Viscosity Testing of Bentonite Clay with ViscoQC

Learn how you can check the quality of your bentonite clay with a rotational viscometer. The thickening agent bentonite is an important mineral for many industries. Let ViscoQC boost your quality control!

1 Introduction

Bentonite clay is a very soft plastic clay which consists predominantly of montmorillonite. Key properties of bentonite are its swelling and water absorption behavior. Bentonite increases its volume several times when coming into contact with water. It creates a gelatinous and viscous substance with a shear thinning behavior. The mineral is in use in pharma, food, cosmetics, and chemical industry.

The swelling properties of bentonite is frequently used in drilling mud. At rest, the clay is a highly viscous gel which gets liquid-like during pumping due to its shear thinning properties. Afterwards the bentonite clay returns to its jelly state again. Before bentonite is taken into use, the quality of the material needs to be checked.

Testing the dynamic viscosity with rotational viscometers like ViscoQC 100/300 guarantees the performance of the clay for the application.

2 Experiment

Bentonite powder was dissolved in distilled water generating a 30 % (w/v) solution. The solution was tested using the rotational viscometers ViscoQC 100/300 from Anton Paar. The Heli-Plus accessory with T-bar spindles was used for the measurements due to the paste-like behavior of the material at rest. The motorized stand adapter Heli-Plus creates a helical movement of the T-bar spindle in the sample and eliminates the "channeling" problem.

Any other spindle which rotates at the same height will create an air channel within such a sample. This will lead to meaningless viscosity values as only part of the sample is in contact with the spindle. The Heli-Plus with T-bar spindles ensures continuous contact to the intact sample during the whole viscosity test.

Sample	Bentonite clay	
Instrument	ViscoQC 100 - L	ViscoQC 300 - L
Measurement type	Single-point	Multi-point
Spindle	T-E	T-E / T-F
Accessories	Flexible cup holder and Pt100 sensor	
Speeds	10 rpm	10 rpm / 1-10 rpm / 0.5 rpm
Temperature	~23 °C	

Table 1: Configuration and measurement conditions during viscosity testing of bentonite clay.

2.1 Test Procedure/Conditions

- 500 mL of bentonite clay were filled into a 600 mL beaker.
- Spindle T-E / T-F was inserted into the clamp for T-bar spindles and attached to ViscoQC via magnetic coupling. ViscoQC recognized that a T-bar spindle was connected and spindle "T-E or T-F" was selected.
- Four measurement positions for the Heli-Plus were defined prior to the measurement.

ViscoQC 100 measurement:

- A speed of 10 rpm was set in the "Stop at Time (@t)" mode with a target time of 2 minutes.

ViscoQC 300 measurements:

- The viscosity of the sample was determined at 10 rpm using the measurement mode "Stop at Time (@t)". Multipoint data collection was set active to collect one data point per second within the measurement time of 2 minutes. In the general method settings "Helix mode" was set active and the mathematical model "Statistics" was selected to determine the average viscosity of the last 30 seconds of the measurement.

- A linear speed ramp from 1 rpm to 10 rpm with 4 measurement points was performed using the measurement mode “Speed Scan (SpS)” to evaluate the flow behavior. The measurement point duration was set to 1 min and 30 s.
- The gel strength of the material was determined with a measurement at 0.5 rpm with a target time of 30 s using the measurement mode “Stop at Time (@t)”. Multipoint data collection was set active to collect one data point per second. Prior starting the test the axis for the online graph have been defined (y1 = Dynamic viscosity; y2 = Torque).

3 Results and Discussion

The single-point viscosity value determined with ViscoQC 100 and Heli-Plus with T-bar spindle is given in Table 2. A maximum speed of 12 rpm is recommended for rotational measurements with T-bar spindles. Preferably the viscosity measurement should only be performed during the first downwards movement. Otherwise already pre-sheared sample is measured which can lead to lower viscosity values.

	Bentonite clay
Speed [rpm]	10
Torque [%]	49.6
Viscosity [mPa·s]	23 226

Table 2: Single point viscosity measurement of bentonite clay with ViscoQC 100 – L and Heli-Plus with T-bar spindle T-E.

The same measurement at 10 rpm can be performed with ViscoQC 300 using multi-point data collection. It offers you the chance to evaluate a change in viscosity over the measurement time. If the software package V-Curve is activated on the instrument, you can additionally follow the measurement via the online graph and perform statistical analysis (Figure 1). At the beginning the viscosity is zero because the measurement started approx. half a centimeter above the sample. Then the spindle rotates through the sample which leads to a viscosity plateau after a short period of time. Within this plateau the viscosity can be averaged. The bentonite clay has an average viscosity of 23,400 mPa·s ± 120.4 mPa·s.

As expected bentonite clay shows a shear-thinning flow behavior (Figure 2) with a Shear Thinning Index of 8.3519. That means the viscosity will decrease as a shear load is applied to the sample. This is advantageous for pumping drilling mud.

A very simple and fast method to roughly determine the gel strength is to measure the viscosity of bentonite clay at a very low speed (Figure 3). It is assumed that first the torque of the measurement increases as an elastic response of the sample. The sample starts to flow when the torque stops increasing. The torque % at this point can be correlated with the gel strength for QC.

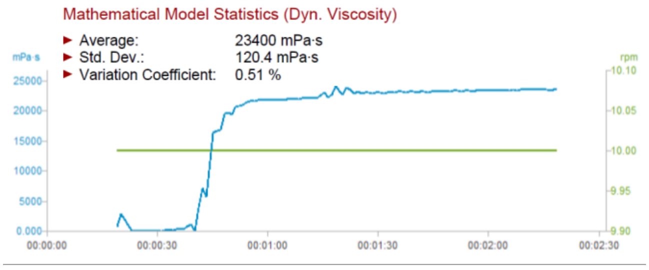

Figure 1: Online graph and statistical analysis of bentonite clay with ViscoQC 300.

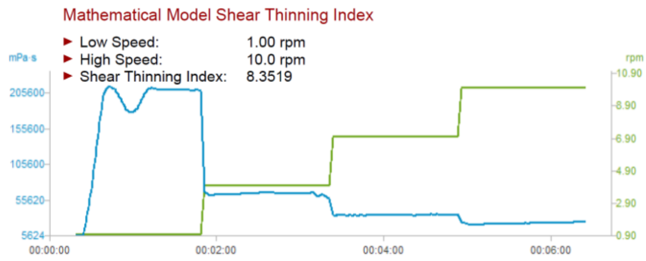

Figure 2: Speed scan of bentonite clay with ViscoQC 300.

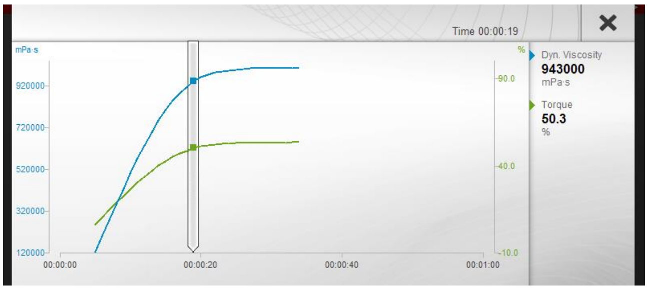

Figure 3: Gel strength measurement of bentonite clay with ViscoQC 300.

4 Summary

The measurements showed that the ViscoQC 100/300 is perfectly suited to determine the quality of bentonite clay. The measurement of the viscosity at single or multiple speeds as well as the gel strength are basic QC tests for bentonite clay. The optional Heli-Plus with T-bar spindles is recommended for pasty and gel-like samples such as bentonite clay. ViscoQC 100 offers fast single point quality control checks at the production line. ViscoQC 300 offers more detailed analysis with multi-point determinations. ViscoQC 300 upgraded with the software package V-Curve offers graph functionality and mathematical model analysis including statistics.

If you have further questions regarding this application report, please contact your local Anton Paar representative.

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