DECOUPLED MOLDING$^{SM}$ and Process Control

Strategies to minimize rejects and part variation
The Molding Problem
Simply Stated
The Molding Problem
Simply Stated

NORMAL PLASTIC VISCOSITY VARIATIONS + LARGE PRESSURE LOSSES

EQUALS...

LARGE VARIABILITY IN PARTS

PRESSURE LOSSES ARE LARGE PRESSURE LOSSES VARY

The greater the PRESSURE LOSS, the MORE the mold acts as an AMPLIFIER OF OTHER PROCESS VARIATIONS.
This is caused by:

Inherent variability of raw material due to the nature of the polymerization and additive compounding processes.
Large pressure losses that are inherent when plastic flows (dynamic) and is pressurized (static)
**Definition:**
A process control method that addresses how the machine controls are used to fill and pack plastic into the mold.

**Objectives:**
- Injection speed reacts only to the machine’s velocity setting(s)
- Constant and repeatable injection speed shot to shot, year to year, regardless of any effective viscosity changes
- Reduce part variation due to effective viscosity variations
- Gain the ability to fill fast to minimize effective viscosity variations
- Make the process capable of always making good parts
- Make polymer rheology work for you
STATIC PRESSURE GRADIENT

Variations caused by VARYING MATERIAL VISCOSITIES using constant machine conditions (filled and packed)

STATIC PRESSURE LOSS

CAN BE MEASURED ONLY WITH MOLD PRESSURE SENSORS

VARIES INDIRECTLY WITH EFFECTIVE VISCOSITY

PRESSURE LOSS IS ALWAYS LARGE IN PLASTICS

THE MAJOR CAUSE OF PART VARIATION
Example of Decoupled II Molding
(2-Stage Control)

Better
But Not
The Best

What effect will a +/- 10% viscosity change have inside the mold?
Can parts be contained if a viscosity change happens which requires re-centering the process?

How?
The molding problem, simply stated:

**THE EFFECT OF...**

**VISCOSITY VARIATIONS**

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**Mean**

- **MP 3,000**
  - 10,000 psi
  - 7,000 psi LOSS

**23% DECREASE**

- **MP 2,300**
  - 10,000 psi
  - 7,700 psi LOSS

**10% INCREASE**

- **MP 3,700**
  - 10,000 psi
  - 6,300 psi LOSS

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**46% END OF FILL PRESSURE VARIATION**

**PLASTIC VARIATION IS WORSE WITH THIN WALLS!**
EOC Variation % = Pressure Loss x % Effective Viscosity Variation

Example:
EOC Variation = 7,000 psiₚ x 20% = 1,400 psiₚ

If EOC Pressure Nominal = 3,000 psiₚ:
EOC Variation = \( \frac{1,400 \text{ psi}_p}{3,000 \text{ psi}_p} \times 100 \)

EOC variation % = 46%!!
Managing Viscosity Change and Pressure Loss using DECOUPLED MOLDING℠ Techniques
DECOUPLED MOLDING\textsuperscript{SM}
as a Molding Technique

The specific technique determines how the mold is packed.
Traditional
Decoupled II
Decoupled III
Overlay
Traditional 10 Shots
Decoupled II 10 Shots
Decoupled III 10 Shots
Traditional 20% Viscosity Change
Decoupled II 20% Viscosity Change

Better!
Decoupled III 20% Viscosity Change

Best!
Machine Capability
DYNAMIC CHECK RING
REPEATABILITY TEST

<table>
<thead>
<tr>
<th>PURPOSE:</th>
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<tbody>
<tr>
<td>To determine the consistency of the check ring seal and the amount of leakage that occurs during injection</td>
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<thead>
<tr>
<th>EQUIPMENT NEEDED:</th>
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<tbody>
<tr>
<td>Injection molding machine with closed loop first stage injection</td>
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<tr>
<td>Injection mold that produce 'short shots' in either automatic or semi-automatic mode</td>
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<tr>
<td>Part weighing scale accurate within 1% of total part weight</td>
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<td>Calculator or excel program</td>
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<table>
<thead>
<tr>
<th>PROCEDURE:</th>
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<tbody>
<tr>
<td>1. Set up molding machine to run a standard Decoupled II process</td>
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<tr>
<td>2. Turn on pack and hold (produce fill only parts)</td>
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<tr>
<td>3. Mold 10 “Fill only parts” short shots</td>
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<tr>
<td>4. Weigh each shot (including parts and runner) and track weights below</td>
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<table>
<thead>
<tr>
<th>Shot Weight Grams</th>
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<tbody>
<tr>
<td>Shot 1</td>
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<tr>
<td>Shot 2</td>
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<td>Shot 3</td>
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<td>Shot 4</td>
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<td>Shot 5</td>
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<td>Shot 6</td>
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<td>Shot 7</td>
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<td>Shot 8</td>
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<td>Shot 9</td>
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<td>Shot 10</td>
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Add shots (1-10) = Total + 10 = Average

Heaviest - Lightest = Difference

(Difference + Average) x 100 = Variation %

Acceptable Range <= 3%

Note Findings:

RJG
LOAD SENSITIVITY

PURPOSE:
To determine to what degree the machine is sensitive to a change in load

EQUIPMENT NEEDED:
- injection molding machine with closed loop first stage injection
- data acquisition device
- purge plate
- calculator

PROCEDURE:
1. Install the data acquisition device
2. Set up machine to run a standard Decoupled II process
3. Turn off pack and hold (produce fill only parts)
4. Document the peak pressure and fill time at transfer
5. Back off the injection unit and install the purge plate on mold
6. Make a shot through the purge plate and record the peak pressure and fill time at transfer
7. Calculate the load sensitivity by using the equation provided below

\[
\text{Load Sensitivity} = \left( \frac{\text{Fill Time}_{\text{mold}} - \text{Fill Time}_{\text{air}}}{\text{Fill Time}_{\text{mold}}} \right) \times 100 = A
\]

\[
\text{Percent Change} = \left( \frac{\text{Peak Hyd PSI}_{\text{mold}} - \text{Peak Hyd PSI}_{\text{air}}}{\text{Peak Hyd PSI}_{\text{mold}}} \right) \times 10000 = B
\]

Choose One:
- Hydraulic Pressure (PSIh)
- Plastic Pressure (PPSI)

\[
\text{Percent Change} = \frac{A + B}{2} \times \frac{\text{PSI}}{10,000} \times \%\text{KPSI}
\]

Acceptable Range: < 5%

*Note: When using plastic pressure, use "10,000" as the factor.
Use "1,000" as the factor for hydraulic pressure.

Note Findings:
Where do I Start?