Hands on session N° 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 flow rate and pressure drop data;

- compare dimensional and dimensionless experimental data against theoretical values.

Flow loop

The flow loop used for the experiment is sketched in Figure 1. Tank A (0.3 m^3 capacity) is used to feed the flow to a centrifugal pump (PEDROLLO NGAm 1A, maximum flow rate 21 m^3/h, 0.75 kW Power) delivering the fluid through the loop. The flow rate is measured by a flowmeter placed downstream the pump. The loop is composed by two parallel lines in plexiglass, branching at node N_1 and N_2. The upper line is characterized by $D_1 = 30\ mm$, $L_1 = 8\ m$; the lower line is characterized by $D_2 = 50\ mm$, $L_2 = 12\ m$. The plexiglass pipes can be considered smooth. A number of valves is used to divert the flow toward line 1 or 2 and to recirculate the flow through the loop by-passing tank A (red arrow). Along the upper and lower lines there are a number of pressure taps (2 mm inner hole diameter) which can be connected to a differential pressure transducer to measure the pressure drop. The distance between pressure taps is about 2 m.
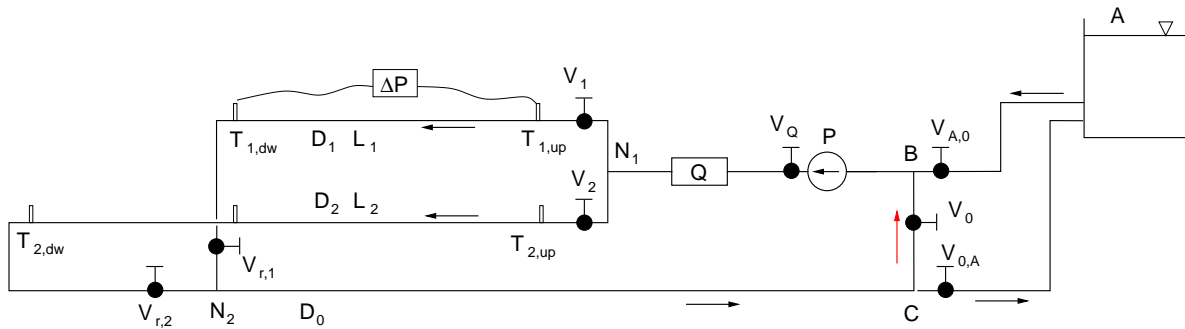

Figura 1. Experimental flow loop: pipe diameters are $D_1 = 30\ mm$ and $D_0 = D_2 = 50\ mm$.

The fluid flow rate circulating in the loop can be varied in the range $0 \div 19.4\ m^3/h$ regulating the opening of valve V_Q which is installed downstream the pump.

Pairs of pressure taps (two on the lower and two on the upper branch of the loop) are connected with pressure transducers. (Mueller capacitive differential pressure transmitter MHDS—ID:HD, accuracy 0.075% of Full Scale − 350 mbar and 100 mbar for the upper and lower line). A Proline Promag volumetric flow-meter (Endress Hauser, model 10W, span 70 m^3/h, accuracy 0.5% of span. is used to measure the flow rate. In house software was written (National Instrument Labview) to record flow rate and pressure drop readings during the tests.

Test execution

Flow rate and pressure drop measurements will be made at many different flow rates to span different values of the Reynolds number. Pressure taps $T_{1,up}$, $T_{1,dw}$ and $T_{2,up}$, $T_{2,dw}$ (4.00 m and 4.00 m) will be used to measure the pressure drop along the upper and the lower line.

- write Bernoulli equation along the pipeline (between point $T_{1,up}$, $T_{1,dw}$ and $T_{2,up}$, $T_{2,dw}$ to find the pressure loss;

- fix the opening degree of valve V_Q (and the flow rate in the loop); monitor flow rate variation during the transient; gather flowrate and differential pressure data for about 1.5 min time period (about 600 samples at 6 Hz); calculate the average value of each time series;

- plot the gross flow variables, average flow rate and pressure drop measuread for each opening degree of the valve 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; compare the data obtained for the upper and lower line;

- transform the experimental data in dimensionless form to build the f, Re curve; compare the experimental points with Blasius equation and von Karman equation.

$$\text{Blasius} \quad f = 0.079 \cdot Re^{-0.25} \tag{1}$$

$$\text{Von Karman} \quad \frac{1}{\sqrt{f}} = 1.7 \ln\left(Re\sqrt{f}\right) - 0.4 \tag{2}$$

Experimental data
The file used to store the experimental data is named HOS1.xls. Sheets inside the file are named according to the reference flow rate they refer to. Each file has two columns: column 1 contain flow rate in m^3/s whereas column 2 contains pressure loss in $mbar$. Sampling frequency is 6 Hz (i.e. 6 measuring points per second). Data are available from the following web address:
http://158.110.32.35/CLASS/DES-IND-PLA/2016/EXE1