EXPERIMENT 3
DETERMINATION OF PIPE RESISTANCE

I. INTRODUCTION

One of the most important problems with hydraulics is the determination of the energy loss when transporting fluids. The steady-state movement of the fluid is represented by the following equation:

$$Eu = f(\mathrm{Re}, \Gamma 1, \Gamma 2) \qquad (3\text{-}1)$$

This is the numerical equation derived from the Naive-Stock equation for a pressurized steady-state moving fluid in a straight pipe.

Where:

$Eu = \dfrac{\Delta P}{\rho . W^{2}}$ Euler number

$\mathrm{Re} = \dfrac{d . W . \rho}{\mu}$ Reynold number

$\Gamma 1, \Gamma 2$ Geometric number

ΔP Pressure drop, N/m^2 (including friction and local resistance).

$$\Delta P = \Delta P_m + \Delta P_{cp}$$

$$\Delta P = \frac{\lambda(l + l_{td}).W^{2}}{d.2g}.\rho \,, \qquad \mathrm{N/m^2} \qquad (3\text{-}2)$$

Where:

Friction resistance:

$$h_m = \lambda \frac{1.W^{2}}{d.2g} \,, \qquad \mathrm{m}$$

or

$$\Delta P = \lambda \frac{1.W^{2}}{d.2g} \cdot \rho \,, \qquad \mathrm{N/m^2}$$

λ Coefficient of frictional resistance

l pipe length, m

d pipe diameter, m

W the velocity of the fluid in the pipe, m/s

ρ fluid density, kg/m

μ fluid viscosity, N. s/m

$l_{tđ}$ equivalent length, m

Local resistance:

$$h_{cb} = \xi \frac{W^2}{2g}, \qquad \text{m}$$

or $$\Delta P_{cb} = \lambda \frac{l_{td}}{d}\frac{W^2}{2g}.\rho = \xi \frac{W^2}{2}\rho, \qquad \text{N/m}^2 \qquad (3\text{-}4)$$

ξ: local resistance coefficient

Causes for pressure drop as the fluid moves through the pipe are:

- Friction resistance (with pipe wall and between layers of liquids together)

- Local resistance (changing directions, valves,...)

If the value of Euler numer (Eu) is known, it is easy to determine the pressure drop:

$$\Delta P = Eu.\rho.W^2 \qquad (3\text{-}5)$$

But since the Eu number is a very difficult quantity, it is common to calculate the pressure drop due to friction resistance according to (3-3) Eq. and local resistance according to (3-4) Eq. Because in Coefficients λ and ρ can be calculated using empirical equations or found in Handbook.

II. EXPERIMENT PURPOSE

1. Find the dependent relationship between coefficient of frictional resistance with the movement of the liquid $\lambda = f(\text{Re})$.

2. Determine the local resistance coefficients of the valve, opening pipe, closing pipe, And observe the resistance of the pipe section gradually opening and closing.

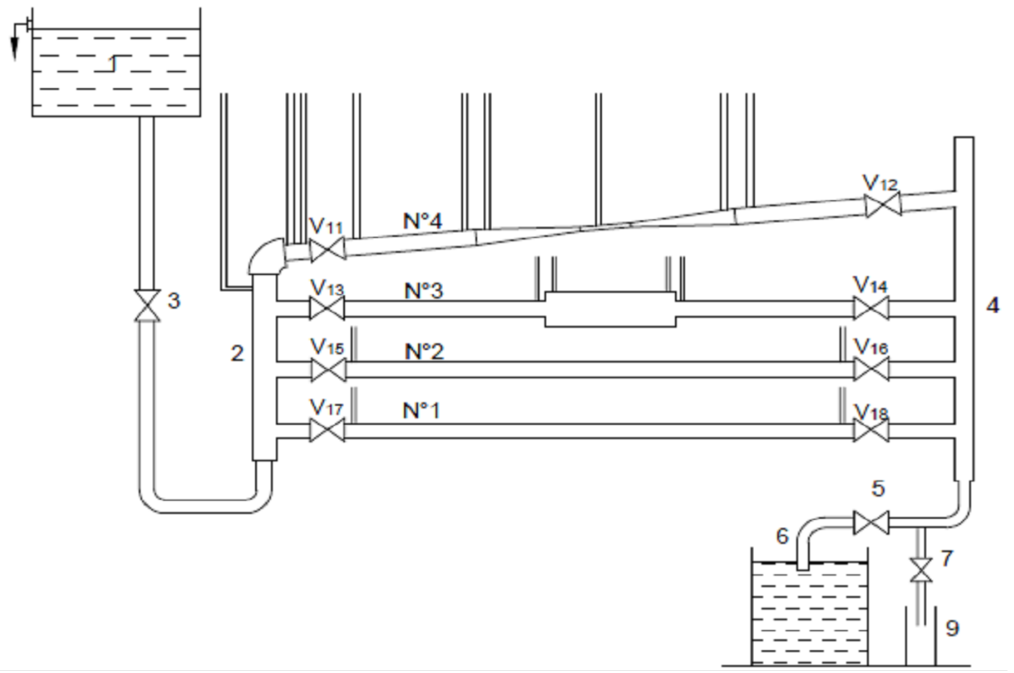


Figure 3.1. *Experiment diagram*

1 – High tank; 2,4 – collected pipe, 3 – general flow control valve; 5,7 - flow control valve; 6 - measuring tank (big flow); 8 – release valve; 9 – measuring tube (small flow). No1 - Rough wall pipe; No.2 - smooth wall pipe; No.3 - opening pipe, closing pipe; No.4 - pipe section gradually opening and closing

III. EXPERIMENT DIAGRAM (FIGURE.3.1)

Water from the initial tank located on the floor of the house (on the diagram not drawn) is pumped by the centrifugal pump to the tank 1 until it is full and flows through the overflow pipe back to the initial tank. Water level in the tank is observed through the clear water pipe. From the tank 1, according to the pipeline, flows down the manifold 2 through the valve 3 to enter the branch pipe system for the determination of different hydraulic resistances: Pipe No1: to determine the resistance due to friction with the rough pipe wall; Pipe No.2: to determine the resistance due to friction with a smooth pipe wall; Pipe No.3: opening pipe, closing pipe; Pipe No.4: pipe section gradually opening and closing. There are valves installed at both ends on each branch to adjust the flow rate in each pipe. On all points where hydrostatic pressure is to be measured, open-ended peppers are installed. The water level in the Piezometre pipes indicates the hydrostatic pressure of the flow at the point where the pipe is placed. Water goes through the manifold 4 on the right and then down to measuring tank 6 through valve 5. After each test, water is drained from the measuring tank by valve 8. When testing with very small flow, water can be calculated using measuring tube 9 through valve 7. **However, the current experiment system does not use measuring tanks and measuring tubes. Flow meters were installed to measure the flow rate.**

IV. CÂU HỎI KIỂM TRA

1. Why is the energy of the stream being lost when the liquid moves along the pipe?

2. How to determine the coefficients of friction and local resistance by experiment?

3. How does Re number and pipe roughness affect frictional resistance on pipe?

4. Why do valves, elbows, opening pipe, closing pipe have different local resistance?

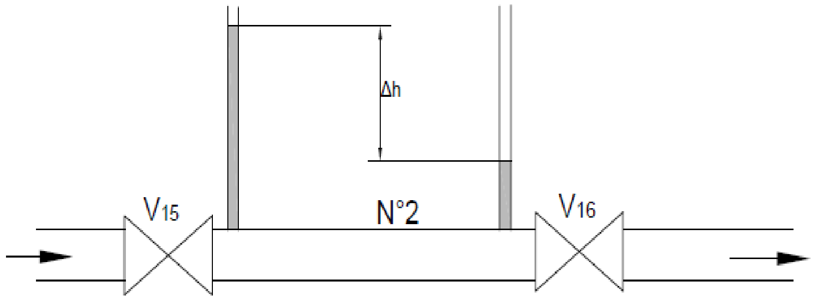
V. EXPERIMENT STEPS

1. Observe and check the entire system of equipment including hydrostatic pressure measuring points and corresponding Piezometre pipes, lock valves.

2. Check the water supply, the water level on the tank 1 (if there is no water in the tank or the water level is low, notify to the lecturer). Check the thermometer.

3. Close all system valves, then started to conduct the experiments according to the following content:

a. Determine the coefficient of friction resistance λ in smooth pipes



Pipe No.2 is a smooth-walled pipe, inner diameter dtr = 26mm, length (distance between two measuring points) l = 1650mm.

1. Experiment steps

Open valve 3 and valve V15, while valve V16 is still closed to allow water to fill pipe No.2 and overflow through Piezometre pipe 15 and 16 to expel air bubbles from the system. After closing valve 3 and valve V15, fully open valve V16, control the small flow. Wait for the flow to stabilize, then measure the flow and hydrostatic pressure difference between the top and bottom of the tube (read the readings on the 15 and 16 Piezometre pipe). To measure the flow we use flowmeter.

2. Friction resistance coefficient is calculated by the following equation:

$$\lambda = \frac{2\Delta P_m . d}{l \, . \, \rho . W^2};$$

3. Table of measurement and calculation results:

No.	ΔP_m		Q			W	Re	λ	logRe	
	mmH_2O	N/m^2	V (lít)	τ (s)	m^3/s	m/s				
1										
2										
3										
4										
5										
6										

4. Draw relationship graphs of $\lambda = f(\text{Re})$

b. Determine the coefficient of friction resistance λ in rough pipes

Pipe No.1 is a tube with artificially roughened wall, inner diameter dtr = 32 mm, length 1650mm.

The experiment steps are repeated like a smooth pipe. Draw graphs $\lambda = f(\text{Re})$ of smooth and rough pipes on the same logarithmic coordinate system.

No.	ΔPm		Q			W	Re	λ	log	
	mmH_2O	N/m^2	V (lít)	τ (s)	m^3/s	m/s			Re	
1										
2										
3										
4										
5										
6										

c. Determine the local resistance coefficient

1. For No.3 - opening pipe, closing pipe:

+ Figure 3.1: inside diameter of small pipe dtr = 32 mm, and of large pipe dtr = 52 mm

+ Steps:

- Fully open valve V14
- Slowly open valve V13 to lead water into the pipe with small flow. Wait for the flow to stabilize, then proceed to measure the first flow while recording the readings of pipes 11, 12, 13, 14 (h1, h2).
- proceed with larger flows by gradually opening the valve V13.

+ Calculation:

Opening pipe: Equation Bernoulli equation for Section 1-1 và 2-2:

$$\frac{P_1}{\rho g} + \frac{W_1^2}{2g} = \frac{P_2}{\rho g} + \frac{W_2^2}{2g} + h_{cb} \tag{3-6}$$

$$h_{cb} = \frac{P_1 - P_2}{\rho g} + \frac{W_1^2 - W_2^2}{2g} = -\Delta h_1 + \frac{W_1^2 - W_2^2}{2g} \tag{3-7}$$

So the local resistance coefficient of opening pipe is:

$$\xi = \frac{2g\,.h_{cb}}{W_1^2} \tag{3-8}$$

Closing pipe: Calculation is similar to opening pipe:

$$h_{cb} = \Delta h_z + \frac{W_3^{\ 2} - W_4^{\ 2}}{2g} \qquad (3\text{-}9)$$

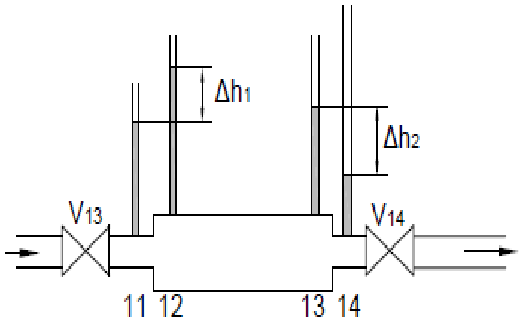
So: $$\xi = \frac{2g.h_{cb}}{W_4^{\ 2}} \qquad (3\text{-}10)$$

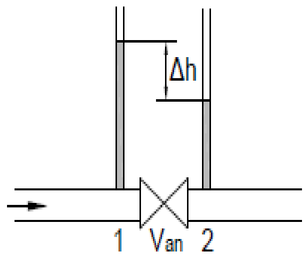
(where velocity $W_1 = W_4$; $W_2 = W_3$)

Table of measurement and calculation results

No.	Opening pipe										Closing pipe		
	h (m)	t (s)	Q (m^3/s)	Δh (m)	W_1 (m/s)	W_2 (m/s)	$\frac{W_1^2}{2g}$	$\frac{W_2^2}{2g}$	h_{cb1}	ξ	Δh_2	h_{cb2}	ξ
1													
2													
3													

2. Valve





Equation Bernoulli equation for Section 1-1 và 2-2:

$$\frac{P_1}{\rho g} + \frac{W_1^{\ 2}}{2g} = \frac{P_2}{\rho g} + \frac{W_2^{\ 2}}{2g} + h_{cb}$$

Because the pipe diameter before and after the valve are equal: $W_1 = W_2 = W$

So : $$h_{cb} = \frac{P_1 - P_2}{\rho.g} = \Delta h$$

Do experiments with 3 different then average flow values:

$$\xi = \frac{2g.h}{W^{\ z}}$$

Table of measurement and calculation results

No.	h(m)	τ (s)	Q(m/s)	Δh (m)	W (m/s)	$\frac{W_2}{2g}$	ξ
1							
2							
3							
tb							

d. Experimental conclusion