COMPRESSIBILITY

When the pressure is applied to a fluid, it contracts and when pressure is released it expands. Compressibility of a fluid then characterises its ability to change its volume under pressure.

The relative change of volume per unit pressure is given by the coefficient of compressibility:

$$\beta_c = \frac{1}{V}\left(\frac{-dv}{dp}\right) \quad \therefore \frac{\left(\frac{-dv}{v}\right)}{dp}$$

where dp is incremental pressure applied to the fluid, $-dv$ is decremental volume change in the original volume(V).

Quite often, the compressibility of fluid is expressed by its bulk modulus of elasticity, (K) which is the inverse of the coefficient of compressibility

$$K = \frac{1}{\beta_c} = -\frac{dp}{(dv/v)}$$

The bulk modulus of elasticity measures the compressive stress per unit volumetric strain.

VAPOUR PRESSURE AND CAVITATION

A change from the liquid state to gaseous state is known as vaporization. This phenomenon is depending upon the prevailing temperature and pressure. It occurs due to continuous escaping of molecules through the free liquid surface.

Consider water (at 20°c and at atmospheric pr.) which is confined in a closed vessel. The water will vaporise at 100°C by escape of molecules through free surface. These vapour molecules get accumulated between the free surface and top of the vessel. These accumulated vapour molecules exert a pressure on the top of the liquid surface. This force per unit area is known as vapour pressure of the liquid. or this is the pressure at which the liquid is converted into the vapours.

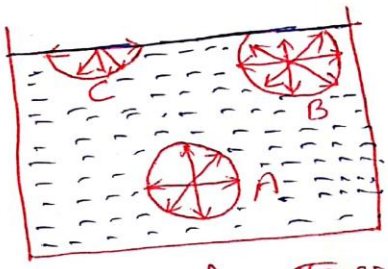
Consider water at 20°C at atmospheric pressure in the closed vessel. If the pressure above the liquid is reduced by some means, the water starts to boil (vaporise) when the pr. is less than or equal to vaporisation pressure. Hence, water (can boil) at room temp also.

Cosider a flowing liquid in a system. If the pressure of the liquid at any point beaomes equal/less than vapour pressure, vaporization of the liquid starts.. When this liquid is entered into high pressure region, the vapours collapse, giving rise to high impact pressure. As the pressure developed by the collapsing bubbles is so high, it erodes the material from the adjoing boundaries. This phenomenon is known as cavitation.

SURFACE TENSION (σ)

Surface tension is defined as the tensile force acting on the surface of a liquid in contact with a gas or on the surface between two immiscible liquids such that the contact surface behaves like a membarance under tension. The magnitude of this force per unit length of the free surface will have the same value as the surface energy per unit area.

Consider three molecules A, B & C of a liquid in a mass of liquid. The molecule 'A' is attracted to in all directions equally by surrounding molecules of the liquid. But the molecule B, which is situated near the free surface, is acted upon by upwards and downward forces which are unbalanced. Thus a net resultant force on molecule 'B' is acting in the downward direction. The molecule C, situated on the free surface of the liquid experiences resultant downward force. All the molecules



Surface Tension

in the free surface experience a downward force. Thus the free surface of the liquid acts like a very thin film under tension of the surface of the liquid.

Surface Tension on Liquid Droplet:

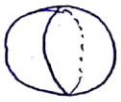
Consider a small spherical droplet of a liquid of radius 'r'. On the entire surface of the droplet, the tensile force due to surface tension will be acting.

Let σ = Surface tension of the liquid

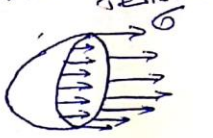
p = Pressure intensity inside the droplet (In excess of the outside pressure intensity)

d = Diameter of droplet.

a. Droplet



b. Surface tension



Let the droplet is cut into two halves.

The forces acting on one half will be tensile force and pressure force

The tensile force is due to surface tension acting around the circumference of the portion as shown in fig.

c. Pr. force

Tensile force = σ x carfumference

$= \sigma \times \pi d$

Pressure force on the area $\frac{\pi}{4}d^2 = p \times \frac{\pi}{4}d^2$

These two forces will be equal and opposite under equilibrium condition.

$$p \times \frac{\pi}{4} d^2 = \sigma \pi d$$

$$\boxed{p = \frac{4\sigma}{d}}$$

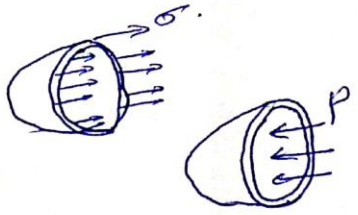
From the above equation it is clear that with the decreas of droplet diameter, pressure intensity inside the droplet increases.

Surface tension on a Hollow Bubble:

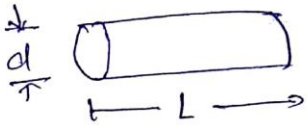
A hollow bubble like a soap bubble in air has two surfaces in contact with air, one inside and other outside. Thus two surfaces are subjected to surface tension.

$$p \times \frac{\pi}{4} d^2 = 2(\sigma \times \pi d)$$

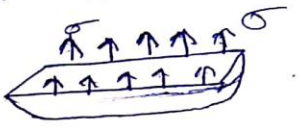
$$p = \frac{8\sigma}{d}$$



Surface Tension on a Liquid Jet



Pressure force = P x Area of semi jet
= P x L x d



Force due to surface Tension = $\sigma \times 2L$

Under equilibrium condition

Pr. force = Surface Tension force

$P L d = \sigma 2L$

$$P = \frac{2\sigma}{d}$$

The surface tension of water in contact with air at 20°C is 0.075 N/m. The pressure inside a droplet of water is to be 0.02 N/cm² greater than outside pressure. Cal. diameter of the droplet.

Given: $\sigma = 0.075$ N/m ; $P = 0.02$ N/cm² $= 0.02 \times 10^{+4}$ N/m²

$P = \frac{4\sigma}{d}$; $d = \frac{4\sigma}{P}$

$= \frac{4 \times 0.075}{0.02 \times 10^4}$

$= 0.00145$ m

$d = 1.45$ mm