Laboratory 4 Sample Protocol

Contents

Friction Losses in a Pipe

Objectives

- Observe how flow behavior changes with velocity and Reynolds number.
- Measure the variation in frictional loss with changing velocity.
- Develop continued experience with automated data acquisition by using the flowmeter calibrated in a prior laboratory.
- Employ electronic pressure transducers using a similar end-user programmed automated data logger. Develop an experimental protocol (step-by-step instructions) to measure flow (two methods), pressure drop (three methods), and head loss (computed), and Reynolds' number (computed). Upon approval of the protocol, conduct a set of experiments in triplicate to measure flow and pressure drop. Document the experiment(s) in a laboratory report and address the following in the report: Compare flow rate measurements using stopwatch and bucket method to the flowmeter (Raspberry Pi). Compare pressure drop using manometers, handheld pressure instruments, and the automated datalogger system. Assess the accuracy and repeatability of the measurements using triplicate data. Evaluate the benefit of automated methods in terms of mean and variance. Discuss potential sources of errors.

Equipment

- Hydraulic bench
- Header tank
- Test pipe with a needle valve
- Hand-held pressure meter
- Pressure transducers
- Flowmeter (calibrated in a prior lab)
- Stopwatch
- Beaker (for flow measurement)
- Bleed pipe
- Automated data logger system (with mass flow meter for flow)
- Automated data logger system (with pressure transducer(s) and ADC microprocessor)

Data Acquisition

1. **Flow Rate Measurement**

Method 1: Stopwatch and Bucket Method

- Setup: Collect water in a known volume container (e.g., bucket).
- Flow Measurement: Start the stopwatch when water begins flowing and stop it when the bucket reaches a predefined volume.
- Calculation: Compute the flow rate Q=VolumeTimeQ=TimeVolume.

Method 2: Flowmeter (Raspberry Pi)

- Setup: Use the previously calibrated flowmeter (from a prior lab). Connect the flowmeter to the pipe and ensure it is properly interfaced with the Raspberry Pi data logger.
- Flow Measurement: Record the flow rate directly from the Raspberry Pi interface, ensuring that the correct meter constant is used.
- Verification: Compare the flow rate obtained from the flowmeter to the stopwatch and

bucket method (see comparisons in report).

2. **Pressure Drop Measurement**

Method 1: Manometer Method

- Setup: Attach the manometer to appropriate ports before and after the test pipe section.
- Pressure Measurement: Record the head difference (Δh) using the manometer, convert to ΔP using fluid properties.

Method 2: Handheld Pressure Meter

- Setup: Connect the handheld pressure meter to the test pipe.
- Pressure Measurement: Record pressure along the pipe using the handheld instrument (direct readout, choose useful units).

Method 3: Automated Data Logger and Pressure Transducer

- Setup: Connect the pressure transducers to the data logger system.
- Calibration: Use the voltage-to-pressure conversion constant obtained during the lab to convert the transducer's output voltage to pressure. (This step can be done as a post-processing step)
- Pressure Measurement: Record pressure differences (ΔP) using the automated data logger system.

3. **Data Analysis**

Flow Measurements:

- Compare the flow rates from the stopwatch/bucket method and the flowmeter.
- Discuss whether low flow rates are measurable using the flowmeter.

Pressure Drop Measurements:

- Compare the pressure drop results from the manometers, handheld pressure instrument, and the automated datalogger.
- Use the manometer and handheld instruments as "ground-truth" to determine the multiplier needed for the automated datalogger's transducer readings.

- Check for linearity of the transducers based on your findings.

Reynolds Number:

- Compute the Reynolds number for each set of measurements.

Friction Factor:

- Calculate the friction factor using the Darcy-Weisbach equation.

Statistical Analysis:

- Compute mean and standard deviation for triplicate data sets.
- Analyze the data to assess accuracy and repeatability.