DR PAUL NUGENT | MNOP

How Much Control Do You Really Need?

Try 'Hands-Free' Rotomolding for Better Parts!

Much has been written of late about the benefits of process control in rotomolding. It simply makes sense for rotomolders to use some form of measurement to improve the quality and efficiency of their operation. So no matter what system you decide to use, just make sure you are using one.

The question is just how much control do you need? The ultimate form of data will come as Rotolog curves taken from inside the mold and will give you real-time insight into the stages of the process taking place. You may want to measure temperatures in specific locations on a mold, you may even want to measure pressure inside the mold. However, the challenges in gathering this data have been well documented: wires, thermocouples, connectors, slip-rings, pressure transducers are all available and can work well in a controlled environment. In a high-pressure, fast moving operation, however, where operators are under pressure to make parts, sometimes the additional steps and details required can be a distraction and sometimes reliability of the component parts of the control system can cause delays.

The alternative is 'hands-free' rotomolding where the machine takes over the gathering and management of the data. Non-contact infrared sensors coupled with machine based

analytical software such as the IRT system offered by Ferry Industries, Inc. of Ohio can measure the surface temperature of a mold as it moves. The data gathered is not specific to any single point but is actually a map of the mold surface and frame.

This mapping feature offers some interesting insights into the process. Rotomolding uses a high-efficiency scrubbing oven (typically) to transfer heat to molds with high-speed air. This can be very effective when properly designed but even under the best conditions, the design of the mold, its thickness, the frame that it is mounted on, the machine arm and rotation settings will create continually varying surface conditions and heat transfer rates. This means that not all points on the mold surface rise at the same rate: some areas will be hotter and some will lag behind. The IRT system can see this distribution of temperature around the mold and tracks the regions which will dictate the molding cycle. During the heating cycle, there will be a cool area on the mold which will need to reach a certain temperature in order to cure the material inside properly while during the cooling cycle, there will be a hotspot on the mold which will retain heat longest. By following these extremes, the machine now has information which can be used to control the cycle – without the need for input from the operator.

The conventional wisdom is that an outer surface temperature cannot give enough detail to allow for process control. However, tests such as those recently carried out by Dru Laws of the Chroma Corporation Rotational Molding Center in McHenry, Illinois show that internal temperature must follow the outer surface temperature that drives it. Some of the sensitivity to powder phase changes is lost but there remains a relationship between the outside temperature and inside which is sufficient for molders to use to stabilize their process. The ideal scenario is for a molder to use a Rotolog (or derivative) system to observe the internal mold temperature while the machine observes the external surface. When the ideal cycle is identified by Rotolog, the machine captures the settings for production [where Rotolog is not available, molders simply adjust their molding cycle until they produce a part with the required degree of cure and lock in their process settings from there]. These settings allow production staff to achieve their main objective, repeatability, not analysis.

Consider the temperature profile shown in Figure 1. This is an IRT trace showing how the outer mold surface temperature rises during the molding cycle at an oven set-point of 550°F (285°C). The IRT system goes one step further by adding a 'Thermal Index' which is an integral of the mold time-temperature profile and gives an indication (although not a specific measurement) of the energy applied to the mold by the machine. By combining a minimum required temperature for the mold surface (remember the IRT tracks the coolest location on the mold) with a specific Thermal Index, a repeatable process control point is created for the machine.

During the cooling cycle, with the assistance of IRT, the

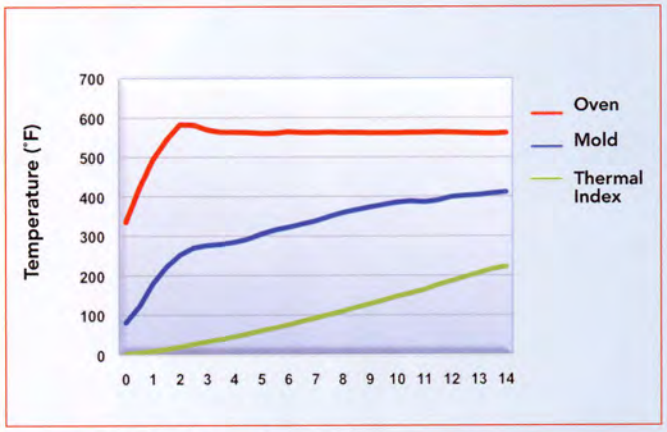


Figure 1: Typical IRT Data - Oven Cycle

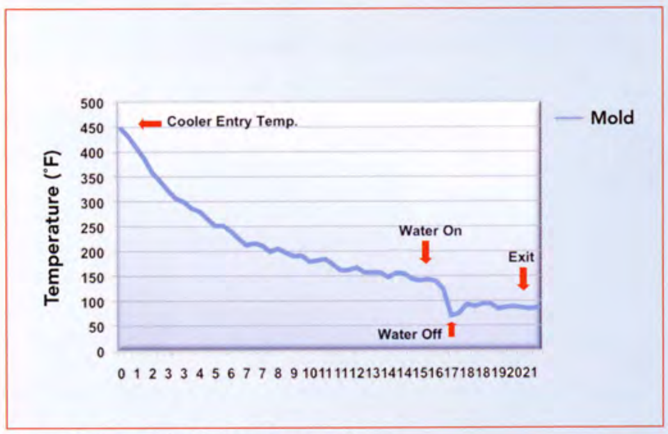
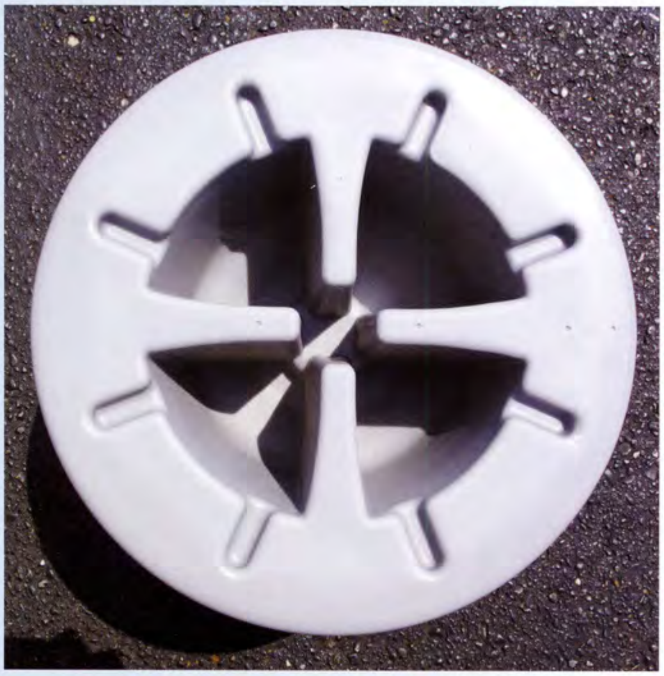


Figure 2: Typical IRT Data - Cooling Cycle

Polycarbonate Light Globe (Formed Plastics, Inc.)



Drum Component (Trilogy Plastics, Inc.)

Washer Tank with Inserts (Formed Plastics, Inc.)

Crosslink Polyethylene Storage Box (Formed Plastics, Inc.)

machine is able to turn water on and off and control the final exit point for the mould based on actual mold surface temperatures as shown by Figure 2. By observing the entry temperature of the mold into the cooling station, the IRT equipped machine is able to adjust automatically for delays in the demolding station or mismatches in cycle times between arms. It will also compensate for changes in ambient conditions in the factory by shortening or extending cooling cycles to ensure that molds are cooled to the same point: this can be significant during seasons where morning to afternoon temperature swings can be as much as 30-40°F (16-22°C).

In essence, the process can be controlled by a temperature and thermal index in the oven and by three settings in the cooler. By fine-tuning these set-points, the molder is able to more tightly control part cure levels and hold tighter dimensions. And once these are set, it is the machine which gathers the data and senses the changes, not the operator. There are no wires or electronics to worry about around the molds and it is this simplification of the control process which makes 'hands-free' so attractive.

Molders in a wide range of industries have seen the benefits of transferring control to the machine. The benefits can be seen on the oven cycle side in terms of cure control, on the cooling cycle side in terms of part size and throughput and in a combination of both for parts with challenges both in the processing window and dimensions.

Controlling the oven cycle can help with improved consistency of cure. This can be a great help when working with materials such as polycarbonate and acetal which have narrower processing windows than typical polyethylenes. The polycarbonate light globe shown on the previous page, produced by Formed Plastics, Inc. of Carle Place, NY is a polycarbonate light globe which benefited in terms of internal surface finish and overall consistency of cure by using full-time IRT controls in the oven. The company also works with tight tolerance aerospace parts and recently was able to rapidly dial in and maintain molding cycles for new acetal components using the full-time control system.

Cooling Cycle Control

A drum component produced by Trilogy Plastics, Inc. of Alliance, Ohio had two challenging tolerances to hold: the opening at the center between the ribs and the outer diameter. One was free shrink and the other was restricted which made the demolding temperature critical. In the past there was lots of rework as the parts were often deliberately made oversize and then reheated to shrink them back to size on a fixture. As Production Manager Bob Moses commented, 'The IRT system did a fantastic job of dialing in part size' by automatically adjusting the cooling settings and tightening the range of dimensional variation. Rework has been reduced dramatically."

A washer tank produced by Formed Plastics, Inc. had 14 inserts which had very tight tolerances on the distances between the inserts. Once again, by controlling the cooling

...by using a simple hands-free approach... part quality can be improved dramatically and continuously without adding to the workload of the operator.

cycle and demolding point with the IRT system, part variation was dramatically reduced and the tolerances held to their specified ranges. Scrap rates for parts have dropped from 2.8% to 1.5% with increases in throughput also reported by the system being able to compensate for delays in the pre-cool station.

Shrinkage is obviously an even bigger problem when making very large parts that interlock. Controlling part size and shape for floating docks, seating for boats or playground systems is a benefit that grows with scale since rotomolding tolerances are measured inch-per-inch (cm-per-cm). Molders who have implemented continuous process control during the cooling cycle have reported much improved consistency and quality.

Combined Oven and Cooling Control

The cross-linked polyethylene storage box shown on the previous page requires careful control of the heating cycle to ensure that the chemical reaction has taken place. Produced by Formed Plastics, Inc., it also had tight tolerance requirements to allow it to fit into a holding fixture for secondary machining on a CNC router. By combining cure control on the oven with cooling and demolding temperature controls, no reheating was required for the secondary process.

As all the parts described demonstrate, by using a simple hands-free approach that allows the machine to gather temperature data and then control the process by compensating for changes in ambient conditions and production delays, part quality can be improved dramatically and continuously without adding to the workload of the operator. If you are making a decision about how much process control to add to your system, lose the wires and consider a 'hands-free' approach – it is by far the simplest and safest approach!

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