

TOV viscometer system focus

TOV Advantage

TOV has advantages in limiting effects of flow rate:

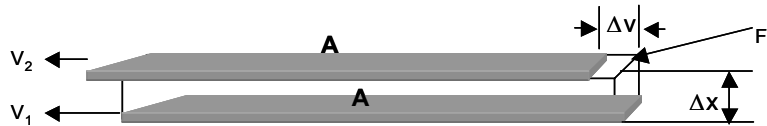
- √ Flow Rate is part of the capillary equation and it directly affects the viscosity measurement....TOV does not rely on the Flow Rate in a formula calculation.
- √ TOV measures constantly, in real-time so at all times the same number of molecules will surround the sensor... regardless of the process flow rate.
- √ TOV is compensated to show ONLY "real" viscosity changes when the molecular structure has really changed.

The TOV and Flow Rate:

Definitions

VISCOSITY: The property of a material to resist flow. Also the measure of this property equal to shear stress divided by shear rate in steady simple-shear flow.

$$\text{Viscosity} = \eta = \frac{\text{Shear Stress}}{\text{Shear Rate}} = \frac{F/A}{\Delta v / \Delta x}$$



APPARENT VISCOSITY: The shear stress divided by the shear rate. Also called viscosity and shear viscosity.

HOMOGENEOUS: Even-well mixed representation of the product in the pipeline where the material at the edges of the pipe and in the center are the same.

Flow Rate and Viscosity

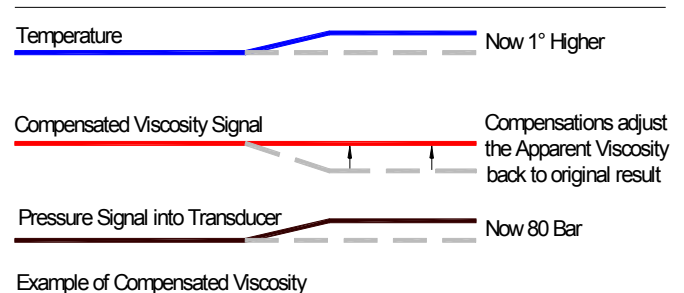
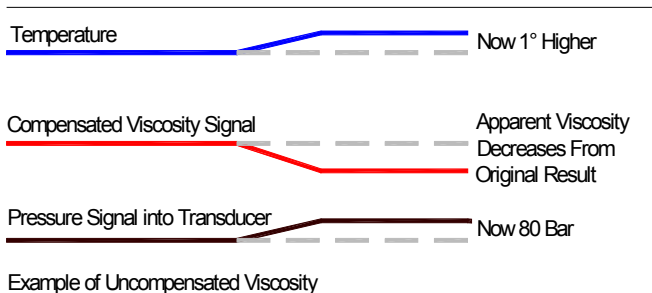
Flow rate of the process can change. In polymer products: ↑ Pressure will ↑ Temperature will ↑ Flow Rate

If the changes in pressure and temperature are minimal, the lab viscosity (IV or RV) will not change. That's because the molecules that make up the polymer have not changed in:

- 1) the types they are
- 2) how they are arranged
- 3) how many there are of them

The molecules may flow faster, but the "real" viscosity has not changed.

The TOV will measure this "apparent" viscosity change, but this is not very useful for process control. So, temperature and pressure compensation are used to remove the affects in the viscosity measurement.



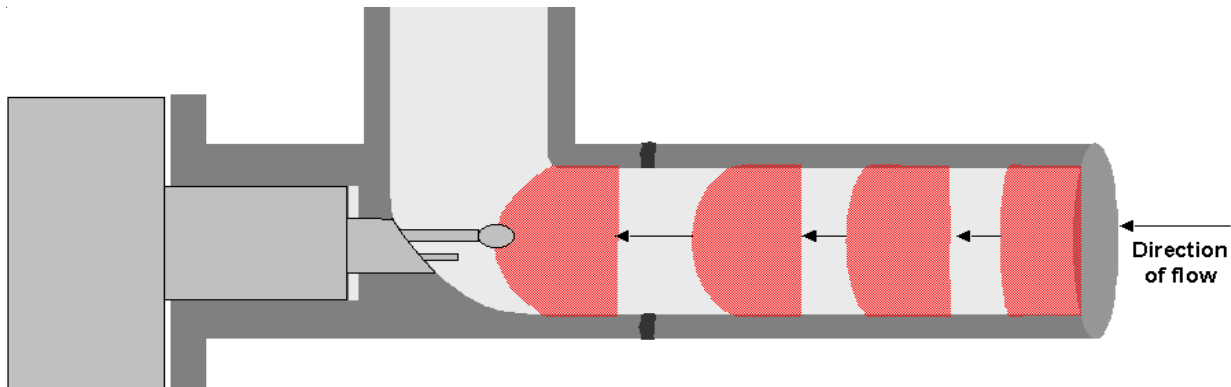
Now, only a "real" viscosity change, a change in the molecules, will show a change in the TOV results.

Process in the Pipeline

Better mixed products produce better viscosity measurements. For example, a homogenous product...such as milk...will have product uniformity and viscosity measurements can be made at any point in the process. However, polymer products, such as polyesters, nylons, spandex, and others, are not uniform like milk or water so flow considerations must be made.

Non-Mixed Flow

Below is typical polymer flow in a pipeline without any mixers installed. The flow is uneven and not homogeneous. The temperature at the pipe wall is lower than the temperature in the middle and this will form a parabolic flow. The viscosity along the pipe walls will be very different from in the middle of the flow....in fact, the molecules in the middle of the flow may be different from along the pipe walls. In this type of flow, a change in flow rate will change the viscosity measurement.

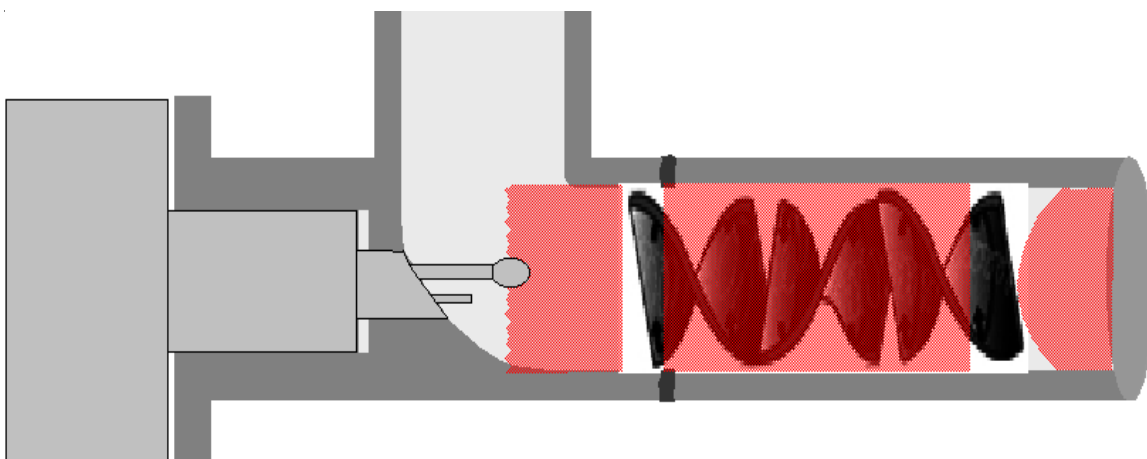


Mixed Flow

This next example shows the same flow only with the recommended static mixers installed before the Probe sensor. The flow as it enters the static mixer is uneven, parabolic and not homogeneous.

- The mixer will:
- 1) Mix the process
 - 2) Remove air pockets
 - 3) Remove the temperature difference between the middle and the pipe wall
 - 4) Make the product uniform

With mixers installed, the changes in temperature, pressure, and flow rate that will affect the measurement in a parabolic flow will no longer have those affects at the Probe sensor.



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