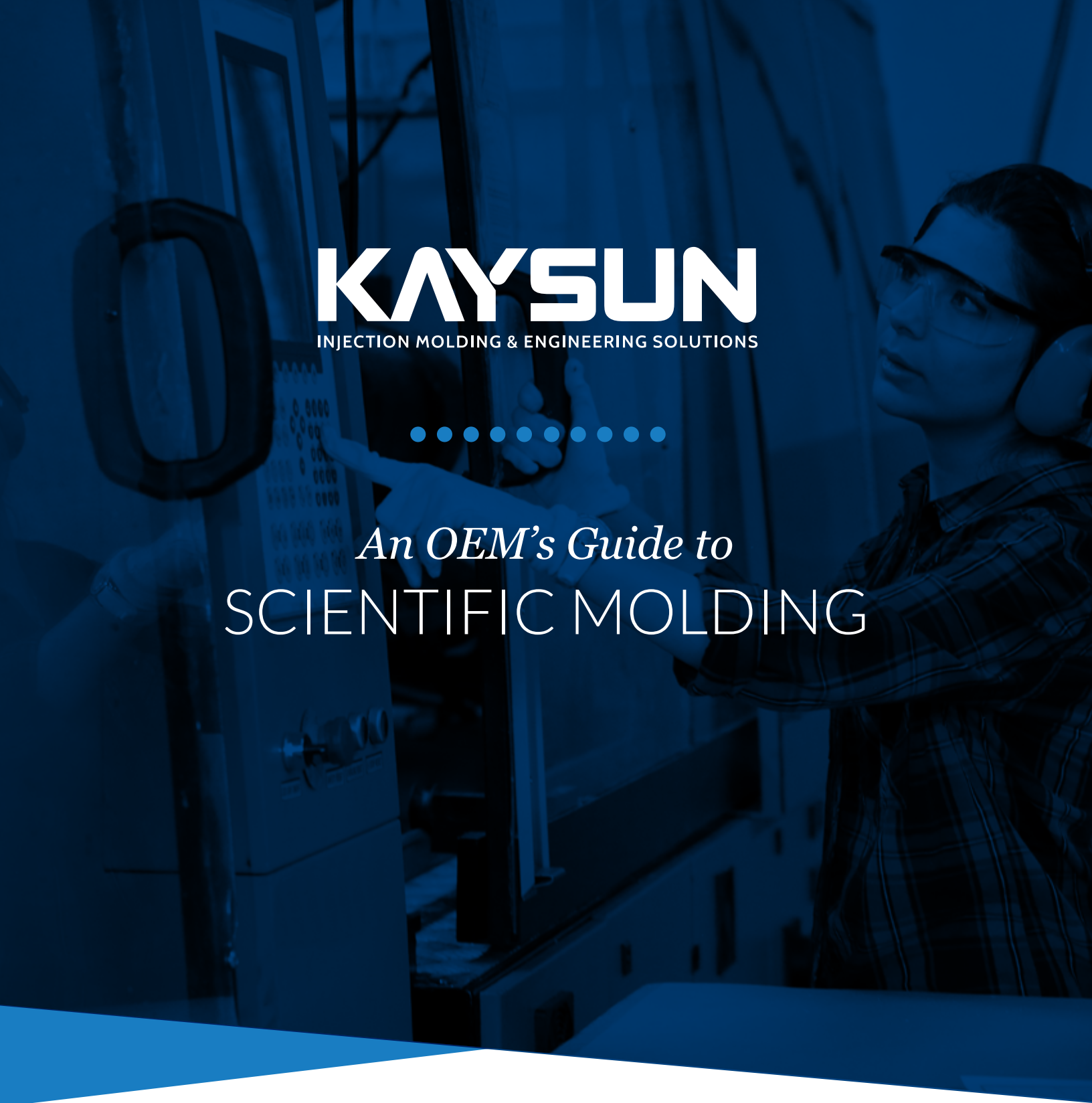




KAYSUN

INJECTION MOLDING & ENGINEERING SOLUTIONS



An OEM's Guide to
SCIENTIFIC MOLDING





Manufacturers of complex devices cannot afford to lose any time getting their products to market. Advances in technology come rapidly, and other companies are vying for market share. To ensure success, products must be designed and produced with ultimate precision, repeatability, and efficiency — all of which depend on eliminating production delays caused by flaws and inconsistencies in the manufacturing process.

Since scientific molding is governed by science rather than art, thoroughly trained and properly certified molding engineers can ensure consistency, specifications conformance and repeatability in production. All data associated with the manufacturing process are recorded and the OEM can count on getting the highest-quality components, parts and products time after time.

A predictably efficient process delivers defect-free parts with minimal loss of materials at minimal time and cost, even when production is transferred from one machine to another. Such an outcome is especially important when manufacturing complex parts and components.

THIS WHITE PAPER:

- Examines the key benefits provided by today's scientific molding procedures, in general and through specific examples
- Explains the importance of molding engineers' training and certification in state-of-the-art scientific molding practices that optimize all aspects of production
- Defines scientific molding principles
- Explains how specialized molding engineers oversee the design, process and production of precision-molded plastic parts, so as to develop templates for repeatable production, contribute to the development and manufacture of precision-molded plastic components, and how it ensures repeatable production

What is Scientific Molding?



Scientific molding uses the key steps of the scientific method — developing a hypothesis, testing it, analyzing the results to draw a conclusion and proving the results are reproducible — to develop a tightly controlled and repeatable manufacturing process that results in parts consistently free of defects. Compared to traditional

“trial and error” molding that relies on guesswork to bring parts within specification, scientific molding uses sophisticated data collection and analysis techniques to document the specifications, settings and steps required to ensure reproducibility over time and across equipment.

Part of what makes scientific molding such a powerful process is the specialized engineers who have undergone thorough training and have the proper levels of scientific molding certifications. These certifications are earned through the Michigan company RJG, Inc., an internationally known provider of injection molding education and technology. In addition to supplying a comprehensive range of courses, RJG provides the equipment, testing and analysis tools, and software essential for scientific molding. Most notable is the RJG eDART™ system, a customizable assembly of measuring and monitoring tools for scientific molding. (See The Importance of Scientific Molding Training and Certification and Testing and Monitoring, below).

Scientific molding engineers' advanced knowledge translates to a thorough understanding of what is happening with the material inside the tool, specifically

in terms of viscosity: they can visualize, rather than guess, how the polymer flows into and behaves inside the tool. These insights prove valuable in designing successful tools and molding processes, identifying process issues quickly and accurately, and determining and executing solutions to return the process to specification.

By recording data when the machine is producing at peak efficiency (top productivity with minimal scrap), the engineers create a template of process parameters to be replicated whenever:

- Specification issues arise during production
- An existing tool is set for a new production run
- Production is moved from machine to machine

Optimizing the process in this way minimizes production time, errors and costs for the OEM.

Molding Variables



Determining and duplicating all of the parameters for a given material and molding situation is the key to process repeatability. The molding engineer, well aware of the interdependence of all process variables, interprets the data and manipulates the parameters to achieve the ideal process. For example, melt temperature is affected by barrel temperature, screw speed and back pressure. The four plastic molding variables are:

- Temperature (of material and tool)
- Material flow rate
- Pressure (pack and hold)
- Cooling time and rate



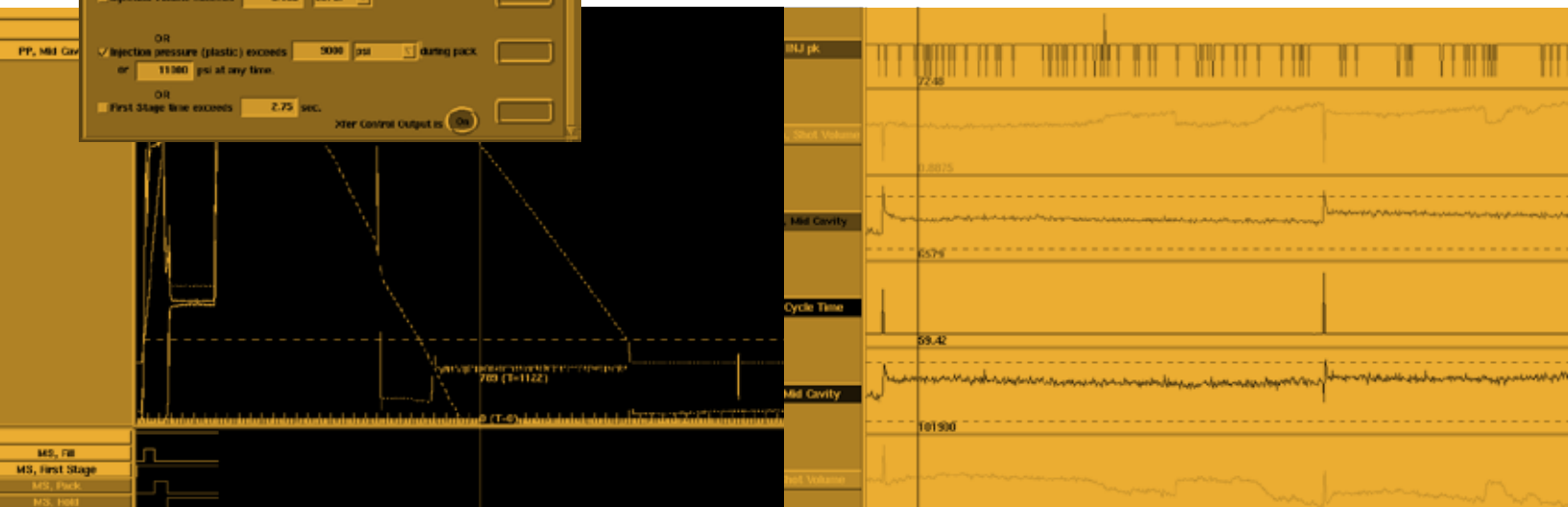
Other variables include material moisture content, fill time and tool conductivity. Cooling time, for example, is influenced by the processing temperature of the material, the conductivity of the tool steel, and the geometry of the part. Since an engineer trained in scientific molding considers everything from the perspective of the plastic, she or he is able to manipulate the variables as needed to return the process to conformation.

The process begins with the tool being put into the press so that the toolmaker and molding engineer can thoroughly and systematically check every aspect of its mechanical functionality. For a starting point, they use the recommended process settings specified by the material supplier of the material, as shown in the example for polypropylene in the chart on page 5.

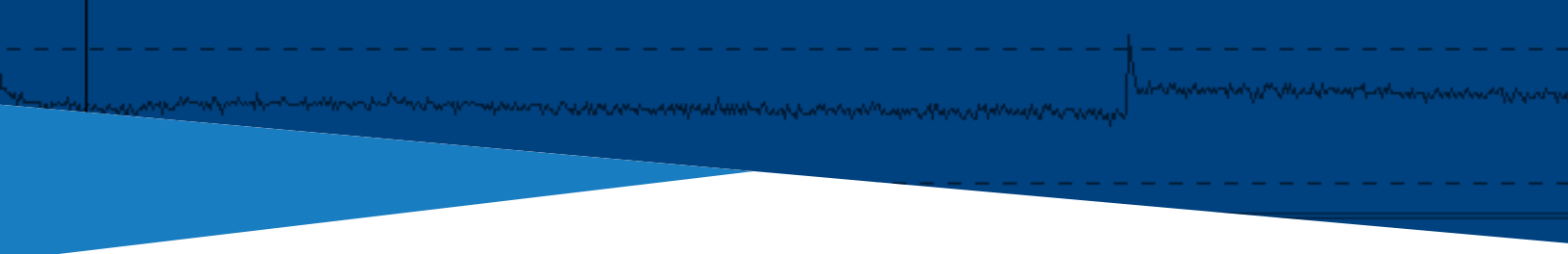
Production snapshots showing cavity pressure parameters.

From there, the optimized parts proceed to inspection for examination of their measurements, shot-to-shot consistencies and overall quality. Any necessary tool adjustments are completed before new samples are made. The new samples then undergo the same quality testing, with necessary adjustments made again as needed.

The images show the acceptable high and low for the cavity pressure. If the pressure rises or falls out of this ideal range, the press will shut down.



Specialty Compounds Polypropylene (PP)		
Typical Injection Molding Conditions	English	SI Metric
Temperatures		
Rear Zone	380 - 420°F	193 - 216°C
Center Zone	390 - 430°F	199 - 221°C
Front Zone	400 - 440°F	204 - 227 °C
Melt	375 - 450°F	191 - 232°C
Mold	90 - 150°F	32 - 66°C
Pressures		
Injection	10000 - 15000 psi	69 - 103 MPa
Hold	5000 - 10000 psi	34 - 69 MPa
Back	50 - 100 psi	0.34 - 0.69 MPa
Speeds		
Fill	1 - 2 in/sec	25 - 51 mm/sec
Screw	60 - 90 rpm	60 - 90 rpm
Drying		
Time & Temperature	2 Hrs @ 175°F	2 Hrs @ 79°C
Dew Point	n/a °F	n/a °C
Moisture Content	n/a %	n/a %



The Importance of Scientific Molding Training and Certification



The required training for scientific molding engineers is rigorous and extensive. Depending on his or her specialty, the engineer completes successive certification levels in order to develop the comprehensive understanding necessary for reaching the objectives in any given precision-molding situation. Kaysun's scientific molding specialists receive most of their ongoing training in the discipline from industry leader RJG, Inc., and hold RJG-designated certifications in Systematic Molding, Master Molder I, and Master Molder II.

Successful scientific molding requires a combination of knowledge, experience, analytical skills, and the proper equipment and tools. The capable molding engineer applies these resources to each unique molding situation. Through their expert analysis and interpretation of the collected process data and their ability to resolve issues, they employ a scientific approach to design and document a robust and repeatable process that delivers consistently defect-free parts.

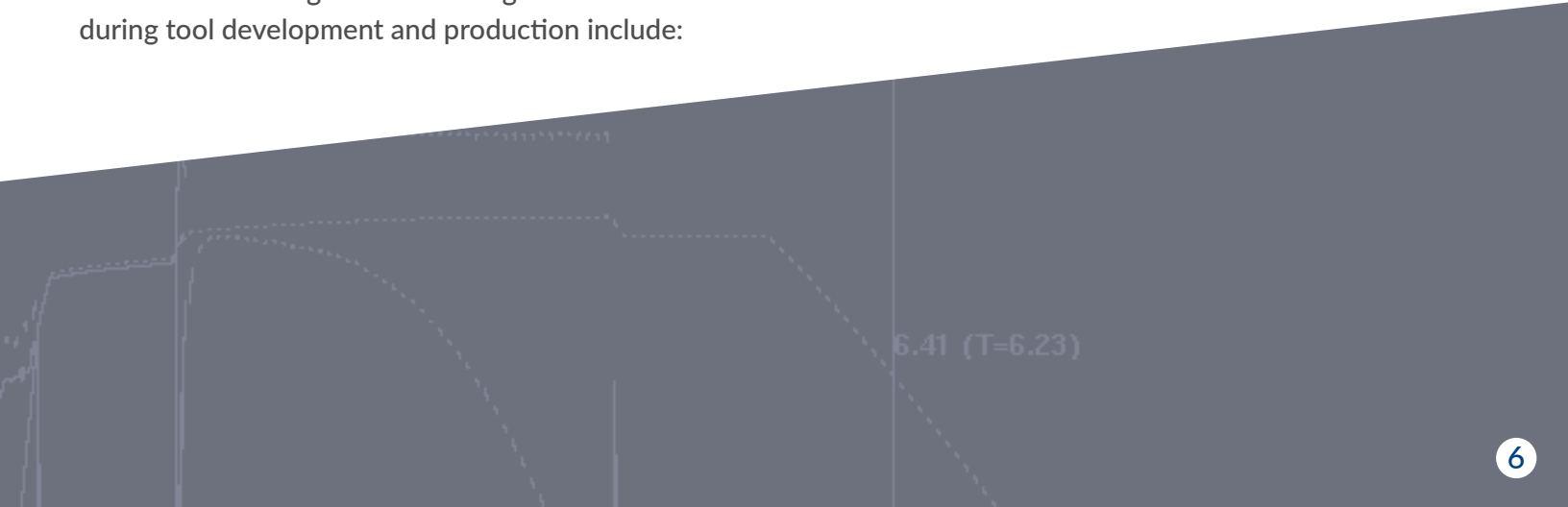
Testing and Monitoring



Once the process engineer verifies the tool is functioning optimally, production begins. Production engineers monitor process parameters according to the template with ongoing quality testing. If issues are identified, the specialist analyzes the data and forms a solution to return the process to conformation.

Some of the testing and monitoring methods used during tool development and production include:

- **Rheology curve (or viscosity curve)** helps determine the optimal viscosity and injection speed making it a crucial part of the scientific molding process.
- **Velocity profiling** helps determine the fastest fill rate that can be used without causing flash or other aesthetic flaws.



- **Cavity pressure readings** show the actual pressure inside the tool, making this the best way to indicate the material's behavior where the eye can't actually see. This is really the core of scientific molding. Specialized training allows the engineer to visualize what's happening to the plastic inside the tool.
- **Design of Experiments (or Experimental Design)** refers to a related group of tests used in setting up the process parameters and troubleshooting process issues. It allows the molder to make simultaneous adjustments to the variables, saving significant time over earlier troubleshooting methods based on intuition and guesswork instead of informed analysis of scientific data.

The RJG eDART™ system may be used throughout the phases of scientific molding for testing as well as troubleshooting. The system is integrated with the injection molding machine control system to monitor molding variables, verify conformance to template, adjust process conditions, set timing and alarms, among other functions crucial to successful molding. This collection of tools can be configured to the job at hand. It contains software that holds and organizes the process data for the molding job, forming the templates and yielding the RJG graphs that the technicians use to achieve the robust and repeatable process.

CASE STUDY: FAUCET MANUFACTURER

Scientific molding helped Kaysun solve a dimensional issue with a manufacturing partner, a producer of faucets.

Kaysun had designed a four-cavity tool to simultaneously produce four valve bodies in order to meet tight-tolerance requirements and increase efficiency. During the molding process, the fourth cavity fell out of tolerance due to an issue with its diverter — there was a sink at the bore's end.

The recorded data on the cavity pressure transducer graphs reflected that the recorded pressure of the affected cavity differed from the other three. Based on this data and the type of defect, our molding engineers determined that there was an issue in the coolant line for the fourth cavity. A restriction was, indeed, detected and removed, allowing the fourth cavity to return to performing at specification.

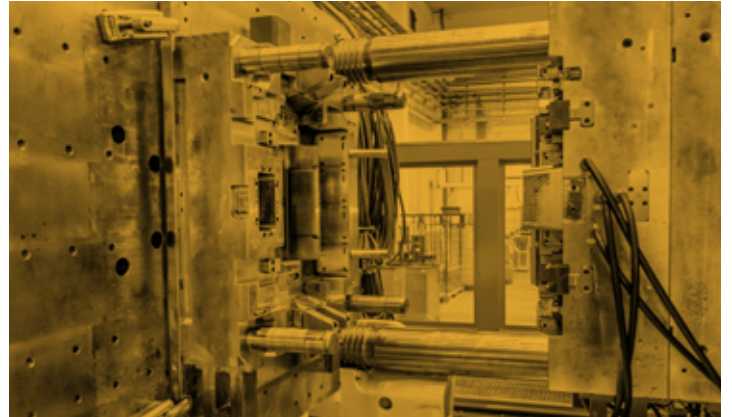
Since the engineers were thoroughly trained in scientific molding principles and they had the pertinent data at hand, they were able to efficiently identify and correct the problem. The production run continued with minimal loss of time and material.



Kaysun Corporation: The Know-How to Ensure Success



Scientific molding is a comprehensive process that runs through every phase in the production of precision-molded plastic components. A tool with robust process capabilities assures the manufacturer of consistent quality and top efficiency, as does working with an experienced custom injection molder that has an in-house team of certified design and production engineers.



Contact Kaysun or request a consultation with one of our specialized engineers to learn how we can apply scientific molding practices to improve your next custom injection molding project.

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