

## Experiment 7

### ORIFICE AND FREE JET FLOW DETERMINATION OF COEFFICIENT OF DISCHARGE FROM JET

#### OBJECTIVE:

- To determine Discharge coefficient of small orifice for constant head flow

#### APPARATUS:

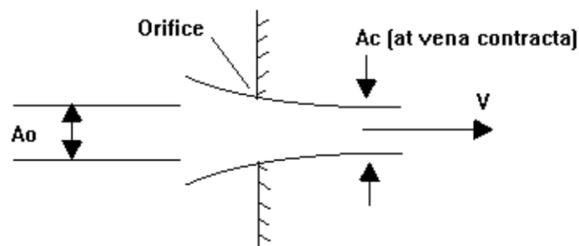
- the F1-17 Orifice and free jet flow apparatus
- The F1-10 Hydraulic Bench
- Stop watch
- Graduated cylinder

#### THEORY:

The ideal (theoretical) orifice outflow velocity at the jet vena contracta (narrowest diameter) is:

$$v_i = \sqrt{2gh}$$

Where **h** is the height of fluid above the orifice.



The actual velocity is:

$$v = C_v \sqrt{2gh}$$

$C_v$  is the coefficient of velocity, which allows for the effects of viscosity

The actual flow rate of the jet is defined as:

$$Q_{act} = A_c C_v$$

Where:  $A_c$  is the cross-sectional area of the vena contracta, given by:  $A_c = C_c A_o$

$A_o$  is the orifice area and  $C_c$  is the coefficient of contraction and, therefore,  $C_c < 1$

Hence;

$$Q_{act} = C_c A_o C_v \sqrt{2gh}$$

The product  $C_c C_v$  is called the discharge coefficient,  $C_d$ , so finally

$$Q_{act} = C_d A_o \sqrt{2gh}$$

If  $C_d$  is assumed to be constant, then a graph of  $Q_{act}$  plotted against will be linear and the slope,

$$S = C_d A_o \sqrt{2g}$$

#### PROCEDURE:

1. Position the reservoir across the channel on the top of the hydraulic bench and level the reservoir by the adjustable feet using a spirit level on the base.
2. Remove the orifice plate by releasing the two knurled nuts and check the orifice diameter; take care not to lose the O-ring seal.
3. Replace the orifice and connect the reservoir inflow tube to the bench flow connector.
4. Position the overflow connecting tube so that it will discharge into the volumetric tank; make sure that this tube will not interfere with the trajectory of the jet flowing from the orifice.
5. Turn on the pump and open the bench valve gradually. As the water level rises in the reservoir towards the top of the overflow tube, adjust the bench valve to give a water level of 2 to 3mm above the overflow level. This will ensure a constant head and produce a steady flow through the orifice.
6. Measure the flow rate by timed collection using the measuring cylinder provided and note that the reservoir head value.

7. Repeat this procedure for different heads by adjusting the level of the overflow tube. The procedure should also be repeated for the second orifice

**TABLE OF OBSERVATIONS AND CALCULATIONS:**

**Small Orifice: Diameter=3mm=0.003m**

	Orifice Diameter d(m)	Head h(m)	Volume V(m <sup>3</sup> )	Time t(sec)	Actual flow rate Q <sub>t</sub> (m <sup>3</sup> /S)	√h (m) <sup>0.5</sup>
1	0.003					
2	0.003					
3	0.003					
4	0.003					
5	0.003					

**Large Orifice: Diameter=6mm=0.006m**

	Orifice Diameter d(m)	Head h(m)	Volume V(m <sup>3</sup> )	Time t(sec)	Actual flow rate Q <sub>t</sub> (m <sup>3</sup> /S)	√h (m) <sup>0.5</sup>
1	0.006					
2	0.006					
3	0.006					
4	0.006					
5	0.006					

**GRAPHICAL RELATIONSHIP:**

- Plot flow rate Q<sub>t</sub> vs. √h and determine the slope of the graph.
- The coefficient of discharge C<sub>d</sub> can then be calculated from the slope equation

**CONCLUSION AND RECOMMENDATIONS:**

- Compare the values of C<sub>d</sub> with values reported in the textbook for an Orifice Meter and discuss any difference (or look for web resources).
- Find the value of C<sub>c</sub> for both orifices.