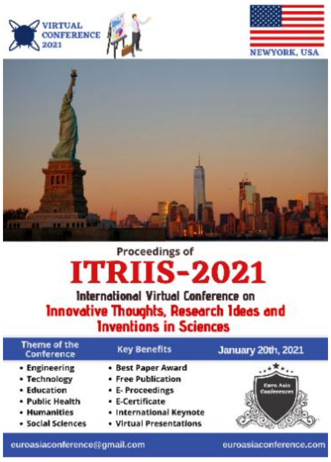

MEASUREMENT OF DYNAMIC VISCOSITY COEFFICIENT OF FLUIDS

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Abstract

In this thesis, measurement of dynamic viscosity coefficient that is one of the most important parameters of liquids is discussed. Unless there are some methods to measure dynamic viscosity coefficient Stock's method is one of the popular method in laboratory conditions. Authors showed the experimental and calculation ways of that method in the thesis.

Introduction

The use of special lubricating coolants in the cutting process – lubricating cooling liquid conditions increases the stability of the cutting tool, reduces cutting forces, improves the quality of the finished surface, increases the operational durability of the product, increases labor productivity, et c[8]. Dynamic viscosity coefficient is one of the most essential and influential properties of lubricating cooling liquids. Change on dynamic viscosity coefficient of lubricating cooling liquids effect the cutting process. Some papers have published about the effect of magnetic field on viscosity coefficient of liquids and it important to measuring dynamic viscosity coefficient of magnetized liquids [1, 6].

When one layer of all real fluids moves relative to another, more or less friction occurs. The accelerating force acts on the slower moving layer by the faster moving layer and, conversely, the slowing down force acts on the faster moving layer by the slower moving layer [6]. These forces, called internal friction forces, which are directed along the surface of the interacting fluid layer. The surface area ∇S of the layer we are examining is much larger, the internal friction force f is such greater, and depends on how fast n the flow velocities between these layers change. If assuming that two layers which distance of them are ∇Z (Fig. 2) flow with velocities respectively ϑ_1 and ϑ_2, the velocity difference is $\vartheta_1 - \vartheta_2 = \Delta v$.

The distance between the layers is taken in the direction, which is perpendicular to the flow rate. The magnitude of the change in velocity, which move from one layer to another, is called the velocity gradient [2-5].

The internal friction force f is proportional to the velocity gradient $\Delta\vartheta/\Delta Z$ b and the friction surface S.

$$\Delta f = \eta \frac{\nabla \vartheta}{\nabla Z} \nabla S \qquad (1)$$

The magnitude η that depends on the properties of the liquid is called the internal friction coefficient or viscosity coefficient of the liquid. If take from formula (1) $\frac{\nabla \vartheta}{\nabla Z}=1$ and S= 1, we get r=f. This means that the coefficient of adhesion is numerically equal to the frictional force, which a velocity gradient is 1 and prepared between the layers on a unit surface. The viscosity coefficient depends on the properties and temperature of the liquid [7]. As the temperature rises, the viscosity decreases. The unit of viscosity in the SGS system is P (poise), which is the coefficient of internal friction acting on a 1 sm^2 surface. To follow the size of viscosity (1) will be:

$$[\eta] = -\left[\frac{f}{\frac{\Delta \vartheta}{\Delta Z} \cdot \Delta S}\right] = L^{-1} M T^{-1} \qquad (2)$$

The water viscosity, which depends on the temperature, is as follow: in 0° S η=0.1775 poise, in 20,5^{0}C, η=0.01

If an object moves in a non-sticky liquid, the liquid will not resist its movement. Resistance occurs only when the body moves in a viscous environment. The fluid follows the body and moves more slowly. As a result, frictional forces are created between the layers of fluid.

In this experiment, steel or lead balls with a diameter of about 1-2 mm are used as a solid. These spherical balls are thrown into the liquid one by one.

If all the sides of a ball are in contact with a liquid (without gas bubbles around it) and fall behind it at a small speed without forming a vortex, the gravitational force which is exerted by the liquid is found according to Stokes' law.

$$f = 6\pi \cdot \eta \cdot \vartheta \cdot r \qquad (2)$$

Where,

η - Coefficient of viscosity or internal friction

ϑ - The falling velocity of the ball

r - The radius of the ball

Three forces affect a ball moving in a viscous liquid; 1) gravitational force P, the lifting force of a liquid according to Archimedes' law $\vec{f}$, the force of internal friction $\vec{f}_2$. These three forces are directed in a straight line (gravity downwards, fluid lifting force and resistance upwards). As the falling velocity of the ball decreases (in proportion to it), the resistance of the fluid also increases [3]. When the falling velocity of the ball reaches a certain value ϑ_0, the force acting on it is equal to zero (the sum of the upward resistance force and the Archimedean force is equal to the gravitational force).

$$R=f_1-f_2=0 \qquad (3)$$

However, the ball continues to move because of its energy (Newton's first law). Due to the size $\frac{4}{3}\pi r^3$ of the ball, its weight is as follows.

$$P = mg = \rho v g = \frac{4}{3}\pi r^2 \rho g \qquad (4)$$

Because of the squeezed volume of liquid is equal to the volume of the bubble lifting(Archimedes) force;

$$f_\gamma = \frac{4}{3}\pi \cdot r^3 \rho_0 g \qquad (5)$$

The friction force is based on (2);

$$f_2 = 6\pi\eta \cdot r\ell_0 r \qquad (6)$$

Substituting 4) (5) and (6) into (3) gives the following equation;

$$\frac{4}{3}\pi \cdot r^3(\rho - \rho_0)g = 6\pi \cdot r\vartheta_0 \cdot \eta \qquad (7)$$

Where:
ρ – the density of the ball
ρ_0 – the density of the liquid
g – acceleration of free fall,,

If ball passes h height with t time in a liquid $\vartheta_0 = \frac{h}{t}$ Putting it in (7), we get what

$$\eta = \frac{2(\rho - \rho_0)}{9h} g \cdot r^2 t \quad (8)$$

All values on the right side of equation are determined during experiment, accordingly from that we can find the coefficient of internal friction of the fluid

The structure of the instrument

Instrument consist of glass cylinder devise, which is fallen with the testing liquids (glycerin, cottonseed oil and water). The cylinder has two height indicators at a distance h from each other.

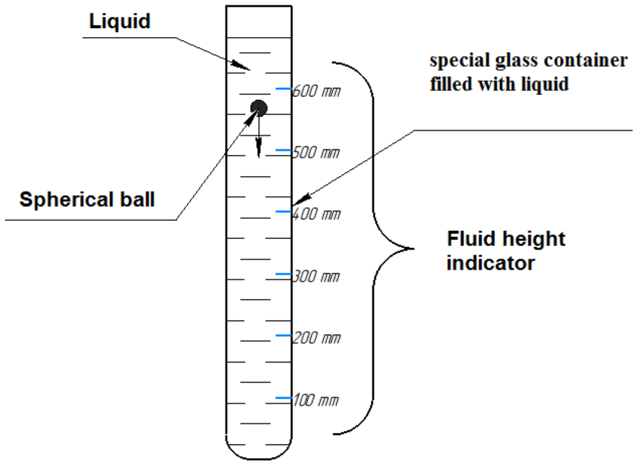

Figure 2. A device for measuring the coefficient of internal friction of a fluid according to

The diameter of the ball is measured to the accuracy at 0.01 mm using a micrometer. The ball is thrown into the liquid inside the cylinder (the ball should be thrown as close to the cylinder axis and the surface of the liquid as possible). The stopwatch is started as the ball passes through the d_1 mark on the cylinder and stops as it passes over the d_2 mark. That measures the time taken for the ball to pass the distance h from d_1 to d_2 (Figure 2).

Measurement of the distance between d_1 and d_2 is found by using the ruler. The experiment is performed with at least 10 balls for each liquid. Knowing the values of κ, h, ρ, ρ_0 and t, viscosity coefficient of the fluid is determined using the equation (8), ρ and ρ_0 are taken from the table.

Conclusion

It is clear from the information above that Stock's method for measuring dynamic viscosity coefficient is one of the easiest and simple methods. Its accuracy is also higher than other methods. Also, this method is not required many equipment, that's why is very popular among laboratories. In addition, it is advisable in experimental research works.

References

1. Umarov E.O., Mardonov U.T., Shoazimova U.Kh., "Influence of the Magnetic Field on the Viscosity Coefficient of Lubricoolant that is used in the Cutting Proces," International Journal of Mechatronics and Applied Mechanics, 2020, Issue 8, Vol. II. pp. 144-149 https://www.doi.org/10.17683/ijomam/issue8.50
2. T.U. Umarov, U.T. Mardonov, O.A. Khasanov, Sh.O. Ozodova, B.D. Yusupov. Research on the variation of firmness of pointed drills by the method of simulation modeling of the process of wear. https://www.psychosocial.com/article/PR201298/12155/.
3. Tursunbaev S.A. "Osobenossti obrabotki detaley iz magnitotverdыx materialov[Features of processing of parts made of hard magnetic materials]" Texnika i texnologii mashinostroeniya Materialы. VIII Mejdunarodnoy nauchno-texnicheskoy konferensii (Omsk, 22-25 maya 2019 g.) Rossiya pp - 23-27.
4. TU Umarov, SA Tursunbaev, UT Mardonov, "Noвые texnologicheskie vozmojnosti povыsheniya ekspluatatsionnoy nadejnosti instrumentov dlya obrabotki kompozitsionnыx materialov[New technological possibilities for increasing the operational reliability of tools for processing composite materials]". Texnika i texnologiya, VII mejdunarodnoy nauchno-texnicheskoy konferensii. Omsk: 2018
5. Uljaev E., Ubaydullaev U.M., Narzullaev Sh.N. (2020). Optimization of the sizes of the cylindrical measuring transducer. Chemical Technology, Control and Management, № 5-6(95-96). – pp. 29-33. journal homepage: https://uzjournals.edu.uz/ijctcm/vol2020/iss5/5/
6. Umarov E.O., Mardonov U.T., "Analyzing the effect of magnetic field on Lubricoolant in machining process, " *International Journal of Applied Research.,* vol. 6(5) 2020, pp. 347-352.
7. Uljaev E., Narzullaev Sh.N., Erkinov S.M. Increasing calibration accuracy of the humidity control measuring device of bulk materials. Technical Science and Innovation, №3(05), 2020. –pp. 172-179. journal homepage: https://uzjournals.edu.uz/btstu/vol2020/iss3/23/
8. E.O. Umarov, U.T. Mardonov, "General characteristic of technological lubricating cooling liquids in metal cutting process", International Journal of Research in Advanced Engineering and Technology, Volume 6; Issue 2; 2020; Page No. 01-03