Hands on session N^o 1: 1.1 measurements of pressure loss (incompressible fluid) along a pipeline

a.

Objectives:

- introduce measuring devices installed for flow control along a pipeline (flow meter, termocouples and pressure transducer)
- gather and process experimental data for flow rate and pressure drop;
- compare dimensional and dimensionless experimental data against theoretical values.

Flow loop

The flow loop used for the experiment is sketched in Figure 1. A 3.0 m^3 capacity tank is used to feed the flow to a centrifugal pump (CALPEDA NM 65/16 AE, maximum flow rate 120 m^3/h) delivering the fluid through the loop; at the end of the loop, the fluid is collected by a receiving tank and recirculates back by gravity to the feeding tank.

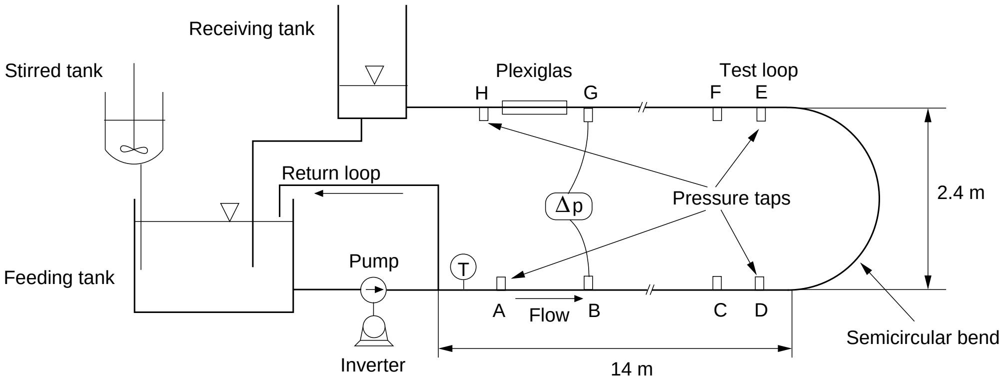

Figura 1. Exerimental flow loop: pipe diameter is $D = 100$ mm, loop length is 350 D overall.

The fluid flow rate circulating in the loop can be varied in the range $10 \div 81$ m^3/h changing the frequency of the inverter (SILCOVERT SVTSplus, AsiRobicon) which controls the pump.
The hydraulic loop is made of two branches of straight, horizontal and smooth pipes (each 14 m long) placed one above the other ($\Delta H = 2.4$ m) and connected by a semicircular bend of large radius. The loop is about 35 m long overall (350 D) The portion of the pipe preceding the receiving tank is made of Plexiglas to allow visual observation of the flow. A short return loop is also available to recirculate the fluid from the feeding tank through the pump and back to the feeding tank (3 m length overall).
High quality pressure tap holes (2 cm diameter) are present at 8 positions along the lower and upper branch; they are connected with 6 mm internal diameter clear vinyl tubing with a Mueller capacitive differential pressure transmitter (MHDS—ID:HD, accuracy 0.075% of Full Scale $-$ 700 mbar $-$ up to turn down 10:1 $\pm[0.0751 + 0.0075\cdot$ Upper Range Limit/URV] for turn down 10:1 to 100:1). The accuracy of the transducer is estimated to be higher than 0.3 mbar. A general purpose resistance thermocouple (K type) is placed upstream the test section and is used to monitor the fluid temperature (accuracy $\pm 1^oC$). A Yokogawa electromagnetic flow-meter (model SE200ME/NE, span 100 m^3/h, accuracy 0.5% of span for $U = [0.3 \div 1$ $m/s]$, 0.25% of span for $U > 1$ m/s) is used to measure flow rate data. In house software was written (National Instrument Labview) to record flow rate and pressure drop readings during the tests. Fluid temperature can be manually recorded for each flow rate acquisition and at the beginning and at the end of each test run.

Test execution

Flow rate and pressure drop measurements will be made at seven different flow rates to span different values of the Reynolds number. Pressure taps B and G (27.03 m apart) will be used to measure pressure drop using the differential pressure transducer.

- write Bernoulli equation along the pipeline (between point B and G) to find the pressure loss; write Bernoulli equation between point B (G) and the pressure port of the differential pressure transducer to link the quantity measured by the transducer to the pressure drop along the pipeline.

- fix the inverter frequency (and the flow rate in the loop); monitor flow rate variation during the transient; gather flowrate and differential pressure data for a 2 min time period; calculate the average value of each time series;
- plot the gross flow variables, average flow rate and pressure drop measuread for each frequency of the inverter in a graph $(Q, \Delta p)$; add the experimental error; compare with theoretical Δp calculated for measured Q using Blasius equation for the friction factor;
- transform the experimental data in dimensionless form to build the f, Re curve; compare the experimental points with Blasius equation and von Karman equation.

Experimental data

Files used to store the experimental data are named according to the inverter frequency they refer to. Each file has three columns: the first is the flow rate in $[m^3/h]$, the second is the pressure drop in $[mbar]$. Sampling frequency is 5 Hz (i.e. 5 measuring points per second). Data are available from the following web address:
http://158.110.32.35/CLASS/DES-IND-PLA/EXE1