ASHLAND

Cycletime Tips - General

Volume 39: A Way to Optimize an Injection Molding Process - Part Two

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In part one of this CycleTime Tip, we reviewed the four plastic conditions (Plastic Temperature, Plastic Viscosity(Flow Rate), Plastic Pressure and Plastic Cooling Rate) and how to optimize mold and melt temperatures.

The Procedure (Continued)
Obtain the mold shot volume from mold design information, mold flow data or quoting worksheets. If this is not readily available, calculate the expected shot volume from part drawings, prototype parts or models. An educated guess should be a last resort. In each case set the machine shot transfer point at about 10 - 25% less than expected full shot volume to prevent over-packing due to math and/or conversion errors during initial start up. Initial shots should have pack & hold pressure set at zero.

Our objective at this step is to produce parts from the fill, injection or boost portion of the cycle only. Set the injection forward time long enough such that gate freeze is probable; a guess at this time. We will verify gate freeze later in the process. Pack & hold pressure should be set to zero to prevent additional material flow into the cavities after the fill portion of the cycle is complete. Also make sure the material is not entering the mold during screw recovery. (Verify by comparing shot weight with screw return & without) The cooling or mold close time should be set per mold flow data or quoting worksheets at this time.

Allow the machine, mold and process to reach a steady-state condition. This time will vary depending on the machine size, mold design and other factors. However, rarely is this less than thirty minutes. As the process settles-in, adjust the shot size or transfer position to make shots that are as short as possible while still maintaining consistent cycle times; (automatic cycle if possible.)

Increase fill-velocity to 90-95% of machine maximum and make sure the injection pressure-set point does not control velocity. See John Bozzelli's 1997 CycleTime Tips about how to set first-stage pressure1. The injection ram will slow down under load if the injection (first, boost, initial)-stage pressure setting is too low. Initial pressure setting too low will create a condition known as "PRESSURE LIMITED" molding. Running under this 'pressure-limited' condition, the pressure setting ends up controlling injection velocity and will make the process less repeatable. Thus our goal is a first or boost pressure setting higher than the maximum pressure required to fill the cavity 95 – 99% full.

Adjust transfer point or shot size in steps until the part is 95-99% full. Observe whether the part(s) fill evenly and without trapping, jetting or racetracking. . Create a 'Melt Flow or On-Machine Rheology Curve'; decrease speed to the slowest fill rate in ten to twelve increments (a pattern of fill times from approximately 0.5 seconds to over 10 seconds), then record the fill-time and peak hydraulic pressure for each increment. A formula in the procedure uses fill times and pressures to create the curve. See the detailed procedure by John Bozzelli2.

Select a fill time based on the following criteria; 1. the part's-visual characteristics, 2. the fill pattern 3. the balance of flow consistency(by measuring of shot weight at transfer) and 4. the position on the Melt Flow Curve. Now plastic viscosity (flow rate) is optimized.

and runner, fill the sprue-runner-and through the gate and fill the mold 95 - 99% full, you have created a pressure loss profile across the mold. If questions or problems arise regarding the filling of the mold, this information helps identify what must be adjusted or modified.

Increase the pack-pressure just enough to complete the last 1-5% of fill and to produce a visually acceptable part. This becomes the lower value of the plastic pressure window. If you have the capability of separating pack and hold pressure or have the ability to set two separate follow-up times and pressures, set the hold pressure to simply stop the screw movement after pack (neither forward or back). The logic of this step is to use hold time only to manage gate seal or gate unseal.

Now increase pack pressure until the part flashes, begins to stick in the mold or some other indication that packing pressure is too high then reduce packing pressure to the maximum level without flash, etc. This becomes the upper value for the plastic pressure window. Set packing pressure to midway between the upper and lower values just established for this mold. Pack time should be set long enough to insure complete packing of material into the cavity while hold time should be set for the balance of the injection time available. This is the pack pressure process center.

Perform a Gate Seal Analysis by finding the minimum hold time that will maintain consistent part weights. This can be achieved by finding the average weight of two to five consecutive shots, parts only, over several hold times. Make sure to adjust mold close or cooling time to keep a consistent overall cycle time throughout this exercise. You will recognize the gate seal time because the part weights will stabilize with very little variation after additional time is added. It may be necessary to explore the entire range of hold time available from 0 seconds on until the part weight does not change. In some molds; those with hot tips, large gates, when molding elastomers and other easy flowing materials, material can continue to enter the cavity by intrusion during screw recovery. In these instances, you may need to add screw delay time or otherwise prevent filling or packing by intrusion.

If you want to insure that the gate has sealed during injection hold, select a hold time slightly longer than what was determined by the Gate Seal Analysis. For parts that require back flow or pressure relief near the gate, then select a hold time slightly less than the gate seal time.

Adjust mold close or cooling time to explore the minimum time necessary for the mold to function and for parts to meet the visual requirements. Watch out for parts that stick to one another in the catch bin, distort upon handling or on the weight of other parts. Produce, label and retain samples at various levels of cooling time for later evaluation.

Verify and record all plastic conditions and machine setpoints. See Process Certification: Measuring the Proper Variables by Bill Fierens, SPE ANTEC 1999. See also, Translating Plastic Variables to Machine/Mold Monitoring by John Bozzelli, Rick Bujanowski and Jack Little, ©Dow Plastics.

After 24 - 72 hours, perform visual, dimensional and physical performance evaluations. Make mold adjustments to produce parts to print mean at the middle of the process window and at the fastest overall cycle time.

Conduct a pilot run or increase process and production monitoring to prove capability at these optimized process parameters. Select several process parameters to track in parallel with key part characteristics. Part weight when checked with precision scales is a good indicator of process cavity packing.

Other Suggestions:

- Consider using several different material lots and use regrind blended at typical production levels to evaluate the effects on the process.
- Is the nozzle sized correctly? The orifice should be just smaller than the sprue bushing opening and the overall length should be a short as possible.
- Is mold movement optimized? Insure minimum open stroke, lowest open dwell time and a single ejection stroke.
- Are all parts captured? Do parts end up on the machine or on the floor?
- Avoid melt decompression or ’suck back’ whenever possible; it can introduce air into the melt.

Correct Potential or Seemingly Minor Problems NOW! They will be more difficult and more expensive to address once the mold is into full production. This process will require a significant investment of time, but only once, rather than constant process adjustments for the life of the mold.

1 - How do you set first-stage pressure? & How do you set first-stage pressure? Part II ©1997, Ashland, Inc. by John Bozzelli General Polymers CycleTime Tips for November and December 1997
2A - Procedure for Establishing Proper Fill Rate for Single or Multiple Cavities an On-Machine Rheology Curve, ©1997, Ashland, Inc. by Bozzelli, Larsen & McDonnell