

OF FLUIDS.

## DEFINITIONS OF A FLUID

- A fluid is a substance which is capable of flowing if allowed to do so.
- A fluid is a substance that has no definite shape of its own, but conforms to the shape of the containing vessel.
- A fluid is a substance which undergoes continuous deformation when subjected to a shearing force/shear force.

Since liquids and gases / vapours possess the above cited characteristics, they are referred to as *fluids*.

### **Ideal Fluid :**

- It is a fluid which does not offer resistance to flow / deformation / change in shape, i.e., it has no viscosity. It is frictionless and incompressible. However, an ideal fluid does not exist in nature and therefore, it is only an imaginary fluid.
- An ideal fluid is the one which offers no resistance to flow/change in shape.

### **Real Fluid :**

It is a fluid which offers resistance when it is set in motion. All naturally occurring fluids are real fluids.

(7.1)

## CLASSIFICATION OF FLUIDS

1. Based upon the behaviour of fluids under the action of externally applied pressure and temperature, the fluids are classified as :
  - (a) Compressible Fluids
  - (b) Incompressible Fluids.
2. Based upon the behaviour of fluids under the action of shear stress, the fluids are classified as :
  - (a) Newtonian Fluids
  - (b) Non-Newtonian Fluids.

A fluid possesses a definite density at a given temperature and pressure. Although the density of fluid depends on temperature and pressure, the variation of density with changes in these variables may be large or small.

### Compressible Fluid :

- *If the density of a fluid is affected appreciably by changes in temperature and pressure, the fluid is said to be **compressible**.*

*If the density of a fluid is sensitive to changes in temperature and pressure, the fluid is said to be **compressible**.*

### Incompressible Fluid :

- *If the density of a fluid is not appreciably affected by moderate changes in temperature and pressure, the fluid is said to be **incompressible**.*

*If the density of a fluid is almost insensitive to moderate changes in temperature and pressure the fluid is said to be **incompressible**.*

Thus, **liquids** are considered to be incompressible fluids, whereas **gases** are considered to be compressible fluids.

Definitions of Newtonian and Non-Newtonian fluids are covered later in this chapter under the title viscosity.

## PROPERTIES OF FLUIDS

The properties of fluids are

- (i) Mass density (specific mass) or simply density ( $\rho$ ).
- (ii) Weight density (specific weight) ( $w$ ).
- (iii) Vapour pressure.
- (iv) Specific gravity.
- (v) Viscosity.
- (vi) Surface tension and capillarity.
- (vii) Compressibility and elasticity.
- (viii) Thermal conductivity.
- (ix) Specific volume.

**Density :**

Density ( $\rho$ ) or mass density of a fluid is *the mass of the fluid per unit volume*. In the SI system, it is expressed in  $\text{kg/m}^3$ . The density of pure water at 277 K (4 °C) is taken as  $1000 \text{ kg/m}^3$ .

**Weight Density :**

Weight density of a fluid is *the weight of the fluid per unit volume*. In the SI system, it is expressed in  $\text{N/m}^3$ . Specific weight or weight density of pure water at 277 K (4 °C) is taken as  $9810 \text{ N/m}^3$ .

The relation between mass density and weight density is

$$w = \rho g$$

where  $g$  is the acceleration due to gravity ( $9.81 \text{ m/s}^2$ ).

**Specific Volume :**

Specific volume of a fluid is *the volume of the fluid per unit mass*. In the SI system, it is expressed in  $\text{m}^3/\text{kg}$ .

**Specific Gravity :**

The specific gravity of a fluid is *the ratio of the density of the fluid to the density of a standard fluid*. For liquids, water at 277 K (4 °C) is considered/chosen as a standard fluid and for gases, air at NTP (0°C and 760 torr) is considered as a standard fluid.

**Vapour Pressure :**

The vapour pressure of a pure liquid is defined as *the absolute pressure at which the liquid and its vapour are in equilibrium at a given temperature* or The pressure exerted by the vapour (on the surface of a liquid) at equilibrium conditions is called as the vapour pressure of the liquid at a given temperature. Pure air free water exerts a vapour pressure of  $101.325 \text{ kPa}$  (760 torr) at  $373.15 \text{ K}$  ( $100 \text{ }^\circ\text{C}$ ).

**Surface Tension :**

The property of liquid surface film to exert tension is called as the surface tension. It is the force required to maintain a unit length of film in equilibrium. It is denoted by the symbol  $\sigma$  (Greek sigma) and its SI unit is  $\text{N/m}$ .