**Physics Laboratory – Report-5**

Experiment: 8

**DETERMINATION OF VISCOSITY OF FLUID BY STOKES' LAW**

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**Laboratory Equipment**

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

**Introduction;**

This report discusses the methods with which the viscosity of liquid glycerin is determined, and uses the data to validate Stokes’ Law.  Two experiments were performed: the viscosity of glycerin was determined using a rotational viscometer, and the data used to validate Stokes’ Law was collected using a falling ball viscometer.  Results showed that either method showed significant error and did not validate Stokes’ Law; though the revised Stokes’ Law equation gave much more accurate results for the viscosity determined from the falling ball viscometer.

**Viscosity;**

The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress. For liquids, it corresponds to the informal concept of "thickness"; for example, honey has higher viscosity than water.

Viscosity is a property of the fluid which opposes the relative motion between the two surfaces of the fluid that are moving at different velocities. It is related with the friction between the molecules of fluid. When the fluid is forced through a tube, the particles which compose the fluid generally move more quickly near the tube's axis and more slowly near its walls; therefore, some stress (such as a pressure difference between the two ends of the tube) is needed to overcome the friction between particle layers to keep the fluid moving. For a given velocity pattern, the stress required is proportional to the fluid's viscosity.

A fluid that has no resistance to shear stress is known as an ideal or inviscid fluid. Zero viscosity is observed only at very low temperatures in superfluids. Otherwise, all fluids have positive viscosity and are technically said to be viscous or viscid. A fluid with a relatively high viscosity, such as pitch, may appear to be a solid.

**References;**

* <https://www.odinity.com/stokes-law-reynolds-number-measuring-liquid-viscosity/>
* <https://physics.info/viscosity/summary.shtml>

**Calculations**;

1. Calculate the mean diameter *d̅* of each ball and the measurement uncertainty *u(d̅)*.

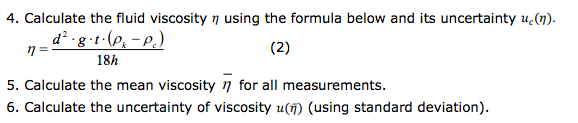
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| (mm) | blue(mm) | white(mm) | black(mm) | grey(mm) |
| 1 | 7.94 | 7.93 | 5.93 | 5.95 |
| 2 | 7.95 | 7.94 | 5.91 | 5.95 |
| 3 | 7.93 | 7.96 | 5.99 | 5.96 |
| 4 | 7.94 | 7.93 | 5.92 | 5.96 |
| 5 | 7.71 | 7.97 | 5.93 | 5.95 |
| 6 | 7.69 | 7.98 | 5.92 | 5.95 |
| mean | 7.86 | 7.95 | 5.93 | 5.95 |

2. Calculate the mean falling time t̅between rings for each ball and measurement uncertainties u(t̅).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| time(s) | blue(s) | white(s) | black(s) | grey(s) |
| 1 | 25.2 | 12.3 | 13.81 | 8.49 |
| 2 | 24.93 | 11.86 | 13.82 | 8.55 |
| 3 | 25.89 | 12.4 | 13.48 | 8.59 |
| 4 | 24.97 | 12.48 | 13.01 | 8.05 |
| 5 | 24.57 | 11.9 | 13.31 | 8.34 |
| 6 | 25.06 | 12.1 | 13.88 | 8.17 |
| 7 | 24.76 | 12.59 | 13.38 | 8.3 |
| 8 | 25.08 | 12.19 | 13.52 | 8.5 |
| 9 | 24.98 | 12.22 | 13.34 | 8.2 |
| 10 | 24.67 | 12.47 | 13.73 | 8.41 |
| average | 25.011 | 12.251 | 13.528 | 8.36 |
| unc(t) | 0.999 | 0.672 | 0.766 | 0.491 |

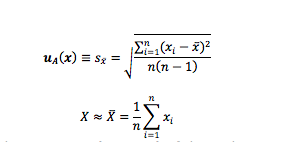
3. Calculate each ball density ρk and their uncertainty uc(ρk).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| (mm) | blue(mm) | white(mm) | black(mm) | grey(mm) |
| unc(d) | 0.253 | 0.043 | 0.058 | 0.010 |



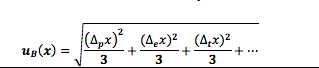
**Uncertainties**

The formula for uncertainty type A (standard deviation):



Calculated using Excel formula “stdev()” for each variable.

The formula for uncertainty type B:



Where we only considered the calibration uncertainty (e.g. uncertainty of used instrument)

Summation of A and B are done by:

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Uncertainty of density:



Translates to:

**Conclusion;**

**Discussion**

The purpose of this exercise is to determine the uncertainty of the results. We can observe that for the measured parameters the value of uncertainty is much smaller than measured. What is important this is true for both calliper and micrometer. In case of volume, its quantity is calculated by use of determined diameter, The uncertainty is smaller more than 100 times to. And finally for density – its value is determined by volume and mass – the uncertainty is exactly the same like the result. We can assume that the uncertainty is relatively bigger for parameters which are determined by combination of measured values that already consist of some uncertainty.

**Results and the Uncertainty**

We found the density of the material to be 2685.25 ± 114.57 [kg/m^3]. Using the method outlined in the calculations sections.

Afterwards the uncertainty that we found for density is expended by “k=2” due to the formula:

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