

Dt = 30/12/19 Long question

## Cup and Bob viscometer

⇒ It is a rotational viscometer used for determination of both Newtonian & non-Newtonian fluids.

### Principle

The instrument consists of mainly 2 parts i.e. cup & bob.

⇒ In bet<sup>n</sup> the cup & bob the fluid to be determined is placed for viscosity determination.

⇒ The revolving cup is called mac-michael viscometer and revolving bob type is called Stommer - viscometer.

⇒ The equation for determination of viscosity can be expressed by

$$\eta = k_v \frac{w}{v} \quad (1)$$

where,  $w$  = weight placed on the hanger

$v$  = velocity in RPM

$\eta$  = apparent <sup>ity</sup> viscometer

$k_v$  = constant for the instrument.

Stomeric viscometer — (Rotating bob type)

The temperature is maintained in the instrument  
for maintenance of constant viscosity.

→ Procedure —

The instrument consists of a cup in  
which the bob is fitted.  
→ The bob is attached with the shaft by  
a spring.

→ In between the cup and bob the liquid in which  
viscosity will be determined is placed.

→ The shaft is attached with a weight  
so that the bob is rotated and the equation  
for the angular velocity for pseudoplastic flow  
can be expressed as

$$\Omega = \Omega_0 \cdot \frac{T}{4\pi\eta h} \left( \frac{1}{R_b^2} - \frac{1}{R_c^2} \right) \quad \text{--- (2)}$$

where,  $\Omega$  = angular velocity

$T$  = Torque

$h$  = Depth of the bob immersed in the  
liquid

$R_b$  = Radius of the bob

$R_c$  = Radius of the  
cup

For a constant instrument  $R_c$ ,  $R_b$  and  $h$  are  
constants which can be written as

so  $k_v$   
the eqn (2) can be rewritten as



$$\Omega = \frac{1}{\eta} \cdot k_v T \rightarrow (3)$$

by rearranging the eqn - we can get

$$\eta = \frac{k_v T}{\Omega} \quad (4)$$

T is equivalent to the weight put in hanger and  $\Omega$  is equivalent to  $\omega$  or rpm. This eqn (4) can be rewritten as

$$\eta = k_v \cdot \frac{\omega}{V}$$

### Plastic flow

→ In case of plastic flow of standard viscometer the plastic viscometer  $V$  will be

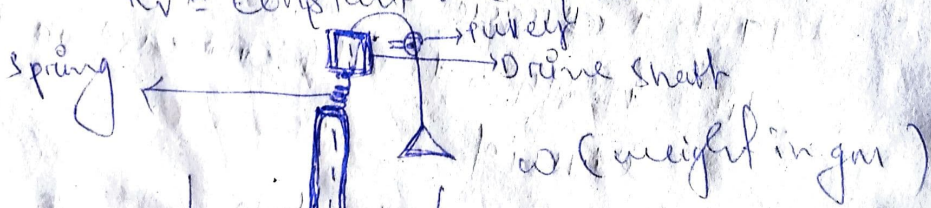
$$V = k_v \cdot \frac{\omega - \omega_f}{V}$$

where,  $\omega$  = weight at any point

$\omega_f$  = weight at yield value of weight

$V$  = angular velocity

$k_v$  = constant for instrument



Rotating bob

stationary cup

liquid in which viscosity to be determined (sample)

(Stanton viscometer)

## Plug flow

In case of plastic system, when the bob is made to rotate at lower rates of shear, the amount of stress exerted near wall of the bob is relatively high as compared to the stress at the inner wall of the cup.  
→ So the stress will be the less than the yield value and the material at the zone remains as the solid plug.

→ The plug flow can be minimized.

1. Using a largest bob by reducing gap.
2. By increasing the speed of the rotation so that the stress at the outer wall of the cup is the above the yield value.

## Cone and plate viscometer

- Cone and plate viscometer possesses several advantages
1. The rate of shear is constant so that the flow will not obscure.
  2. The sample required is small (0.1 to 0.2 ml)
  3. Cleaning & filling is easy.
  4. Less time is required for temperature equilibration.

Principle:

It is a rotational viscometer used for determination of either Newtonian or non-Newtonian flow.  
→ The sample is placed at the centre of the plate which is raised into the position under the cone.



→ The cone is driven by a variable speed motor and the sample is sheared in the narrow gap in bet<sup>n</sup> stationary plate and rotating cone.

→ The rate of shear is increased or decreased by a selector dial and the torque produced on the cone is read by an indicator scale.

### Newtonian system

In Newtonian system the viscosity can be measured by the following equation

$$\eta = c \cdot \frac{T}{V}$$

where,  $c$  = constant for the instrument

$T$  = Torque reading and  $V$  = rotation per minute in the cone

For plastic viscosity

### Plastic viscosity

$$\eta = c_f \cdot \frac{T - T_f}{V}$$

$$\text{yield value } f = c_f \times T_f$$

where,  $f$  = yield value in shearing stress

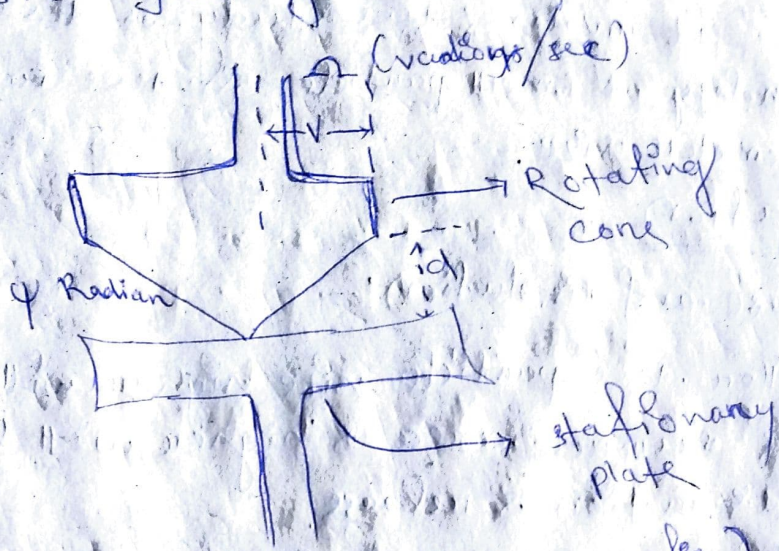
$c_f$  = constant for plastic flow

$T_f$  = yield value in terms of torque

$V$  = RPM on cone



$T =$  Torque at any point on ~~the~~ cone  
of plastic viscosity



(Cone & plate viscometer)