Introduction

1.1 Introduction

Chemical engineering has to do with industrial processes in which raw materials are changed or separated into useful products.

The chemical engineer must develop, design, and engineer both the complete process and the equipment used; choose the proper raw materials; operate the plants efficiently, safely, and economically; and see to it that products meet the requirement set by the customers.

A Fluid is any substance that conforms to the shape of its container and it may be defined as a substance that dose not permanently resist distortion and hence, will its shape. *Gases and liquids and vapors* are considered to have the characteristics of fluids and to obey many of the same laws.

In the process industries, many of the materials are in fluid form and must be stored, handled, pumped, and processed, so it is necessary that we become familiar with the principles that govern the flow of fluids and also with the equipment used. Typical fluids encountered include water, acids, air, Co_2, oil, slurries.

If a fluid affected by changes in pressure, it is said to be "*compressible fluid*", otherwise, it is said to be "*incompressible fluid*".

Most liquids are incompressible, and gases are can considered to be compressible fluids. However, if gases are subjected to small percentage changes in pressure and temperature, their densities change will be small and they can be considered to be incompressible fluids.

The fluid mechanics can be divided into two branches;

"Fluid static" that means fluid at rest, and

"Fluid dynamics" that means fluid in motion.

1.2 Physical Properties of Fluids

1. **Mass density or density [symbol: ρ (rho)]**

   It is the ratio of mass of fluid to its volume, $$\rho = \frac{\text{Mass of fluid}}{\text{Volume of fluid}}$$

   The common units used of density is (kg/m^3), (g/cm^3), (lb/ft^3).

2. **Specific Volume [symbol: υ (upsilon)]**

   It is the ratio of volume of fluid to its mass (or mole); it is the reciprocal of its density, $$\upsilon = \frac{\text{Volume of fluid}}{\text{Mass of fluid}}$$

   The common units used of density is (m^3/ kg), (cm^3/g), (ft^3/lb).

3. **Weight density or specific weight [symbol: sp.wt.]**

   It is the ratio of weight of fluid to its volume, $$sp.wt. = \frac{\text{Weight of fluid}}{\text{Volume of fluid}}$$

   The common units used of density is (N/m^3), ($dyne/cm^3$), (lb_f/ft^3).

4. **Specific gravity [symbol: sp.gr.]**

It is the ratio of mass density or (density) of fluid to mass density or (density) of water, Physicists use 39.2°F (4°C) as the standard, but engineers ordinarily use 60°F (15.556°C)

$$\boxed{sp.gr. = \frac{\text{Mass density of fluid}}{\text{Mass density of water}}}$$

The common density used of water is (1000 kg/m^3), (1.0g/cm^3), (62.43 lb/ft^3).

5. **Dynamic viscosity [symbol: μ (mu)]**

It is the property of a fluid, which offers resistance to the movement of one layer of fluid over another adjacent layer of the fluid.

The common units used of dynamic viscosity is (kg/m.s), (g/cm.s), (lb/ft.s), (poise) (N.s/m^2 ≡ Pa.m), (dyne.s/cm^2). [poise ≡ g/cm.s ≡ dyne.s/cm^2] [poise = 100 c.p]

6. **Kinematic viscosity [symbol: ν (nu)]**

It is the ratio of the dynamic viscosity to mass density of fluid, $\boxed{\nu = \frac{\mu}{\rho}}$

The common units used of kinematics viscosity is (m^2/s), (cm^2/s), (ft^2/s), (stoke). [stoke ≡ cm^2/s] [stoke = 100 c.stoke]

7. **Surface tension [symbol: σ (sigma)]**

It is the property of the liquid, which enables it to resist tensile stress. It is due to cohesion between surface molecules of a liquid.

The common units used of Surface tension is (N/m), (dyne/cm), (lb_f/ft).

1.3 Useful Information

1. **The shear stress [symbol: τ (tau)]**

It is the force per unit surface area that resists the sliding of the fluid layers.

The common units used of shear stress is (N/m^2 ≡ Pa), (dyne/cm^2), (lb_f/ft^2).

2. **The pressure [symbol: P]**

It is the force per unit cross sectional area normal to the force direction.

The common units used of shear stress is (N/m^2 ≡ Pa), (dyne/cm^2), (lb_f/ft^2) (atm) (bar) (Psi) (torr ≡ mmHg). The pressure difference between two points refers to (ΔP).

The pressure could be expressed as liquid height (or head) (h) where,

$\boxed{P = h\,\rho\,g}$ and $\boxed{\Delta P = \Delta h\,\rho\,g}$

h: is the liquid height (or head), units (m), (cm), (ft).

3. **The energy [symbol: E]**

Energy is defined as the capacity of a system to perform work or produce heat.

There are many types of energy such as [Internal energy (U), Kinetic energy (K.E), Potential energy (P.E), Pressure energy (Prs.E), and others.

The common units used for energy is (J ≡ N.m), (erg ≡ dyne.cm), (Btu), (lb_f.ft) (cal).

The energy could be expressed in relative quantity per unit mass or mole (J/kg or mol).

The energy could be expressed in head quantity [(m) (cm) (ft)] by dividing the relative energy by acceleration of gravity.

4. **The Power [symbol: P]**

It is the energy per unit time. The common units used for Power is (W ≡ J/s), (Btu/time), (lb_f.ft/time) (cal/time), (hp).