EXPERIMENT 1
TYPES OF FLOW

I. INTRODUCTION

The type of flow is very important when calculating fluid motion. There are two types of flow: streamline flow (laminar flow) and turbulent flow. In laminar flow, elements of the fluid flow move in parallel with each other. In turbulent flow, they show a chaotic, fluctuating type of motion. The characteristics of fluid motion depend on hydraulic diameter, velocity, viscosity and mass density. Measurements with different fluids and diameters, Reynolds have shown that the transition from laminar to turbulent flow take place at a critical value Reynolds number:

$$R_e = \frac{d_{td}.W.\rho}{\mu} = \frac{d_{td}.W}{\nu}$$

d_{td}	:	hydraulic diameter	m
W	:	mean velocity	m/s
ρ	:	mass density	Kg/m^3
μ	:	dynamic viscosity	$N.s/m^2$
$\nu = \frac{\mu}{\rho}$	:	kinematic viscosity	m^2/s

In case of flow through smooth, straight, circular pipe:

Re < 2320	laminar flow
2320 ≤ Re ≤ 10.000	transition to turbulent
Re > 10.000	turbulent flow

Re = 2320 is lower critical value, Re = 10000 is upper critical value.

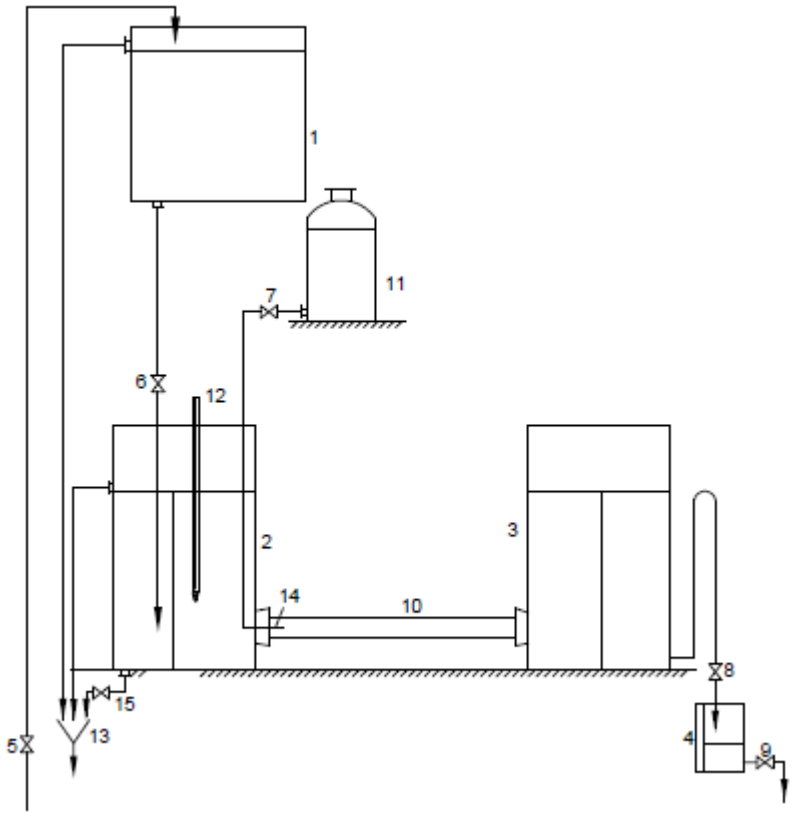

Figure 1.1. *Experiment setup*

1. Supply tank
2. Input buffer tank
3. Output buffer tank
4. Flowmeter
5. Water supply valve
6. Water input valve
7. Dye flow control valve
8. Water flow control valve
9. Flowmeter drainage valve
10. Glass pipe, Φ = 25mm, l = 14000 mm
11. Dye tank
12. Thermometer
13. Drainage
14. Dye inject needle
15. Water drainage valve

II. PURPOSE

1. Have knowledge of the experiment setup
2. Observe different types of flow
3. Determine flow type from Re

III. EXPERIMENT SETUP

(Figure 1.1).

Water from underground tank (not shown) is pumped to supply tank 1, whose level level is regulated by a level relay (not shown). Water flows from tank 1 through valve 6 into tank 2. Excess water returns to underground tank through overflow pipe. Water flows from tank 2 through glass pipe (the main part of the setup) into tank 3 then through flowmeter to sewage. Flowrate through glass pipe is controlled by valve 8. Dye from tank 11 is injected at the center of glass pipe by inject needle 14. Dye flow is regulated by valve 7. Water in the setup must be drained after experiment.

IV. OPERATING PROCEDURE

Start the experiment with low flow in glass pipe. When laminar flow is established, increase flowrate slowly so that flow in the glass pipe change from laminar to turbulent. Observe dye flow in different types of flow and measure all physical quantities needed for Re calculation. Record three flowrates for each type of flow.

Operation procedure:

1. Study the experiment setup.
2. Check water level in tank 1, dye level in tank 11, valves, ...
3. Close valves 6, 7, 8, 15 completely
4. Open valve 6 slowly so that water flows from tank 1 into tank 2 without too much turbulence.
5. Adjust inject needle at the center of glass pipe 10.
6. When glass pipe 10 and tank 3 are full of water and water starts flow out of tank 2 through overflow pipe, turndown valve 6 to regulate water flow into tank 2 then open valve 8 slowly.
7. Open valve 7 slowly so that dye flows in a thin straight stream. Record flowrate.
8. Increase water flowrate through glass pipe slowly until dye stream becomes wavy. Record flowrate.
9. Increase water flowrate through glass pipe slowly until dye starts dissolve into water. Record flowrate.
10. Increase flowrate until dye dissolves completely into water right behind inject needle. Record flowrate.
11. Decrease flowrate until thin wavy dye stream appears again. Record flowrate.
12. Decrease flowrate until dye stream becomes straight again. Record flowrate.
13. Finish: close valve 7, 6, 5; open valve 15, 9 to drain water from experiment setup; tidy up and clean working space.

V. QUESTIONS

1. What are types of flow?
2. What is Reynolds number and its meaning?
3. How are velocity profiles over cross-section in laminar and turbulent flows?
4. Explain quantities in Reynolds number and their effects on types of flow?
5. What are hydraulic radius and diameter?
6. What are critical values of Reynolds number?

VI. CALCULATION

1. Water velocity:

$$W = \frac{V_{tb}}{0{,}785 d_{td}^2}, \text{ m/s} \qquad (1\text{-}2)$$

V_{tb} - water flowrate, m^3/s

d_{td} – hydraulic diameter, m

2. Calculate Re in three cases:

- Straigh dye stream
- Wavy dye stream
- Dye dissolves in water

3. Record:

Dye stream	No.	Flowrate V_{tb} (m^3/s)	Temperature t, ^0C	Viscosity μ (Ns/m^2)	Velocity W m/s	Re
Straight	1					
	2					
	3					
Wavy	1					
	2					
	3					
Dissolved	1					
	2					
	3					

4. Comments on experiment

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