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MEASURING VISCOSITY IN CHANGING INITIAL PARAMETERS

Reznikova M., Antoniuk V.
National Technical University of Ukraine
«Kyiv Polytechnic Institute»

Introduction. Viscosity is a fundamental characteristic property of all liquids. When a liquid flows, if has an internal resistance to flow. Viscosity is a measure of this resistance to flow or shear. Viscosity can also be termed as a drag force and is a measure of the frictional properties of the fluid. Viscosity is a function of temperature and pressure[1]. There are numerous methods to measure viscosity of liquids. The proposed method is based on a linear motion of a magnet in a field concept and gravitational force. It can measure the viscosity as a function of temperature and pressure.

Main part. Based on falling sphere viscometer a device to measure viscosity of dielectric liquids was designed. The device is an inset to an autoclave system where the temperature and the pressure could be controlled[2]. It consists of a magnet and a coil. The magnet is externally driven to a location in the device and then will fall with removal of the driving force. The time-to-fall can be recorded and converted to viscosity for a known dielectric fluid.

The main purpose of developing the presented system is to be able to measure the viscosity of a dielectric fluid (e.g. oil) as a function of temperature (up to 400°C) and pressure (up to 350kg/cm^2). We propose to design a device composed of a coil to generate the magnetic field and a magnet, which moves in up in the coil. The coil should be built around a glass structure. Later the magnet will be let fall in the liquid medium. The time-of-fall can be measured between the current shut-off of the field and the impact of the magnet to the bottom of the glass tube. The measured time should be correlated to the viscosity by using a transfer function between the time-of-fall and viscosity for a known oil at low temperatures (T below 120°C).

A glass tube structure (1 cm in diameter) about 30 cm high (due to high temperature requirements) should be used. Small rods are to be putted in 2 cm spacings to help the winding process to form the magnetic coil. A container at the top part of the tube can be used to capture any oil in case of its expansion with temperature. The field coil is to be built in a cyclone-shape with increasing number of turns toward the top of the tube due to required driving force for the magnet. Once the magnet will be inserted in the tube, and the coil is energized with a direct-current, the magnet levitates. The device is to be inserted inside an autoclave with electrical ports. The pressure and temperature inside the autoclave could be controlled in the chamber. Then measurements can be taken without changing the initial pressure in the system; observing that due to increase in temperature the pressure in the chamber increases slightly.

Magnet selection is important due to the de-magnetization properties of magnetic materials above their Curie temperature; therefore, alnico magnet (composed primarily of aluminum, nickel and cobalt) is to be employed; Tc about 800°C. The alnico magnet can be a sphere or cylindrical shape.

After removal of the applied current the magnet will drop. The impact of the falling magnet will create a vibration in the autoclave that can be registered using an accelerometer. The accelerometer is to be connected to the bottom of the autoclave through a cantilever to improve its response; without the cantilever the signal-to-noise won't be satisfactory. The signal from the accelerometer should be increased using an operational amplifier. The time-to-fall can be measured with an oscilloscope. The time of the current switch-off and the accelerometer trigger response are used for the time-to-fall t value. Measurements can be performed every several minutes while the temperature of the autoclave can be increased slowly.

To test the measurement setup, and build the transfer function between measured time-to-fall and viscosity. Oil with existing viscosity data should be selected. Its viscosity can be previously measured using a conventional method. The data can be described with a log-log model.

Conclusion. A device to measure liquid viscosity properties as a function of temperature and pressure is proposed. A straightforward fall time of a magnet can be measured to estimate the viscosity of the liquid. The obtained time data is to be converted to viscosity by employing natural logarithmic dependencies[3] due to un-physical nature of the negative time and viscosity.

Literature

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