

CHME 302 CHEMICAL ENGINEERING LABOATORY-I
EXPERIMENT 302-1
FLOW MEASUREMENT TEST

OBJECTIVE

The purpose of the experiment is to demonstrate the working principles of four most common devices used to measure the instantaneous flow rate in pipes; the orifice meter, the nozzle meter, the venturi meter, and rotameter, and to determine discharge coefficients for the first three of them.

PRELIMINARY WORK

1. Study the basic principles of flow measurement devices including the venture meter, the orifice meter, the nozzle meter and the rotameter. Show all steps of derivations of flow rate expressions in your lab. notebook.
2. Visit the lab. in advance to experiment and familiarize yourself with the experimental set-up with the consent of the teaching assistant.

SET-UP DESCRIPTION

The set-up is designed to demonstrate three basic types of pipe-flow meter. The apparatus enables the following instruction capabilities:

- Comparison of different flow meter types
- Study of flow and pressure measurement methods
- Determining the meter coefficient
- Calibration of flow meters

The test section, located over a hydraulics bench (Fig. 1), consists of a Venturi meter (3), an orifice meter/ or nozzle meter (4), and a rotameter (5). A flow control valve (6) permits variation of the flow rate. Pressure tappings enable measurement of the head losses of each flow meter. The tappings are connected via hoses to a multi-tube manometer bank (2). The manometer panel incorporates a manifold with an air bleed valve. All components of the flowmeter demonstration unit are assembled on a panel (1) with stand. The unit is suited on the top of the hydraulic bench in order to make use of water supply and volumetric measurement facilities of the bench. The hydraulics bench unit provides the basic services for the pumping and volumetric measurement of the water supply in a certain period of time. A calibrated level indicator (11) allows measuring the amount of water circulated through the meters in the period.

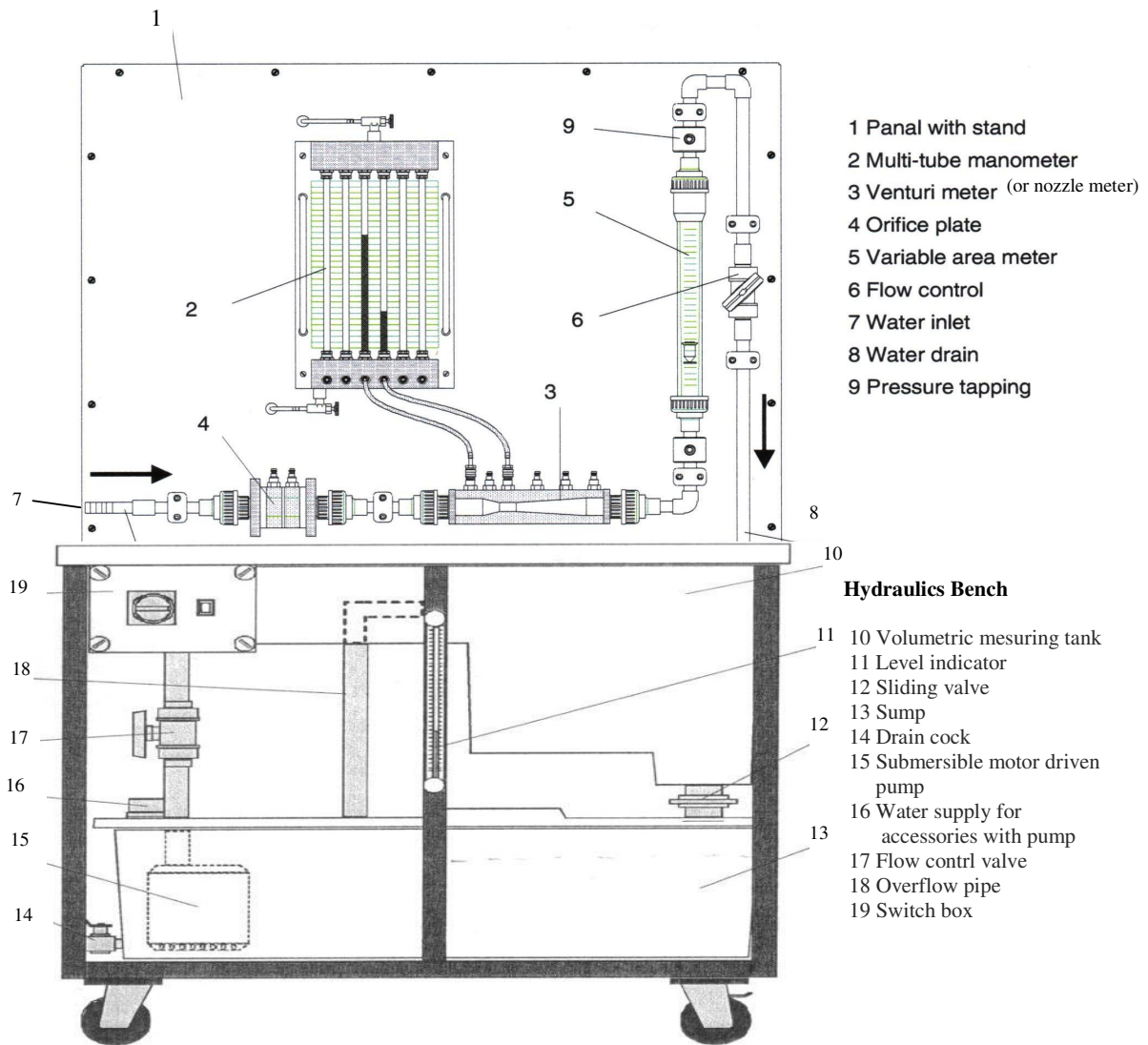


Fig. 1 Test section and hydraulics bench

EXPERIMENTATION

Notes on Safety

The set-up is kept in perfect condition from a safety point of view. To maintain this state and ensure safe operation, the following points should be observed:

- Pull the power cord before working on the electric circuits.
- Any modifications and repairs to the electrical equipment must only be carried out under the supervision of the lab technician and/ or the academic staff.
- In the event of obvious defects (e.g. split insulation on the electric wires), operation of the system is potentially fatal. In such cases, shut down the system immediately.
- Never allow the electrical components to come into contact with water.
- Never operate the submergible pump with the tank empty.

Procedure

Check the level of water in the sump tank. If necessary, fill sump tank with tap water until the water level is 100 mm below edge of the sump tank.

- Control the type of the meter at part (4). Depending on the requirement of the supervisor, assemble, either the orifice meter or the nozzle meter by screwing the terminal nuts, pay attention to the direction of the flow through the meter.
- Join the test unit to the bench with water inlet and water drain hoses.
- Connect the up-stream and down-stream taps of the meters to the multi-tube manometer. Note that all level tubes are connected to one another at the top and have a common vent valve. Differential pressure is measured with the vent valve closed, and the gage pressure with the vent valve open. (Fig.2)

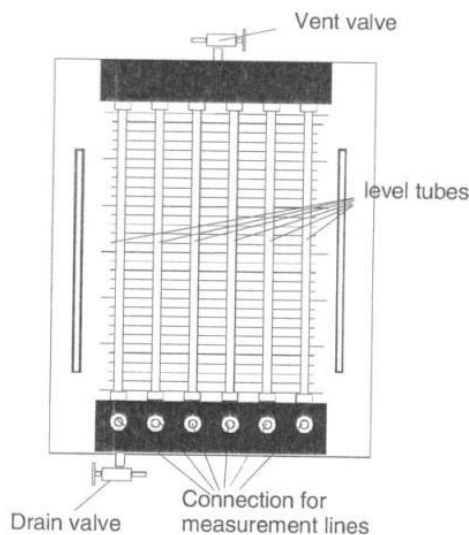


Fig. 2 6-Tube manometer panel

- Connect electric power supply.
 - Switch on main power switch.
 - Open all valves at pipe section and 6-tube manometer.
 - Switch on the pump.
 - Open flow adjustment valve of the bench (17) carefully, (Note that if the handle of the valve is parallel to the axis of the pipe, the valve is open).
 - Let the water to flow for ~1 minute.
 - Close flow control valve (6).
 - Close drain valve of the 6-tube manometer to vent the measurement lines.
 - Close vent valve of the 6-tube manometer.
 - Close water inlet.
 - Disconnect measurement lines.
 - Open vent and drain valve to discharge level tubes of the 6-tube manometer.
 - Close vent and drain valves.
- Open flow control valve slowly.
 - Connect measurement lines again.
 - Open water inlet slowly.
 - Adjust the heights of the water in the manometer tubes with the help of flow control valve until water becomes visible.
 - Set the flow rate and the measuring scale with the inlet and outlet control valves
 - Record the up-stream and down-stream pressures across the meters on the "Experiment Data Sheet".
 - Close the siding valve (12) and determine the volumetric flow rate by reading the amount of water stored in the tank of the bench from, e.g. from 20 to 30 liters and dividing this amount to the time period for such a filling, use a stopwatch to establish the time period. Write down the values on the Experiment Data Sheet. Repeat the calibration using a graduated cylinder.
 - Measure the temperature of the water; determine its necessary physical properties at that temperature.
 - Set a new flow rate and repeat the pressure and flow rate measurements.

Analysis

Calculate the discharge coefficient for the Venturi meter and the orifice meter (or that for the nozzle meter, if it is at the unit) for, at least five different values of the flow rate. The necessary dimensions are as follows:

Orifice hole diameter, $d = 18.50$ [mm]

Minimum diameter of the nozzle, $d = 14.00$ [mm]

Pipe inside diameter, $D = 28.35$ [mm]

Venturi throat diameter, $d = 10.38$ [mm]

Venturi upstream diameter, $D = 20.76$ [mm]

- Calculate the volumetric flow rates using different devices
- Plot the C_V vs Re number curve for the Venturi meter.
- Plot the C_O vs Re number curve for the orifice (or nozzle) meter.
- Check the rotameter calibration

