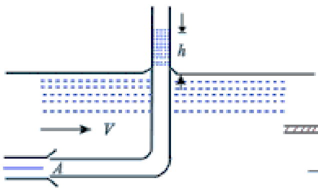
Where: P_s, v_s, and z_s= static pressure, velocity, and elevation at the pipe flow.

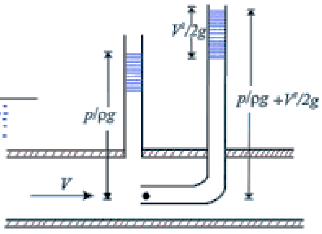
P_o, v_o, and z_o= pressure, velocity, and elevation at the stagnation point.

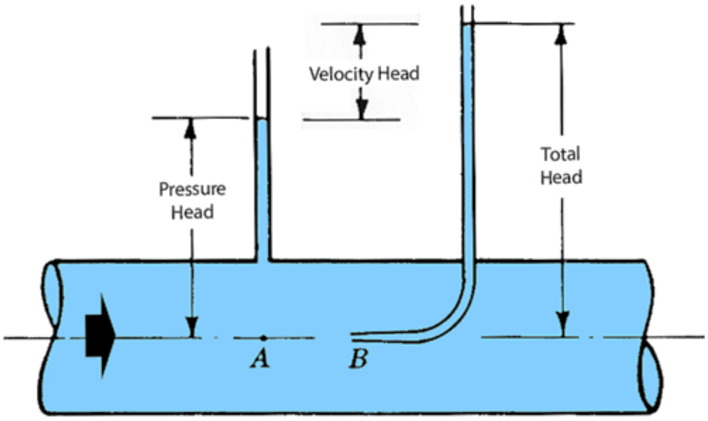
v_o= zero.

Assuming that z_s=z_o. calculating the velocity at stream flow:

$$v = \sqrt{2g\frac{(p_o - p_s)}{\gamma}}$$







Ex 1:

The pitot-static tube of Fig. 6.30 uses mercury as a manometer fluid. When it is placed in a water flow, the manometer height reading is *h* = 8.4 in. Neglecting yaw and other errors, what is the flow velocity *V* in ft/s?

Solution

From the two-fluid manometer relation (2.33), with $z_A = z_2$, the pressure difference is related to h by

$$p_0 - p_s = (\gamma_M - \gamma_w)h$$

Taking the specific weights of mercury and water from Table 2.1, we have

$$p_0 - p_s = (846 - 62.4 \text{ lbf/ft}^3)\,\frac{8.4}{12}\text{ ft} = 549 \text{ lbf/ft}^2$$

Applying pitot formula: $v = \sqrt{2g\frac{(p_o - p_s)}{\gamma}}$

γ_m= 846 lbf/ft^3, and γ_w= 62.4lbf/ft^3 , so:

$$\therefore v = \sqrt{2 \times 32.2 \times \frac{(549)}{62.4}} = 23.8 \text{ ft/s.}$$

2. Orifice plate

An orifice plate is a plate with a hole through it, placed in the flow; it constricts the flow, and measuring the pressure differential across the constriction gives the flow rate. It is basically a crude form of Venturi meter, but with higher energy losses.

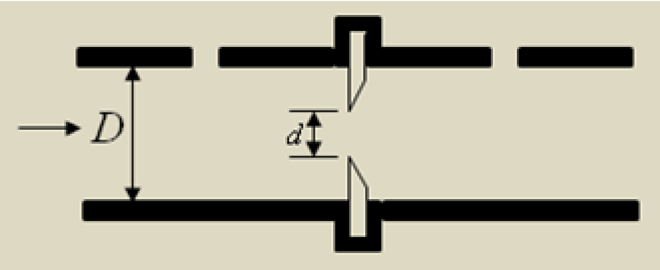
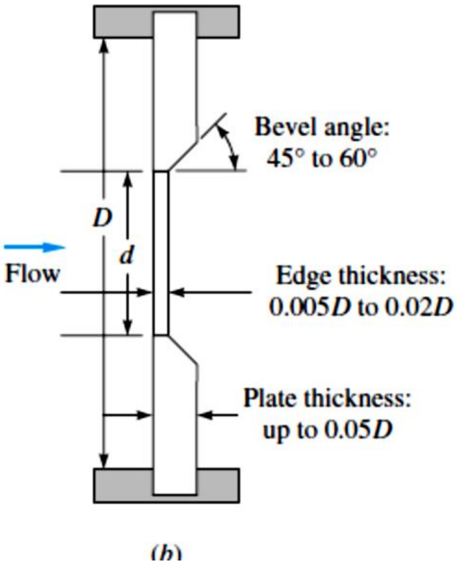


Fig 2: thin plate orifice.



the ration d to D is: $\beta = \frac{d}{D}$

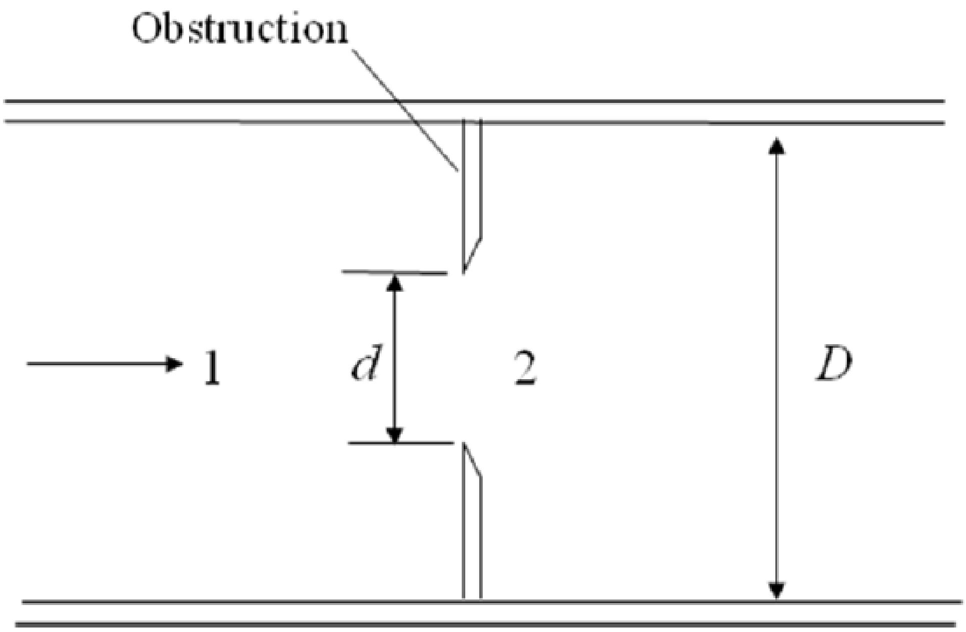


Fig. 7.2.3: Flow through a constriction in a pipe.

Continuity: $Q = \frac{\pi}{4}D^2V_1 = \frac{\pi}{4}D_2^2V_2$

Bernoulli: $p_0 = p_1 + \frac{1}{2}\rho V_1^2 = p_2 + \frac{1}{2}\rho V_2^2$

$$Q = A_1V_1 = C_dA_1\left[\frac{2(p_1-p_2/\rho)}{1-\beta^4}\right]^{1/2} \qquad (1)$$

Where: C_d= discharge coefficient

C_d= Cc. Cv

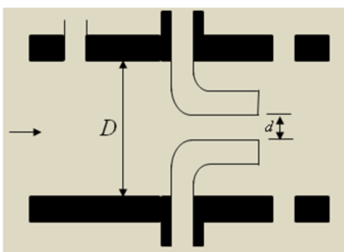
Cc= contraction coefficient

Cv= velocity coefficient

Note: Cc, and Cv values depend on shape and size of orifice open.

3. **Nozzle**

The design of the nozzle is as shown in the figure. The measuring method and calculating formula is the same as for orifice. The losses at a nozzle is less than that for an orifice and the flow coefficient an orifice.



(b)