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A New Experimental set up for Verification of Newtons Law of Viscocity for different fluids.

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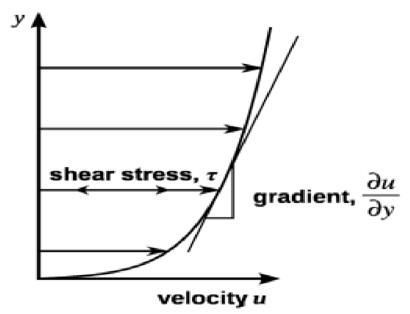
Abstract: An experimental setup has been developed for theverification of newtons law viscocity. This experiment confirms direct proportionality between shear stress and the rate of shear strain. Different fluids with known value of viscocity such as glycerien, honey, water, engine oil etc were tested for charecterization.Results shown that honey shows the non newtonian behaviour and glycerian and unburnt engine oil shows the newtonian behaviour. Fluid mechanics is the study of fluids either in motion or at rest for both liquids and gases. There is a theory available for fluid flow problems and it should be backed up by experiment. As there are the various experimental setup for verifying the different laws in fluid mechanics, but there is no setup to verify Newton's law of viscosity. Here we propose the experimental setup for verification of Newton's law of Viscosity.
Keywords: Viscocity, shear stress, shear strain, honey, glycerien, engine oil.

I. INTRODUCTION

Viscosity is the physical property that characterizes the flow resistance of simple fluids (1). Newton's law of viscosity defines the relationship between the shear stress and shear rate of a fluid subjected to a mechanical stress. The ratio of shear stress to shear rate is a constant, for a given temperature and pressure, and is defined as the viscosity or coefficient of viscosity. Newtonian fluids obey Newton's law of viscosity. The viscosity is independent of the shear rate. Non-Newtonian fluids do not follow Newton's law and, thus, their viscosity (ratio of shear stress to shear rate) is not constant and is dependent on the shear rate.Dynamic viscosity is the coefficient of viscosity as defined in Newton's law of viscosity. Accurate descriptions of viscosity have a broad range of applications, from the characterization of blood flow as it relates to corollary heart disease to optimizing lubricants for mechanical systems.(2) Newton's Law of viscosity state that "The shear stress on fluid element layer is directly proportional to the rate of shear strain"

$$\tau = \mu . \frac{du}{dy}$$

Where, τ = Shear stress developed across layers of fluid
μ= Cofficient of dynamic viscocity,
du= change in velocity
dy =distance between fluid layers
du/dy is also called as rate of shear strain



Viscosity, $\tau=\mu\frac{du}{dy}$

Where,

μ=Dynamic Viscosity

τ=Shear stress=F/A

$\frac{du}{dy}$=Rate of sheardeformation

Fig1: Shear stress Vs Rate of shear Strain

For introductory courses students, it is well known the Newtons' law of viscocity . However, usually, this law is introduced in its final form without any demonstration or experimental verification. (3) The importance of the phenomena related to this law substantiates the existence of a specific experiment to study it. We propose here a simple experimental setup for verifcation of this law. By using the proposed experimental setup shear stress developed across intermidate fluid layers and rate of shear strain can be calculated. if fluid is newtonian fluid then calculated shear stress and rate of shear strain will be nearly equal.

II. PROPOSED SETUP

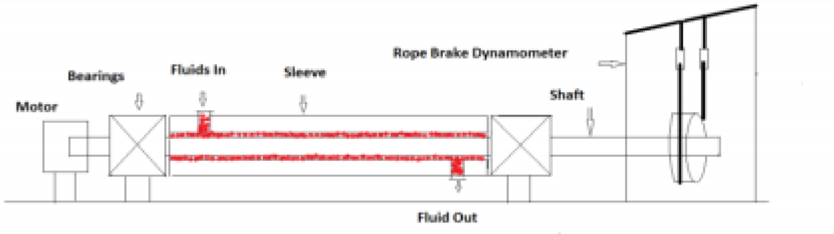


Fig2: Proposed experimental setup

The shaft passes through the metal sleeve and supported by the bearing, as the one end of the shaft is coupled to the motor and other end is passes through pulley of dynamometer. The sleeve has two knobs, one is opening knob and other is closing. The sleeve if filled with certain fluid and close both knobs. As the dc source given to the motor the shaft starts rotating and the fluid in contact with shaft get displace. Because of rotation of shaft it exerts shear force on fluid and the speed is to be measure by using tachometer. At the dynamometer a specific load is applied to stop the rotation of shaft and measure required load to stop the shaft. This operation should carry at different speed and to check how much torque is require restricting shaft rotation. As shown in fig the one end of shaft is connected to the motor spindle. The sleeve is provided between the two bearings. The bearings are provided for support the shaft. The inlet port is provided at the upper side of sleeve and the two outlet port is provided at the bottom side of the sleeve. At the other end of shaft the rope break dynamometer is provided for measurement of the torque.

Different fluids with known values of viscocities such as honey,glycerien, engine oil etc were tested. Firstly a dry run is conducted and corresponding shaft power is measured. Then fluid is introduced and setup is run for different speeds. At every speed again the shaft power is measured. This value of power is compared with dry run shaft power and corresponding power lost is calculated. RPM of shaft is measured by using tachometer and from power lost corresponding torque hence the force is calculated. by dividing the force by shear area, shear stress τ is calculted.

Now in order to calculate the rate of shear strain (du/dy), du i.e change in velocity rotational speed of shaft is converted into linear speed and as covering sleeve is fixed, the change in velocity is obtained by zero from the linear velocity. dy is the difference between shaft and fixed sleeve which is 0.0045m.Multiplying by value of viscocity of fluid under study, rate of shear strain can be calculated.

If fluid shows the newtonian behaviour,then LHS ie shear stress τ and shear strain calculated (RHS) will be nearly same. Which is the experimental verification of newtons law of viscocity.

III. OBSERVATION

Thus the experiment is carried out on the various fluid such as Water, Honey,Glycerine,unburned Engine oil on the experimental setup. Following observations were recorded.

Sr No	Fluid tested	Speed (RPM)	Spring load (kg)	Dead Load (kg)	Torque (N-m)	Power (W)	Power Lost (W)
1.	Dry Run	600	2	0.3	1.666	105.85	--
2.		700	2.5	0.5	1.96	143.82	--
3.		800	3.2	0.7	2.4	205.46	--
4.		900	4.5	0.8	3.6297	342.091	--
5.	Honey	600	1.2	0.2	0.98	61.63	44.21
6.		700	1.5	0.3	1.17	86.29	57.52
7.		800	3	1	1.962	169.36	97.098
8.		900	4	1	2.943	277.33	64.71
9.	Glycerien	600	1.5	0	1.4715	92.45	13.39
10.		700	2	0.3	1.66	122.24	21.57
11.		800	3	0.7	2.2563	189.02	16.93
12.		900	4	0.5	3.4335	323.59	18.49
13.	Unburnt	600	2	0.5	1.4715	92.45	13.39

14.	engine oil	700	2	0.3	1.66	122.24	21.57
15.		800	3	0.8	2.1582	180.804	24.65
16.		900	4	1	2.943	277.37	64.71

The shear stress τ and rate of shear strain developed for each fluid is calculated and tabulated as below.

Name of fluid	Speed	Shera Stress (N/m2)	Rate of Shear Strain
Honey	600	372.95	686.40
	700	415.92	800.80
	800	260.24	915.14
	900	364.19	1029.31
Glycerien	600	113.05	132.64
	700	156.10	154.74
	800	104.03	176.84
	900	104.03	198.95
Unburnt engine oil	600	113.05	116.98
	700	156.10	135.96
	800	156.07	155.88
	900	364	175

IV. CONCLUSION

A completely new type experimental setup is developed for the verification of Newtons law of viscocity. Three fluids namely Honey, glycerien and engine oil were tested.from the experimentation it was observed that glycerien and engine oil shows the newtonian behaviour as the values of shear stress and Rate of shear strain are coming near about same for various speeds And honey showed the non newtonian behaviour because values of shear stress and rate of shear strain, both the sides of equation become unequal so that Honey shows the Non-Newtonian behavior.

The setup is easy to operate, it can easily Determine the type of fluid either Newtonian or Non Newtonian This setup can be used for testing of various fluids. It can also be used to determine the viscocity of unknown fluids.

Actual Experimental Setup developed.

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