Wroclaw University of Science and Technology

GENERAL PHYSICS
LABORATORY REPORT

Theme of class: DETERMINATION OF VISCOSITY
OF FLUID BY STOKES'LAW

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1 Introduction

1.1 Theory

An equation known as Stokes' Law expresses the drag force that a spherical object encounters when travelling through a fluid at a constant speed. The drag force is influenced by a number of variables, including the size of the object and the fluid's viscosity.

A fluid's viscosity is a gauge of how difficult it is for it to flow. Fluids with greater viscosities tend to be thicker and more flow-resistive, whereas fluids with lower viscosities tend to be thinner and less flow-resistive. By measuring the drag force a sphere experiences as it moves through a fluid at a constant speed, Stokes' Law offers a way for calculating a fluid's viscosity. The equation links the gravitational constant, the fluid's viscosity, the object's velocity, and its radius to the drag force that an object experiences.

Stokes' Law is frequently utilized in a wide range of scientific and technical applications, including the analysis of sedimentation rates in geological processes, the research of fluid dynamics, and the design of pumps and turbines. By accurately measuring the viscosity of a fluid using Stokes' Law, scientists and engineers can gain valuable insights into the behavior of fluids in various contexts, leading to improved designs and processes in a wide range of industries.

1.2 Equipment

The equipment used in this experiment included:

- Cylindrical tank with examined fluid
- Aerometer
- Set of balls
- Scales
- Micrometric screw
- Ruler with millimeter scale
- Stopwatch

2 Experiment

Data

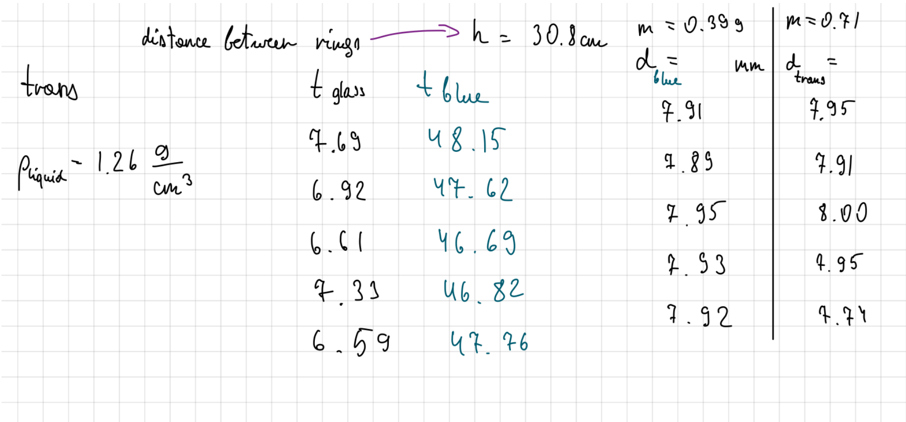

Figure 1: Experiment data

lp.	m [kg]	d [m]	h [m]	t [s]
1	0.000399	0.00791	0.308	48.15
2		0.00789		47.62
3		0.00795		46.69
4		0.00793		46.82
5		0.00792		47.76
X		0.00792		47.408
Δ_p	0.0000001	0.00001	0.001	0.01
ua(X)		0.00001		0.2812
ub(X)	0.000000058	0.0000058	0.00058	0.0058
u(X)	0.000000058	0.0000116	0.00058	0.2813
uc(X)				
n	0.1367207265			
u(n)	0.0012			
uc(X)				
η	0.1367207265			
u(η)	0.0012			
	ρk[kg/m$\hat{2}$]	ρc[kg/m$\hat{3}$]	η[Ns/m$\hat{2}$]	
	1533.905938	1260	0.1385153566	
			0.1362988097	
			0.1356771765	
			0.1353712533	
			0.1377410366	
uc(X)	6.8		0.0096	

Table 1: Blue ball

lp.	m [kg]	d [m]	h [m]	t [s]
1	0.00071	0.00795	0.308	7.69
2		0.00791		6.92
3		0.008		6.61
4		0.00795		7.33
5		0.00774		6.59
X		0.00791		7.028
Δ_p	0.0000001	0.00001	0.001	0.01
ua(X)		0.00005		0.2131
ub(X)	0.000000058	0.0000058	0.00058	0.0058
u(X)	0.000000058	0.0000504	0.00058	0.2132
uc(X)				
n	0.0202312096			
u(n)	0.0013			
u(η)	0.0013			
	ρk[kg/m$\hat{2}$]	ρc[kg/m$\hat{3}$]	n[Ns/m$\hat{2}$]	
	2739.872011	1260	0.02234648719	
			0.01990708759	
			0.01945046997	
			0.02130035775	
			0.01815164552	
uc(X)	12.1		0.0379	

Table 2: Blue ball

2.1 Formulas

Calculating the average time of ball falling:

$$\bar{t} = \frac{t_1 + t_2 + \cdots + t_{10}}{10}$$

Calculating the average diameter of the ball:

$$\bar{d} = \frac{d_1 + d_2 + \cdots + d_{10}}{10}$$

Calculating the density of the ball:

$$\rho_k = \frac{6m}{\pi d^3}$$

Calculating the average coefficient of viscosity:

$$\eta = \frac{d^2 gt(\rho_k - \rho_c)}{18h}$$

Calculating the uncertainty of the mass measurement:

$$u(X) = \frac{\Delta_p}{\sqrt{3}}$$

$$u(m) = \frac{0.0000001}{\sqrt{3}} \approx 5.8 \times 10^{-8} \text{ kg}$$

Calculating the uncertainty of the density measurement:

$$u_c(\rho_k) = \sqrt{\left(\frac{6}{\pi d^3} u(m)\right)^2 + \left(\frac{-18m}{\pi d^4} u(d)\right)^2}$$

Calculating the uncertainty of the coefficient of viscosity:

$$u_c(\eta) = \sqrt{\left(\frac{2dgt(\rho_k - \rho_c)}{18h} u(d)\right)^2 + \left(\frac{d^2 g(\rho_k - \rho_c)}{18h} u(t)\right)^2}$$

2.2 Calculations

Calculations

$$\bar{t} = \frac{t_1 + t_2 + t_3 \ldots t_5}{5} = \frac{48.15 + 47.62 + \ldots + 47.76}{5} = 47.408 \text{ s}$$

$$u_A(\bar{t}) = \sqrt{\frac{(47.408 - 48.15)^2 + \ldots (47.408 - 47.76)^2}{5(5-1)}} = 0.2131$$

$$u_B(\bar{t}) = \frac{0.01}{\sqrt{3}} = 0.0058$$

$$u(t) = \sqrt{0.0058^2 + 0.2131^2} = 0.2132$$

$$u_c(\rho_k) = \sqrt{\left(\frac{6}{\pi \cdot 0.00751^3} \cdot 0.000000058\right)^2 + \left(\frac{-18 \cdot 0.00071}{\pi \cdot 0.00751^4} \cdot 0.0000504\right)^2} = 52.4$$

3 Conclusion

Before starting the measurements, we examined the values of the given three balls. We measured the diameter for each ball, weighed each ball using an electric scale, and calculated the density of the liquid.

Based on the obtained measurements, we calculated the coefficient of viscosity for each ball. Using a stopwatch, we timed the duration for which the ball fell in a cylindrical vessel with the tested liquid. We used the formulas provided (given above).

In conclusion , the laboratory experiment on determining the viscosity of a fluid using Stokes' Law has provided valuable insights into the behavior of fluids and the motion of spherical bodies within a continuous medium. Through careful observation and analysis of the falling motion of various spherical bodies, we were able to understand the fluid's resistance and calculate its viscosity using Stokes' Law.