A New Electronic Instrument to Perform the Simultaneous Measurement of the Density and Viscosity of Fluids Using a Dual Vibrating-Wire Technique

J.L.G.C. Mata and J.M.N.A. Fareleira
Centro de Química Estrutural
Departamento de Engenharia Química
Instituto Superior Técnico
1096 Lisboa, Portugal

W.A. Wakeham
Chemical Engineering Department
Imperial College of Science Technology and Medicine
Prince Consort Road
London SW7 2BY, United Kingdom

Recently, a vibrating-wire instrument for the simultaneous accurate measurement of the viscosity and density of fluids, over wide ranges of temperature and pressure, has been validated, and used to perform measurements on various pure liquids. The technique makes use of the buoyancy force acting on a solid sinker to determine the fluid density. This force is detected by means of a vibrating-wire sensor, operated in the forced mode of oscillation, placed inside the measuring cell. The transverse oscillations of the vibrating-wire are originated by an electric signal passing through the wire, which is subject to a permanent magnetic field. A complete theoretical description of the resonance characteristics for the transverse oscillations of the vibrating-wire, enables the calculation of the density and viscosity of the surrounding fluid, from their measurement.

It is the purpose of the present communication to present a new electronic equipment that enables the use of the mentioned vibrating-wire cell, either in the free decaying, and in the forced oscillation modes of operation. The main objective of the new dual technique is to increase the speed of measurement of the viscosity and density, without loss of accuracy, by using both modes of operation in combination. For this purpose, the equipment is capable of measuring, under computer control, either the frequency, or the time response of the vibrating-wire. The basis of the operation relies on the fact that, both the forced oscillation mode of operation - where the resonance curve, characterized by a peak frequency and a quality factor, is obtained - and the free decaying mode - where the natural frequency and the rate of decay are the resulting parameters - contain all the information needed to determine the density and viscosity of the fluid surrounding the vibrating-wire. The consistency of the two approaches and the quality of the measuring system have been assessed using toluene as the test fluid.