Resin Transitions and Extruder Purging

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Purging Overview

- Theory - Flow in extrusion systems
- Theory - Melt rheology
- Design problems - difficult areas to purge
- Practice - Purge methods & procedures
- Practice - Commercial purge compounds
Velocity Profile
Flow Through a Pipe

* Shear Stress increases with Shear Rate
Effect of Viscosity on Purging

$\eta_A \ll \eta_B$

$\eta_A \gg \eta_B$
Circulation Dead Spots
Melt Viscosity vs. Temperature

- Ionomer
- Acid Copolymer
- LDPE

Temperature: 190°C

Log melt viscosity vs. temperature graph.
Effect of Shear Rate

- Constant $M_w$
- Log melt viscosity
- Log shear rate
- Long-chain branched
- Linear
- Short-chain branched
Difficult Spots to Purge

- Breaker plates
- Valved adapters
- Screw tips with hour-glass adapters
- Coextrusion elbows
- Keyhole style T-slot dies
Breaker Plates

Counter-bored

Screen Pack

Dead Zones

Normal Bored Breaker Plate
Streamlining - Breaker plate
Back Pressure Valves

Dead Zones

Solution: must rotate value when purging
Typical Coextrusion Elbow

Dead Zone
Streamlined Elbow

Expensive to Manufacture
# Typical Payback Analysis

<table>
<thead>
<tr>
<th>Cost of Elbows</th>
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<tbody>
<tr>
<td>Additional Hours of Machining</td>
<td>10</td>
</tr>
<tr>
<td>Machine Shop Hourly Charge</td>
<td>$200</td>
</tr>
<tr>
<td>Additional Cost of Machining</td>
<td>$2,000</td>
</tr>
<tr>
<td>Number of elbows</td>
<td>2</td>
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<tr>
<td>Total increase in investment</td>
<td>$4,000</td>
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<table>
<thead>
<tr>
<th>Savings</th>
<th></th>
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<tbody>
<tr>
<td>Purge time saved per transition (Hours)</td>
<td>0.25</td>
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<tr>
<td>Average purge rate in PPH</td>
<td>300</td>
</tr>
<tr>
<td>Purge resin saved per transition</td>
<td>75</td>
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<tr>
<td>Cost of purge resin at $.40/pound</td>
<td>$30</td>
</tr>
<tr>
<td>Machine hourly rate</td>
<td>$500</td>
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<tr>
<td>Machine time savings</td>
<td>$125</td>
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<tr>
<td>Total savings per transition</td>
<td>$155</td>
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<tr>
<td>Transitions per week</td>
<td>2</td>
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<tr>
<td>Annual transition cost savings</td>
<td>$16,120</td>
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<table>
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<tr>
<th>Payback</th>
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<tbody>
<tr>
<td>Payback time in months</td>
<td>3</td>
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Screw Tips & Hour Glass Adapters

Dead Zone (requires foaming purge)

Breaker Plate

Extended Screw Tip
Purge Procedure Basics

- Open external deckles *(if older die type)*
- Rotate valve spindle periodically
- Don’t “let it drool”
- Vary the RPM
- Don’t try to purge a dirty extruder with a high MI polymer
- Use temperature differentials
Purging Edge Bead Reduction Dies

- Introduce new resin, then purge at moderate to high rate (50-80%) until most of old resin is displaced
- Open bleed valve, if so equipped
- Open both deckles all the way
- Close both deckles all the way
- Alternately open and close each deckle several times
Disco Purge Method
Disco Purge Procedure*

MAXIMUM EXTRUDER RPM = __ RPM

1st min: 30% of max = 0.3 × __ RPM = __ RPM

2nd min: 90% of max = 0.9 × __ RPM = __ RPM

3rd min: 50% of max = 0.5 × __ RPM = __ RPM

4th min: 15% of max = 0.15 × __ RPM = __ RPM

5th min: 70% of max = 0.7 × __ RPM = __ RPM

6-10 min’s: 10% of max = 0.10 × __ RPM = __ RPM

(small extruders 20% of max = 0.20 × __ RPM = __ RPM)

minutes 11-15: Repeat the cycling steps of the first 5 min.

*developed by Al Soutar
Disco Purge Method

(*** preferred method for most resin changeovers and purging with low MFR LDPE )

+ Varies the shear rate to change flow patterns
+ Slow periods allow resins to bond together
+ Slow periods interrupt flow circulation
+ Often effective without purge compounds
+ Minimizes time and resin over “let it run”
- Does not scour tough die deposits
- Not always effective in removing tough gels
Alternate methods

• The following are alternate methods which some people use in the industry.
• Some are for specific problems, such as purging out nylon or PET resin.
• Some are for cleaning extrusion lines when they get too dirty for the Disco method to work with low MFR LDPE.
Water Purge Method

+ Pros +

+ Foaming action reaches tough dead spots
+ Unzips nylon and PET molecules to make lower viscosity, and help to pull off metal surfaces
+ Breaks down anhydride gels (acid based)
+ Inexpensive and effective
Water Purge Method
- Cons -

- Too much water could shock hardware
- Too much water could cause explosive out-gassing at feed, die or vent port
- Spitting polymer at die is hazardous
- Can take a long time to eliminate water from the system
- Should not be performed without a well thought out and approved procedure
Interactive Purge Method

- Uses burst of relatively high RPM spaced with periods of moderate RPM
- Watch the melt curtain at high RPM until the purge becomes less productive
- Run moderate (but varied) RPM, do something else for a few minutes - repeat
- Purge is complete when web is clear at both high and low RPM
- Like a ‘disco method’, but without disciplined process, thus is less effective.
Line Shutdown

• What to do when shutting down a line?
Shutdown Purging

- Introduce LDPE or PP resin. Consider adding antioxidant to LDPE
- Lower extruder barrel settings 100°C (200°F), but leave adapter, die, etc. hot
- Remove external deckles and open back-pressure valve
- Begin cycling internal deckles
shutdown purging (continued)

- Use disco or interactive purge method while barrel is cooling and at new settings
- Purge until melt is clear at high, medium and low RPM’s
- Set all zones to 175°C (350°F)
- Run occasional bursts of higher RPM until all zones are below 200°C (400°F)
- Turn off extruder and seal the die exit
Use of Purge Compounds

• What to do when the extrusion line is dirty, and using the “disco method” and manually cleaning the die lips does not help enough?

• There are “purge compound resins” which can be utilized. But each has its own difficulties for getting back out of the machine system, so allow extra re-purging time with PE afterward.

• A few examples of purge compounds follow.
“DPE-6611” & “SP-1500”

- Mainly for use in flat die systems (extrusion coating & cast film).
- DPE-6611 occasionally used in blown film lines.
- SP-1500 specifically for use cleaning out acid copolymer / ionomer when disco method with PE is not enough.
- (available from DuPont)
“DPE-6611” & “SP-1500”

+ Contains scouring agent to clean surfaces
+ Foams to help clean
+ High viscosity
+ Does not require removal of screen packs
- More expensive than PE
- Takes time to purge back out
“Rapid Purge”

+ Chemically breaks down polymers
+ Very high viscosity
+ Foams
+ Highly filled to scour surfaces
  - Requires removal of screen packs
  - Expensive
  - Takes time to purge back out
  - Removes varnish from inside barrel
“Super Nova Purge”

+ Very high viscosity
+ Foams
+ Highly filled to scour surfaces
+ Does not require screen pack removal
+ Less noxious fumes
- Does it chemically break down polymers?
- Expensive
- Takes time to purge back out