MEASUREMENT OF VISCOSITY BY THE STOKES METHOD

OBJECT

- To measure coefficient of the dynamic viscosity of the glycerine and ricine oil with a Stokes viscometer.
- Evaluate the error of measurements.
- Compare your results to the accepted value.

THEORY

Viscosity is a measure of the resistance of a fluid which is being deformed by either shear stress or tensile stress. Viscosity describes a fluid's internal resistance to flow and may be thought of as a measure of fluid friction. For example, high-viscosity felsic magma will create a tall, steep stratovolcano, because it cannot flow far before it cools, while low-viscosity mafic lava will create a wide, shallow-sloped shield volcano. All real fluids (except superfluids) have some resistance to stress and therefore are viscous, but a fluid which has no resistance to shear stress is known as an ideal fluid or inviscid fluid.

Viscosity coefficients can be defined in two ways:
Dynamic viscosity, also absolute viscosity, the more usual one. The SI physical unit of dynamic viscosity is the pascal-second (Pa·s), (equivalent to N·s/m^2, or kg/(m·s)). The usual symbol for dynamic viscosity used by mechanical and chemical engineers — as well as fluid dynamicists — is the Greek letter mu (μ).
Kinematic viscosity is the dynamic viscosity divided by the density (units m^2/s).

Accepted values of the dynamic viscosity of some selected liquids and gases for temperature of 20ºC and pressure 1.10^5 Pa.

Liquid	mPa.s	Gas	µPa.s
Glycerine	1480	Neon	32.1
Ricine oil	989	oxygen	20.8
Mercury	1.554	air	18.6
Water	1.002	hydrogen	9.0

Stokes viscometer.
Viscosity is measured with various types of viscometers. The theory of the Stokes viscometer is based on the study of the free fall of the ball in investigated liquid.
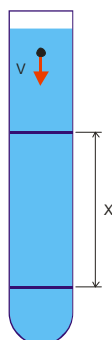
The Stokes viscometer is usually a transparent cylinder filled with the investigated liquid in which we measure the time of the free fall of the ball between two marks. The ball is made from the suitable material, e.g. iron or steel.

For calculation of the viscosity we use a formula:

$$\mu = \frac{2}{9} g r^2 \left(\rho_{ball} - \rho\right)\frac{\Delta t}{\Delta L},$$

where g is acceleration due to the gravity, r is the radius of the ball, ρ_{ball} is the density of the material of the ball, ρ is the density of the investigated liquid, Δt is the time of the free fall of the ball between the two rings placed at the distance ΔL.

(Density of the glycerine $\rho = 1261$ kg/m^3, density of the ricine oil $\rho = 960$ kg/m^3, density of the balls $\rho_{ball} = 7860$ kg/m^3).

PROCEDURE
The method of measurement is the same for both glycerine as well as for ricine oil.
- Place 12 balls into the Petri dish. Measure the diameter of each ball.
- Determine the probable mass of the Petri dish together with the balls, using the balance weigh.
- Determine the mass of the balls using the analytical weigh in such a way that first of all you will weigh the mass of the Petri dish with the balls and then the mass of the dish without the balls.
- On the walls of the measuring cylinders are placed two rubber rings between you will measure the time of the fall of the balls in the liquid. Adjust the distance between these rubber rings in such way that the upper ring will be placed at least 5 cm below the surface of the liquid.
- Using the stopwatch measure the time of the fall of each ball between the upper and lower rubber rings. Eliminate the smallest and the biggest values.
- Using the densitometer measure the density of each liquid.
- Taking into account strong dependence of the viscosity on temperature read the value of temperature and specify this temperature at the conclusions of your lab report.
- Compare your results of the measurement of the viscosity with the accepted values.

Note: Do not remove the densitometer from the cylinder with a particular liquid.

SEMESTER WORK INSTRUCTIONS

Input parameters of the program: diameter of the sphere, material (density) of the sphere, medium around the sphere (density + viscosity), initial velocity of the sphere when entering the medium.
Output of the program: graph of the time dependence of the sphere position, velocity and acceleration.