How to do Effective Color Changes

Presented by

Moulds Plus International
Presentation Outline

- Understanding colorants & pigments
- Polymer flow & color change
- Equipment design considerations
- Impact of melt viscosity & homogeneity
- 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

Dyes-Soluble
- Liquids

Organics
- Non effect

Minerals
- Non effect
- Effect
How Different Pigments Work

- Fillers
  - Inorganic Pigments
    - Titanium Oxide
  - Organic Pigments
    - Carbon Black
- Platelet structure
  - Metal/Pearl lustre pigments
- Round shaped
- Absorption Pigments
- Reflection 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: OPACITY

**Organic**
- Incident Light
- Transmitted Light

**Mineral**
- Incident Light
- Transmitted Light

Same amount of pigment
Non-Effect Pigments: COLOR STRENGTH

**ORGANIC**

- Incident Light
- Reflected Light

**MINERAL**

- Incident Light
- Reflected Light

COLOR STRENGTH

Same amount of pigment
Non-Effect Pigments: PARTICLE SIZE

**ORGANIC**

- Ø 0.01-0.1 μm
- (-) Harder
- Need good mixing

**MINERAL**

- Ø 0.5-1 μm
- (+) Easier
- Standard mixing sufficient

Specific surface area = Area in contact with polymer

“Dispersability”
Non-Effect Pigments: PARTICLE SIZE

Mixing Requirements

ORGANIC

MINERAL
Physics of Polymer Flow

Velocity & Shear Rate Profiles in a Runner

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

Boundary Layer at the Runner Wall:
\[ \begin{cases} V = 0 \\ \dot{\gamma} = 0 \end{cases} \]
Infinite Residence Time

Fountain Flow during cavity filling:
Layer at the runner wall (Old Color) deposited on part surface

\[ R_e = \frac{\rho V D}{\mu} \ll 2100 \]
Plastics Laminar Flow: Layered Flow Motion (No mixing)
Boundary Layer from a Color Change

- Plastic pulled from melt channel
- Velocity near 0 at melt channel wall
- Velocity Profile
- Shear Profile
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/Nozzle Interface**
  - Avoid channel mismatches

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

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

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

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

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

Cooler Area

Hotter Area

Removed melt channel
Boundary Layer vs. Thermal Profile

COLD AREA IN A MELT CHANNEL

HOT AREA IN A MELT CHANNEL

Section AA

Section BB
Elimination of Cold Areas

Optimized Temperature Profile

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

- 250 shots
- 150 shots
- 150 shots
- 50 shots

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

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

200 shots 100 shots 50 shots 50 shots

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

33% reduction in resin usage

Note: 32-drop mold
3gram 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

• 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.
Down Time

• Downtime is normally 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.
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

Color Change

Ultra Purge

Reduce Scrap

Reduce Down Time

Increases Profits and Productivity

More Competitive in the Market

Shut Downs
• 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

Lower temperature = Higher viscosity resin

Higher Temperature = Lower viscosity resin

Cooler Melt Channel Wall

Hotter Melt Channel Wall

Lower temperature = Higher viscosity resin

Higher temperature = Lower 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>Resin</td>
<td>Lbs of PE</td>
</tr>
<tr>
<td></td>
<td>Lbs</td>
</tr>
<tr>
<td>Time required for purging</td>
<td>hr</td>
</tr>
<tr>
<td>Total Cost Material</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></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</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>
</tr>
<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>
</tr>
<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)
Adjust the screw back-pressure to allow the loading of Ultra Purge (generally 20 to 30 psi).

*For larger machines (over 200 Ton), 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
• 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
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.
• 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

Hot Tip HR (without Insulator) vs. 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

Machine-Nozzle/Sprue Mismatch

Optimized

Sprue Bushing
Machine Nozzle
Extruders
• 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)
• 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
• 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.
Compression Molding
For more information please contact us

**Moulds Plus International s.r.l.**
Via D. Carbone, 104 - Villalvernia (AL) - 15050 – ITALY
Tel +39 0131 83140     Fax +39 0131 836 882

**Moulds Plus International USA, Inc.**
1521 E McFadden Ave Unit G, Santa Ana, CA 92705 - USA
Tel (714) 708-2663     Fax (714) 708-2659

**Moulds Plus Mexico SA. de CV.**
Ahorro Postal 103 – Col. Miguel Aleman
Del. Benito Juarez CP 03420
Mexico D.F.
Tel (55) 8590-8834

www.ultrapurge.com     info.usa@moulds.org
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
Conclusion

- 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

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