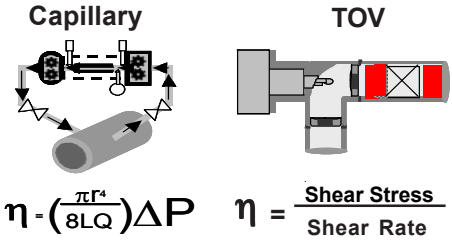


tov viscometer system

focus

TOV System vs. Capillary Comparison



Principles: Operating principles of TOV and capillaries

Capillaries: Uses Pressure, pipe radius, other parameters to calculate viscosity.

TOV: Simply uses the constant shear rate of the TOV Probe and the changing shear stress.

Pressure: Typically does not directly affect the structure of the polymer

Capillaries: Rely on pressure in equation. A process pressure change, will directly affect capillary results.

TOV: Not affected by normal pressure changes in the process and compensates for large changes.

Pipe Radius: Material builds-up on pipe walls over time causing radius to change

Capillaries: Use pipe radius in equation. As radius changes, measurement accuracy/sensitivity decreases.

TOV: Does not rely on the pipe radius in the equation.

Bypass line: Time delay of viscosity measurement

Capillaries:

- located in bypass line NOT in the main process line
- viscosity of product not the same as nominal production conditions
- pressure and temperature different than main process line

TOV:

- located in the main process pipeline,
- measures the viscosity of the main process itself
- measures viscosity at the nominal production pressure and temperature.

Temperature: Bypass lines (side-streams) and main process line temperatures are different.

Capillaries: Needs a separate temperature system that is **NOT** the same temperature as the actual process.

TOV: Measures viscosity at the actual process temperature in the main process pipeline.

Maintenance: Need for recalibration, regular repair, frequency of breakdown

Capillaries:

- Require a bypass line that needs pumps and a separate temperature bath.
- Bypass lines must be cleaned regularly due to pipe wall buildup.
- Pumps often break down meaning more total line shutdowns.

TOV:

- The Probe is insulated like the pipeline and once installed, becomes a part of the pipeline.
- The TOV does not use any gears or motors, so it does not break down.
- Once installed, the TOV Probe does not require recalibration.

Summary

Capillaries

- Appear to be less expensive at first, actually are more expensive when considering:
 - installation costs of the complete side-stream
 - maintenance costs over the life of the instrument
 - lack of ability for tight process control
- Equation relies on changing factors such as pressure and pipeline radius
- Requires regular cleaning and recalibration
- Measures viscosity in side-stream where the process viscosity may differ from the main process TOV

TOV

- Appear to be more expensive at first, actually is an investment with a payback when considering:
 - virtually no maintenance costs
 - ability for tight, real-time process control
- The most accurate and sensitive viscosity measuring instrument
- Equation relies on only one changing parameter, does NOT require recalibration, maintains performance over time
- Some processes using the TOV have achieved under 1% and even under 1/2% viscosity control

Method Comparisons

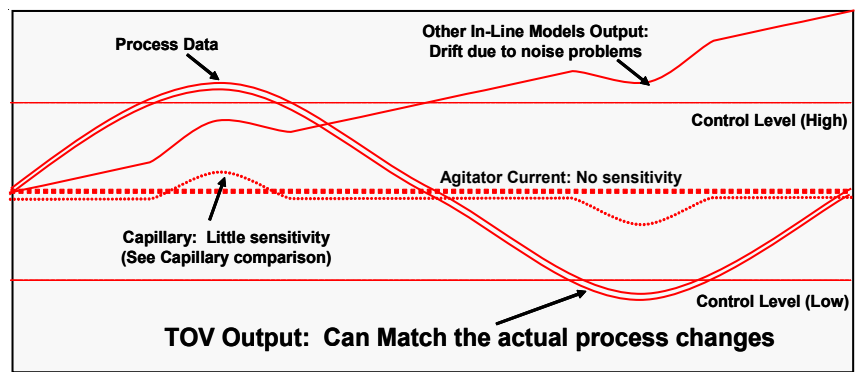
There are many methods to measure viscosity, but how do they compare?

Agitator Current:

- Power used to drive the agitator
- By far least sensitive method
- Provides only a very general guess of the viscosity and how it is changing

In-line Models:

- Can measure process viscosity in real time
- Some in-lines are extremely sensitive to vibrations
- Some in-lines require special installation for cooling
- Illustration shows some in-line models can drift and are not as sensitive as they should be.



Graphical Representation for Illustrative Purposes Only

Capillary:

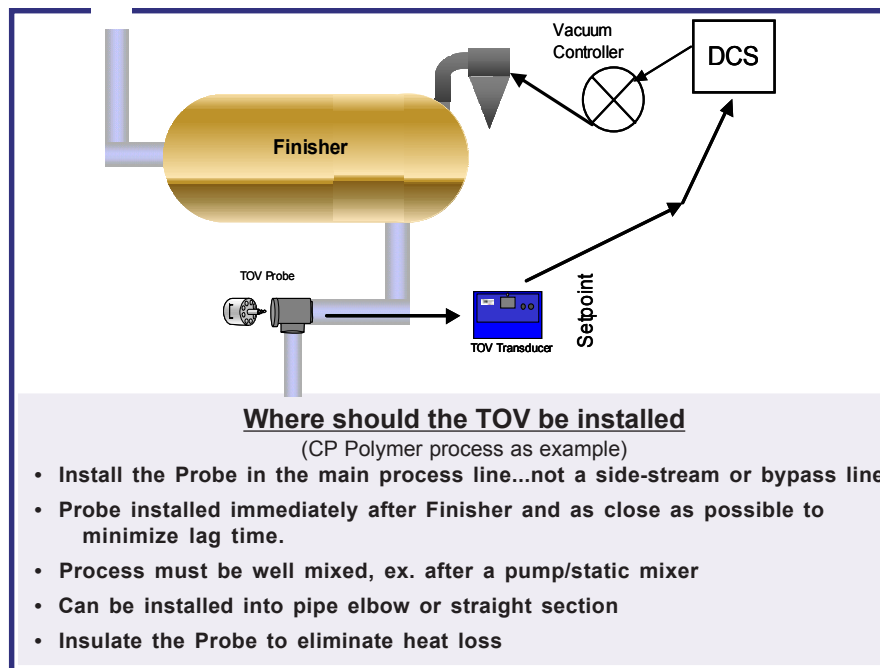
- Illustration shows capillary's long lag time in results
- Not very sensitive to changes main process viscosity
- Measures only large viscosity changes, not in real-time

Then there is the **TOV SYSTEM** by Mansco Products:

- TOV measurement is in-line, in the actual process, and in real-time
- Designed to eliminate problems of vibrations of the pipeline
- No special cooling required (up to 350° C)
- Most sensitive instrument for in-line measurement with 40+ years experience to prove it
- High sensitivity based upon simple physics (see Viscosity vs. Shear Rate sheet)
- TOV designed for use with Extruders, Vessels (Batch Systems), and CP process lines

Influence of Temperature

Temperature and viscosity are directly related. In a typical polymer, an increase in temperature will decrease the viscosity. This change may or may not be a real structure ("real" viscosity) change of the polymer. Since only "real" viscosity changes are important in viscosity control, temperature compensation must be used. The Transducer has Temperature compensation so that the TOV results only show real or structure changes of the polymer. Capillaries do not compensate for a temperature variance and, in fact, measure the viscosity at a completely different temperature than the nominal temperature of the main process.



Where should the TOV be installed

(CP Polymer process as example)

- Install the Probe in the main process line...not a side-stream or bypass line
- Probe installed immediately after Finisher and as close as possible to minimize lag time.
- Process must be well mixed, ex. after a pump/static mixer
- Can be installed into pipe elbow or straight section
- Insulate the Probe to eliminate heat loss

Influence of Pressure

Pressure: In true viscosity equations, Pressure has no affect. In practice, pressure may affect the "apparent" viscosity when sudden pressure changes are made. This is most common during a filter change when the Pressure very suddenly drops from very high to very low. The Transducer has Pressure compensation available to eliminate this affect on the viscosity measurement. This same change will drastically affect the measurement of the capillary.

When sensitive, reliable viscosity measurement *is* needed . . . the **TOV** is the *answer*.

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