

Vibrating-Wire Sensors for Viscosity Measurements under Extreme Conditions

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Vibrating-wire instruments have long been used for accurate measurements of viscosity, or of viscosity and density, under laboratory conditions. Typical laboratory instruments are capable of measuring the viscosity of a fluid of known density with an accuracy of better than 1 percent. Furthermore, vibrating-wire instruments in which the wire is tensioned by means of a suspended weight permit sensitive simultaneous measurements of both viscosity and density. A single wire diameter usually permits measurements to be made over a range of about two orders of magnitude in viscosity, and the design may be optimized for measurements on gases or on liquids having viscosities up to at least a few hundred mPa's.

Recently, a number of investigators have developed compact and robust sensors in which the vibrating wire is held under tension between fixed end clamps. Such an arrangement may be suitable for industrial/field applications including, for example, in-situ measurements on petroleum-reservoir fluids under conditions of high temperature and high pressure. In this paper, we review some aspects of the design and application of such a sensor, including:

- Optimization of the wire diameter;
- Inertial effects associated with the wire holder;
- Test results in Newtonian fluids at temperatures up to 450 K and pressures up to 140 MPa;
- Measurements in flowing systems over a range of Reynolds numbers; and
- Observations on the effects of non-Newtonian fluid properties.