Testing low viscosity fluids with the HAAKE Viscotester iQ Rheometer

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Introduction

Testing water on a rotational rheometer always poses a challenge due to the low torque reading arriving at the transducer. This is especially true for mechanically mounted instruments like the Thermo Scientific™ HAAKE™ Viscotester™ iQ Rheometer. Although equipped with an ultra low friction ball bearing, the lower torque limit is 0.2 mNm and thus about 5 orders of magnitude higher compared to a research grade rheometer like the Thermo Scientific™ HAAKE™ MARS™ 40/60 Rheometer. Still many relevant rheological QC tests conducted in industries (e.g., polymer coatings) deal with low viscosity fluids. In this application note we will demonstrate how an extremely low viscous fluid, like water, can be tested with the HAAKE Viscotester iQ Rheometer.

Experimental Results and Discussion

The rheometer setup used to perform the tests on water is shown in Figure 1. The HAAKE Viscotester iQ Rheometer was equipped with the 48 mm diameter liquid controlled temperature module for coaxial cylinder geometries TM-LI-C48 and the corresponding CC41DG double gap geometry. To obtain meaningful data on such a low viscous fluid the measuring routine has to be adjusted accordingly. Figure 2 shows the Thermo Scientific™ HAAKE™ RheoWin™ measurement routine used for the tests presented in this report. One of the most important parameters for such a test is the total duration for every single measuring point as well as the integration time. Here, a measuring time of 45 s was used in combination with an integration time of 15 s. Temperature control was achieved via an external circulator SC100-A10 from Thermo Scientific. Measuring temperature was 20 °C and a thermal equilibration time of 3 minutes was chosen.

Figure 1: HAAKE Viscotester iQ Rheometer with TM-LI-C48 liquid cylinder.

In addition to the rheological test, the automated data analysis and report functionalities of the HAAKE RheoWin Software were used.

Figure 3 shows the results of 9 separate test runs of this method on water. As can be seen in Figure 3 the results are extremely reproducible starting from a torque of 0.2 mNm. Off course the accessible shear rate range is limited, however, water can be tested with the HAAKE Viscotester iQ Rheometer over roughly 1 order of magnitude from approximately 500 to 4000 s^{-1}. Below 500 s^{-1} the torque reading is below specification, above 4000 s^{-1} an increase of viscosity can be monitored due to the onset of Taylor vortices (1). This onset arises exactly where it was predicted by the HAAKE RheoWin “Range Calculator“ as can be seen in Figure 4. To further emphasize the quality and reproducibility of the data, Figure 5 shows the same results seen in Figure 3 however, this time plotted on a linear scale.

As can be seen in Figure 5, the HAAKE Viscotester iQ Rheometer is able to measure water with a large diameter, double gap measuring geometry. Before onset of the Taylor instabilities, all data is within ± 10 % of the theoretical water viscosity of 1.00 mPas (cP) at 20 °C.

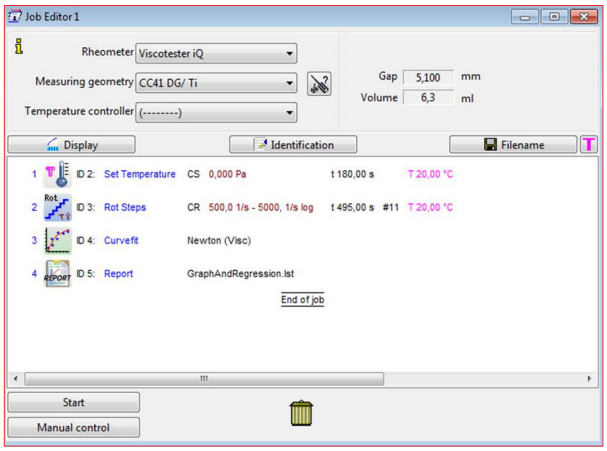

Figure 2: HAAKE RheoWin routine screen to test low viscosity fluids on the HAAKE Viscotester iQ Rheometer.

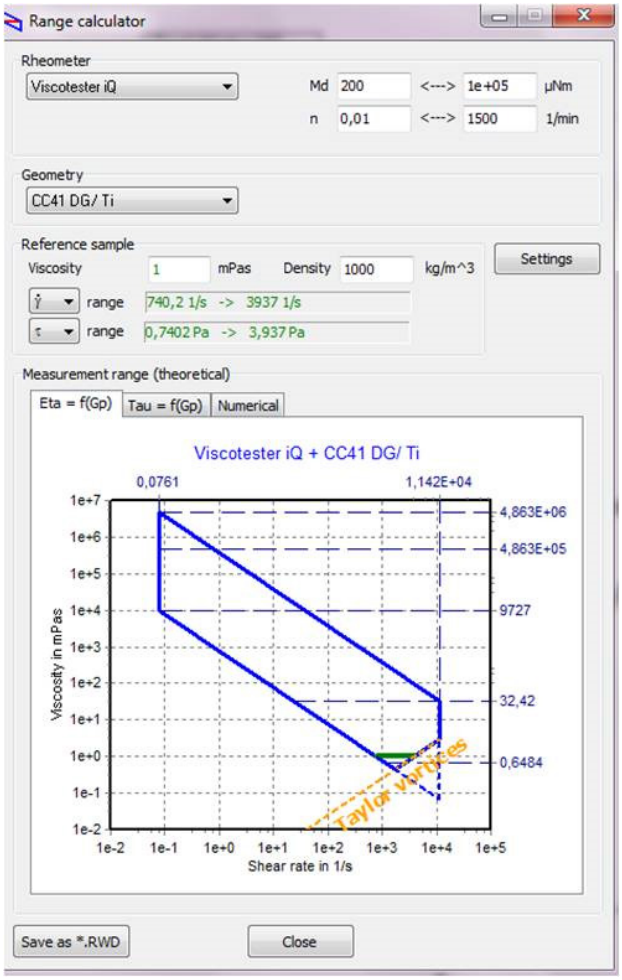

Figure 4: Calculated measuring range for the HAAKE Viscotester iQ Rheometer with double gap rotor CCB41 DG with Taylor vortex prediction taken directly from the HAAKE RheoWin Software.

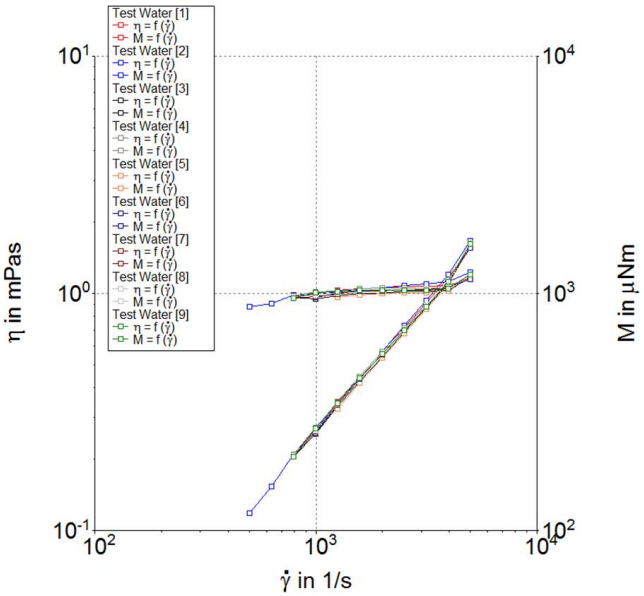

Figure 3: Viscosity η and torque M as a function of shear rate γ for water at 20 °C on the HAAKE Viscotester iQ Rheometer. The data are plotted on a logarithmic scale.

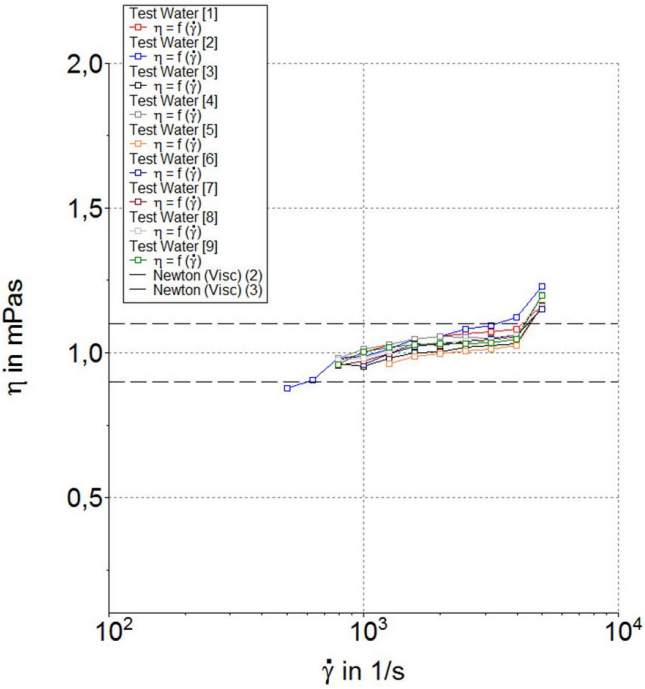

Figure 5: Viscosity as a function of shear rate for water at 20 °C on the HAAKE Viscotester iQ rheometer. The data are plotted on a linear scale.

Conclusion

The HAAKE Viscotester iQ Rheometer provides a quick, simple and accurate tool for Quality Control. Although it is a rheometer with a mechanical bearing, the viscosity of extremely low viscous fluids like water can be correctly evaluated.

Reference

1. Taylor, G.I. "Stability of a Viscous Liquid contained between Two Rotating Cylinders", 1923. Phil. Trans. Royal Society A223, 289–343.

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