Scientific injection molding (SIM) is a systematic process of evaluating a polymer’s viscous flow and solidification in a molded design to maximize physical properties and dimensional stability. This process is ideal for complex plastic parts but can be applied to any molding project.

This eBook will examine scientific injection molding, outline the five components of the molding process, and provide practical insight into establishing SIM programs for various organizations and manufacturers.

**WHAT IS SCIENTIFIC INJECTION MOLDING?**

Merriam-Webster defines science as “knowledge or a system of knowledge covering general truths or the operation of general laws especially as obtained and tested through scientific method.”

With this definition in mind, Scientific Injection Molding is aptly named because the process is disciplined and focused on resolving the “Root Cause;” using data to drive process development. The ultimate goal of SIM is to view the process from the perspective of the plastic and allow that insight and point of view to inform and drive decision making.

**BENEFITS OF SCIENTIFIC INJECTION MOLDING**

Scientific injection molding offers numerous benefits, including:

- The ability to maximize the physical properties of the material
- The ability to identify flaws in design and equipment
- Failure Analysis - Keep installation abuse and poor design the responsibility of the customer. In a good SIM system, the molder should address these issues during the part design review to ensure they are properly resolved before the design being approved for manufacturing and a tool being cut.

**THE FIVE COMPONENTS OF THE SIM PROCESS**

### #1. Material:

**Fit the Resin to the Application**

When it comes to materials there are some key areas to consider. First and foremost, it is essential to fit the resin to the application of the component being produced. If the part will be subjected to rigorous use, it is important to choose material that is capable of withstanding that type of strain. Thermal conditions and fluctuation in temperature are also key considerations in this area, as is any exposure to chemicals or other harsh compounds. If these conditions are applicable, a resin that is resistant or specifically designed for high heat may be necessary.

**Properly Dry Material**

Proper drying of material is another component that must not be overlooked. One of the primary reasons drying resins properly is so critical regards property performance – moisture can cause internal voids, lead to loss of properties, or can degrade molecular weight. Proper handling and drying of resin helps ensure that the material hasn’t degraded before being processed. Polymers can be dried at temperatures of 212 degrees Fahrenheit or higher (the temperature at which water boils). This process will help ensure the resin is at the appropriate moisture level before molding.

### #2. Part Design:

**Design for Manufacturing**

Part design is a critical component of the SIM process, and one of the most important steps in the design process is what is known as "design for manufacturing" (DFM). DFM refers to the various factors that go into a design so that it can be manufactured at the lowest cost possible without sacrificing quality.

When a product is designed for manufacturing the goals are: reduce cost by focusing on standards, shorten the development cycle, and reduce unnecessary costs related to labor, overhead, and material. Depending on how knowledgeable a company is regarding plastic part design, DFM could ultimately make or break the launch of a project.
Mold Flow Analysis
Creating a high performing mold is a vital part of the injection molding process. Many manufacturers have proven mold flow analysis (MFA) to be the linkage between a flawless design and production.

MFA processes are performed via MFA software; which allows manufacturers to create virtual simulations depicting how plastic will flow into a mold. This program can identify design flaws and quality issues – such as flowlines, weld lines, deep undercuts, inadequate draft angles, warp, and sink marks – and mold complications before actual tool build begins. MFA software can test various mold designs and material selections in a virtual simulation, saving both time and the materials needed for physical prototyping. MFA also helps eliminate imperfections and allows for retesting before finally cutting a production tool.

MFA can be used to simulate numerous "what-if scenarios." By efficiently creating and testing different hypothetical mold designs, companies can ultimately produce higher quality products. In contrast, adjusting a mold for every design adjustment can be costly, as physically redesigning will consume manufacturers time and waste resources.

Many manufacturers create parts or pieces that require texturing. A secondary, post-SIM finishing process can be avoided by etching or milling the mold to create a custom finish or texture. This process can save both time and money.

Do not underestimate the importance of cooling. Effective cooling means that heat added to the plastic to initiate flow is removed as quickly as possible. This should be done using the fewest flow circuits that will provide turbulent flow in all channels with a maximum coolant temperature difference between the inlet and the outlet of 4°F (2°F on critical jobs). For semi-crystalline materials, any extended temperature that the molded product will see in its final application can determine the correct mold temperature. Consistent cooling requires consistent cycle time.

#3. Mold
The mold itself is a critical part of the SIM process. It is important in SIM to follow best practices for tool design. Outlined below are a few tips and key considerations in regards to the mold:

- Match the mold material to the life expectancy of the program and what resin is being processed. Each resin will have nuances that need to be taken into consideration when designing a tool. It’s important that the material chosen for the mold matches the resin and production environment expected.
- Ensure the mold has a proper runner system, or channel, in the mold for the plastic to get from the sprue to the gate and into the part. Runner design can have a significant impact on the way the part fills and processes.
- Ensure adequate venting to allow for the evacuation of air and gasses. A lack of proper venting can result in: burn marks, poor mold filling, weak weld lines, stress and sinks/voids.
- Be sure to account for the parting line, or the point at which the two halves of the mold separate, when designing a part. Parting line locations can affect cosmetics and structural integrity. Also incorporate a few degrees of taper into the design where necessary, allowing the part to be removed from the mold more smoothly with minimal resistance or damage.

#4. Machine
Though the molding machine is the very foundation of the SIM process, too often molders become bogged down with operational and procedural concerns and neglect machine maintenance. This leads to overlooking some key considerations and performance measures.

It is crucial to calibrate injection molding machines annually. Most importantly, just as the resin should be matched to the application, the machine should be matched with the project regarding tonnage, barrel size, and screw type.

Know the Machine
Molders must study their machines, learning all of its nuances, issues and unique requirements. This is
important because an assumption regarding performance, control, or response can result in error and process failure.

While performance is a key component of knowing one's machine, the concept also extends to areas such as plastic pressure; which requires the person responsible for process development to be knowledgeable in the intensification ratio on a hydraulic machine, or the relationship between hydraulic pressure and plastic pressure.

Understanding how to produce a “fill only” sample is also a valuable skill. Fill only samples are created by leaving the pack and hold time on while adjusting the machine’s pressure to its lowest setting, typically 0 psi. This requires the molder to monitor the screw’s position to ensure that the screw does not drift forward while the pack and hold process is occurring.

**Performance Evaluations**
Just as proactive companies evaluate employee performance, strong SIM operations must evaluate machine performance. Some essential elements to consider when assessing machine performance include:

- **Velocity Linearity** - A study performed to compare varying velocity settings to actual velocity during fill.
- **Load Sensitivity** - Testing a machine’s ability to compensate for changes in material viscosity.
- **Valve response at V to P transfer** - From the point of transfer to stable pack/hold, the pressure should be .4 seconds or less (0.2 seconds for world-class machines).
- **Check ring/valve performance** - Static and dynamic testing for consistency.
- **Tie Bar Stretch**
- **Platen Flatness/Parallelism**
- **Temperature control**
- **Machine Repeatability**
- **Screw & Barrel Design/Condition**
- **Injection pressure**

**#5. Process**
Naturally, the SIM process is data-driven and rooted in science and proven methodologies. Data is collected by in-mold sensors, which transmit valuable information and measurements, eliminating as much variation as possible in the process.

In-process monitoring via RJG eDart technology allows for the analysis of various stages individually including the fill, pack, and hold stages. Data gathered via the sensors enable production teams to understand what is precisely occurring throughout the process entirely.

Collecting and analyzing data also provides the ability to easily replicate the manufacturing process and store designs and information electronically. This is invaluable not only in ensuring that engineers are not “reinventing the wheel,” but also saves a significant amount of time and helps ensure regulatory compliance.

Overall, the SIM process offers significant advantages regarding efficiency. Issues and variations can be identified and resolved quickly ensuring both consistency and quality.

**CONCLUSION**
As outlined above, SIM is a well-defined, evidence-based and data-driven process. As with any worthwhile undertaking, a successful SIM program is complicated and requires a multitude of factors and processes. Effective implementation and operation of scientific molding involves on-going comprehensive training, full support, a long-term vision, and data-driven decision-making. Not every company has the internal processes or funds to implement a robust scientific molding program successfully. But at New Berlin Plastics, we have all the tools and expertise necessary to perform high-quality scientific molding on even the most complex projects.

**Saving You Time**
If you want to partner with a company that knows the SIM process inside and out contact New Berlin Plastics. We offer DFM services that will include an in-depth review and ensure that you have an efficient design.
Long-Standing Partnerships with Quality Providers
New Berlin Plastics partners with OEMs and tiered suppliers that require high-quality products, engineering services, and value-added activities from a single supplier. We strive to be a partner that handles your project from start to finish by leveraging our internal capabilities with those of other high-quality area companies.

A One-Stop-Shop
New Berlin Plastics offers many services and capabilities to support you throughout your project’s life cycle. By employing advanced technologies and processes, we can ensure the product delivered to you meets and beats your expectations.

MFA In-House
New Berlin Plastics is capable of performing MFA in-house. We can broaden your knowledge base and guide you through the software program to enhance your production efficiency and part quality.

A Commitment to Testing and Process Improvement
At New Berlin Plastics experts review design, test, and mass produce parts for a range of industries and multitude of products.

The Expertise to Get the Job Done
Our knowledgeable team has years of experience developing and manufacturing a wide variety of parts for medium to large OEMs from diverse industries. Let us help you successfully launch your new or existing project!

Learn More
Contact the team at New Berlin Plastics at 262-784-3120, or visit us online at nbplastics.com to learn how you can reduce costs and improve your end-user experience through the innovative scientific injection molding process.