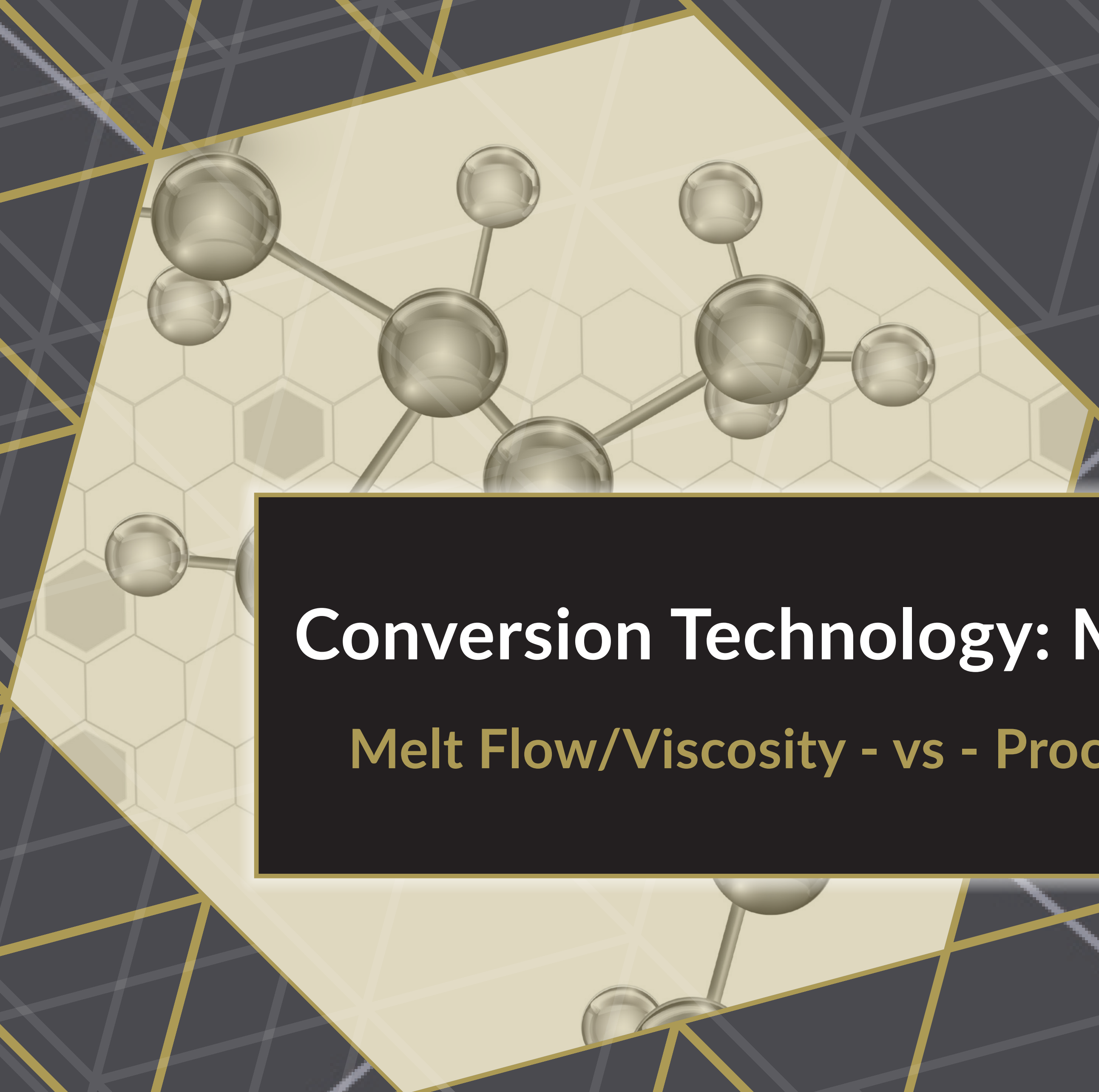

Conversion Technology: Melt Flow Matters

Melt Flow/Viscosity - vs - Processing Methodology

4/18/2019

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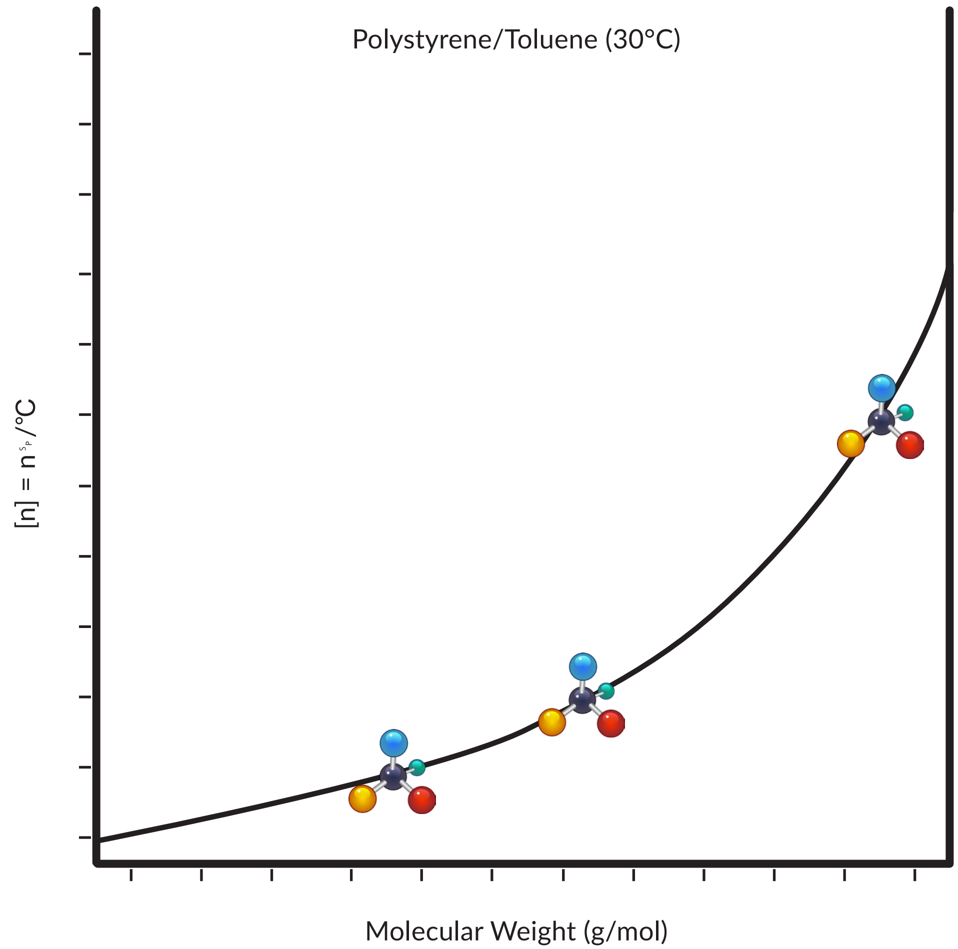
One of the first steps when selecting a product for a new application is to determine the required melt flow for the polymer being utilized in a given conversion process. The plastics industry typically regards melt flow as a surrogate for viscosity or melt strength. In general, viscosity is a measure of a fluids resistance to flow. As with all fluids, molten polymers have characteristic viscosities that vary with molecular weight, molecular weight distribution, temperature, morphology and plasticizer content. Many resin manufacturers produce varying grades of each polymer class in order to target relative viscosity or melt flow for specific processes or applications. Just as different weight oils are used in different automotive engines, polymer melt flows vary from process to process. In Newtonian fluids, viscosity varies linearly with shear rate, but the viscosity of molten polymers are highly dependent on shear rate. Polymers are typically referred to as shear thinning visco-elastic materials; the viscosity dramatically reduces as the shear rate is increased.

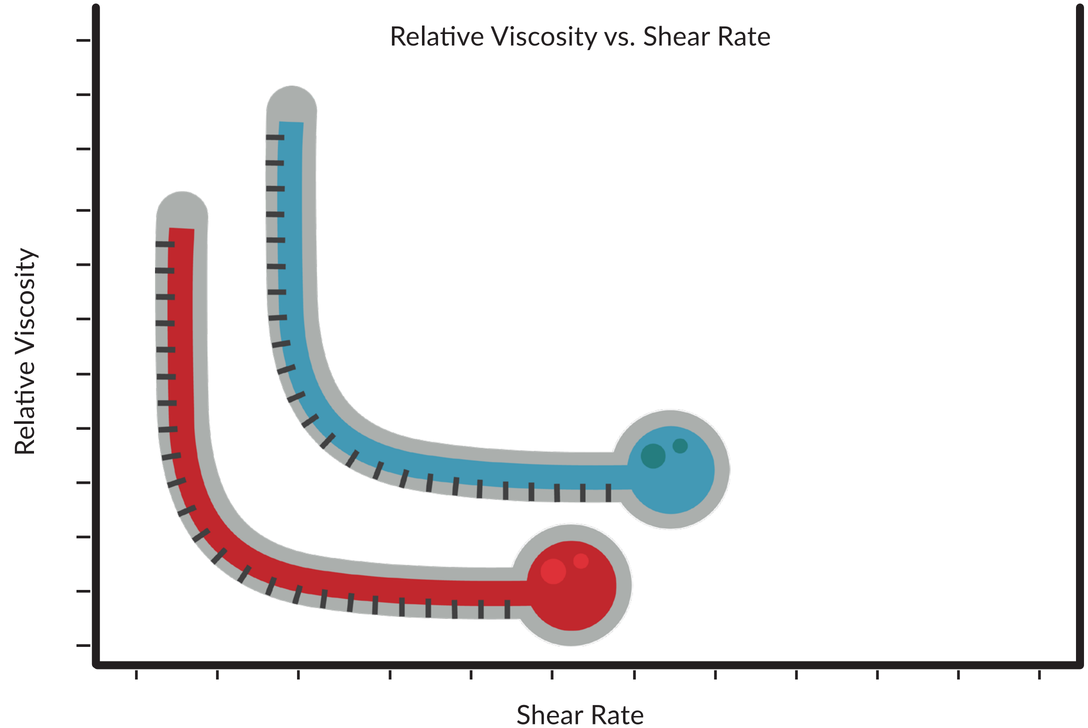
MOLECULAR WEIGHT

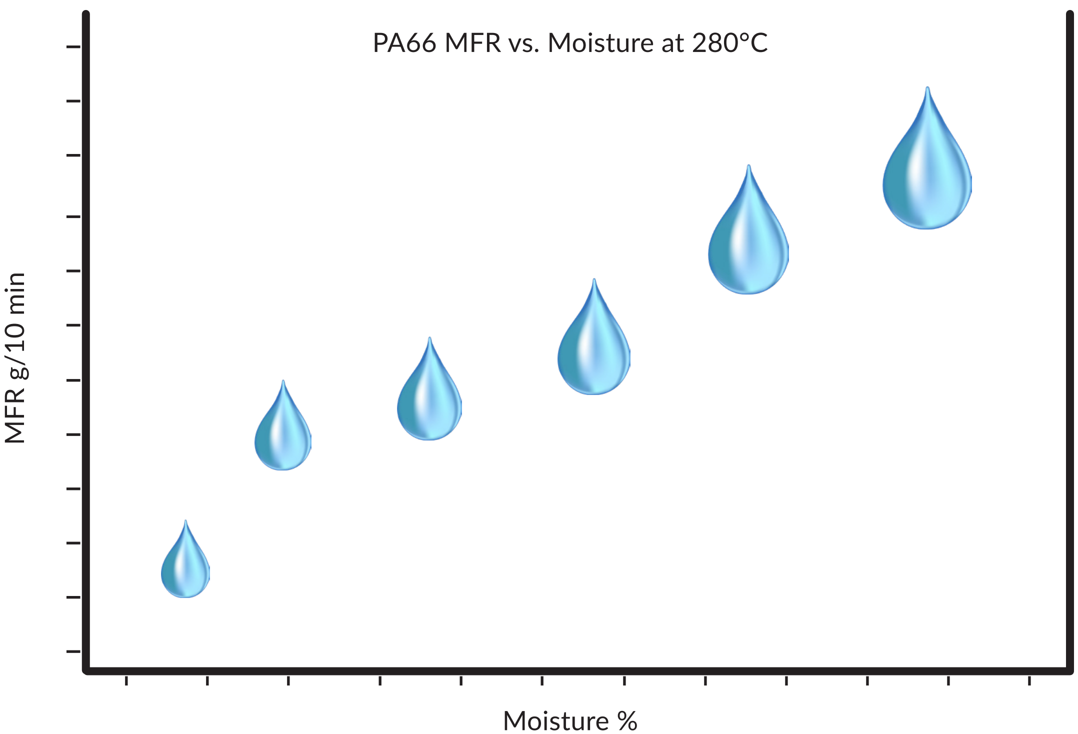
As a polymer grows in molecular weight, so does its relative viscosity. The image shown to the right shows the general correlation between molecular weight and viscosity. Higher molecular weight generally produces increased melt strength products that have elevated tensile and impact strength. Higher molecular weight and higher viscosity materials are typically positioned in applications requiring high melt strength (unsupported tube extrusion, blow molding, etc.)



TEMPERATURE

Viscosity of a molten polymer is effected by the temperature of the process. As a material increases in temperature, the viscosity is reduced. Increased heat allows for increased segmental motion and reduced viscosity/melt strength. This is especially important for material selection as the effects of changes to temperature profile on material viscosity are constrained by the melting point of the polymer and degradation temperature.





PLASTICIZER CONTENT

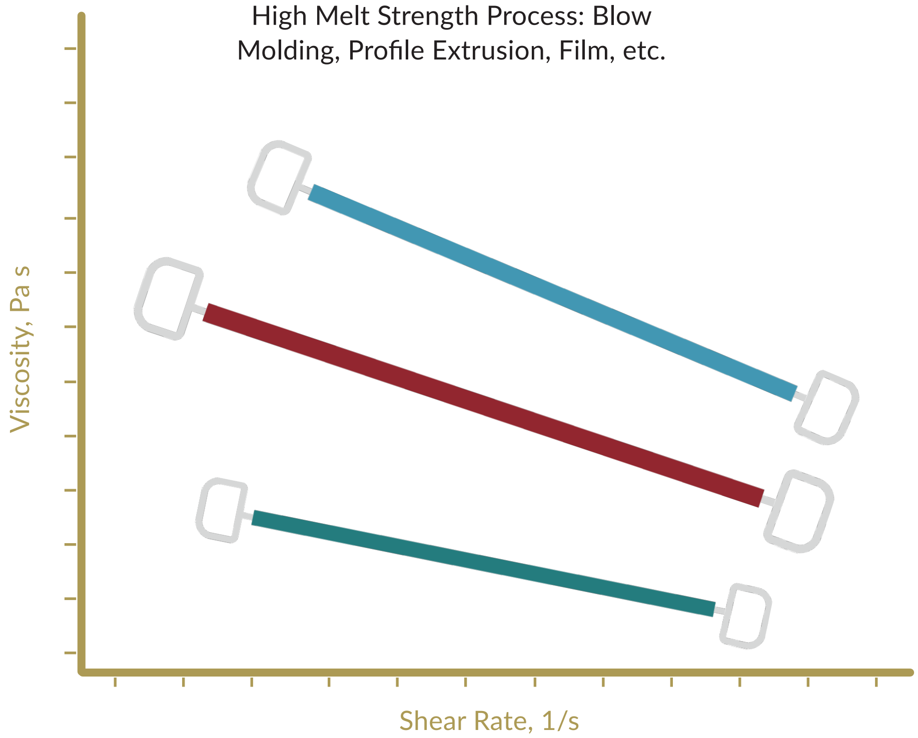
Many plastics are internally lubricated in order to boost melt flow. This allows a higher molecular weight polymer to process at a higher melt flow for ease of processing. This plasticizer changes the required shear in order to reduce polymer viscosity. There are many different types of plasticizers that act differently on the varying chemistries of polymer classes. As an example, nylon is plasticized by water in the molten phase. In general, melt flow is not reported for nylon as the atmospheric moisture content greatly effects flow and affects the consistency of the melt flow results. As shown in the summary chart, relative viscosity or viscosity number are reported for nylon.

SHEAR RATE

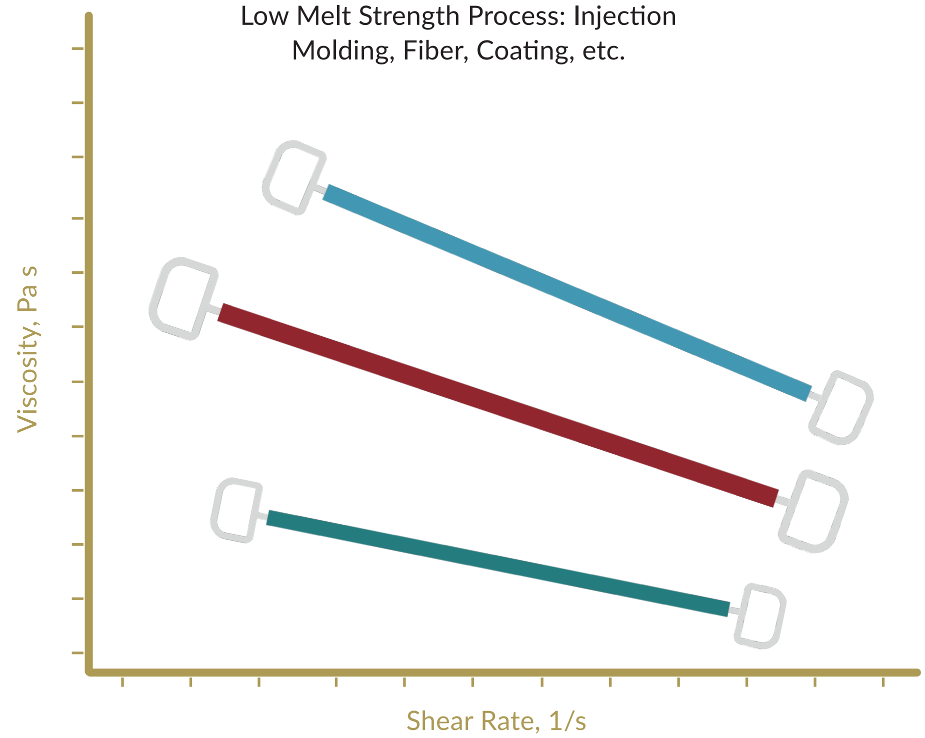
Resin can be processed or converted to functional objects in a variety of process machinery. Each conversion process utilizes different types of equipment in order to shape the molten polymer into its final product dimension. We will be discussing the viscosity related parameters for each of the processes below:

- ✓ Injection Molding
- ✓ Blow Molding
- ✓ Fiber/Monofilament
- ✓ Profile/Tube/Sheet Extrusion
- ✓ Cast/Blown Film

High Melt Strength Process: Blow Molding, Profile Extrusion, Film, etc.



Low Melt Strength Process: Injection Molding, Fiber, Coating, etc.



MATERIAL CATEGORY	ASTM D1238/ISO 1133 CONDITIONS	INJECTION MOLDING	BLOW MOLDING	FIBER/ MONOFILAMENT	PROFILE/TUBE/ SHEET EXTRUSION	CAST/ BLOWN FILM
ABS	200°C / 5 kg	2.0 - 80.0	0.2 - 0.8	6.0 - 20.0 (160°C, 2.16 kg)	0.8 - 2.0	N/A
PMMA	230°C / 3.8 kg	1.5 - 26.0	1.0 - 2.2	N/A	1.0 - 2.0	1.0 - 2.0
PC	300°C / 1.2 kg	5.0 - 60.0	Branched 2.0 - 7.0	N/A	3.0 - 8.0	4.0 - 10.0
POM	190°C / 2.16 kg	1.5 - 40.0	0.5 - 1.1	N/A	1.5 - 6.0	1.5 - 8.0
HDPE	190°C / 2.16 kg	2.0 - 60	0.25 - 0.8	2.0 - 20	0.08 - 2.0	0.8 - 4
LDPE	190°C / 2.16 kg	4.0 - 35.0	0.25 - 1.0	2.0 - 20	0.08 - 2.0	0.8 - 4
PP	230°C / 2.16 kg	2.0 - 100	0.5 - 1.0	10.0 - 20.0	0.4 - 3.0	0.5 - 10.0
PA66*	Rel. Visc. 96% H_2SO_4	MV	HV	2.4 - 3.3	3.5 - 4.2	2.73 - 3.8
PA6*	Rel. Visc. 96% H_2SO_4	MV	HV	2.4 - 3.3	3.0 - 3.7	2.73 - 3.8
PBT	250°C / 2.16 kg	5.0 - 65.0	2.0 - 6.0	30 - 65	5.0 - 20	10.0 - 25
PEEK	380°C / 5 kg	4.5 - 40	3.0 - 10.0	6.0 - 40.0	5.0 - 10.0	3.0 - 15.0
PPS	316°C / 5 kg	15 - 100	5.0 - 20.0	120 - 200	N/A	1500 - 5000 Coatings