

## Revised Theory of a Vibrating Wire Viscometer

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Modeling the thermophysical behaviour of fluids still depends strongly on accurate property measurements. For measuring the viscosity of fluids, the vibrating wire viscometer has served as the primary experimental method over the past 25 years. Deviations from the theoretical behaviour of the instrument were explained by interactions with the electric measurement circuit (Padua, 1994) and non-linear characteristics of the oscillator (Aumann et al. 2000). One observation by Wilhelm (1998) could not be resolved so far, the dependence of the results on the wire's amplitude squared. All these experimental groups use the theory of the instrument developed by Retsina et al. (1987). Retsina assumed point symmetry in the flow field in order to derive an analytical solution of the Navier-Stokes differential equation required for the working equation of the instrument. Flow visualisations published by van Dyke (1982) indicate axis symmetry for the flow field which is supported by the Boundary Layer Theory (Schlichting, 1965). Recent CFD simulations clearly show the axis symmetry. Re-evaluating the Navier-Stokes equation with the correct symmetry, a series of inertia terms remain in the equation that are canceled in Retsina's solution. These findings are in line with the dependence on the amplitude squared as the amplitude is directly proportional to the velocity and therefore enters the inertia terms. A new working equation is derived for the vibrating wire viscometer based on axis symmetry and deviations between the two working equations are shown for a wide range of experimental conditions. CFD simulations of the fluid-body interaction allow the validation of the new working equation based on the complete Navier-Stokes equation. Furthermore, CFD is used to derive the point of flow separation at the vibrating wire in order to extend the operating range of the instrument to larger amplitudes.