Processing of Metallocenes in Extrusion Coating Applications

Presented by:
Christine Ronaghan
Cloeren Incorporated

TAPPI
people resources solutions®

Introduction

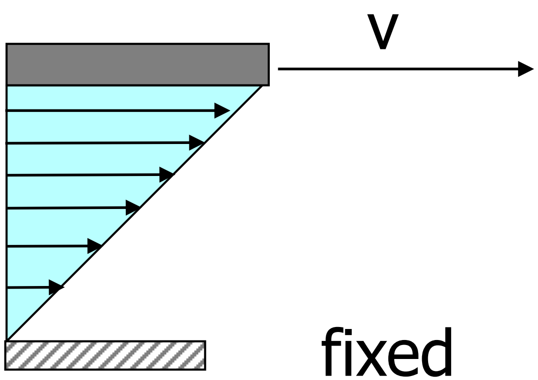
- Newer resins beyond the traditional workhorse LDPE continue to be used and explored in extrusion coating applications.
- mLLDPE: Introduced into some EC applications, and have continued to evolve. Challenges remain, but with increased experience, hardware design and process optimization, processing of this growing class of materials has become more efficient. *But, can we do better?*
- Concurrently, rheological testing capability is advancing… "Learning from Shear and Extensional Rheology of a few Extrusion Coating Polyethylenes" (Olivier Catherine, TAPPI PLACE 2016)

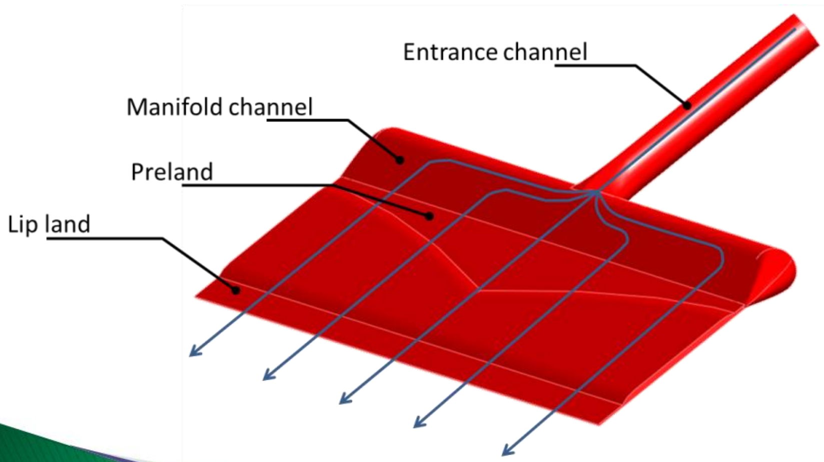
→ Question: Can we use advanced rheological analysis to understand, and predict, behavior of mLLDPE (and other resins) in extrusion coating applications?

→ Answer: Definitely, maybe.

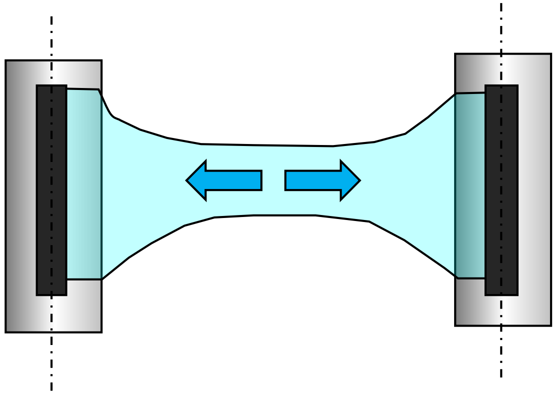
Viscosity – What matters where….

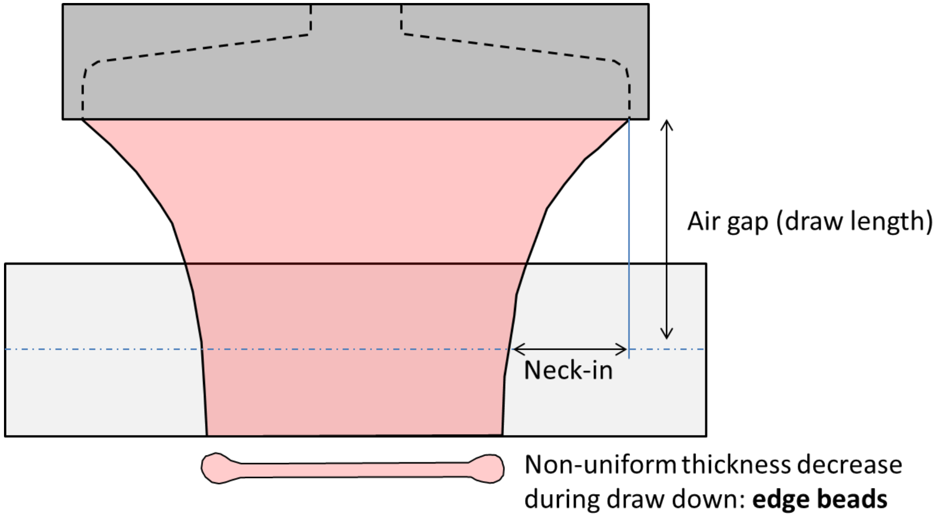
- Shear flow





- Extensional flow

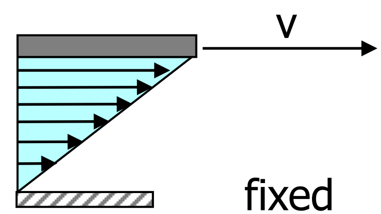




Areas of Interest in Extrusion Coating

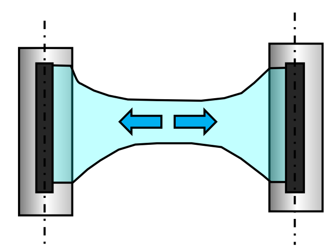
<u>Shear Flow Driven (primarily):</u>

- Extrusion (melting / mixing / pressure development)
- Melt Filtration
- Pressure Regulation (sometimes)
- Melt Transfer
- Convergence of multiple melt streams
- Melt forming through a flat die



<u>Extensional Flow Driven (primarily):</u>

- Neckin
- Edge Stability (or lack thereof)
- Draw-down Behavior



Agenda

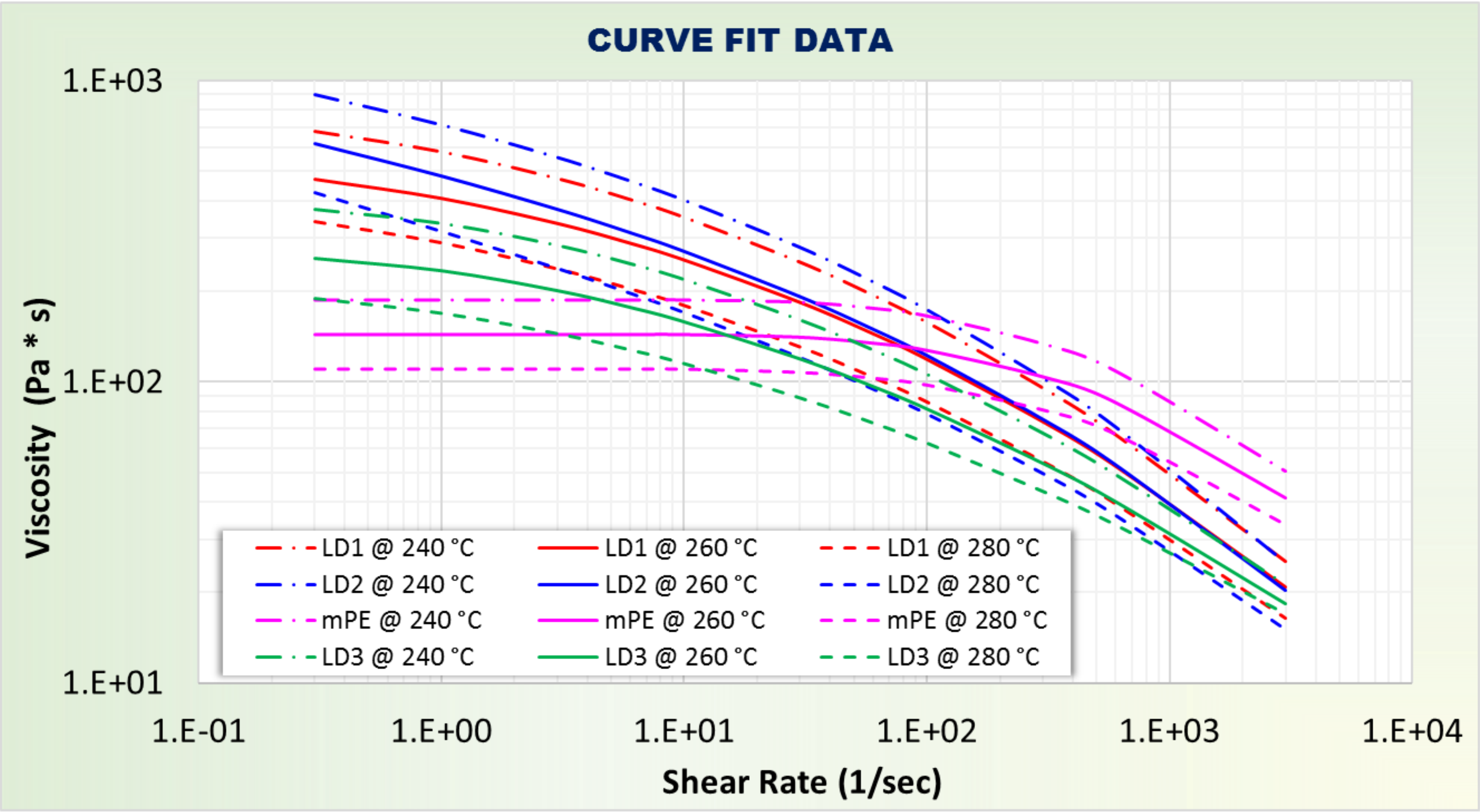
- Review polymers of interest
- Future work

Polymers

Name	Commercial name	Type	Density (g/cm³)	MFI (g/10 min)	Comment
LD1	Chevron Phillips Marflex 1017	Autoclave LDPE	0.917	7.0	Reference material
LD2	Westlake Chemical EC808AA	Autoclave LDPE	0.917	7.0	Similar to reference
m-PE	ExxonMobil Exceed 0019XC	m-PE	0.918	19	Molecular structure and molecular weight
LD3	Chevron Phillips Marflex 1019	Autoclave LDPE	0.917	16	Similar molecular weight as 0019XC?

Others to be added as single point references as noted.

Shear Viscosity Comparison

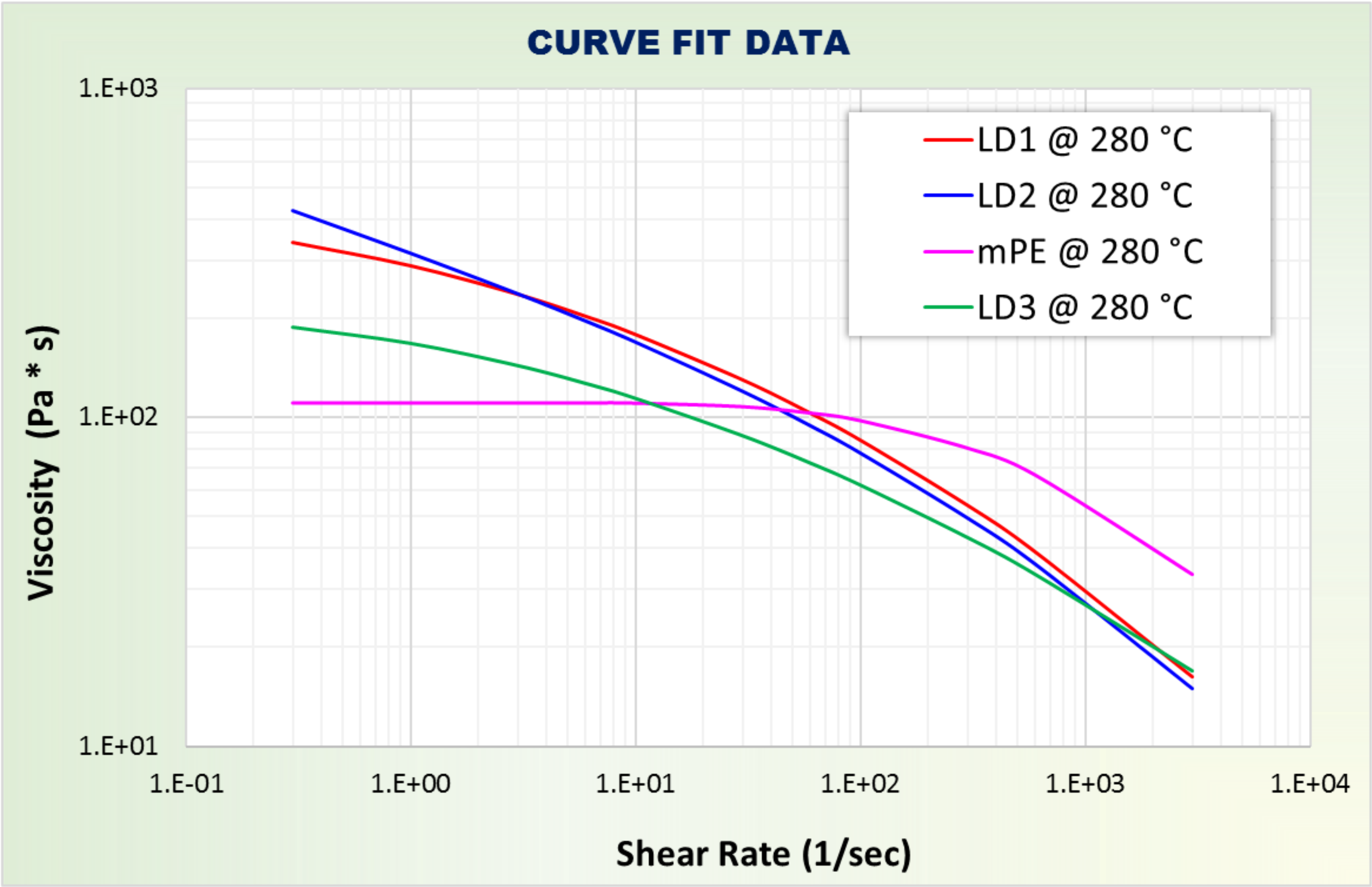


www.tappiplace.org

PLACE

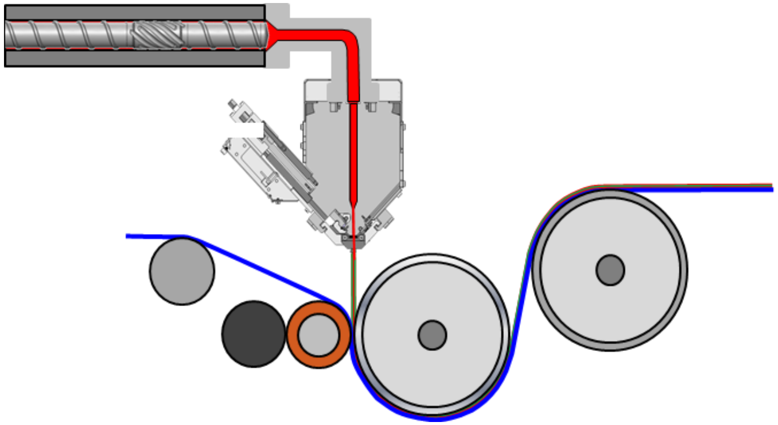
Polymers • Laminations • Adhesives • Coatings • Extrusions

Viscosity Comparison at 280°C

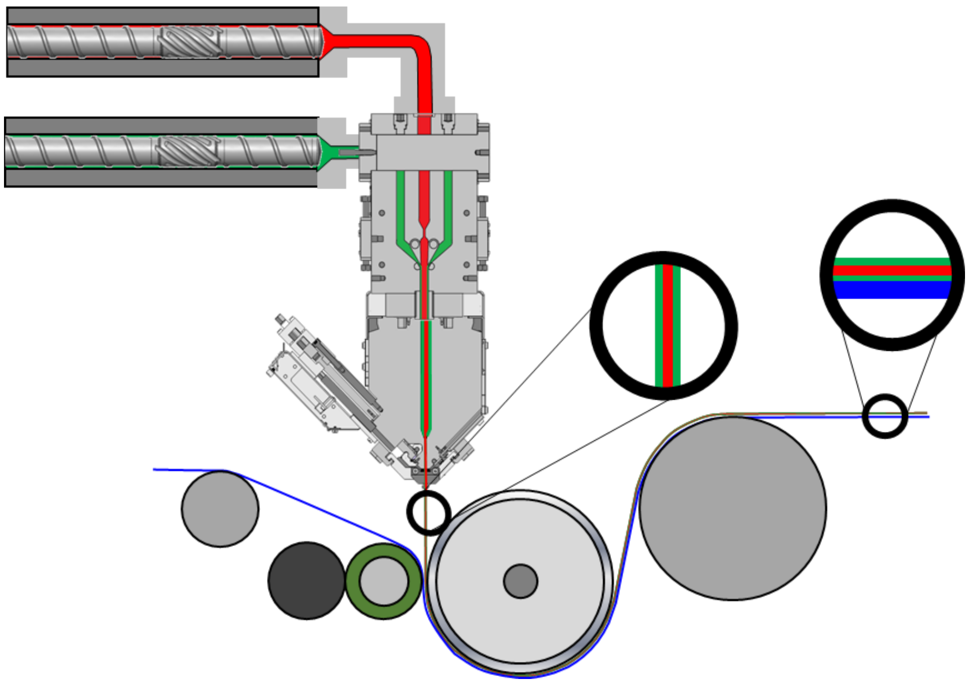


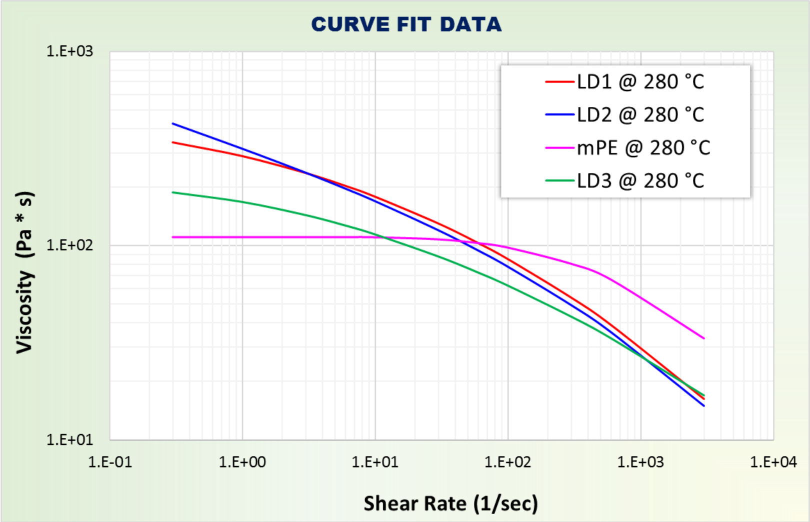
Process Implications

- Extruder / Screw
- Filtration / Valved Adapter
- Melt Piping
- Feedblock
- Die
- Air Gap / Cooling



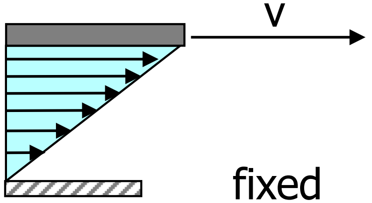
Shear Rate References





Component	Shear Rate (1/sec)
Screw	300 / 3,000
Valve	7,000 – 10,000
Melt Pipe	100
Feedblock	10 / 1,000
Die Manifold	10 – 30
Die Lip	1,000 – 3,000

Extrusion Performance

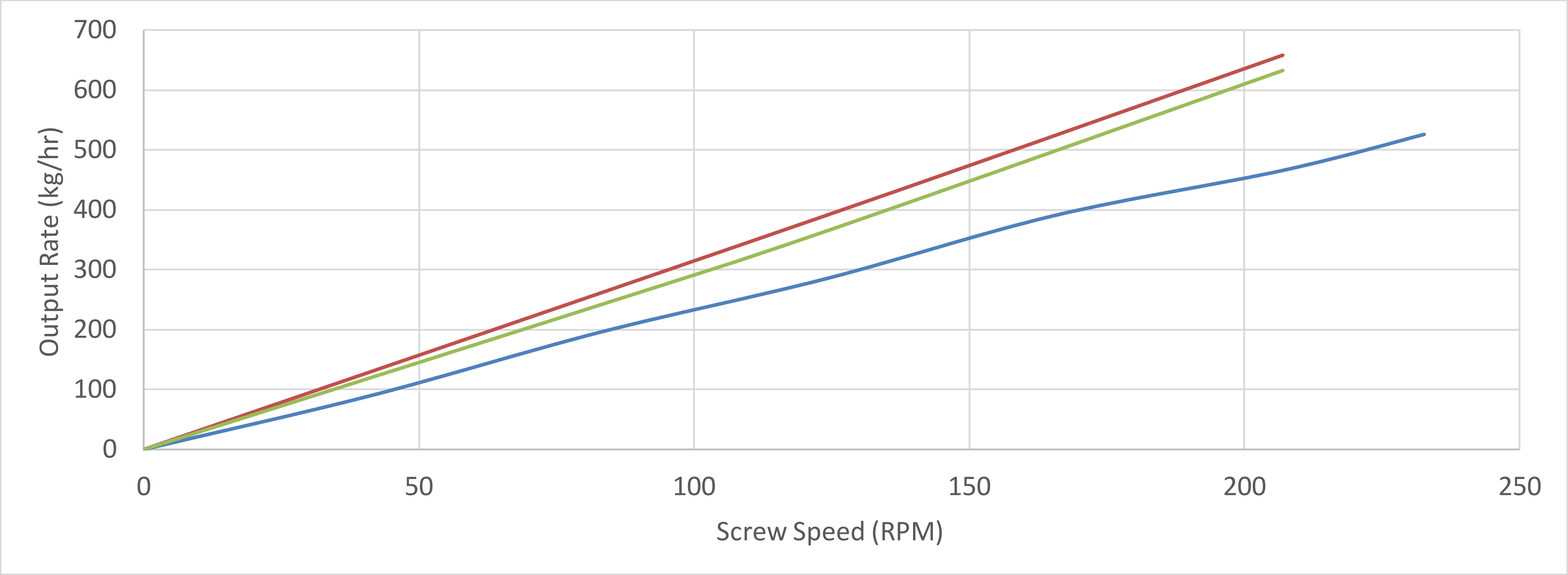


Screw Designs

LD1, Metering Screw with Dual Helical Mixers
LD1, Shallow Barrier Screw with Single Helical Mixer
LD1, Alternative Barrier Screw with Single Helical Mixer

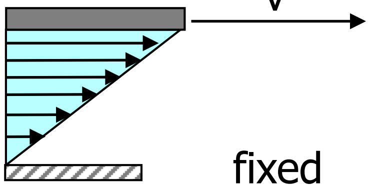
Process Conditions

Barrel Profile: 200/230/260/290/320/320°C; 50Bar at 200RPM
Barrel Profile: 200/230/260/290/320/320°C; 75Bar at 200RPM
Barrel Profile: 200/230/260/290/320/320°C; 85Bar at 200RPM



114mm, 30L/D Extruder
LD1 Output Rate vs. RPM

Extrusion Performance

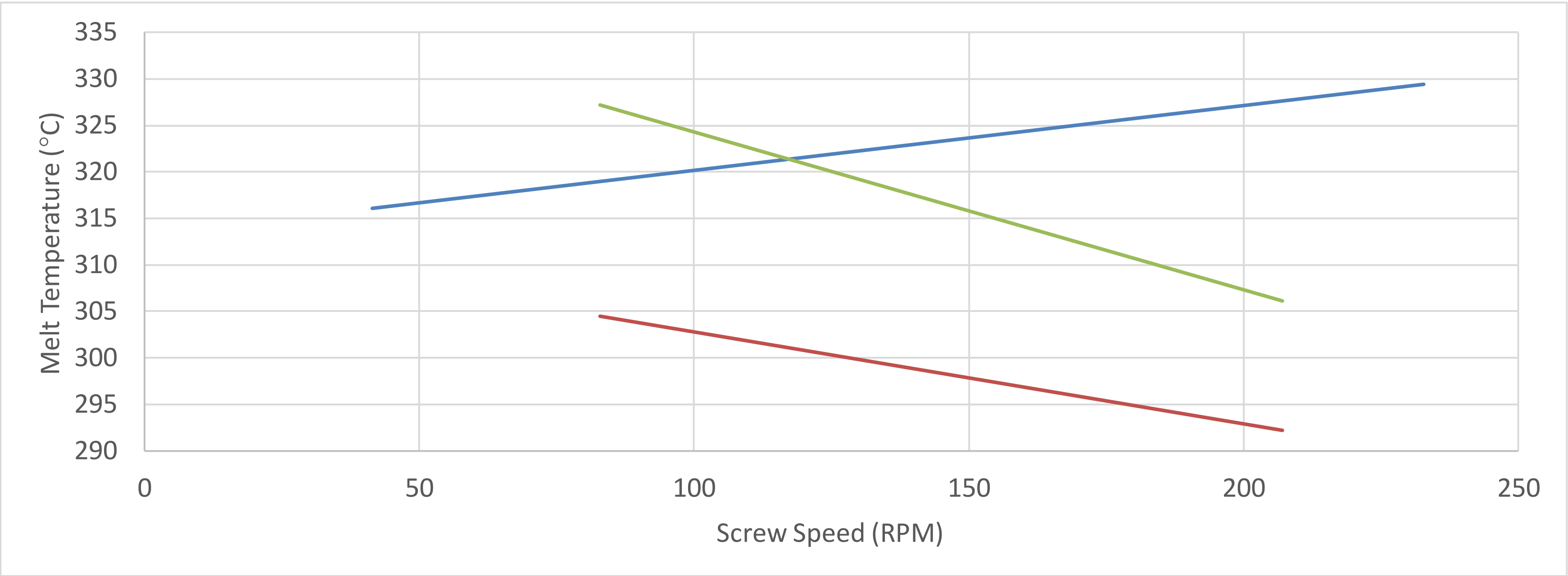


Screw Designs

LD1, Metering Screw with Dual Helical Mixers
LD1, Shallow Barrier Screw with Single Helical Mixer
LD1, Alternative Barrier Screw with Single Helical Mixer

Process Conditions

Barrel Profile: 200/230/260/290/320/320°C; 50Bar at 200RPM
Barrel Profile: 200/230/260/290/320/320°C; 75Bar at 200RPM
Barrel Profile: 200/230/260/290/320/320°C; 85Bar at 200RPM



114mm, 30L/D Extruder
LD1 Melt Temperature vs. RPM

Valved Adapter

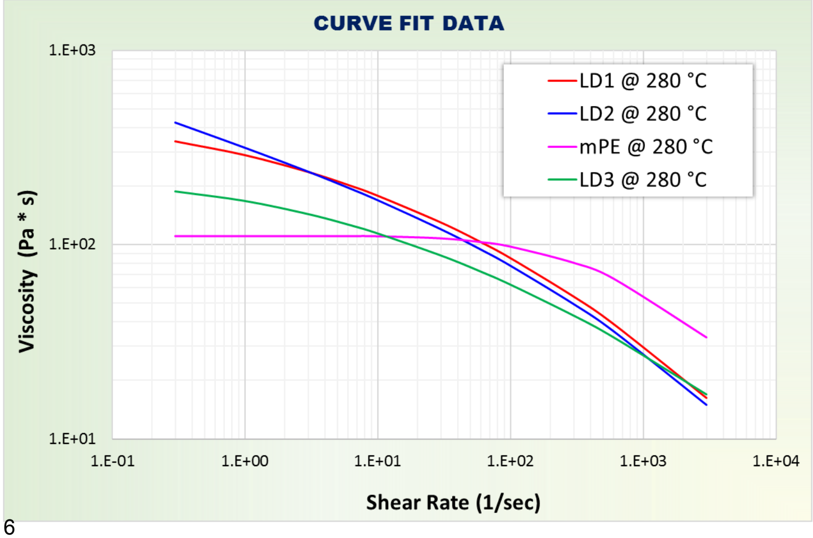
- Shear rates in an engaged valve system are very high.
- Notice where these values fall on the shear viscosity curve.

mPE will demonstrate ↑ (ΔP) at same restriction

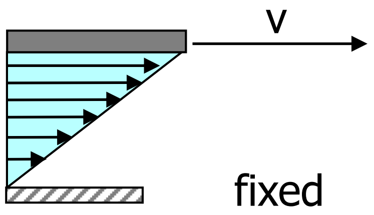
Example:

0.76mm (0.030”) radial clearance at 6mm (0.25”) engagement
545kg/hr at 280°C

LD1: 18.5 bar (270 psi)
mPE: 27.5 bar (400 psi)

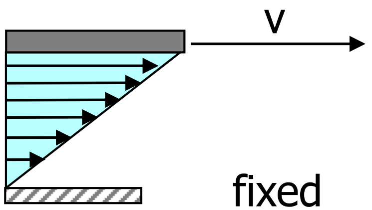


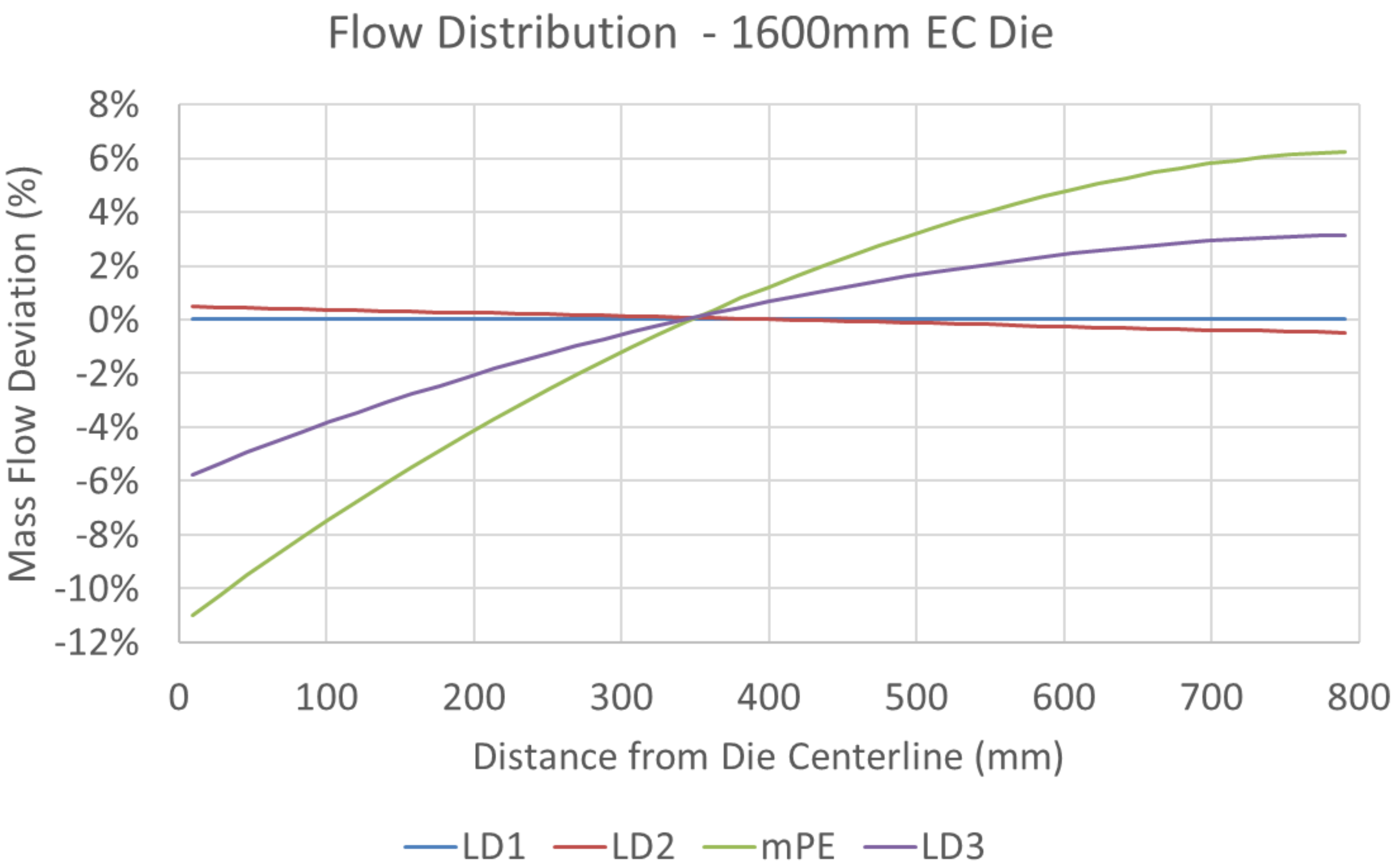
Die Design Considerations



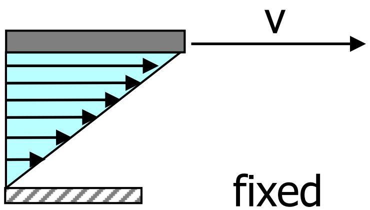
- Process Specifications:
  - Resin: LD1, LD2, mPE, LD3
  - Output Rate: 545 kg/hr
  - Melt Temperature: 280 °C
  - Die Slot Width: 1600mm
  - Die Lip Gap: 0.635mm (0.025”)

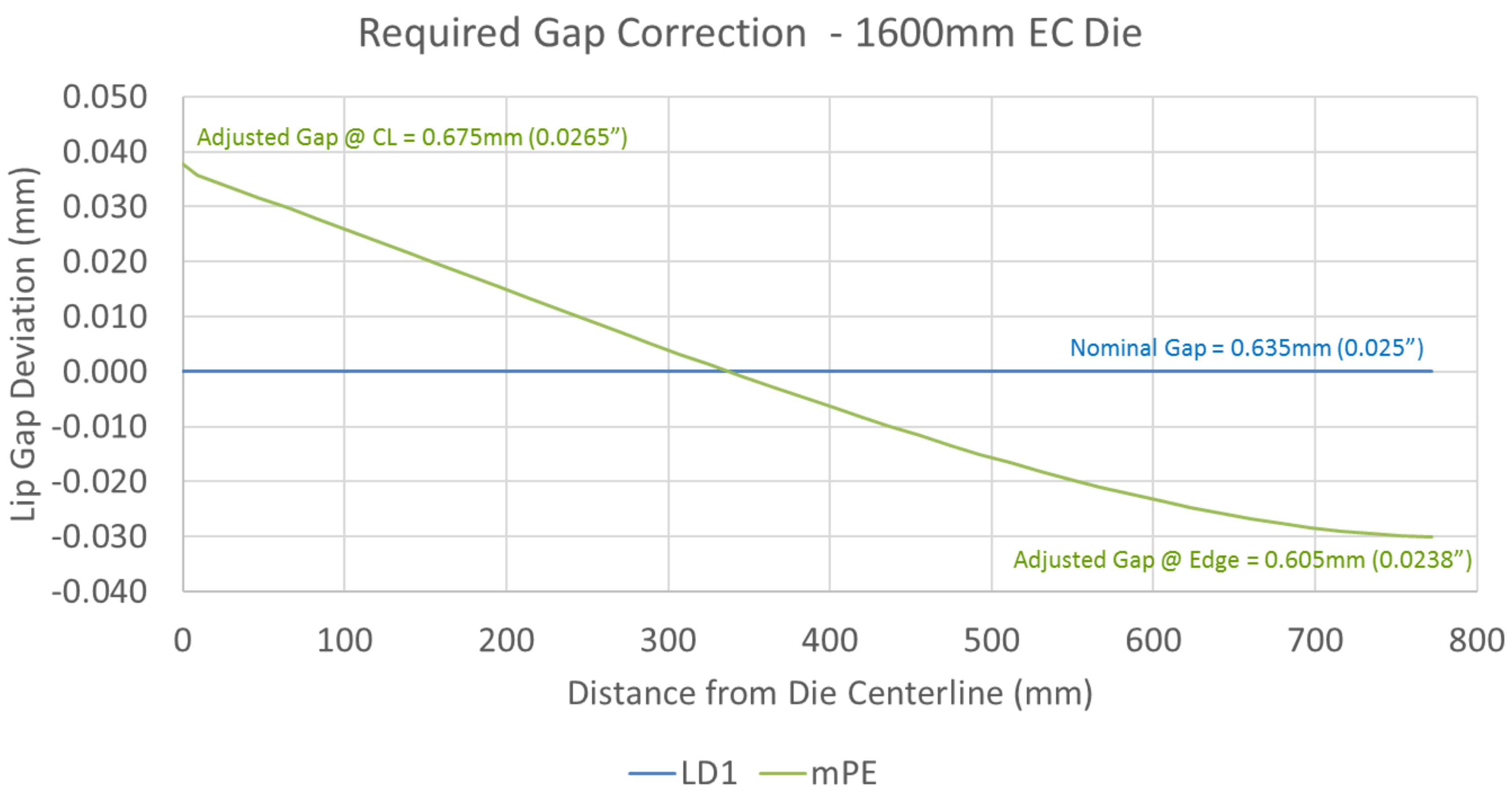
Die Design Considerations

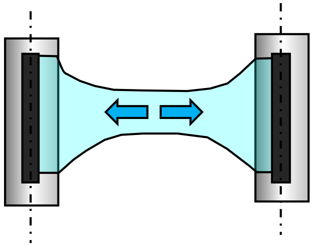




Die Design Considerations

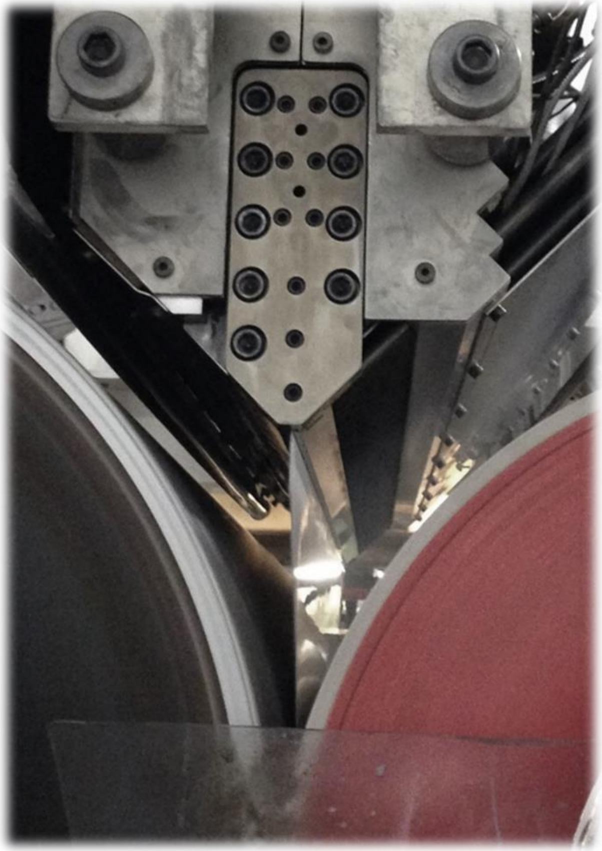






Air Gap

- No longer in shear viscosity regime.
- Melt curtain is drawn from the die lip to the laminator nip.



Typical Draw Ratio:

- 0.635 mm lip gap → 20 μm coatweight

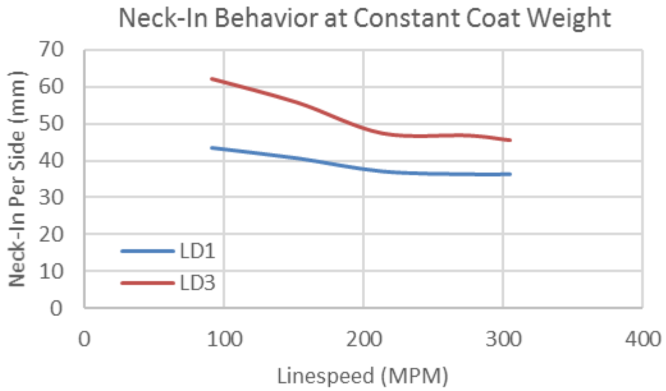
Typical Draw Rate:

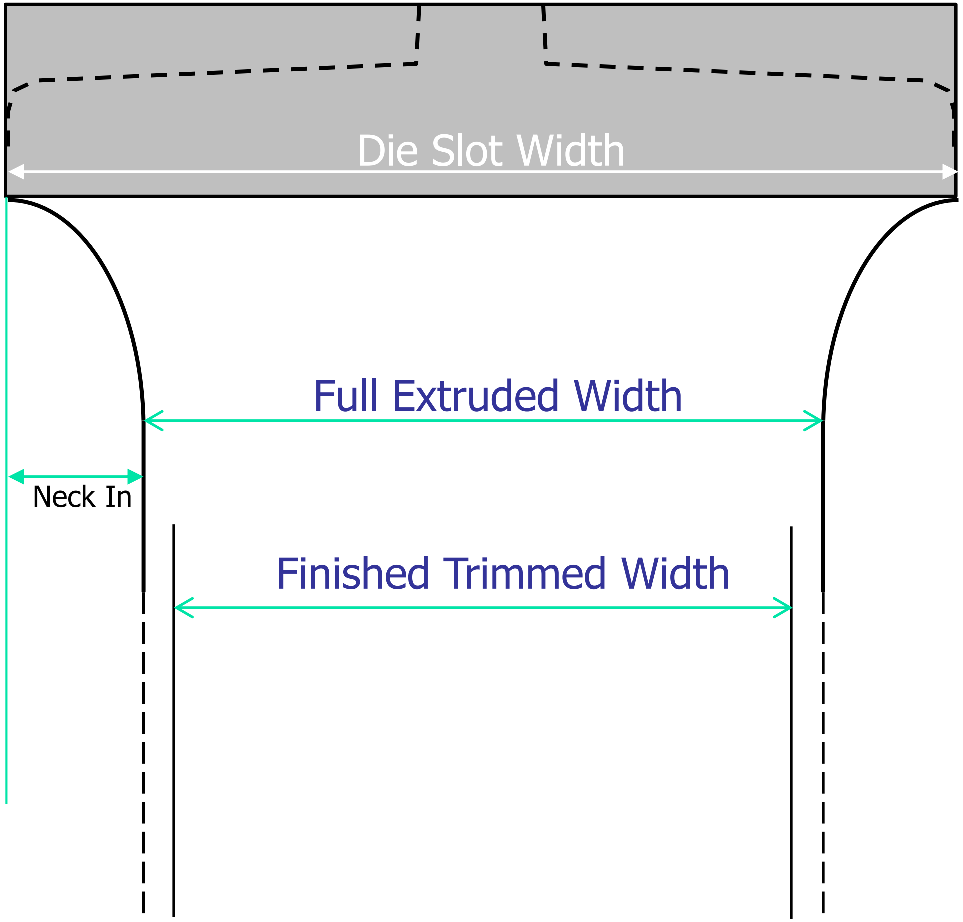
- 200-300mm air gap
- 600mpm at laminator

Concerns: neckin, edge bead, edge stability

Neck-In

- As melt curtain draws down, a reduction in width occurs.





Future Work

- Combined effort with Olivier Catherine (“Learning from Shear and Extensional Rheology of a few Extrusion Coating Polyethylenes”, Tappi PLACE 2016) to validate the theories and models developed.
  - Empirical evaluation of LD2, LD3 and mPE
  - Further investigation and experimental confirmation of rheological correlations developed for other extrusion coating resins (including EVA, PET, etc.)

Thank you

PRESENTED BY
Christine Ronaghan
Cloeren Incorporated
cronaghan@cloeren.com