

DENSITOMETER / VISCOMETER MODELING

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Problem Description:

Densitometers and viscometers measure density and viscosity, respectively. Both are used in various industrial processes, in particular in the oil industry where they are used to try to detect the fractional constituents (oil/gas/water) of what is being extracted from the ground, or what is being supplied to the consumer. I participated in the modeling for a densitometer (CGU Math Clinic '82-'83, see Chapter 3, Cumberbatch and Fitt, "Mathematical Modeling; Case Studies from Industry," CUP) and for the densitometer/viscometer (U. of Lancaster Study Group, 2002). In both of these, the modeling for density is satisfactory and provides accurate algorithms. Both devices depend on vibrations of a probe in the fluid (the latter being a tuning fork geometry) and density modeling uses the added mass concept introduced in fluids courses. Viscous modeling is much more difficult as the effect is quite small and the viscous equations are much harder to solve. The viscous treatment at Lancaster looked unsatisfactory, but closer analysis makes the approach have validity. Here there is relevant work used in atomic force microscopy (Sader : J of App Phys Vol. 84, #1, 1998). However the algorithm used by the industrial client for viscosity still looks unsatisfactory. Apart from the fluid mechanics there are also issues concerning the quantity of data necessary to determine parameters in a suggested model.

The goal of the project will be to ascertain whether it is possible to measure viscosity accurately using the tuning fork device.