4.1 REYNOLD'S EXPERIMENT

As we are aware that for determining the type of flow we use to calculate the Reynolds number and on the basis of Reynolds number we use to decide the flow type. So let us see here the basics behind the determination of type of flow based on the Reynolds number.

Value for Reynolds number might be calculated with the help of following formula

$$Re = \rho V D / \mu$$

Where,

V = Flow velocity of the Hydraulic fluid i.e. liquid (m/s)

D = Diameter of pipe (m)

μ = viscosity (poise)

O Reynold had explained this concept with one experiment, which is explained here, in 1883. Reynold had concluded that transition from laminar flow to turbulent flow in a pipe depends not only on the velocity but also it depends on the diameter of the pipe and viscosity of the fluid flowing through the pipe.

Reynolds experiment apparatus

Apparatus for Reynolds experiment are as mentioned here

1. A tank containing water at constant head
2. A small tank containing some dye
3. A glass tube with bell-mouthed entrance at one end and a regulating valve at other end

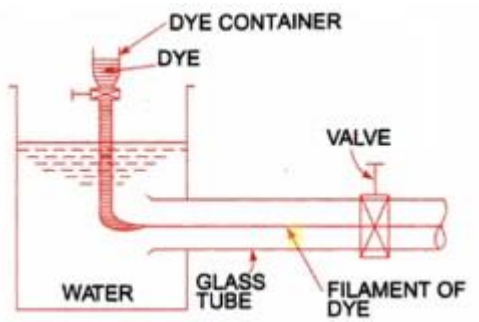


Figure 4.1.1 Apparatus for Reynolds experiment

[Source: "Fluid Mechanics and Hydraulics Machines" by Dr.R.K.Bansal, Page: 442]

Now we will allow water to pass through the glass tube from the water tank. Regulating valve is provided here to vary the velocity of water flowing through the glass tube.

We will introduce a liquid dye, of having same specific weight as of water, in to the glass tube as displayed here in following figure.

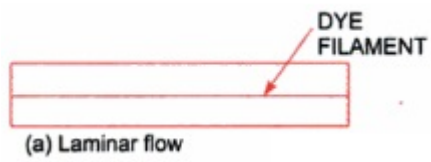
Observations made by Reynold

Observation I

When velocity of water flow is low, dye filament will be in the form of straight line in the glass tube. It could be seen in the glass tube that dye filament is in the form of straight line and parallel to the wall of glass tube.

Above condition is the example of laminar fluid flow. Therefore at lower velocity of water flow through the glass tube, the type of water flow will be laminar.

Following figure, displayed here as figure a, indicates the case of water flow through the glass tube at low velocity of water flow.



Observation II

Now velocity of flow is increased with the help of regulating valve. Dye filament will not be in the form of straight line in the glass tube. It could be seen in the glass tube that dye filament is in the form of wavy one now.

Above condition is the example of transition of fluid flow. Therefore when velocity of water flow through the glass tube is increased, the type of water flow will be transition flow. Transition flow means the flow between laminar flow and turbulent flow.

Following figure, displayed here as figure b, indicates the case of transition flow through the glass tube.

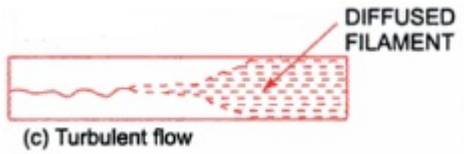
Observation III

Now velocity of flow is increased again with the help of regulating valve. Wavy dye filament will be broken and finally diffused in the water as displayed here in following figure.

It could be seen in the glass tube that particles of dye filament liquid are moving in random and irregular fashion at this higher velocity of water flow. Mixing of particles of water and dye filament is intense and water flow will be random, irregular and disorderly.

Above condition is the example of turbulent fluid flow. Therefore when velocity of water flow will be higher, the type of water flow will be turbulent flow.

Following figure, displayed here as figure c, indicates the case of turbulent flow through the glass tube.



(c) Turbulent flow

In case of laminar fluid flow, loss of pressure head will be proportional to the velocity of fluid flow.

While in case of turbulent fluid flow, loss of pressure head will be approximately proportional to the square of velocity of fluid flow.

The Reynolds number is a very useful parameter in predicting whether the flow is laminar or turbulent.

Re < 2000 viscous / laminar flow

Re → 2000 to 4000 Transient flow

Re > 4000 Turbulent flow