Stability analysis of drilling fluids thanks to microrheology

Application
Petroleum

Objective
Analyze the stability of various drilling fluids thanks to microrheology.

Device
RHEOLASER® LAB

Introduction

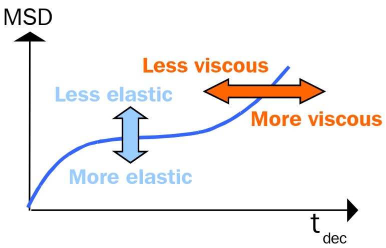
Rheology of drilling fluids is a key parameter that must be controlled before and during their use. Indeed viscoelastic behavior drives several end use properties such as physical stability or efficiency during their use (structure has to remain strong as it allows particles to stay in suspension)…
Microrheology enables to easily and deeply characterize these properties by measuring the viscosity and the elasticity of samples at rest, versus ageing time thanks to a non contact measurement, without the limitations of classical rheology (sampling issues due to the strong structure, weak interactions not to be broken, …).

In this example, three different drilling fluids (water, clay, and other additives) are analyzed at rest. The goal is to determine their physical stability and rank them depending on this criteria, by monitoring their rheological properties over ageing.

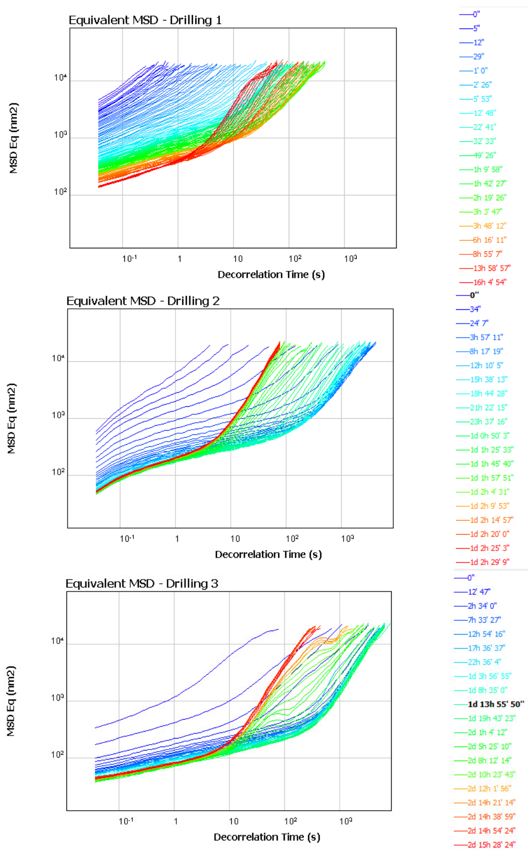
Raw data: Particle Mean Square Displacement (MSD)

In microrheology, particles probe the viscoelastic behavior of the sample. Thus, particle Mean square displacement curve is the signature of the product rheology.
Rheolaser® LAB enables the monitoring of a very same sample during ageing time. The evolution of the MSD curves are then characteristic of the viscoelastic properties changes.

Reminder about Mean Square Displacement



MSD curves are the signature of the product's microrheology. It reflects the visco-elastic behaviour of a sample.
By acquiring MSD curves at different ageing times for a same sample, it is therefore possible to identify the evolution of both viscosity, elasticity, and microstructural properties of a given product.



MSD curves (see left) give a first indication about the products viscoelastic properties and their evolution during ageing.

Indeed, the user can observe the motion of the curves (first curves are in blue, then green, and lastly in red). The displacement of the curves to the right means an increase of the viscosity, and the motion to the bottom means an increase of elasticity.

The first stage in these 3 products reflects the structure recovery after an initial shear (curves move to the right and bottom, and a plateau is created).

After a given ageing time, the curves don't move toward the bottom anymore (elasticity is constant), but the user can observe the curves moving back to the left, meaning a decrease of the viscosity, thus a physical destabilization of the samples.

Stability of the 3 samples

The user can easily compare the physical stability of the samples using a classic tool such as viscosity monitoring, or a more elaborated one such as relaxation time evolution during ageing, which has the advantage to take into account not only the viscosity but also the elasticity. These computations (see Figure 1) are available just by a one-click feature in the software, allowing a quick comparison of various samples.

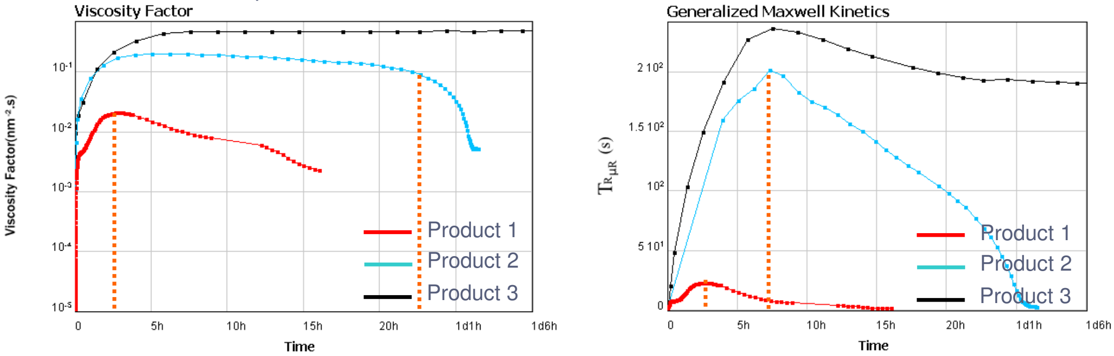


Figure 1. Comparison of the 3 samples using Viscosity Factor and Relaxation Time.

In that case, the user can observe the following:

- The stability of the products can be distinguished easily: product 1 is the least stable (Viscosity drops after 3 hours, so does the relaxation time), product 2 is more stable (viscosity drops after 22 hours, relaxation time even sooner, after 8 hours), product 3 is the most stable (viscosity does not decrease during the 30 hours of analysis, relaxation time is almost stable as well).
- Relaxation time is a more powerful tool for the formulators than the viscosity, as it allows a monitoring of both viscosity and elasticity with just one parameter (as seen above, relaxation time t_R drops earlier for the 3 products than viscosity, thus allowing faster ranking of the samples).

Note:
The relaxation time t_R is the characteristic time for which a sample moves from a solid-like behavior to a liquid-like behavior. It is linked both to elasticity and viscosity.

A full characterization of the samples is also possible through moduli computations. It can be noticed that the computation of the ratio G'' / G', when each product is at viscoelastic equilibrium, gives the same ranking at low frequency (Figure 2 : for low frequencies, product 3 has the lowest ratio, product 1 has the highest).

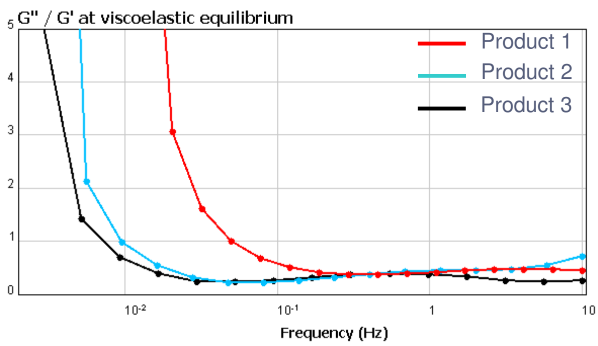


Figure 2. G'' / G' ratio at viscoelastic equilibrium.

Summary

The differences in the stability of these products can be distinguished thanks to the monitoring of various parameters, such as the viscosity, or the relaxation time.
Rheolaser® LAB can fully and easily characterize the viscoelasticity of various products, and their evolution during ageing. Measurement is done thanks a non-contact method which enables to analyze the sample at rest, on the very same sample versus ageing time and over a large frequency range.