

FV-30 Extensional Viscometer

Designed for evaluating the extensional properties of fluids

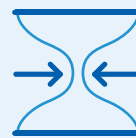


Overview

The FV-30 extensional Viscometer from EKO Instruments is designed to measure the behavior of fluids and suspensions under extensional flow conditions, closely mimicking the conditions in industrial processes. In many manufacturing processes, such as slot-die coating, roll coating, jet printing, and bottle filling, extensional flow is the predominant mode of deformation.

FV-30 extensional Viscometer quantifies extensional viscosity by stretching the sample at high speed in the axial direction. For analyzing the sample, the FV-30 extensional Viscometer uses a high-speed camera and a load cell. By monitoring the decreasing filament's diameter and measuring the tensile force (the fluid's resistance to extensional deformation), the software accurately determines the extensional viscosity. Unlike standard rotational viscometers that measure shear stress, the FV-30 extensional Viscometer captures fluid behavior under stretching force for an accurate evaluation of extensional properties.

Features



Analyzing stringing issues and breakup time of liquid samples



Process-near conditions bridge lab and industry



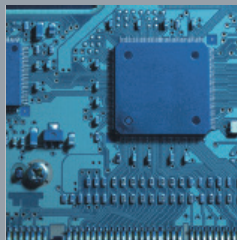
High-speed camera to analyze the filament thinning dynamics and breakup behavior



Highest precision: engineered with 'Made in Japan' quality



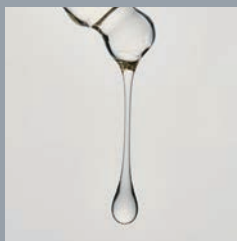
Applications:



Solder Paste and
Electronic materials



Paints, Inks and Coatings



Cosmetic and Personal
care products



Food and Beverages

Understanding extensional behavior is key to managing stringing issues.

While rotational viscometers and rheometers can measure shear viscosity of a sample, they cannot predict its behavior under axial forces. Issues such as stringing are driven by extensional viscosity, which represents a fluid's resistance to stretching. To accurately capture this behavior, an extensional viscometer, such as the FV-30 extensional Viscometer, is essential.

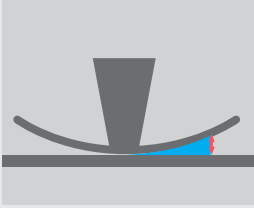
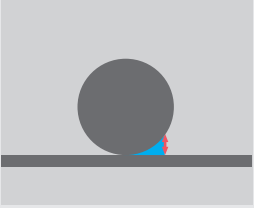
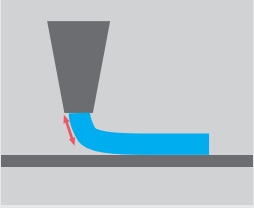
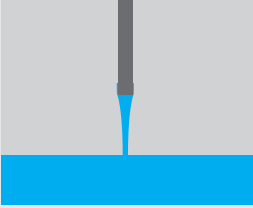
Measuring extensional viscosity with the FV-30 extensional Viscometer:

The FV-30 extensional Viscometer mimics the high-speed extensional deformation characteristic of flows found in industrial processes, from the filling of food and personal care products to high-speed inkjet-printing.

Utilizing a high-speed camera and high-precision load cell, the FV-30 extensional Viscometer measures:

- **Filament breakup kinetics:** Tracking filament diameter shrinking over time until break.
- **Extensional rheology:** Calculating extensional viscosity by analyzing the extensional deformation (image analysis) and force (load cell).

The FV-30 extensional Viscometer is equipped with a CCD camera. The CCD camera enables precise observation of the stringing and breakup behavior of fluid samples, enabling results to be directly applied to production optimization. This technology is applicable to paste printing, roller coating, slot-die coating, and dispensing processes, where phenomena such as stringing, misting, and breakup time critically determine process stability and product quality.

				
Application	solder-paste printing process	rotary printing and web printing process	slot-die-coating process	dispensing and bottle filling process
Problem(s) occurring during the process	solder paste tailing (dog-ears)	spraying (misting)	tap welding and thickness uniformity	stringiness and long breakup behavior

When process stability depends on extensional viscosity

Solder-paste printing process

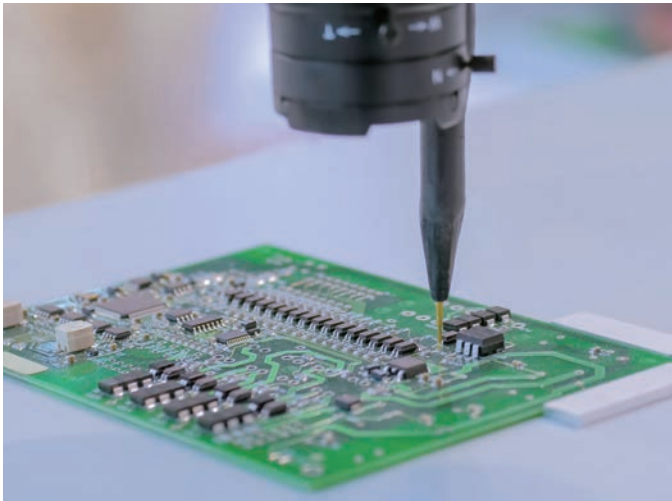
Applying solder paste to the printed circuit board (PCB) is a crucial step in the surface-mount assembly process. The aim of the solder paste printing process is to accurately deposit the correct amount onto each pad to be soldered. During the solder paste printing process, the squeegee blade applies the force needed to move the paste across the stencil and onto the PCB.

The rheological properties of the solder paste significantly influence the printing process quality, including stencil separation speed. During stencil release, a phenomenon known as solder paste tailing, also called dog-ears, can occur. This is a defect in which the edges of the paste deposit are pulled upward. Furthermore, stringing can lead to contamination of PCBs.



Jet printing and dispensing solder paste

To achieve high-yield solder paste jet printing, the system must deposit sharply defined droplets with precise volumes onto the PCB. If the solder paste exhibits excessive "stringing", where the paste stretches into a thin filament rather than snapping cleanly, it can lead to paste carryover (smearing). This results in poorly defined deposits or contaminated solder joints that compromise electrical integrity.



Slot-die-coating process

The extensional rheology of battery electrode slurries is a primary determinant of their processing behavior. It is well known in the industry that extensional properties can vary significantly between formulations, even when their chemical compositions are nearly identical. The slurry's behavior under extensional deformation cannot be predicted solely from shear rheology measurements. While shear measurements are standard in the industry, they fail to capture extensional flow behavior.

Since processes such as slot-die and curtain coating involve significant extensional deformation, measurement of the extensional behavior is critical for the accurate modeling of these processes. Understanding the extensional properties of slurries is therefore crucial for preventing defects, such as ragged edges, and for ensuring uniform coating thickness.



Filling process

The filling process in the food and personal care product industry is a crucial step in the production chain. The filling rate depends on both the technical limitations of the filling system and the product's rheological characteristics. Product formulations may exhibit stringiness, which leads to the contamination of containers, ultimately limiting filling speeds and reducing throughput.

Characterizing extensional behavior early in product development can therefore prevent difficulties during the filling process.



Maximizing process efficiency through advanced fluid formulation

Process management / Process control

- Optimal material design
- Process troubleshooting / problem solving
- Design of manufacturing conditions
- Quality control

Optimizing the fluid formulation for extensional flow

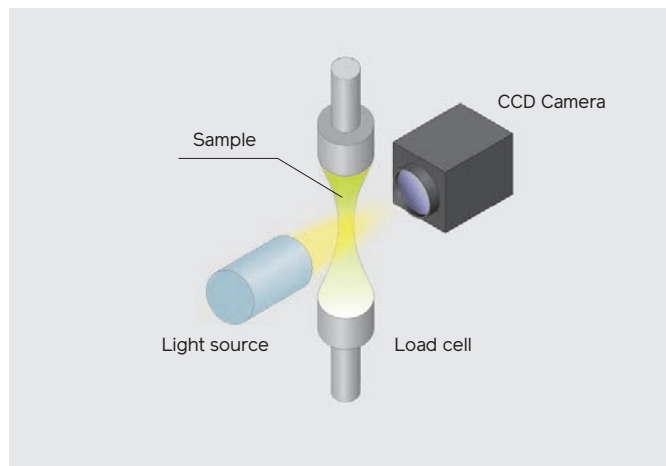
- Understanding the stretching behavior
- Process optimization
- Quality control

Measuring method and principal of the FV-30 extensional Viscometer

For measuring the extensional properties of a liquid sample, the sample is placed between two parallel plates. In the next step, the upper plate moves upwards over a short, predefined distance, exposing the sample to a step strain.

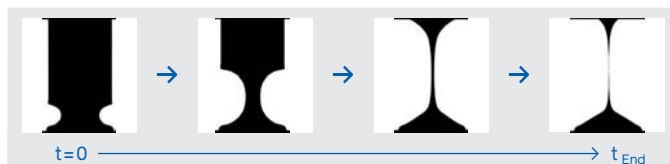
When the sample is stretched uniaxially, the center begins to neck, gradually deforming into a thin filament. This shape change is continuously monitored using a CCD camera, and image analysis is used to track changes in the minimum diameter over time.

Simultaneously, a load cell on the lower plate measures the stress associated with deformation. Finally, by combining the deformation rate (extensional strain rate) from image analysis with the stress data from the sensor, the sample's extensional viscosity is calculated.

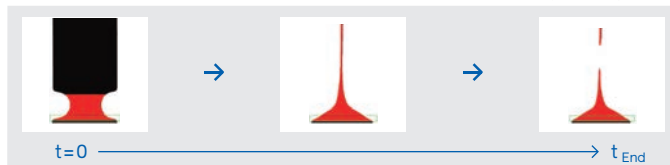


Visualization of elongation behavior using a high-speed camera

Recording of the filament breakup process with the CCD camera.

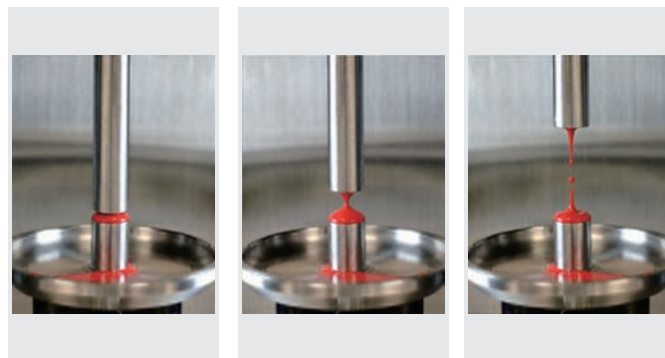


The software determines the minimum diameter via image analysis.



Deformation of the sample during measurement

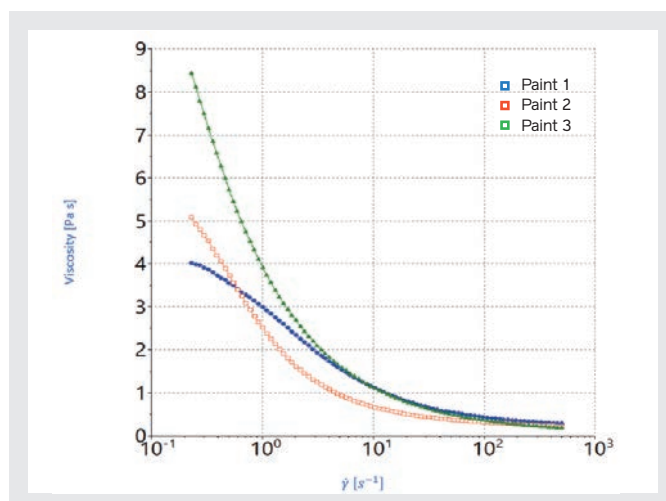
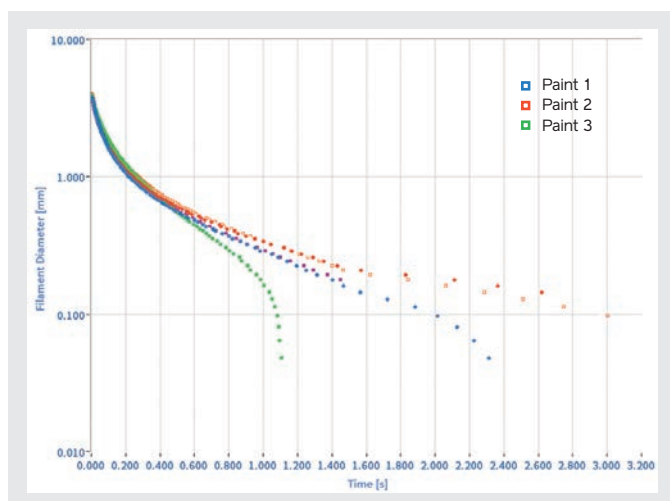
Generate liquid filaments under the same conditions as the process and evaluate their behavior.



Beyond rotation: Why shear viscosity is only half the story.

While rotational rheological testing showed nearly identical shear viscosities for three different paint samples (graphic on the right), suggesting similar filament breakup behavior during filling, results from the FV-30 extensional Viscometer told a different story (graphic on the left). The extensional measurements revealed significant variations in breakup times that shear data failed to capture.

The thinning dynamics and the breakup behavior of fluids are not classical fundamental physical quantities, yet they are well-suited for characterizing complex fluids.

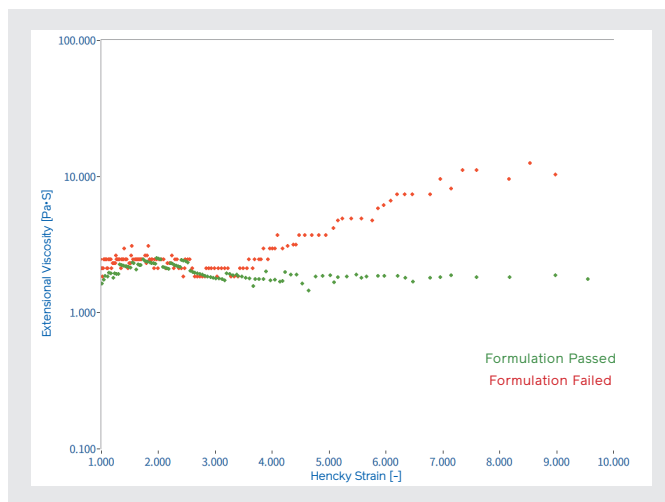
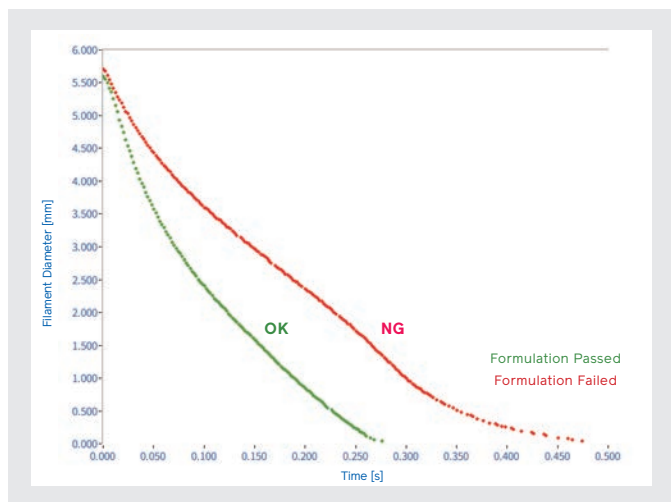


Adhesives for electronics components

Best practices for minimizing stringing in adhesive applications.

Adhesives play an essential role in the assembly of electronics, ensuring component safety, functional conductivity, and high structural reliability under stress. Therefore, it is crucial for the adhesive to be deposited exactly where it is needed. If an adhesive tends to string during spot dispensing, it often leads to application defects (long breakup time during the measurement).

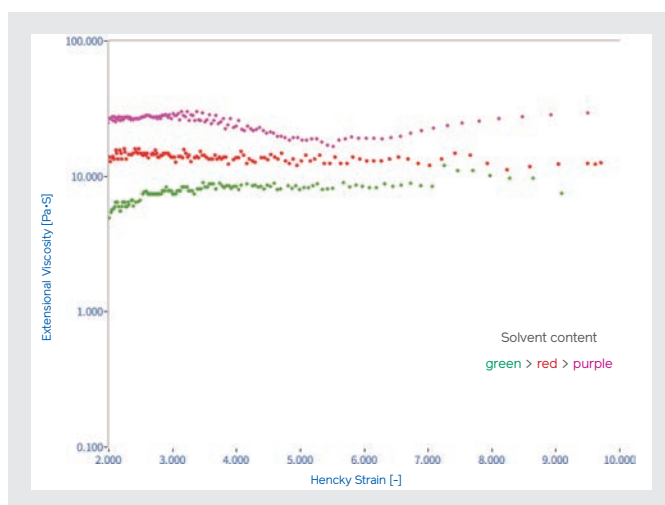
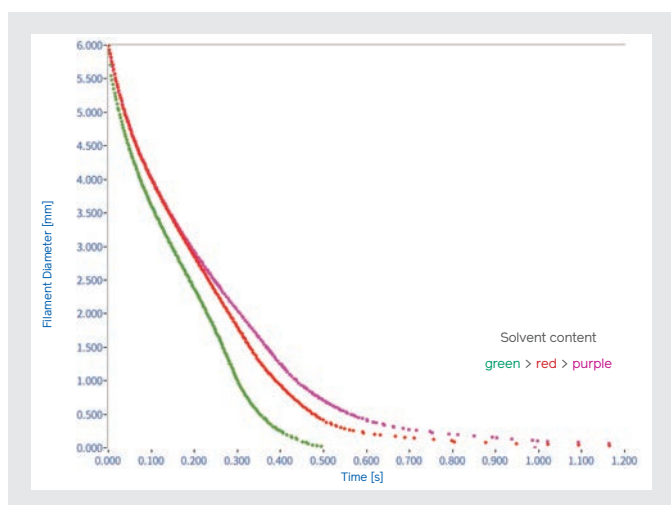
Measuring stringing and filament breakup time with the FV-30 extensional Viscometer enables a clear distinction between acceptable (ok) and defective resin formulations (NG), facilitating the selection of the optimal adhesive for the process.



Paints and Inks

Optimizing workability of paints and inks through extensional viscosity measuring.

To ensure uniform leveling during brush application, paints must exhibit low stringiness and a clean filament breakup. Evaluating extensional viscosity and breakup time is essential for determining a paint's processing quality. Since breakup time increases as the paints dry, monitoring these shifts is critical to ensuring a clean, streak-free finish throughout the application window. The diagram illustrates the same base paint with varying levels of solvent content (solvent content (green > red > purple)). The proportion of solvent influences both the breakup time and the extensional viscosity. The FV-30 extensional Viscometer enables the determination of the optimal solvent ratio.

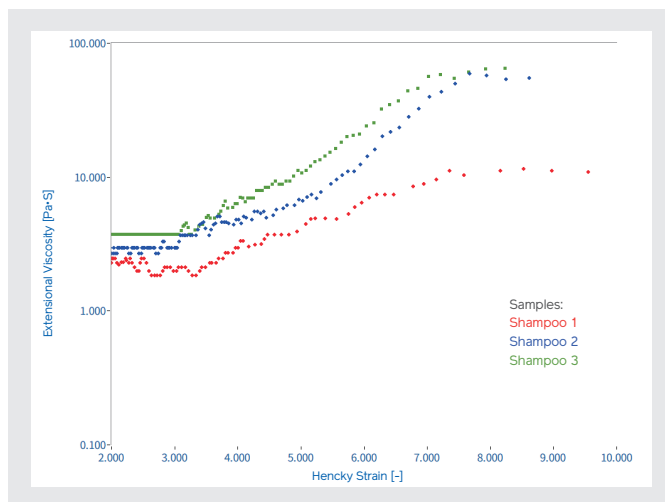
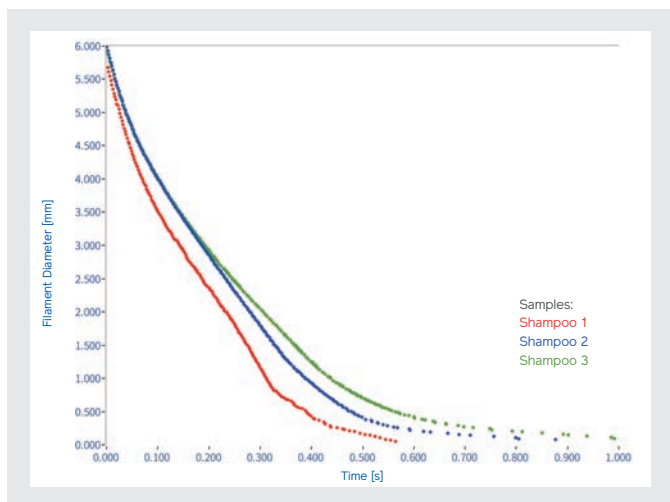


Personal care products

Optimizing filling processes with the FV-30 extensional Viscometer.

Long breakup times and stringing during the filling of personal care products, such as shampoos, can significantly impact the filling process and, consequently, the entire production process. Long breakup times can increase dwell time during the filling cycle or lead to packaging contamination.

By determining the breakup time with the FV-30 extensional Viscometer during the product development phase, the behavior during the filling process can be evaluated at an early stage.



Shear and extensional rheology: understanding the contrast

Shear Viscosity

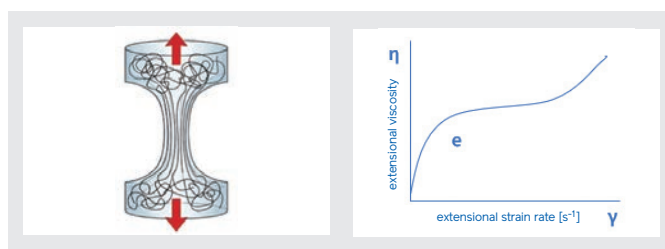
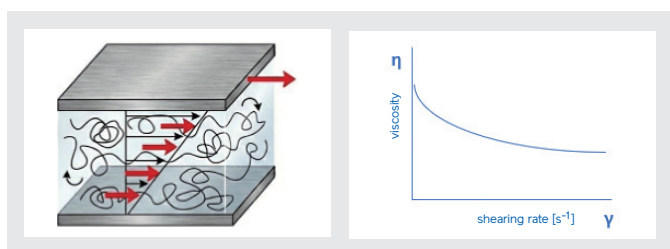
Shear viscosity describes the resistance of a liquid to motion.

A rotational rheometer shears a sample between two holders. The rotation causes fluid layers to slide against each other; the measured resistance determines the material's viscosity and flow behavior. The resulting velocity profile is parallel to the sample holders and perpendicular to the flow direction.

In complex fluids, such as long-chain polymer solutions or suspensions, this flow field can cause molecular or particle alignment, often leading to shear-thinning behavior. Because rotational rheometers apply shear stress, they cannot predict how a material behaves under axial stress.

Extensional Viscosity

Extensional viscosity represents the resistance of a fluid to elongation (stretching). To simulate extensional flow in the FV-30 extensional Viscometer, the sample is positioned between two plates. A step-strain displacement of the upper holder, defined by a specified length and velocity, applies an axial force to the sample, initiating necking of the liquid bridge. This stretching aligns the long-chain polymers, inducing molecular entanglements that cause a sharp increase in viscosity, a phenomenon known as strain hardening. Understanding these extensional properties is crucial for industrial processes where materials undergo rapid stretching rather than shear stress.



Specification

Measured Parameters	- Extensional viscosity - Filament diameter (filament breakup dynamic) - Extensional strain - Extensional force
Sample	
Viscosity range	> 200 mPa•s
Probe sample volume	< 0.2 ml
Measuring	
Plate diameter	4 mm and 6 mm
Axial velocity range	0 - 30 mm/sec, 0 - 100 mm/sec (conditional)
Maximum axial distance range	50 mm
Minimum measurable filament diameter	50 µm
Hencky Strain	up to 10
CCD Camera System	
Pixel resolution	16 µm
Sample rate	500 fps
Load cell	
Load range	0.001 g – 200 g
Resolution of the load cell	0.001 g
Instrument	
External Dimension	W300 x D250 x H620 mm
Weight	23 kg
Power supply	AC 100 - 240 V (70 W)
Software	Operating and analysis software comes included.
Export Format	CSV (Excel)
Languages	English, Japanese

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