

ISTANBUL TECHNICAL UNIVERSITY  
DEPARTMENT OF CIVIL ENGINEERING  
**CIE 354 HYDRAULIC ENGINEERING**  
Lab Tutorial 1:  
Continuous Head Losses (Friction Losses) in Pipes

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## 1 Scope of the Work

In the scope of this lab assignment, you are asked to conduct an experiment about the continuous head loss in pipe, report your results in a proper engineering format and present your results in the class (if applicable). You will organize the obtained data and make relevant calculations to compare your results with the Darcy-Weisbach equation.

## 2 Lab Preparation

1. Read this handout including the appendix.
2. Review our lecture notes and preferably make an additional search about the subject.
3. Read “the lab safety instructions” once again.
4. Bring your own meter, calculator and a lab notebook to take notes.

## 3 Experimental Apparatus

Experimental setup consists of the following elements:

1. A circulation pump with a control valve (Fig. 1);
2. A triangular weir to measure the flow rate (discharge) (Fig. 2);
3. A vernier to measure the head above the weir (Fig. 2);
4. A transparent smooth pipe connected to the circulation pump (Fig. 3);
5. Two piezometer tubes on a gage connected to the beginning and the end of pipe, respectively (Fig. 4).



Figure 1: The control valve of the circulation pump.

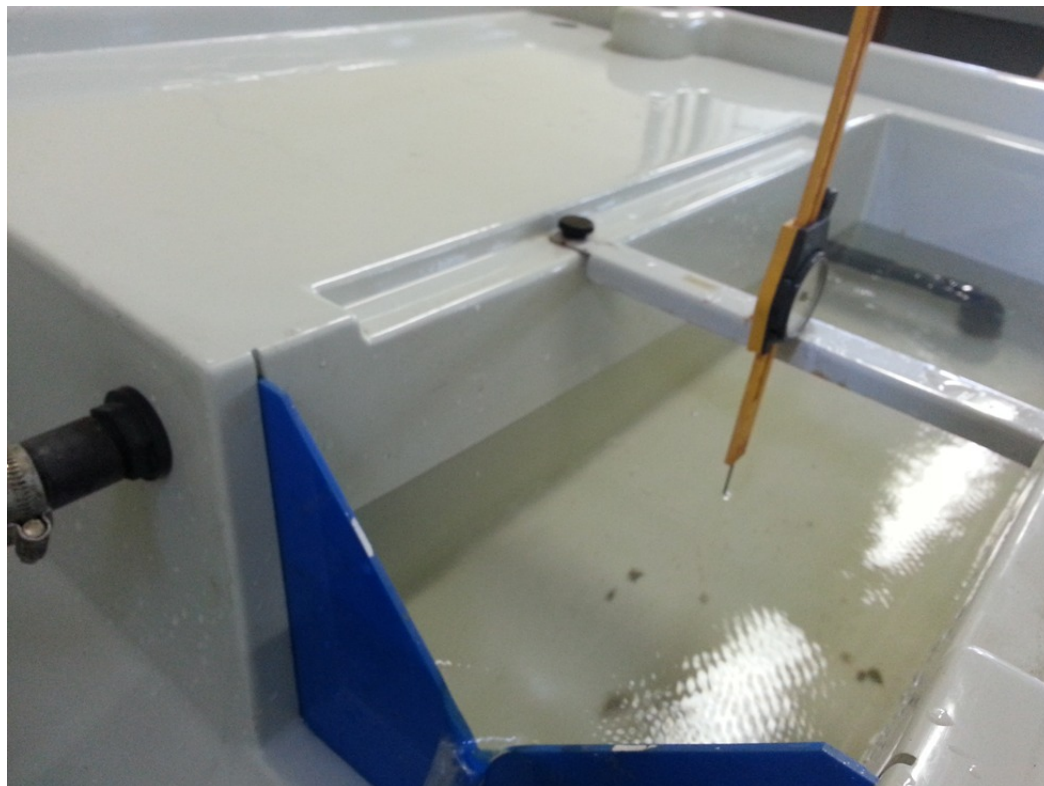


Figure 2: The triangular weir and the vernier.

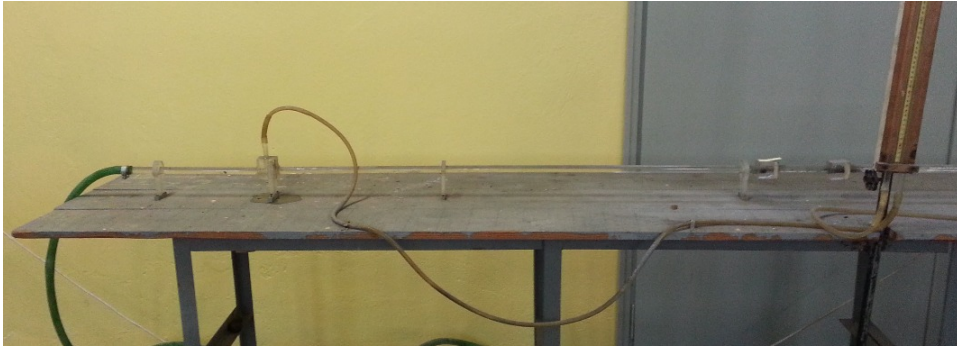


Figure 3: The smooth transparent pipe with the piezometer tubes.



Figure 4: The gage connected to the piezometer tubes.

## 4 Experimental Procedure

Follow the below steps for the experimental procedure:

1. Measure the outer diameter ( $D_{outer}$ ) of the pipe and ask your instructor the wall thickness ( $t_{pipe}$ ) of the pipe. In this way you can calculate the inner diameter ( $D_{inner}$ ) of the pipe.
2. Measure the length of the pipe between the connections of the piezometer tubes ( $L$ ).
3. Start to pump and wait until the system becomes stable.
4. Adjust the valve if necessary. Do this in a mild and gradual fashion. DO NOT MAKE SUDDEN CHANGES WITH THE VALVE!
5. Wait until the system becomes stable again and make sure there are no large bubbles in the pipe.
6. Adjust the needle of the vernier to slightly touch the water level, read the gage of the vernier and record the value. You will use this value to calculate the discharge ( $Q$ ).
7. Once the system is stable you can observe that the pressure drops through the pipe. Record the piezometric levels at the beginning and end of the pipe ( $(z + \frac{p}{\gamma})_1$  and  $(z + \frac{p}{\gamma})_2$  respectively). Calculate the head loss ( $h_l$ ).
8. Repeat the steps 4. to 7. for two more times. You will have three set of data in total (i.e.  $Q_1$ ,  $Q_2$  and  $Q_3$ ).

All the basic parameters mentioned above are given in Table 1 along with some remarks. Refer to this table during experiments and report writing.

## 5 Calculation Procedure

Follow the below steps for the calculation procedure in your reports (Do not take these as “bible” and please feel free to modify these if you need to):

1. Calculate the cross-sectional area of the pipe ( $A$ ).
2. Calculate the discharge ( $Q$ ) using the gage value you read on the vernier ( $h_v$ ). Note that the vernier reads 4.00 cm when the weir head is zero. use the below formula:

$$Q = \frac{8}{15} c_d \sqrt{2g} \tan\left(\frac{\theta}{2}\right) h^{2.5}$$

where  $c_d$  is the discharge constant for the weir ( $c_d = 0.578$  for the present setup),  $g$  is the gravitational acceleration,  $\theta$  is the angle of the weir notch ( $\theta = 90^\circ$  for the present setup) and  $h$  is the weir head ( $h = h_v - 4.08$  cm).

3. Calculate the mean sectional velocity ( $V = \frac{Q}{A}$ ).
4. Calculate the hydraulic slope ( $J = \frac{h_l}{L}$ ).
5. Calculate the Darcy-Weisbach friction factor by use of the relevant formula:

$$J = \frac{f V^2}{D 2g}$$

6. Now, calculate the pipe Reynolds number,  $Re = \frac{V D}{\nu}$  where  $\nu$  is the kinematic viscosity of water.
7. Repeat the steps 2. to 6. for two more times. You will have three set of data in total (i.e.  $Q_1$ ,  $Q_2$  and  $Q_3$ ).
8. Plot your results as  $f$  vs.  $Re$  and compare with the curve found in the literature (the so-called Moody diagram). Preferably plot your results “on” the same figure. Alternatively you can use the Colebrook-White equation to calculate  $f$ .

Table 1: The parameters involved in this experiment.

	Parameter	Unit in SI	Remark
$D_{outer}$	Outer diameter of the pipe	m	to be measured.
$t_{pipe}$	Wall thickness of the pipe	m	to be given.
$D_{inner}$	Inner diameter of the pipe	m	to be calculated.
$A$	Cross-sectional area of the pipe	m <sup>2</sup>	to be calculated.
$h_v$	The value in the gage of vernier	m	to be measured.
$Q$	Flow discharge	m <sup>3</sup> /s	to be measured.
$V$	Mean sectional velocity in the pipe	m/s	to be calculated.
$\left(z + \frac{p}{\gamma}\right)_1$	Piezometric level at the beginning of the pipe	m	to be measured.
$\left(z + \frac{p}{\gamma}\right)_2$	Piezometric level at the end of the pipe	m	to be measured.
$h_l$	Head loss in the pipe	m	to be measured.
$L$	Pipe length in between the piezometer tubes	m	to be calculated.
$J$	Hydraulic slope in the pipe	—	to be calculated.
$f$	Darcy-Weisbach friction factor	—	to be calculated both from the data (using Darcy-Weisbach equation) and from the theory (Colebrook-White equation).

## 6 Remarks on Report Writing

Make sure that your report reflects the work you have conducted properly. It must be comprehensive but also brief. It should include the following sections: Title Page, Table of Contents, Introduction (Objectives) Background (Theory), Lab Procedure, Results (Including calculations, graphs, animation, etc.), Discussion and Conclusion, Appendix and Bibliography. The report should include necessary photos, sketches, figures, etc. No handwriting is allowed. Before the deadline, a hardcopy should be submitted and a softcopy (pdf,doc, etc.) should be e-mailed to the instructor (kircave@itu.edu.tr).