To Determine the Coefficient of Viscosity of a Given Viscous Liquid by Measuring Terminal Velocity of a Given Spherical Body

Aim

To determine the coefficient of viscosity of a given viscous liquid by measuring terminal velocity of a given spherical body.

Apparatus

A half metre high, 5 cm broad glass cylindrical jar with millimetre graduations along its height, transparent viscous liquid, one steel ball, screw gauge, stop clock/watch, thermometer, clamp with stand.

Theory

Terminal velocity, $$v = \frac{2}{9}\frac{r^2(\rho - \sigma)g}{\eta}$$

or $$\eta = \frac{2}{9}\frac{r^2(\rho - \sigma)g}{v}$$

Knowing r, ρ and σ, and measuring v, η can be calculated.

Diagram

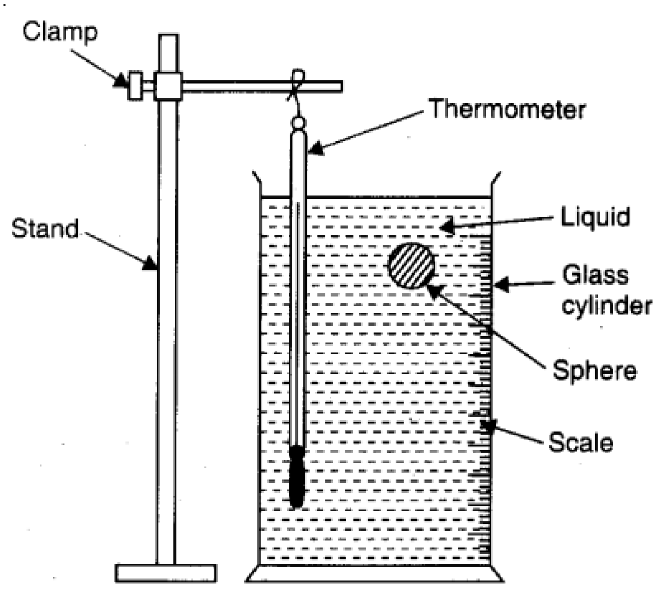

Fig. Small sphere falling in a long glass cylindrical jar.

Procedure

1. Clean the glass jar and fill it with the viscous liquid, which must be transparent.
2. Check that the vertical scale along the height of the jar is clearly visible. Note its least count.
3. Test the stop clock/watch for its tight spring. Find its least count and zero error (if any).
4. Find and note the least count and zero error of the screw gauge.
5. Determine mean radius of the ball.
6. Drop the ball gently in the liquid. It falls down in the liquid with accelerated velocity for about one-third of the height of liquid. Then it falls with uniform terminal velocity.
7. Start the stop clock/watch when the ball reaches some convenient division (20 cm; 25 cm ;………..). Note its fall.
8. Stop the stop clock/watch just when the ball reaches lowest convenient division (45 cm).
9. Find and note the distance fallen and time taken by the ball.
10. Repeat steps 6 to 9 two times more.
11. Note and record temperature of the liquid.
12. Record your observations as given ahead.

Observations

Least count of vertical scale	=	1 mm.
Least count of stopclock/watch	=	…… s.
Zero error of stopclock/watch	=	…… s.
Pitch of the screw gauge (p)	=	1 mm.
Number of divisions on the circular scale	=	100
Least count of screw gauge (L.C.)	=	$\frac{1}{100}$ = 0.01 mm.
Zero error of screw gauge (e)	=	…… mm.
Zero correction of screw gauge (c)	=	$(-e)$ = …… mm.

Diameter of spherical ball

(i) along one direction, D_1 = ……. mm

(ii) In perpendicular direction, D_2 = …… mm

Terminal velocity of spherical ball

Distance fallen S = …… cm

Time taken, t_1 = …… s

t_2 = …… s

t_3 = …… s

Calculations

Mean diameter $D = \frac{D_1 + D_2}{2}$ mm

Mean radius $r = \frac{D}{2}$ mm = ... cm

Mean time $t = \frac{t_1 + t_2 + t_3}{3}$ = ... s

Mean terminal velocity, $v = \frac{S}{t}$ = ... cm s^{-1}

From formula, $\eta = \frac{2r^2 (\rho - \sigma) g}{9v}$ = ... C.G.S. units.

Result

The coefficient of viscosity of the liquid at temperature (θ°C) =…….C.G.S. units.

Precautions

1. Liquid should be transparent to watch motion of the ball.
2. Ball should be perfectly spherical.
3. Velocity should be noted only when it becomes constant.

Sources of error

1. The liquid may not have uniform density.
2. The ball may not be perfectly spherical.
3. The noted velocity may not be constant.

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Question. 1. Why liquid taken must be transparent ?
Answer. It is so because the motion of ball must be visible in the liquid.

Question. 2. How does the viscosity of liquid and gases change ?
Answer. The viscosity of liquid decreases with increase in temperature while that of gases increases with increase in temperature. The viscosity of liquid increases with increase of pressure. The viscosity of gases does not change with pressure.

Question. 3. Why does a hot water move faster than cold water ?
Answer. It is because that viscosity of hot water is smaller than cold water.