SURFACE TENSION

AIM: To determine the surface tension of water using the 'break-away' method.

To Do:

1. Creating a liquid layer between the edge of a metal ring and the surface of the liquid.
2. Measuring the tensile force acting on the metal ring just before the liquid layer breaks away.
3. Determining the surface tension from the measured tensile force
4. To determine the density of material of ring.

APPARATUS USED:

Metal ring for measuring surface tension, Precision dynamometer 0.1N, Vernier caliper, Crystallization dish, Laboratory Jack, Distilled water

FORMULA USED:

Part A (Surface Tension):-

The surface tension of water is

$$\sigma = \Delta E / \Delta A = F/4\pi R$$

where R is the radius of the ring and

$F=F_2-F_1$

Weight of the ring F_1 = …..N

Tensile force just before the layer breaks away F_2 = ……N

Actual Tensile force with water $F = F_2 - F_1$ = ……N

Part B (for density of material of ring) :-

Density of material of ring $\rho_R = \frac{F'}{Vg} + \rho_L$

Where F' = Apparent weight

V = Volume of Ring

g = gravitational force

ρ_L = density of liquid, ρ_R = density of material of ring

PRINCIPLE:

Part A (Surface Tension):-

The surface tension is due to the fact that a molecule on the surface of a liquid is acted upon by attractive forces from adjacent molecules towards one side only (see Fig.1). The resultant force acting on the molecule points into the liquid and is perpendicular to the surface. In order to enlarge the surface, i.e, to take more molecules to the surface, energy has to be supplied. The ratio of the energy ΔE supplied at a constant temperature and the change the surface ΔA is called surface energy or surface tension of the liquid:

$$\sigma = \Delta E/\Delta A$$

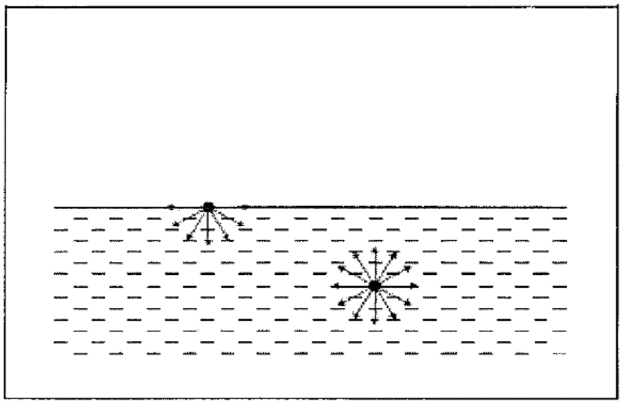

Fig.1: Forces exerted by adjacent molecules on molecules on the surface of a liquid and inside the liquid

The surface tension can be measured, e.g, by means of metal ring with a sharp edge which at first is immersed in the liquid so that it is completely wetted. If the ring is slowly taken out of the liquid, a thin liquid layer is pulled up (see Fig. 2). The outside and inside surface of the liquid changed is

$$\Delta A = 4\pi R\Delta x$$

R: radius of the metal ring. When the metal ring is lifted by Δx. Pulling up the ring requires the force

$F = \Delta E/\Delta x$ to be applied. If this force is exceeded, the liquid layer breaks away. Now the surface tension is

$$\sigma = \Delta E / \Delta A = F/4 \pi R$$

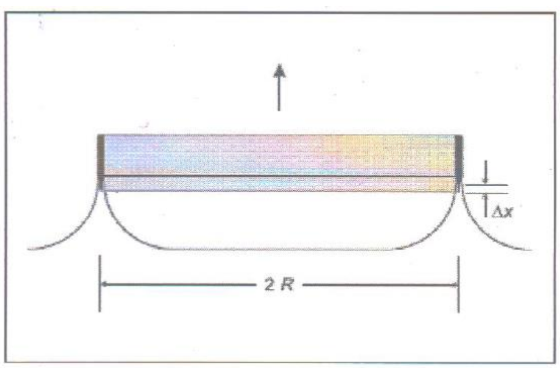

Fig. 2

Part B (for density of material of ring) :-

When an object is partially or fully immersed in a liquid it looses weight, the apparent loss in weight is equal to the weight of the liquid displaced by it.

Thus,

Volume of ring 'V' = π D h x

Where D = diameter of ring

h = height of ring; x = thickness of ring

Apparent weight = weight of ring – weight of liquid displaced

F' = F_1 – weight of liquid displaced

$F' = V \rho_R g - V \rho_L g$

$\frac{F'}{Vg} = \rho_R - \rho_L$

this gives $\rho_R = \frac{F'}{Vg} + \rho_L$; where ρ_R is the density of the material of ring and ρ_L = density of liquid.

SETUP PROCEDURE:

The experimental setup is illustrated in Fig.3.

1. Carefully clean the crystallization dish.
2. Carefully remove fat from the metal ring, e.g. with ethanol, and suspend it from the dynamometer. Suspend the dynamometer from the clamp with hook so that the ring hangs over the crystallization dish.
3. Set the laboratory stand to a height of approx.10cm.

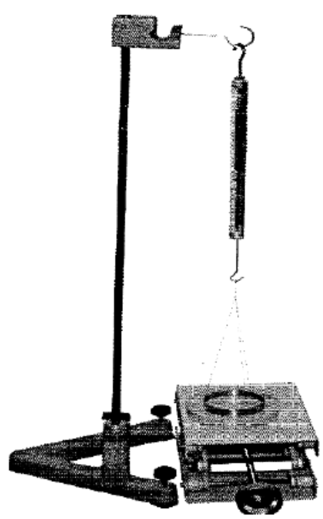

Fig. 3 Experimental setup

EXPERIMENTAL PROCEDURE:

Part A (Surface Tension):-

1. Determine the diameter of the metal ring.
2. Make the zero adjustment at the dynamometer using the movable tube.
3. Fill distilled water into the crystallization dish.
4. Lower the clamp with hook until the metal ring is completely immersed.
5. Cautiously lower the laboratory stand, always observing the tensile force at the dynamometer. As soon as the edge of the metal ring emerges from the liquid, the liquid layer is formed. When the tensile force does no longer increase although the laboratory stand is further lowered, the layer is just before breaking away.
6. Read the tensile force just before the layer breaks away, and take it down.
7. Pour the distilled water out, and dry the crystallization dish and the metal ring.

Part B (for density of material of ring) :-

1. Take water in a beaker to half filed.
2. Measure weight of ring in air.
3. Now completely immerse ring in water so that on further dipping no change in reading of dynamometer. Take the reading of dynamometer when completely immersed, say this value is *F'* (Apparent weight).
4. Measure the thickness of ring (x) with the help of screw gauge and height of ring (h) with Vernier callipers.

OBSERVATIONS:

Part A (Surface Tension):-

Diameter of the metal ring: 2R = 61.5mm

S.No.	Weight of the ring F_1 (N)	Mean F_1 (N)	Tensile force just before the layer breaks away F_2 (N)	Mean F_2 (N)	Actual Tensile force with water F = $F_2 - F_1$	Surface Tension (σ) = $F/4\pi R$ (mN/m)
1.						
2.						
3.						
4.						
5.						

Part B (for density of material of ring) :-

S.No.	Apparent Weight of the ring *F'* (N)	Mean *F'* (N)
1.		
2.		
3.		
4.		
5.		

Dynamometer reading when ring is completely immersed = *F'* = ……..*N*

Height of the ring (h):-

Least count of Vernier calliper = ………..cm.

S.No.	Main scale reading (cm)	Vernier scale reading (cm)	Total reading (cm)	Mean reading (cm)
1				
2				

Thickness of the ring (x):-

Least count of screw gauge = …….cm

S.No.	Main scale reading (cm)	Vernier scale reading (cm)	Total reading (cm)	Mean reading (cm)
1				
2				

EVALUATION:

Part A (Surface Tension):-

Experimental value of surface tension for water: σ = …..mN/m

Literature value for water at 25^0C: σ =72.5 mN/m

Part B (for density of material of ring) :-

Density of the material of ring = ………g/cm^3

RESULT:

Compared with other liquids, water distinguishes itself by a particularly high surface tension.

PRECAUTIONS:

1. Carefully clean the crystallization dish.
2. Carefully remove any dirt from the metal ring.
3. Suspend the dynamometer from the clamp with hook so that the ring hangs over the crystallization dish.
4. Cautiously measure the tensile force when the layer is just before breaking away.
5. When you finish experiment leave the dynamometer at zero force so that there is no tension in the spring.