APPLICATION**NOTE**

Rheological Properties of Lubricating Grease in Accordance with DIN 51810-1

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Introduction

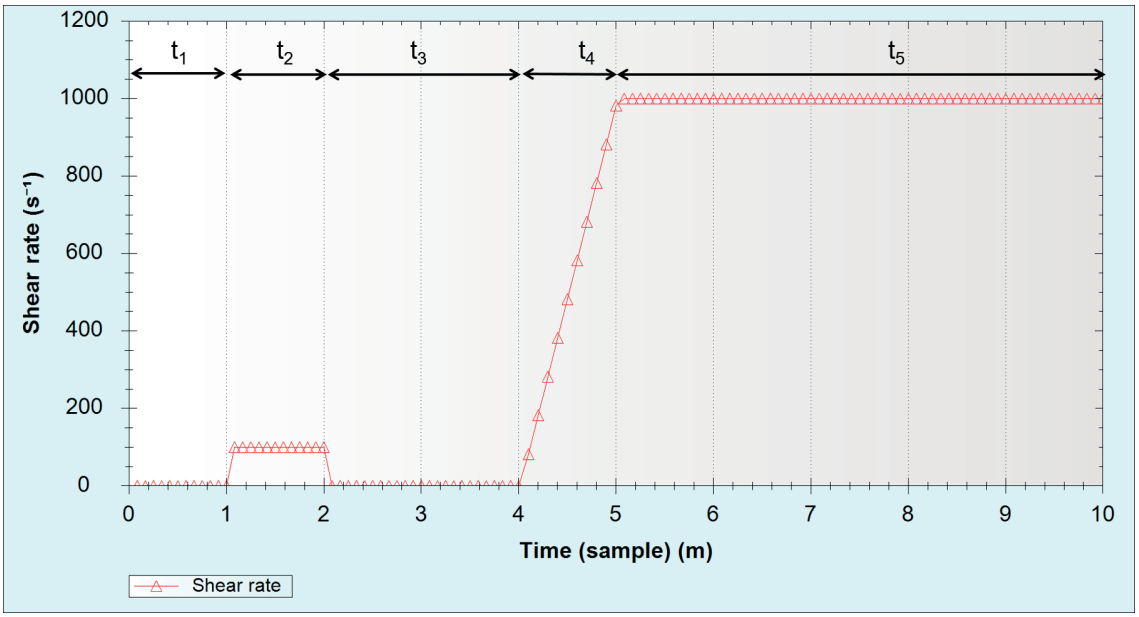
The rheological properties of materials help understand and anticipate their behavior during the process. For example, they play a role in the lubrication ability, pumpability, flow (yield) point of lubricating greases.

Measurement Conditions

In the following, the shear viscosity of a lubricating grease is determined with the Kinexus pro+ under the measurement conditions described in the DIN 51810-1 standard. Table 1 and figure 1 summarize the test parameters specified in this standard.

Tab 1. Measurement Conditions

Geometry	CP/25 (cone-plate system, cone angle: 1°, plate diameter: 25 mm)
Temperature	25°C (± 0.1°C)
Measurement gap	24 µm
Measurement program	Phase t_1: 1 min at rest, 0 Pa
	Phase t_2: 1 min pre-shear, 100 s^{-1}
	Phase t_3: 2 min at rest, 0 Pa
	Phase t_4: Linear increase in shear rate from 0 to 1000 s^{-1} in 1 min
	Phase t_5: 5 min at a constant shear rate (1000 s^{-1})



1 Measurement program in accordance with DIN 51810-1

NGB · Application Note 222 · EN · 0721 · Technical specifications are subject to change.

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Measurement Results

The torque required for each applied shear rate is measured which is automatically converted by the rSpace software to determine the shear stress. The shear rate and shear stress are then used in the calculation of the shear viscosity using the equation as follows:

$$\eta = \frac{\sigma}{\dot{\gamma}}$$

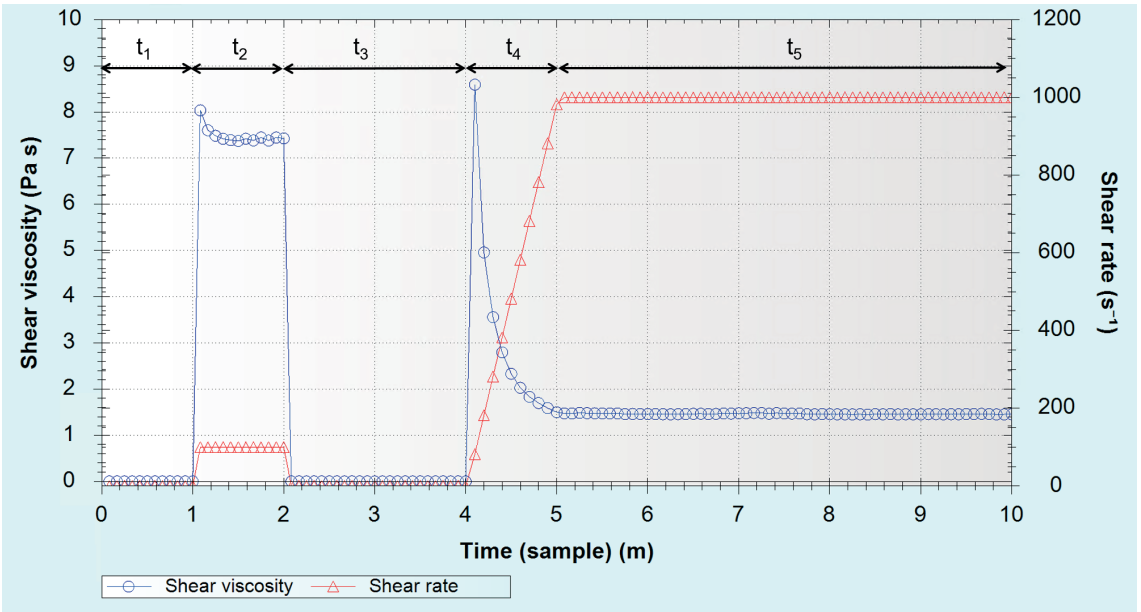
with η: Shear viscosity [Pa·s]
σ: Shear stress [Pa]
$\dot{\gamma}$: Shear rate [s^{-1}]

Figure 2 displays the applied shear rate (orange curve) and the resulting shear viscosity (blue curve). As expected, the shear viscosity amounts to zero when no shear stress is applied (phase t_1). An increase in shear rate to 100 s^{-1} leads to a measured increase in shear viscosity to 7.5 Pa·s (phase t_2). The response of the sample to the following cessation of any deformation is an immediate return of the shear viscosity to effectively zero (phase t_3). The linear increase in shear rate (phase t_4) highlights the structured and shear-thinning behavior of the lubricating grease: The shear viscosity generally decreases with increased shear rate. The reaction of the material to the following constant shear rate at 1000 s^{-1} (phase t_5) is of utmost importance because it shows if the shear viscosity remains stable when subjected to a high constant shear rate; and, if it doesn´t remain stable, how strong it changes under a consistent, and high deformation rate.

DIN 51018-1 standard indicates how to quantify this change in shear viscosity η_{rel} during the last step. For that, the shear viscosity at 2 s (η_A) and at 300 s (η_B) after the start of the fifth phase as well as the relative viscosity change between both values are reported. The relative viscosity change is defined as:

$$\eta_{rel} = \frac{(\eta_A - \eta_B)}{\eta_A} \cdot 100$$

The powerful rSpace software used for the measurements and the evaluation is capable to automatically calculate these parameters. Figure 3 shows the table extracted from the rSpace software with the required values of the shear viscosity at 2 s and 300 s and the resulting relative viscosity change η_{rel} of 0.7%. This low value of less than 1% indicates that the sample adapts very quickly to the applied shear rate.



2 Applied shear rate (orange curve) and resulting shear viscosity (blue curve) during measurement in accordance with DIN 51810-1

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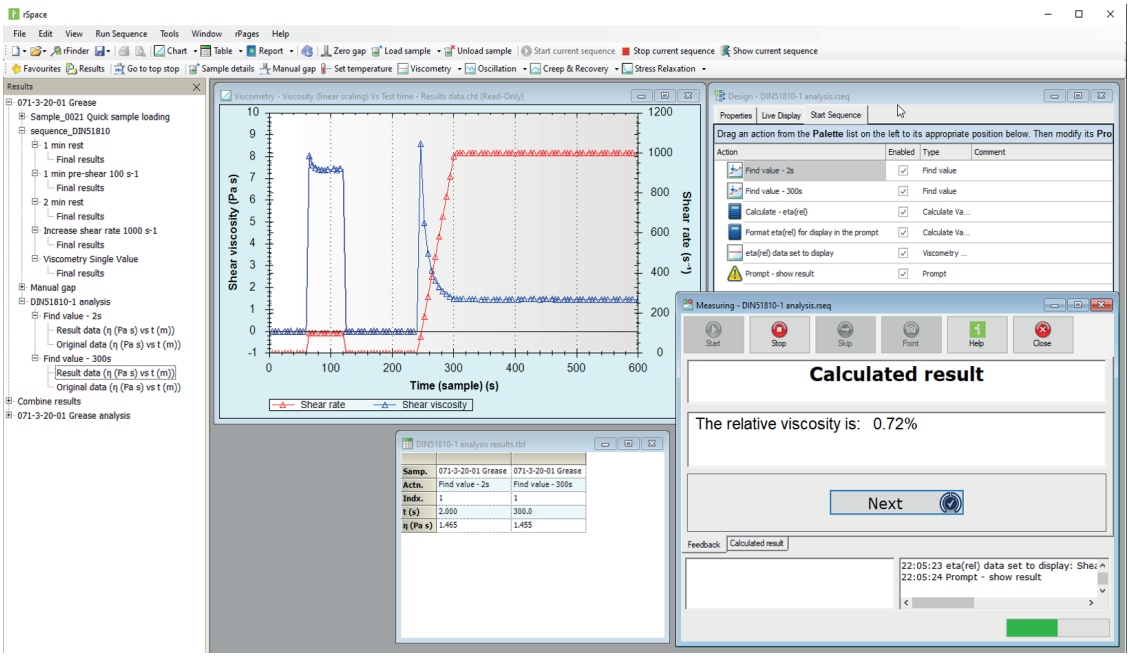

3 Shear viscosity at 2 s and 300 s after the beginning of the 5th phase and automatically calculated value of the relative viscosity change, extracted from the rSpace software

Conclusion

A lubricating grease was measured under the conditions described in DIN 51810-1. Evaluation was successfully carried out automatically thanks to an analysis that can even be included in the measuring method for easy and fast execution of the measurements with the objective of user-independent determination of the results.

References

[1] DIN 51810-1, Testing of lubricants – Testing rheological properties of lubricating greases – Part 1: Determination of shear viscosity by rotational viscosimeter and the system of cone/plate

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