FREDERICK UNIVERSITY

Department of Mechanical Engineering

Calibration of an Orifice Meter

Objective: The volumetric flow-rate, Q, of a given fluid through an orifice nozzle flow meter is proportional to the square root of the pressure drop across the meter. Thus, $Q = K\sqrt{h}$ where K is the meter calibration constant and h is the manometer reading that measures the pressure drop before and after the orifice. The purpose of this experiment is to determine the value of K for a orifice.

Equipment: Pipe with an orifice flow meter, pump with flow control valve, manometer, weighing tank, stop watch.

Experimental Procedure: Adjust the flow control valve to give the desired flow meter manometer reading, h. Estimate the time required to fill the weighing tank. Repeat the measurements for various valve settings (i.e. flowrates).

Calculations: For each set of results determine the flowrate using the volume of the tank and the time required to be filled. Estimate the discharge coefficient C from the figure using the Reynolds number and diameter ratio.

Graph: Plot flow-rate Q as ordinates and square root flow meter manometer reading, $\sqrt{h}$, as abscissas on a linear graph. Draw the best-fit straight line through the data.

Results: Use your data to determine the calibration constant, K, in the flow meter equation. Compare your value with the value obtained through the use of the discharge coefficient C.

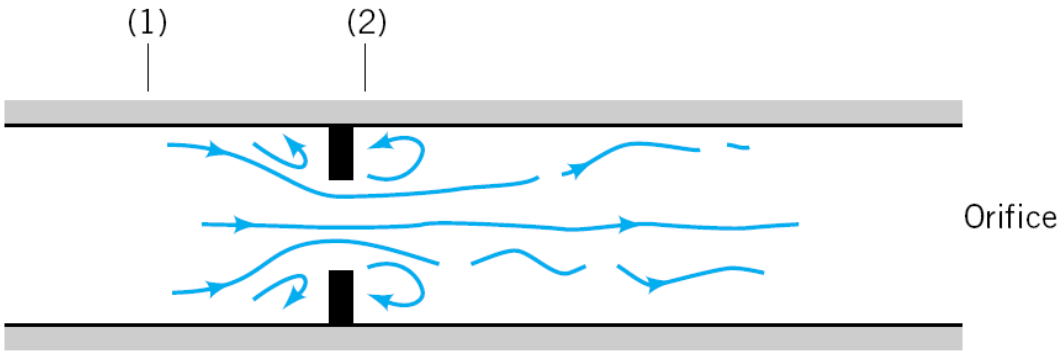
Data: To proceed, print this page for reference and use the table below as an example.

t(s)	Q = V / t (m^3/s)	Δh (m)	Δh^(0.5)
23	2.39E-03	0.2323	0.482
24.3	2.26E-03	0.207	0.455
26.6	2.07E-03	0.175	0.418
27.5	2.00E-03	0.145	0.381
31	1.77E-03	0.1225	0.350

volume of tank (V) 0.054955 m^3

THEORY:

The orifice flow meter consists of a contraction as shown the diagram.



Writing Bernoulli's equation between section 1 and 2 we have:

$$\frac{p_1}{\rho g}+\frac{V_1^2}{2g}+z_1=\frac{p_2}{\rho g}+\frac{V_2^2}{2g}+z_2+h_L,$$

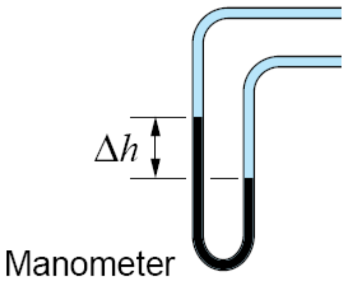
where V is the velocity (m/s), P is the pressure (Pa), z is the velocity (m) and h_L head loss (m/s). If the meter is horizontal z_1 and z_2 cancel. Also from continuity $V_1A_1=V_2A_2$, where A_1 and A_2 are the areas. Solving for V_2 we have:

$$V_2=\sqrt{\frac{2\left(p_1-p_2-\rho g h_L\right)}{\rho\left(1-\left(A_2/A_1\right)^2\right)}}.$$

The value of h_L must be determined experimentally. But it is more convenient to modify the equation by dropping h_L and introducing a discharge coefficient C. Hence the volumetric flow rate Q is given by:

$$Q=CA_2\sqrt{\frac{2\left(p_1-p_2\right)}{\rho\left(1-\left(A_2/A_1\right)^2\right)}}$$

The pressure difference $\left(p_1-p_2\right)$ is measured using a mercury manometer:



$$\therefore Q=CA_2\sqrt{\frac{2g\Delta h(\rho_{Hg}-\rho_{H_2O})}{\rho_{H_2O}\left(1-\left(A_2/A_1\right)^2\right)}}$$

Hence, in general, the volumetric flow rate is proportional to the square root of the manometer reading.

The discgarge coefficient (C) can be obtained from the following figure. In this figure d is the diameter of the throat section and D the diameter of the inlet (section 1).