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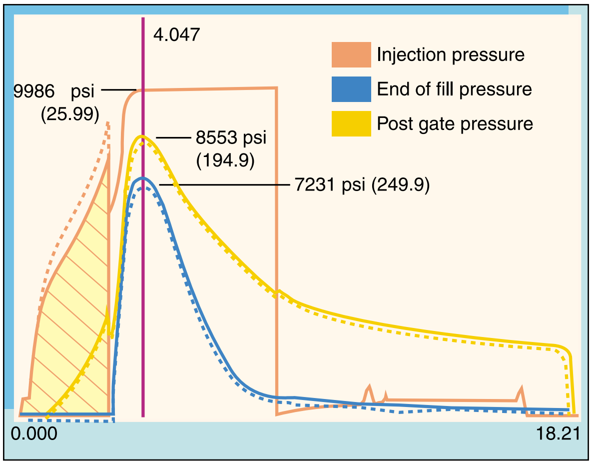
Technology Notebook

Putting cavity pressure transducers to the test

Editor's note: Cavity pressure transducers are being used more and more by molders, especially those practicing scientific or Decoupled molding. Jay Carender, principal engineer at The Tech Group, has developed several uses for transducers. Following is a review of these practices.

Mold cavity pressure transducers are frequently used at The Tech Group and they provide a variety of data about what takes place inside the mold's cavity. The benefit is not limited to what happens in the cavity, but extends to monitoring injection pressure and melt viscosity. They're also used to assess press repeatability and to troubleshoot out-of-spec processes.



The yellow cross-hatched area represents pressure under fill. The dotted orange line is the standard, or template. The cross-hatches show that resin viscosity was reduced, caused by underdrying. Also monitored are curves for end-of-fill and post gate cavity pressure.

Optimizing

For example, in the process represented by the graph to the right, a new mold qualification was in progress. The dotted line is a template or master trace documenting how the process should look normally. The solid line indicates that the current cycle is different.

The difference is higher EOF (end of fill) cavity pressure by 249.9 psi. The postgate cavity pressure is also greater by 194.9 psi. Other screens tell the engineer that material viscosity has dropped by 13 percent. This alone triggers alarms, as do the cavity pressure cycle integrals and peak values. Such alarms result in product that is automatically rejected by the robot attending to the machine.

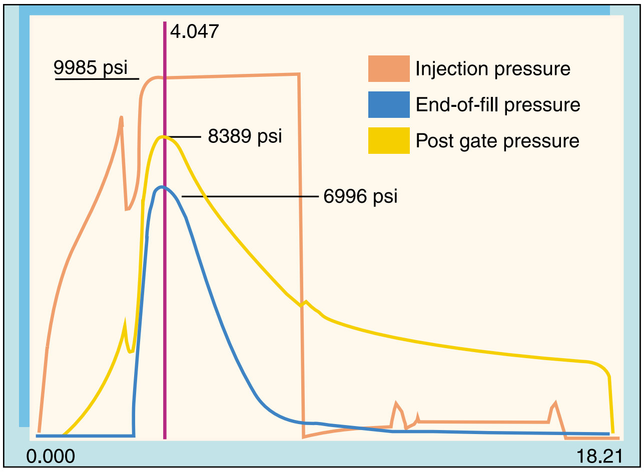
A quick manual check indicates the resin lot is the same, the melt temperature is correct, and the molded parts look good, but something has changed. Further examination reveals that the resin is not fully dried. After additional drying, the process is restarted with conditions in proper conformance to the template curve.

We collect data with the ePak system and Insight software from RJG (Traverse City, MI). This data is used for most new mold qualifications at Tech Group. With this system we can:

- Verify minimum cavity pressure at EOF is at least 3000 psi.
- Establish pressure curves for future reference.
- View cavity pressure decay.
- View the gate seal performance.
- Identify resin effects on peak pressure and pressure decay—cooling rate.

Once in production, these cycle integrals are more comprehensive than just looking at peak pressures. The cycle integral looks at the area under the pressure curves (cycle integral reflects indicated pressure for full duration of the molding cycle).

This data is more comprehensive because the (EOF) cavity pressure area can change based on many sources of variation: melt viscosity changes, cooling rate changes, peak pressure changes, resin lot variations, or melt temperature differences. A water flow blockage or reduction can cause enough of a cooling rate change to alter the area



The Tech Group uses pressure transducers to evaluate machine repeatability. This graph represents an overlay of 280 relatively consistent shots on a Milacron Roboshot all-electric. Assuming material and mold variables are stable, overlays like this can help identify potential malfunctions and faulty machine components.

under curve or the slope of pressure decay, triggering an alarm. Such alarms indicate the process has changed such that it might adversely affect the quality of the molded product.

BUILDING PRESSURE CURVES FOR A MOLD ALLOWS A MOLDER TO EVALUATE MACHINE REPEATABILITY.

IDENTIFYING VARIABLES

Building pressure curves for a mold also allows a molder to evaluate machine repeatability. Assuming all viscosity and temperature variables are stable, a reliable, consistent machine should build the same cavity pressure curves from shot to shot.

Such control requires mold temperature control units with increased pump capacity for high water flow rates, excellent drying of the resin, well tuned barrel temperature controllers, molds that are properly built with good balance and venting characteristics, and a robust machine. A good preventive maintenance program is needed to keep the machine and mold running at optimum levels.

Even when a system is created that performs at this level, process monitoring equipment is needed to catch inevitable hiccups in the injection molding process. Such hiccups (process variation) are typically introduced when a variable changes. Following are some common culprits of process disintegration:

Shot variation:
- Insufficient backpressure and/or incorrect screw rpm results in poorly compacted plasticated shot volume.
- Decompression after screw run permits a small amount of resin to pass through to the front side of the check ring.
- Check ring does not seat during injection forward; or, dirt, metal, or debris in the seat area periodically prevents a good seat.
- Barrel wear permits some leakage on OD of check ring.

Resin viscosity variation:
- Lot-to-lot resin molecular weight and/or weight distribution variation.
- Change in additive distribution within the base resin or variation in additive distribution.
- Regrind variation.
- Poor drying conditions, including reduced air flow, incorrect dewpoint, hopper residence time variation, and conveying with undried air.
- Change to or malfunction of melt temperature setpoint, backpressure setting, screw, rpm, or machine nozzle size or design.
- Shear thinning of thermoplastic material.
- Cycle interruption that prolongs residence time.

Cooling rate variation:
- Poor coolant flow rates, which lead to increased backpressure in return lines.
- Blocked or clogged coolant lines and bubblers.
- Coolant line IDs fouled with rust and scale, affecting heat transfer.
- Pumps become worn, affecting flow rates, heat transfer, and the Reynolds number value.
- Coolant lines inadvertently shut off.
- Coolant lines connected with incorrect hose sizes, fitting sizes, number of loops, direction of flow, number of ins and outs, and so forth.
- Cycle interruption or malfunction increases melt temperature, prolonging cooling time.

Other variables:
- Imbalanced fill in a multicavity tool.
- Blocked gates.
- Clogged vents.
- Equipment breakdowns or malfunctions such as heater band failures, nozzle leaks, hydraulic valve problems, and so forth.
- Mold wear or breakage.
- Electrical spikes or interruptions.

Pack pressure:
- This variable is not too hard to control consistently if one thinks in terms of hydraulic packing pressure, but the critical value to measure here is cavity pressure. Cavity pressure peaks, time to peak, and cavity pressure cycle integrals are all hugely important and can be monitored with cavity pressure transducers to identify changes caused by many of the above variables.

The Tech Group is currently working with RJG, Shotscope (from Moldflow, Lexington, MA), and machine onboard monitoring systems to identify variation. Real-time SPC rejects discrepant products. **PA&M**

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