1.0 INTRODUCTION

The **SOLTEQ® Reynolds Number Experiment (Model: FM 11)** has been designed for demonstration on the laminar, transition and turbulent flow. It consists of a transparent header tank and flow visualization pipe. The header tank is provided with a diffuser and stilling materials at the bottom to provide a constant head of water to be discharged through a bell mouth entry to the flow visualization pipe. Flow through this pipe is regulated using a control valve at the discharge end. The water flow rate through the pipe can be measured using the volumetric tank (or volumetric cylinder). Velocity of the water can therefore be determined to allow the calculation of the Reynolds Number. A dye injection system is installed on top of the header tank so that flow pattern in the pipe can be visualized.

2.0 GENERAL DESCRIPTION

2.1 Unit Assembly

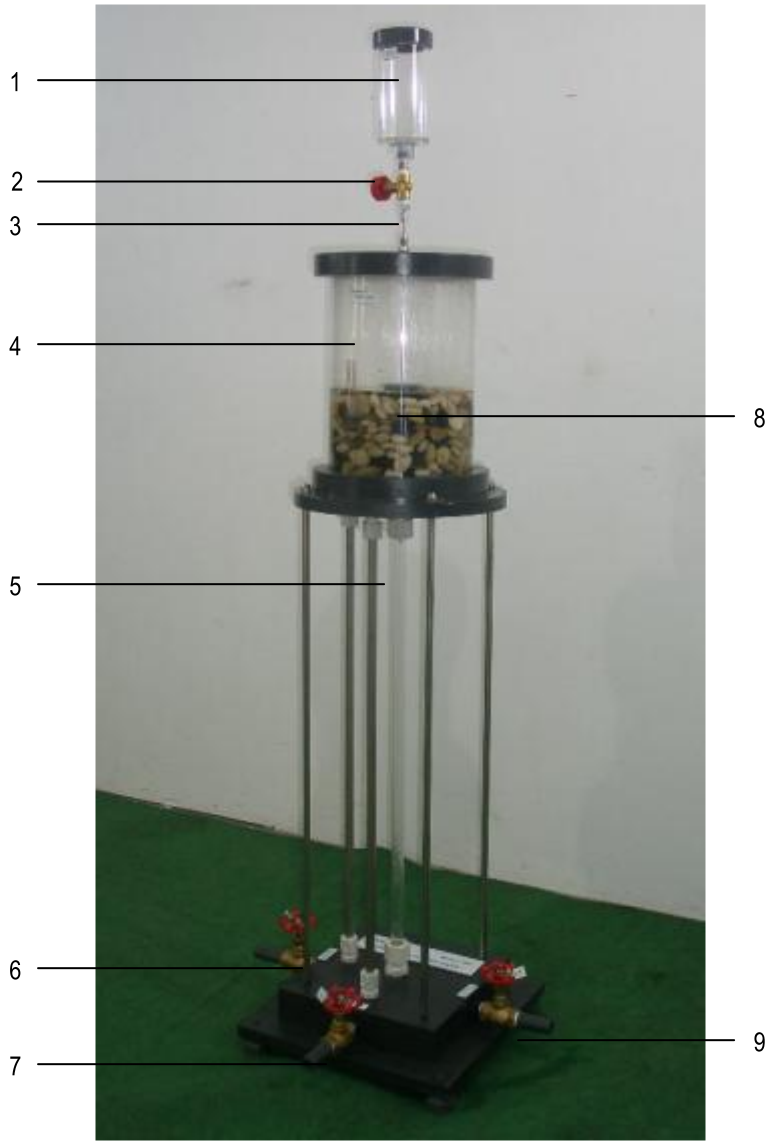

Figure 1: *Unit Assembly of Osborne Reynolds Demonstration (Model: FM11)*

1. Dye reservoir
2. Dye control valve, V4
3. Dye injector
4. Head tank
5. Observation tube
6. Overflow valve, V3
7. Water inlet valve, V1
8. Bell mouth
9. Water outlet valve, V2

The Osborne Reynolds Demonstration apparatus is equipped with a visualization tube for students to observe the flow condition. The rocks inside the stilling tank are to calm the inflow water so that there will not be any turbulence to interfere with the experiment. The water inlet / outlet valve and dye injector are utilized to generate the required flow.

3.0 INSTALLATION AND COMMISSIONING

1. Assemble the Osborne Reynolds apparatus as shown in the picture.
2. Place the Osborne Reynolds apparatus on a level ground. Use a level spirit to level the apparatus.
3. Connect hose to the apparatus outflow, inflow and overflow.
4. Fill up the dye reservoir with the provided blue ink.
5. Establish water supply by connecting the inlet hose to a water source and open the inlet valve.
6. Fill the stilling tank with the aquarium stones that are being provided and proceed to fill up the stilling tank with water.
7. Open the outflow valve to test the unit. Check for any leaking of water and proceed to inject the ink.
8. The unit is now ready to use.

4.0 SUMMARY OF THEORY

The theory is named in honor of Osborne Reynolds, a British engineer who discovers the variables that can be used as a criterion to distinguish between laminar and turbulent flow.

The Reynolds number is widely used dimensionless parameters in fluid mechanics.

Reynolds number formula: $R = \frac{UL}{V}$

R = Reynolds number
U = Fluid velocity, (m/s)
L = characteristic length or diameter (m)
V = Kinematic viscosity (m^2/s)

Reynolds number R is independent of pressure

4.1 Pipe Flow Conditions

For water flowing in pipe or circular conduits, L is the diameter of the pipe. For Reynolds number less than 2100, the pipe flow will be laminar. For Reynolds number from 2100 to 4000 the pipe flow will be considered a transitional flow. Turbulent occur when Reynolds number is above 4000. The viscosity of the fluid also determines the characteristic of the flow becoming laminar or turbulent. Fluid with higher viscosity is easier to achieve a turbulent flow condition. The viscosity of fluid is also dependant on the temperature.

4.2 Laminar Flow

Laminar flow denoted a steady flow condition where all streamlines follow parallel paths, there being no interaction (mixing) between shear planes. Under this condition the dye observed will remain as a solid, straight and easily identifiable component of flow.

4.3 Transitional Flow

Transitional flow is a mixture of laminar and turbulent flow with turbulence in the center of the pipe, and laminar flow near the edges. Each of these flows behaves in different manners in terms of their frictional energy loss while flowing, and have different equations that predict their behavior.

4.4 Turbulent Flow

Turbulent flow denotes an unsteady flow condition where streamlines interact causing shear plane collapse and mixing of the fluid. In this condition the dye observed will become disperse in the water and mix with the water. The observed dye will not be identifiable at this point.

5.0 EXPERIMENT PROCEDURES

5.1 Experiment A

Experiment objectives:

- To compute Reynolds number (R).
- To observe the laminar, transitional and turbulent flow.

1. Lower the dye injector until it is seen in the glass tube.
2. Open the inlet valve, V1 and allow water to enter stilling tank.
3. Ensure a small overflow spillage through the over flow tube to maintain a constant level.
4. Allow water to settle for a few minutes.
5. Let water flow through the visualizing tube.
6. Slowly adjust the dye control valve, V4 until a slow flow with dye injection is achieved.
7. Regulate the water inlet valve, V1 and outlet valve, V2 until a straight identifiable dye line is achieved. The flow will be laminar.
8. Measure the flow rate at the outlet valve, V2 using volumetric method.
9. Repeat the experiment by regulating water inlet valve, V1 and outlet valve, V2 to produce transitional and turbulent flow.

5.2 Experiment B

Experiment objectives:

- To determine the Reynolds number (R)
- To determine the upper and lower critical velocities at transitional flow.

1. Lower the dye injector until it is seen in the glass tube.
2. Open the inlet valve, V1 and allow water to enter stilling tank.
3. Ensure a small overflow spillage through the over flow tube to maintain a constant level.
4. Allow water to settle for a few minutes.
5. Let water flow through the visualizing tube.
6. Slowly adjust the dye control valve, V4 until a slow flow with dye injection is achieved.
7. By repeating the procedures to create a laminar flow, slowly increase the flow rate until the laminar flow produce small disturbance or eddies. This will be lower critical velocity.
8. Measure the flow rate at the outlet valve, V2 using volumetric result.
9. Repeat the experiment by first introducing a turbulent flow and slowly decrease flow rate till the flow become transitional. This will be upper critical velocity

5.3 Data sheet

Reynolds number	R_e	(non-dimensional)
Friction Factor	λ	(non-dimensional)
Kinematics viscosity	v	mm^2/sec
Pipe diameter	D	mm
Mean velocity	U	mm/sec
Higher Critical velocity	U^{crit}	mm/sec
Lower Critical velocity	U^{crit}	mm/sec
Flow rate	Q	L/s

Volume (L)	Time (s)	Flow rate, Q (L/s)	Flow rate, Q (m^3/s)	Reynolds Number