Laboratory 3 Sample Protocol

Contents

Objective

To determine the flow rate of an incompressible fluid using various flow measurement devices, including Venturi meter, orifice plate meter, and rotameter, and to evaluate their accuracy and efficiency.

Apparatus and Materials

- Hydraulic bench with adjustable flow control
- Venturi meter
- Orifice plate meter
- Rotameter
- Stopwatch
- Measuring beaker
- Manometer tubes
- Raspberry Pi Zero-W computer
- Mass Flow Meter
- Safety goggles

Procedure

1. **Setup Preparation**:
    - Close all valves and ensure the hydraulic bench pump is turned off.
    - Connect the Venturi meter, orifice plate meter, and rotameter to the hydraulic bench in series.
2. **Flow Initialization**:
    - Open the inlet valve gradually.
    - Start the pump and adjust the discharge valve until the rotameter indicates a reading of approximately 10 mm.
3. **Data Collection**:
    - Use the beaker and stopwatch to measure volumetric discharge at the outlet. Usually record time to fill the beaker, repeat several times (at least 3), then compute the average time to fill the beaker.
    - Record the rotameter and manometer readings for each flow condition.
    - Incrementally increase the rotameter reading to approximately 220 mm, recording at least six measurements.
    - Connect to the Raspberry Pi computer, find and start the measurement program (the instructor will usually get this working in advance as well as plumb the mass flow meter into the system); you can either program it to read meter counts or liters.
    - Collect adequate readings to populate a data table like the one below (be sure you have 5 different flow rates)

Quantity	Device	Trial 1	Trial 2	Trial 3	Trial
	A				
	B				
	C				
	D				
Manometer Reading	E				
	F				
	G				
	H				
	I				
_____	_____	_____	_____	_____	_____
	Venturi				
	Orifice				
Volume Flow (l/sec)	Rotameter				
	Beaker				
	Mass Flow Meter				
_____	_____	_____	_____	_____	_____
	Venturi				
	Orifice				
Mass Flow (kg/sec)	Rotameter				
	Beaker				
	Mass Flow Meter				

Quantity	Device	Trial 1	Trial 2	Trial 3	Trial
———————————	———————————	———	———	———	———
	Venturi				
	Orifice				
Head Loss (meters)	Rotameter				
	Diffuser				
	Elbow				
———————————	———————————	———	———	———	———
	Venturi				
	Orifice				
ΔH/Kinetic Head$_{inlet}$	Rotameter				
	Diffuser				
	Elbow				

4. **Calibration Curve**:
    - Use the five different rotameter readings to construct a calibration curve.
    - Calculate discharge and mass flow using the Venturi meter and orifice meter equations for each condition from the appropriate manometer pairings.
    - Record the flow rate (or meter counts) from the Raspberry Pi computer.
5. **Shutdown**:
    - Stop the mass flow meter program (do an elegant exit from the program).
    - Turn off the Raspberry Pi (from the console type “sudo shutdown -h now”)
    - Close the discharge valve, then the inlet valve, and turn off the pump.

Safety Considerations

- Always wear safety goggles when handling pressurized systems and adding air to manometers.
- Ensure that the bench and surrounding area are free of obstructions to avoid tripping hazards.
- Follow TA instructions when troubleshooting equipment, especially when dealing with flooded manometer tubes.