Class: 2^{nd} stage

Subject: Fluid flow

Ministry of Higher Education and Scientific Research

Al-Mustaqbal University College

Chemical engineering and petroleum industries

(Fluid Flow Lab)

Experiment No. 1

Viscosity

Prepared by

Asst.Lect. Rand Fadhil Kadhim

Eng. Zeena Qasim Alwan

Viscosity

The aim of the experiment:

- determine the coefficient of viscosity for different liquids.

Theoretical part:

When a metal ball falls into a liquid, its velocity becomes constant after a short period. In this case, the algebraic sum of the forces acting on the ball will be equal to zero, and these forces are its weight (Gravity force) and its downward direction, symbol **Fg**, an upward buoyant force $\mathbf{F_B}$ (Archimedes' Principle) and the force obstructing the movement which result from the viscosity of the liquid (viscous force, $\mathbf{F_V}$) also in the upward direction since it opposes the downward motion of the sphere. This state of equilibrium can be expressed with the following equation:

$$\mathbf{F_g = F_B + F_v}$$

$$\mathbf{\Sigma F_y = 0}$$

$$\mathbf{F_g - F_B - F_v = 0 \quad \ldots (1)}$$

- If we assumed that:

r = radius of sphere (m)

ρ_S = density of sphere (ball) (Kg/m^3)

ρ_L = density of liquid (Kg/m^3)

g = gravitational acceleration (m/s^2)

v = velocity of sphere (m/s)

- Then:

$\mathbf{F_g = mg = \rho_s V_s g,}$
$\mathbf{m_s = \rho s\ Vs,\ \ Vs = 4/3\ \pi\ r^3}$ **, Vs = volume of sphere**

$$\mathbf{F_g = 4/3\ \pi\ r^3\ \rho_s\ g}$$

$$\mathbf{F_b = 4/3\ \pi\ r^3\ \rho_L\ g}$$

If we assumed that **η** is the coefficient of viscosity, then according to stoke's law:

$$\mathbf{F_V = 6\ \eta\ \pi\ r\ v}$$

By substitute the values of $\mathbf{F_g}$, $\mathbf{F_B}$, $\mathbf{Fv}$ into equation (1):

$$\mathbf{(4/3\ r^3\ \pi\ \rho s\ g) - (4/3\ r^3\ \pi\ \rho_L\ g) - (6\ \eta\ \pi\ r\ v) = 0 \quad \div\ 4/3\ \pi r}$$
$$\mathbf{r^2\ \rho s\ g - r^2\ \rho_L\ g = 9/2\ \eta\ v}$$
$$\mathbf{r^2\ g\ (\rho s - \rho_L) = 9/2\ \eta\ v}$$

$$\mathbf{\eta = [2r^2\ g\ (\rho s - \rho_L) / 9v] \quad , v = L/t}$$

Where:

η = coefficient of viscosity (Pa. s)

Equipment:

Graduated glass cylinder

Stopwatch

Steel balls

Hydrometer

Procedure of the experiment:

1. Each tube is filled with a specific liquid (oil, water).

2. Two balls of different diameters are used for each liquid, if possible, the time required for the ball to travel a vertical distance from the liquid is measured. In addition, the level lines marked on the tube are used.

3. A hydrometer is used to measure the relative density of a liquid.

Results and conclusions:

For oil:

D mm	t sec	V m/s	η (Pa.s)

For water:

D mm	t sec	V m/s	η (Pa.s)

Discussion:

1. Define the viscosity and mention its types and units.
2. What are Stoke's law of viscosity and Newton's law of viscosity?
3. What is the effect of temperature on viscosity?