

# Flow Properties and Temperature Dependency of Crude Oil

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## Key words

Viscosity, Yield Stress, Temperature, Flow Properties

## Introduction

Crude oil is still the most important source of energy worldwide. In addition, it also serves as raw material for many important materials like polymers and pharmaceuticals. Due to the complex individual composition of different crude oils and the increasing demand, the recovery processes need to be optimized for each individual oil field.

The rheological properties of a specific crude oil are among the most important parameters for oil recovery and transport processes. The viscosity, for example, regarded over a certain range of shear rates and temperatures, represents different application properties of crude oil such as mobility in the field, storage stability or transport properties. The temperature dependency itself will directly affect the pipeline transport process under different conditions. The quick and reliable determination of the rheological properties of a crude oil is crucial for the design of a cost effective recovery or transport process.

The Thermo Scientific™ HAAKE™ Viscotester™ iQ rheometer (see Fig. 1) is a powerful instrument, which can be used to test the rheological properties of crude oils such as their viscous behaviour, yield stress, temperature dependency etc. with great accuracy. When equipped with the Peltier cylinder TM-PE-C and the heat exchanger HX iQ the HAAKE Viscotester iQ becomes a self-contained instrument, which only needs to be plugged in to be ready to run. Thus the HAAKE Viscotester iQ is a compact portable instrument suitable for mobile applications in the field.

Fig. 2 shows the viscosity of a crude oil sample at 21 °C as a function of shear rate within the range of 0.023 - 3526 s<sup>-1</sup> (0.01-1500 rpm) using the HAAKE Viscotester iQ with the Peltier temperature control TM-PE-C and the cylindrical measuring geometry CC26.

It can be seen that this crude oil shows a strong pseudo-plastic behaviour. The viscosity of the crude oil is about 1000 mPas at lower shear rates and quickly decreases to approx. 35 mPas at high shear rates above 3000 s<sup>-1</sup>. At higher shear rates the pseudoplasticity is less pronounced, here the crude oil behaves almost like a Newtonian fluid. The result also shows that this crude oil has a certain



Fig. 1: The Thermo Scientific HAAKE Viscotester iQ equipped with a cylindrical measuring geometry in the Peltier cylinder.

yield stress at the test temperature. This yield stress can be calculated using the Thermo Scientific™ HAAKE™ RheoWin™ software applying the Herschel-Bulkley

$$\tau = \tau_0 + K \dot{\gamma}^n$$

[1]

The temperature dependency test was conducted using the HAAKE Viscotester iQ with the cylindrical geometry CC26 in the temperature range of 50 – 0°C with a cooling rate of -1 K/min at a shear rate of 50 s<sup>-1</sup>. The result is shown in Fig. 3.

## Viscosity of Crude Oil as a function of Shear rate

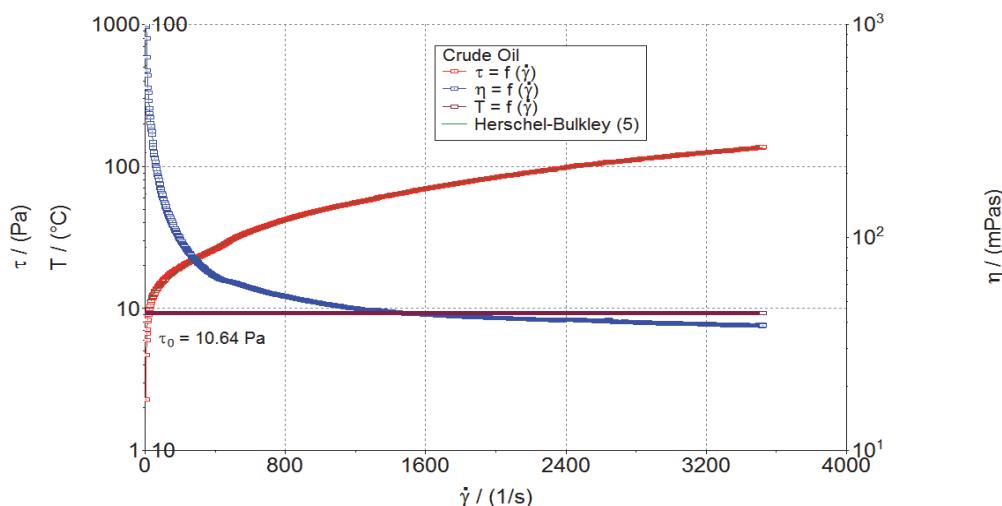


Fig. 2: Viscosity of a crude oil as a function of shear rate at 21 °C.

## Temperature Dependency of Crude Oil

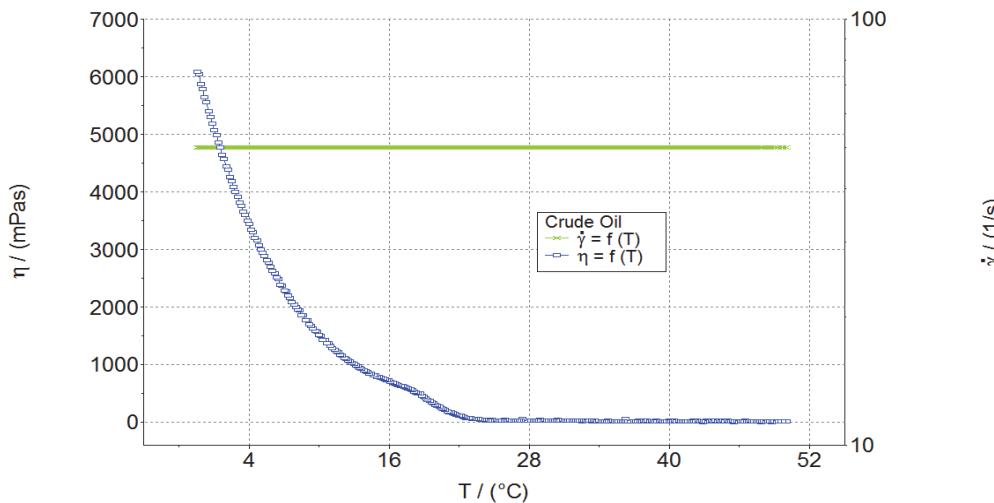


Fig. 3: Temperature dependency of crude oil at shear rate of 50s<sup>-1</sup>.

At temperatures above 25 °C, the viscosity of this crude oil stays almost constant at relative low values. When the temperature decreases below 20 °C however, the viscosity begins to increase quickly, indicating the onset of crystallization, and exceeds 6000 mPas at about 0 °C. With this quick test, the temperature dependency of the crude oil can be characterized in a very efficient way.

## Conclusion

The Thermo Scientific HAAKE Viscotester iQ is a quick, simple and accurate approach to measure the full rheological properties of crude oil. Due to its flexibility, the test parameters can quickly and easily be adapted to the respective process conditions. The results will be very meaningful to oil field applications both in research and on-site operation. Based on the data acquired, the optimum transport technology and the best chemical additives can be selected to guarantee smooth and efficient operation.

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