How to do Effective Color Changes

Presented by Moulds Plus International
Know Your Process

- Understanding colorants & pigments
- Polymer flow & color type
- Equipment design
- Melt viscosity
- Planning for effective color change
- Process set-up for fast color change
- Using Ultra Purge for fast color change

A Systems Approach!
Pigments

Coloring Materials

Pigments-Insoluble
Discrete particles

Organics
- Non effect

Minerals
- Non effect
- Effect

Dyes-Soluble
Liquids
How Different Pigments Work

- **Inorganic Pigments**
  - Titanium Oxide

- **Organic Pigments**
  - Carbon Black

- **Reflectance Pigments**

- **Absorption Pigments**

- **Round shaped Fillers**

- **Platelet structure**
  - Metal/ Pearl lustre pigments
Non-Effect Pigments: PARTICLE SIZE

**ORGANIC**

- Ø0.01-0.1µm
- (+)

**MINERAL**

- Ø0.5-1µm
- (-)

Specific surface area = Area in contact with polymer
Non-Effect Pigments: PARTICLE SIZE

**ORGANIC**
- 0.01-0.1 μm
- Easier
- Need good mixing

**MINERAL**
- 0.5-1 μm
- Harder
- "Dispersability"
- Standard mixing sufficient

Specific surface area = Area in contact with polymer
Non-Effect Pigments: PARTICLE SIZE

ORGANIC

MINERAL

Mixing Requirements
Physics of Polymer Flow

Velocity & Shear Rate Profiles in a Runner

\[ \dot{\gamma} = \frac{dv}{dr} \]

Boundary Layer at the Runner Wall:

- \( V = 0 \)
- \( \dot{\gamma} = 0 \)  
  - Infinite Residence Time

Fountain Flow during cavity filling:

- Layer at the runner wall (Old Color) deposited on part surface

Plastics Laminar Flow:

- Layered Flow Motion (No mixing)

Reynolds Number:

\[ Re = \frac{\rho V D}{\mu} \ll 2100 \]
Velocity near 0 at melt channel wall

Plastic pulled from melt channel

Boundary Layer from a Color Change
Molding System Considerations

**Hot Runner:**
- Reduced hot runner volume
- No-mismatches
- No hang-up spots
- Uniform thermal profile
- Mixing capability

**Screw/Barrel:**
- Good mixing capability
- No bridging in feed zone
- No mismatches (nozzle)
- No hang-up spots (check valve)

**Color Dosing:**
- Easy/fast cleaning
- No hang-up spots
- Repeatable dosing

**Resin Conveying:**
- Easy/fast cleaning
- No hang-up spots
Best Design Practices for Hot Runners

**Valve Gate**
- Nozzle well size/layout
- Tip insulator

**Manifold Bushings**
- Channel mismatches
- Fit in manifold
- Stem guidance

**Manifold**
- Channel mismatches
- Channel layout
- Thermal uniformity
- Residence time

**Manifold/Nozzle Interface**
- Avoid channel mismatches

**Sprue Bushing/Sprue Bar**
- Channel size changes (Tapers, etc.)
- Thermal profile

**Hot Tip Gate Area**
- Nozzle well size/layout

**Plugs**
- Blended plugs
Melt Channel Sizing
Why Thermal Uniformity Matters

Cooler Area

Hotter Area

Removed melt channel
Boundary Layer vs. Thermal Profile
Elimination of Cold Areas

Melt channel

Optimized Temperature Profile

- Overall $\Delta T = 30^\circ C$
- $\Delta T = +17^\circ C$
- $\Delta T = -13^\circ C$
Color Change Planning – Not Optimized

Total # of shots: 600 shots
Resin used: 57.6kg

Note: 32-drop mold
3gram part
Color Change Planning - Optimized

Total # of shots: 400 shots
Resin used: 38.4kg

33% reduction in resin usage

Note: 32-drop mold
3 gram part
Purge Compounds Can Improve Color Change

80% reduction
Two significant costs are generated when purging:

- **Scrap**: Amount of resin and purging compound used to clean the machine
- **Downtime**: Amount of time used to purge/clean the machine. This is inclusive of:
  - Lost of production
  - Energy used to run the machine while purging
  - Manpower
Scrap is normally the smallest component of the purging cost but it is definitely the most visible. Many companies monitor this as an indicator of efficient production. Reducing scrap during a color change can only be achieved by using a purging compound.
• Downtime is normally the largest component of the purging cost when analyzing the purging process.

• Fast purging means gaining production up time as well as reducing the cost of energy and manpower.

• Purging compound are designed to reduce down time making color and material changes faster.
Cost Efficiency

Using Ultra Purge will yield the following results:

• Reduce scrap production by **50 to 80%**
• Reduce downtime by **60 to 85%**
Using Ultra Purge:

• will reduce the rejects due to black specks and color streaking.

• will eliminate 100% of all remnants of color and resin that can potentially generate black specks or color streaking during production.

• will remove carbon deposits generated from thermo-sensitive resins.
Material Change → Ultra Purge → Reduce Scrap
Color Change → Ultra Purge → Reduce Down Time
Shut Downs → Ultra Purge

Increases Profits and Productivity → More Competitive in the Market
• What is Ultra Purge
• How Ultra Purge Works
• When to use Ultra Purge
• Why use Ultra Purge
• Ultra Purge Benefits
• Product Line
• Purging Procedures
What is Ultra Purge

• Ultra Purge is a chemical Purging Compound in a ready-to-use or concentrated pellet form.
• It is designed to clean screws, barrels, shooting pots and hot runners when changing color or removing carbon contaminations.
How Ultra Purge Works

- Ultra Purge is nonabrasive and works through a chemical reaction. With the presence of a chemical component, color incrustation, black specks and rust are softened, removed and ejected from machines.
- An expanding agent is added to Ultra Purge which allows the compound to be more efficient - even in hard to clean situations.
- Ultra Purge cleans at the processing temperature of the previous production material.
Molecule of HDPE with red color

Ultra Purge
Temperature: Effect on Viscosity

Cooler Melt Channel Wall

Higher Temperature = Lower viscosity resin

Hotter Melt Channel Wall

Higher temperature = Lower viscosity resin

Lower temperature = Higher viscosity resin

350°F

450°F

Lower temperature = Higher viscosity resin
Ultra Purge is designed to be used with all thermoplastic resins in:

- Injection Molding Machines (all types and sizes)
- Hot Runner Systems
- Injection Blow Molding Machines
- Compression Molding Machines
Why use Ultra Purge

- to save money by reducing downtime and scrap material when changing color. Improvement of **50 to 80%** scrap reduction and **60 to 85%** downtime reduction
- to improve the quality of production by removing black specks
- to make start-up time faster
- to eliminate “slip screw” problems
- to preserve equipment from steel oxidation
## Cost Analysis PE Application

<table>
<thead>
<tr>
<th>Colorant Used</th>
<th>Red (liquid)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resin</td>
</tr>
<tr>
<td>Lbs of PE</td>
<td>Lbs</td>
</tr>
<tr>
<td>Cost of PE</td>
<td>USD/Lb</td>
</tr>
<tr>
<td>Lbs of Ultra Purge P-O</td>
<td>Lbs</td>
</tr>
<tr>
<td>Cost of Ultra Purge P-O</td>
<td>USD/Lb</td>
</tr>
<tr>
<td>Total Cost Material</td>
<td>USD</td>
</tr>
<tr>
<td>Time required for purging</td>
<td>hr</td>
</tr>
<tr>
<td>Down-Time/Lost Production Hourly Cost</td>
<td>USD</td>
</tr>
<tr>
<td>Total Down-Time Cost</td>
<td>USD</td>
</tr>
<tr>
<td>Total Cost per Purging</td>
<td>USD</td>
</tr>
<tr>
<td>USD saved per color change using Ultra Purge</td>
<td>394.10</td>
</tr>
</tbody>
</table>
Ultra Purge Benefits

• Very efficient in cleaning process
• Moldable purging compound
• Cost effective (small quantities are needed - plastic processors can save a lot of money and downtime)
• Easy to be removed from the machine
• All Ultra Purge grades are food contact certified by EU and FDA regulation
• 100% safe. All ingredients are GRAS from the FDA as substances added indirectly to human food
• Easy to use
• Odorless - does not produce dangerous gases
<table>
<thead>
<tr>
<th>Product Line</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultra Purge P-O</td>
<td>338°-572°F 170°-300°C</td>
</tr>
<tr>
<td>Ultra Purge P-OH</td>
<td>338°-572°F 170°-300°C</td>
</tr>
<tr>
<td>Ultra Purge PO-C</td>
<td>374°-608°F 190°-320°C</td>
</tr>
<tr>
<td>Ultra Purge BP</td>
<td>338°-572°F 170°-300°C</td>
</tr>
<tr>
<td>Ultra Purge High-E</td>
<td>374°-608°F 190°-320°C</td>
</tr>
<tr>
<td>Ultra Purge Low-E</td>
<td>284°-500°F 140°-260°C</td>
</tr>
<tr>
<td>Ultra Purge HT</td>
<td>555°-750°F 290°-400°C</td>
</tr>
<tr>
<td>Ultra Purge PET-E</td>
<td>374°-608°F 190°-320°C</td>
</tr>
<tr>
<td>Ultra Purge PET-C</td>
<td>374°-608°F 190°-320°C</td>
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<tr>
<td>Ultra Purge 9010</td>
<td>284°-608°F 140°-320°C</td>
</tr>
<tr>
<td>Ultra Purge CE-E</td>
<td>284°-500°F 140°-260°C</td>
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<tr>
<td>Ultra Purge PLUS</td>
<td>374°-608°F 190°-320°C</td>
</tr>
<tr>
<td>Ultra Purge 5060</td>
<td>374°-608°F 190°-320°C</td>
</tr>
<tr>
<td>Ultra Purge 5050</td>
<td>374°-650°F 190°-343°C</td>
</tr>
</tbody>
</table>
Purging Procedures

Screw and Barrel
Keep the barrel of the press full of the resin/color you want to purge when adding the Ultra Purge to the machine (we recommend loading one barrel full of Ultra Purge for machines that are in good working condition)
STEP 2

Adjust the screw back-pressure to allow the loading of Ultra Purge (generally 20 to 30 psi)

*For larger machines (over 200Ton), we recommend reducing the shot size to 10-15% of the maximum shot size
STEP 3

Allow a 3 to 5 minute soak time with a full barrel of Ultra Purge
• When the previously loaded quantity of Ultra Purge is used up, load machine with the next production material. It is important **not to run the barrel empty** to improve the performance of Ultra Purge.

• Continue running the machine for a total of 4-5 full shots to eliminate remnants of Ultra Purge within the machine.

• Begin normal production.
Pictures
Purging Procedures

Hot Runners
STEP 1

- Increase the temperature of the hot runners in all zones by 30 to 40°F. (20 to 30°C)
- Follow steps 1 and 2 for the injection molding purging procedures that were previously stated.

**Remember to keep the barrel of the press full of the resin/color you want to purge when adding the Ultra Purge to the machine**
STEP 2

- Start to make injections through the hot runners with the mold closed or opened (we suggest to keep the mold open if the molded part is difficult to be ejected from the mold).
- Make three injections through the hot runners then allow for a **3 minutes soak time**.
STEP 3

- Continue molding until the molded parts appear visibly clean (we suggest to perform at least 4 injections).
- Load neutral or production material to eliminate the remnants of Ultra Purge within the machine.
- Begin normal production.
CLOSURES

Sequence of shots from red to natural molding Ultra Purge
Bubbles
Solidified Layer in Tip Slows Color Change

Reduced Gate Bubble

Large Gate Bubble
Using Tip Insulators Improves Color Change

75% reduction

# of shots

Hot Tip HR (without Insulator)  Hot Tip HR (with Insulator)
Cavity Filling During Color Change

Red color from cooler bubble layer shows up in gate area first in = first freeze
Watch for Mismatches

Not Optimized

Optimized

Sprue Bushing

Machine Nozzle

Machine-Nozzle/Sprue Mismatch
Extruders
STEP 1

• If a screen pack is present, please remove it from the machine
• **Keep the barrel of the machine full of the resin/color you want to purge when adding the Ultra Purge.** Run the machine at the same temperature as the previous production material (we recommend loading the barrel with Ultra Purge at twice the amount of the barrel size for machines that are in good working condition)
STEP 2

- Adjust screw rotation to low to allow the compound to expand inside the machine. The ejected purging compound should have a foamy appearance. If it does not, further reduce the screw rotation speed.

*For larger extruders, allow Ultra Purge to soak for 3 minutes once it begins to eject out of the machine
STEP 3

- When the Ultra Purge is extruded from the machine, load machine with the new production material and flush out any remnants of contamination. It is important not to run the barrel empty to maximize the performance of Ultra Purge.
- Begin normal production
For more information please contact us

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Don't just purge...ULTRA PURGE!™

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Summary

- Pigment selection and processing have a direct impact on color change time
- Color change time with hot runners is dependent on multiple design factors:
  - Melt channel layout and sizes
  - Temperature uniformity
  - Elimination of hang up spots
- Improved melt mixing in machine & hot runner can make a difference
• To master color change:
  • Know your resin (e.g., viscosity behavior)
  • Know your colorant (e.g., mineral vs. organic, mixing requirements)
  • Select/configure equipment appropriately (e.g. easy to clean, no hang-ups, optimized hot runner design)
  • Use mixing to disperse color (M/C nozzle, hot runner nozzle tip)
  • Use purging compound as required
  • Apply a proven color change procedure
How to do Effective Color Change

Presented by

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