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A SIMPLE VISCOMETER FOR ABSOLUTE MEASUREMENTS.*

BY E. MONESS AND P. M. GIESY.

The laws of flow of liquids through capillaries have been worked out by Poiseuille and the formula as given by Bingham[1] is: $\eta = \dfrac{\pi g p R^4 t}{8\,Vl} - \dfrac{m\rho V}{8\pi l t}$ where η is the viscosity, V the volume of flow in the time t, l and R respectively the length and radius of the capillary, g the acceleration of gravity, p the pressure in grams per sq. cm., ρ the density of the liquid and m a constant equal to 1.12.

Many of the viscometers used in industry, among these being the Saybolt, are based on simply allowing a definite quantity of liquid to flow from a standard container through a standard opening, the assumption being that the time of efflux of the liquid is a measure of its viscosity. The opening is usually a short tube to which the laws of flow above stated are not applicable, and the flow is allowed to take place by gravity thus giving a variable pressure as the flow proceeds. Such measurements are not capable of giving even relative viscosities of liquids, since the time of flow depends not only on the viscosity but also on the density of the liquid. If we wish to get absolute values for viscosity, the measurement must be made under conditions which yield data susceptible to mathematical treatment, according to the laws for the flow of liquids.

We have designed a rather simple viscometer[2] in which the liquid is allowed to flow through a capillary of known dimensions, and in which the pressure is kept constant throughout the run due to a constant hydrostatic head.

Figure 1 shows its construction. An inverted 8 L. bottle from which the bottom has been cut is used as the water-bath. A tube about 1 inch in diameter and about 10 inches long serves as the container for the viscous liquid. The upper end of the tube is closed by a rubber stopper through which passes an air tube, while the lower end is similarly closed by a rubber stopper through which passes the capillary, ending flush with the surface of the stopper. The lower end of the capillary passes through the rubber stopper closing the neck of the water-bath, and protrudes only about 2 mm. beyond the stopper. The air-tube has a piece of rubber tubing attached to the upper end, closed by means of a pinch cock.

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[1] "Fluidity and Plasticity," p. 18 (1922).

[2] Allen (*J. Soc. Chem. Ind.*, 1886, 131) and Schmid (*Chem.-Ztg.*, 1885, 1514) had designed viscometers in which flow took place under a constant head, but neither used a capillary tube for the flow, this taking place in Allen's viscometer from an orifice, and in Schmid's through a tube.

The container is filled about three-quarters with the viscous liquid and closed with the rubber stopper. By opening the pinch cock for a moment the capillary is filled with the liquid and the air-tube with air. The temperature is next adjusted to the desired point, a 60-cc. receiving flask such as is used with the Saybolt viscometer is placed under the opening of the capillary, and the pinch cock is opened. At this moment the time is taken, air enters from the air-tube and the liquid flows through the capillary into the receiving vessel. As long as the viscous liquid has not reached the bottom of the air-tube the flow takes place under a constant head, and, of course, enough liquid must be present to fill the receiving vessel before this occurs. The time is again taken when the receiving vessel is filled to the mark. It will be seen that all the necessary data for the calculation of the viscosity according to the formula mentioned above are thus obtained.

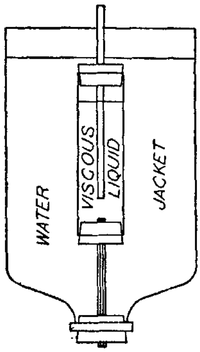

Fig. 1. Viscometer.

That the apparatus works in accordance with the formula will be evident from the following calibrations:

A run was made at 0° C. with a 37% by weight mixture of alcohol and water, which has a fluidity of 13.9 rhes. The distance between the upper end of the capillary and the lower end of the air-tube was 3.8 cm., the length of the capillary was 16.8 cm., and the temperature 0° C. The time was found to be 321 seconds for a volume of 60 cc.

Substituting in Bingham's equation the values:

$\eta = 1/13.9$	$p = (3.8 + 16.8)\ 0.9452$	$l = 16.8$
$\rho = 0.9452$	$t = 321$	$m = 1.12$
$g = 980$	$V = 60$	

we obtain for R, 0.742 mm.

A check calibration by weighing the mercury thread gave 0.745 mm. The former value is of course to be preferred, since it takes in all variations of the capillary from a true cylinder.

That the viscometer gives consistent results is seen from the following:

With a distance between the upper end of the capillary and the end of the air-tube = 3 inches, the length of the capillary = 18 cm., the diameter = 1.817 mm., and the temperature 100° F., two check runs made with liquid petrolatum gave results of 969 and 972 seconds for 60 cc.

Under the same conditions, except that the temperature was kept at 0° C., two runs on a 37% by weight mixture of alcohol and water gave results of 133 and 134 seconds.

SUMMARY.

A viscometer is described which is cheap, easily constructed, and sound in principle, and which will give absolute results for viscosity.

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