Laboratory Exercise: Flow Measurements

Introduction
Volumetric discharge is a principal system characteristic. However, discharge is not directly measured. Instead, fluid velocity is measured and applied to the channel geometry to calculate volumetric discharge. This laboratory exercise will focus on two stations: pipe flow and open channel flow. At each station, a variety of topics will be discussed, such as placement of sensors, types of sensors available to measure water current (velocity) within that specific system, and transfer functions. The outline provides topics to be discussed during the lab exercise as well as points to discuss in student reports. There will be very little data analysis for this lab report. Instead, students will be discussing and comparing different types of flow sensors. An outline for the lab write up is provided at the end of this document.

Objectives
1. Understand the differences between measuring flow in open channels versus pipes;
2. Read sensor output with a National Instruments DAQ board;
3. Create calibration curves for pipe flow and open channel flow

Required for this Lab
- Two laptops with MATLAB R2009a
- National Instruments USB 6008 DAQ board
- Pressure transducer (KPSI series 700);
- Fuji M-flow ultrasonic flow meter
- ELD Model B16 Hydraulic Demonstration Channel (teaching flume)
- ELD 6 meter flume for open channel flow demonstration

Procedure
Due to the space in this area of the lab and the amount of discussion necessary, the lab session will be split into two 1-hour groups.

The one hour block is split into two stations: pipe flow and open channel flow. This lab period concentrates mainly on the discussion of the sensors within each system. A simple collection of data will also be performed at each station to calibrate the sensors.

Station I: Pipe Flow (Fuji M-flow ultrasonic flow meter)
1. Demonstration/Discussion
   a. Observe the placement of the sensor in the pipe
   b. Discuss the sensor specifications
2. Various forms of calculating flow rate of in pipes
   At this station, students will compare finding flow rate calculations through MATLAB and by hand. A laptop with both MATLAB R2009a and the NI USB 6008 DAQ board already installed is connected to the hydraulic channel.
   a. Observe the setup of the sensor and the DAQ board. On the laptop, open up “Get_Depth_Measurement.m”. A simple change in the file
needs to be made for the program to run successfully. Make this alteration.
b. Start up the hydraulic demonstration channel. Using the knob on the side of the machine, turn it to a lower flow.
c. Once there are no air bubbles in the pipe, run “Get_Depth_Measurement.m” in MATLAB. Record the output in MATLAB, as well as the information (velocities) outputted next to the mounted DAQ board. Turn the knob on the machine up to four other speeds, recording the MATLAB and mounted board data for each.
d. Calculate the velocities from the data outputted in MATLAB. Use the given area to calculate the flow rates. These calculations should be performed in MATLAB. Be sure to include them in your published document in your lab appendix.
e. Plot the outputted flow rates from the device on the wall (the flow rates will need to be calculated from the outputted velocities) and the calculated flow rates from the data found through “Get_Depth_Measurement.m” on the same graph in MATLAB. By this time in the course, you are expected to be able to do this on your own.
f. Calculate the percent error of the Get_Depth_Measurement technique in comparison to the data outputted on the wall. Include this data in a table in your results section. The percent error calculations need to be performed in MATLAB and included in the published file in your appendix.

Station II: Open Channel Flow (Pygmy, Argonaut, Velocimeter, and Pressure transducers)

1. Demonstration/Discussion
   a. The mechanical means of water current measurement
   b. Depth is monitored by a submersible pressure transducer and by physical means.
   c. Discharge at a specific depth is calculated based on cross sectional current measurements
      i. A variety of current meters are available for the cross sectional measurements. For example: pygmy meter, price AA current meter, Acoustic Doppler meters, ultrasonic meters

2. Open Channel Flow Experiment
   A laptop with both MATLABR2009a and National Instruments “Measurement and Automation Explorer” installed will be connected to a pressure transducer through an NI USB-6008 Device prior to lab period. Students will all observe the same data recorded through this laptop.
   a. The pressure transducer will be connected to a laptop through a NI USB-6008 DAQmx device. The same procedure as in last week’s Pressure Lab will be followed to measure the depth of the water.
i. Begin running the water through the channel. At 5 different depths, use a meter stick and measure the current depth of the water (cm). Run Get_Depth_Measurement to find the transducer voltage at each depth. These five data points will be used to plot the calibration curve.

Flow Rate Equation

\[ Q \left( \frac{cm^3}{s} \right) = V \left( \frac{cm}{s} \right) \times A \left( cm^2 \right) \]

Results section should include:
1. The plot created in MATLAB comparing the flow rates from the different calculation techniques.
2. The percent error calculations in table form.
2. MATLAB plots of calibration curves for both pipe flow and open channel flow. Refer to the pressure lab exercise for appropriate labeling.

Discussion Questions:
1. Describe the placement of the sensors in both the pipe and the open channel.
2. Discuss what the two sensors output (current? voltage?)
3. Describe two other methods of measuring velocity in pipes and how the flow is obtained from that information.
4. (Pipe Flow) What is the percent error compared to the amperage and transfer function measured in MATLAB? What about the percent error of the transfer function versus the device on the wall? Which is the most reliable device?

Appendix should include:
1. All MATLAB coding performed should be published from an m-file into a Word document. See the appropriate tutorial for assistance.