AE 204 FLUID MECHANICS

REYNOLDS DYE EXPERIMENT / EXP8

2024

OBJECTIVE

Osborne Reynolds test devices are used to display laminar and turbulent flows. The Reynolds number is used to assess whether a flow is laminar or turbulent. The purpose of this experiment is to observe laminar flow, transition zone flow and turbulent flow and perform related calculations.

THEORY

When a fluid flows in a conduit, it adheres to the solid contact surface between the solid and the fluid. This adhesion is the result of the force field at the boundary. This effect also forms the common surface tension between the solid and the fluid. Thus, if the wall in the system is stationary, the velocity of the fluid on the common surface is zero. As the speed away from the wall is a certain value, the speed within a flowing streamline will change from one point to another. Thus, the velocity at any point will be the function of the space coordinates at that point, a velocity field will occur at the place occupied by the flow. For Newtonian fluids, the shear stress is simply proportional to the velocity gradient, i.e.

$$\tau = \mu \frac{du}{dy}$$

The flow of a fluid in the pipe can be laminar or turbulent flow. The British scientist Osborne Reynolds (1842-1912) was the first to distinguish the difference between these two flows. The Reynolds assembly has a flow of water in a transparent tube, which enables the flow lines to be examined with the ink injected into the flow. At low water velocities, the injected ink advances in the direction in which it is injected and there is no deterioration in the flow direction. At higher water velocities, irregular movements occur in the flow line and there are splashes. At sufficiently high water velocities, the flow is completely irregular and the injected ink is irregularly distributed in the tube. These three flow patterns are called laminar, transition regime and turbulent flow as given in Figure 1.

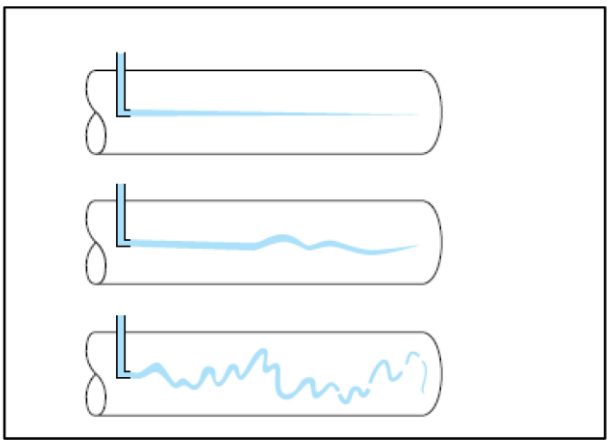

Figure 1. Laminar, transitional, and turbulent regimes of a flow in a pipe

The flow of fluid particles is parallel to each other and flowing uniformly on one another is called laminar flow. In this flow regime, the flow streamlines glide over each other. At higher speeds turbulence occurs, resulting in eddies. This flow pattern, in which the fluid particles exhibit a completely mixed, irregular shape, is called turbulent flow. The region that connects these two regions is also called the transition zone. In this region, the laminar flow starts to deteriorate. Viscous forces are dominant on laminar flow and inertial forces are dominant on turbulent flow. The laminar boundary layer is characterized by a dimensionless group of numbers called the Reynolds number where the turbulence begins.

$$\mathrm{Re} = \frac{\rho V D}{\mu}$$

Re : Reynolds number (dimensionless) ρ : Fluid density (kg/m^3)

D : Pipe diameter (m) V : Mean velocity (m/s) μ : Fluid viscosity (Pa.s)

Reynolds number above 2100 is considered as start of the transition flow, and 2300 is considered as the critical Reynolds number for the flow in a pipe. The flow in a round pipe is turbulent if the Reynolds number is greater than nearly 4000.

PROCEDURE

1. To make the test installation ready, the end of the drain must be connected to a source where the ink water can flow without polluting the environment.

2. If the test is to last for a long time, the water in the tank will not be enough and it will be appropriate to connect the water to the tank.
3. The pump is started by switching on the main switch and using the circuit pump switch.
4. Initially, the water flow rate is selected low by using the flow adjustment switch and the water is fully filled. In this case, a regular flow is provided by reducing the drain.
5. After the system enters the regimen, the injector tap underneath the ink chamber is opened slowly and the ink flowing in the test tube, the ink flows like a rope. If the drainage tap is opened a little more, it will be observed that a slow turbulent flow occurs when the flow gradually deteriorates or even a little more is opened.
6. The temperature of the water should be measured with the help of a thermometer.
7. The dye flowing through a thin rope in the glass pipe is indicative of laminar flow.
8. We open the discharge or discharge valve a little more until the dye flowing in the rope form becomes vibrating. Such flow is an expression of the transition to turbulent flow.
9. As a result of opening the drain valve slightly, the dye flowing into the glass pipe is completely mixed with water. This indicates turbulent flow.
10. Flow rate is measured by the rotameter.

REFERENCES

1. http://www.ogen.com.tr/katalog/osborn-reynolds_deney_seti_int.pdf, Access date: Apr 25th, 2022.

2. Munson, B.R. et al., Fundamentals of Fluid Mechanics, 7th Ed., 2013.

THE REYNOLDS DYE EXPERIMENT / LAB 8 DATA SHEET DATE:

STUDENT NAME, SURNAME: SIGNATURE:

TABLE 1

Data No	Q, Volumetric flow rate (ml/min)	Regime by observation (Laminar, Transition or Turbulent)	Q, Volumetric flow rate (m^3/s)	Reynolds number	V , Velocity (m/s)	Regime by calculation (Laminar, Transition or Turbulent)
1						
2						
3						
4						
5						
6						

Calculation steps:

1. Determine the flow rate in each of the three valve positions using a flow meter or a measured container. Since the drain pipe diameter is D = 12 mm, calculate the velocity values for all three conditions.
2. Calculate the Reynolds numbers by reading the density and dynamic viscosity properties of the water for the temperature you measured in the experiment. Fill in the table.
3. Determine the regime of the flow using the Reynolds numbers.

LAB RULES:
•Each group should submit one report.
•Each group should write each part by their own and get together with their group members to merge all of them.
•Reports are due to next Monday. They must be submitted to the corresponding assistant **till 17:00** on the next Monday.
•Students must sign the data sheet from the lab assistant at the end of each experiment and the signed sheet must be attached with the report. Reports without the signed data sheet will not be graded.
•Students are advised to read the detail of each experiment sheet before coming to the corresponding lab class.

LAB REPORT FORMAT (HANDWRITTEN EXCEPT COVER PAGE, TABLES AND PLOTS):
The lab report (no longer than 15 pages – all included –) should include the followings (unless otherwise specified):

1. Objective
2. Theory
3. Procedure
4. Results
5. Sample calculation
6. Necessary plots
7. Discussion on results, errors and graphs
8. Conclusion