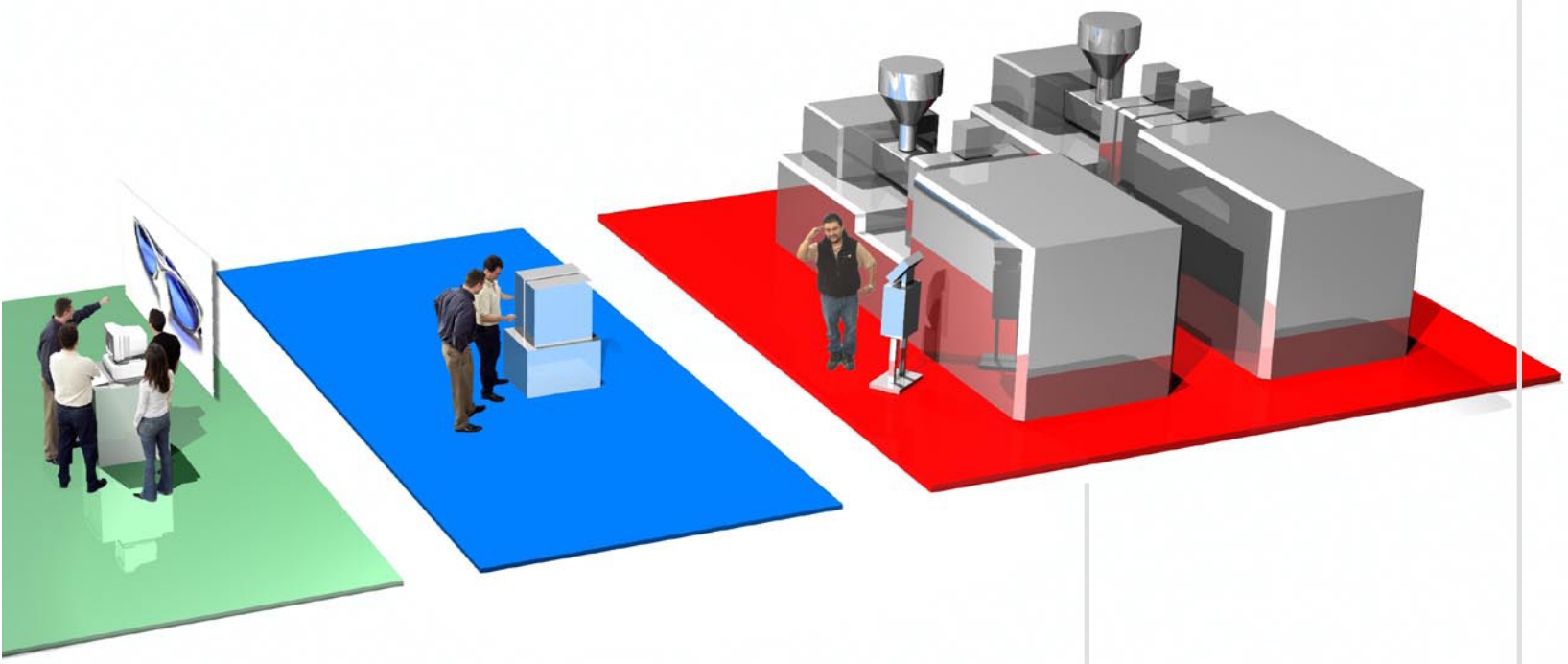
Injection Molding Automation: From Concept to Flawless Volume Production in One Go

White Paper



This document discusses the various manufacturing tasks that must be performed, optimized, and implemented by companies involved in injection molding to work smarter and remain competitive in today's global economy and how Moldflow Manufacturing Solutions™ (MMS™) products contribute to achieving these tasks.

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plastics made perfect™

Contents

Introduction

There is no need to dwell on the challenges facing today's injection molding industry. In the last couple of years, injection molders have made sizable capital investments to improve quality and efficiency in an effort to counter competitive pressures as well as rising material and labor costs. New injection molding machines, advanced automation and inspection devices, to automated assembly machinery and sophisticated materials handling equipment have enabled molding plants to significantly increase output with a lower operating cost basis. As a result, they now enjoy the highest historical productivity rates.

However, in spite of all these advances, the injection molding industry faces its biggest challenge yet. To further optimize efficiency, there is a need for an integrated approach that guarantees a flawless execution from the conceptual stage of part design, to its high volume production, to its ultimate delivery to the customer. Unfortunately, the injection molding manufacturing process is a patchwork of disparate systems with which it is difficult to intelligently exchange data, making the planning, setup and ramp-up of new production lines time-consuming and plagued by inefficient trial-and-error and finetuning methods.

From Design to Manufacturing Optimization

Moldflow needs no introduction into the world of part and mold design optimization. It virtually invented the space, and Moldflow's design analysis products have become the world's most widely used CAE solutions in the injection molding industry.

The CAE space has gradually evolved from basic problem solving tools in the 1980s to modeling and simulation for problem avoidance in the 1990s. The new frontier for CAE is a more comprehensive approach that also includes manufacturing optimization, an area where Moldflow remains on the forefront.

Moldflow Plastics Advisers® (MPA®) products are easy-to-use, 3D solids-based plastics flow simulation tools that allow part designers and mold makers to predict the manufacturability and quality of their designs during preliminary product development stages. MPA users benefit by avoiding potential downstream problems that can lead to production delays and cost overruns.

Moldflow Plastics Insight® (MPI®) products are a complete suite of advanced plastics process simulation tools for predicting and eliminating potential manufacturing problems and optimizing part design, mold design, material choice and processing conditions. MPI products simulate the broadest range of manufacturing processes and support all design geometry types associated with plastics molding processes.

Set Up, Optimize, Control and Monitor

Once the part and mold designs are optimized and the effects of the molding processes have been taken into account, the logical next step is to deliver optimal processing parameters to the primary equipment and other process controls in the manufacturing cell.

Automating the setup process enables production to start more quickly and shortens the time required to determine and achieve the ideal process parameters such as shot size, injection speed, temperature and pressure settings. Used intelligently, design analysis simulation (DOE) results can provide appropriate initial conditions from which to begin the manufacturing process setup and downstream optimization and control tasks. The more complex the part, the material or the mold, the narrower is the processing window and the higher is the need for continuous monitoring and optimization during production.

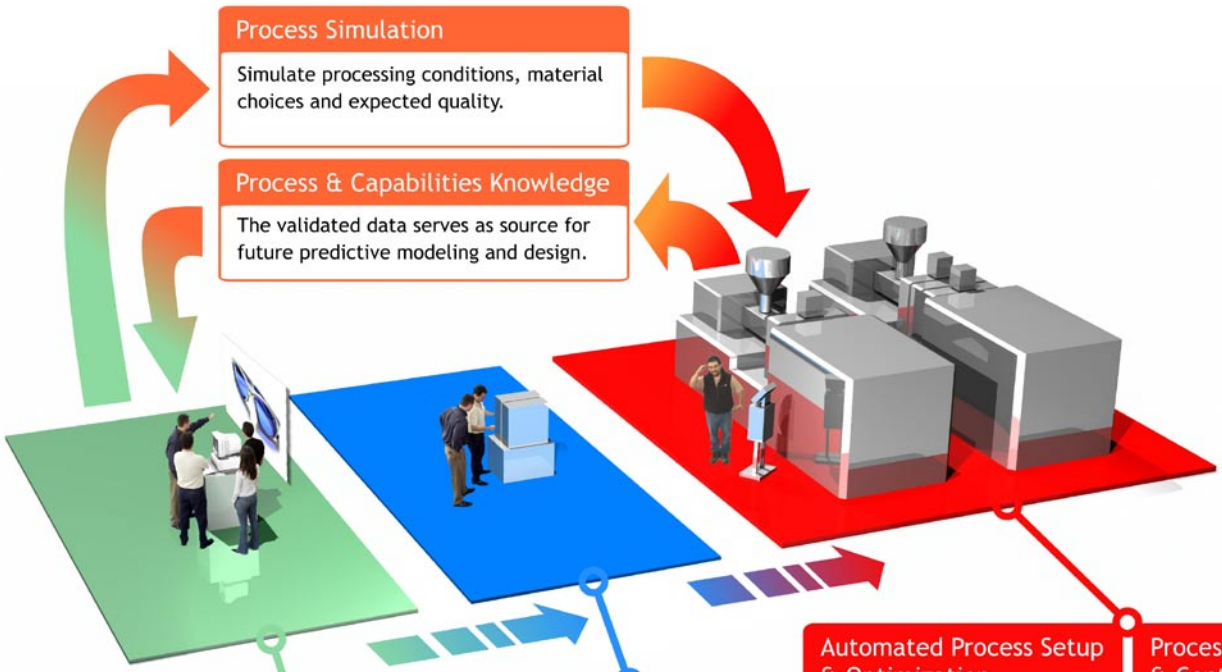
In a networked environment, monitoring and optimization can now be handled automatically from a single operator console in a central location, limiting operator interventions in the production cell to major equipment failures.

Optimal Temperature and Flow

Production capacity and yield are ultimately determined by the speed, reliability and quality by which the melt flows from the machine into the mold. This is where advanced hot runner controls come in, as they assure that materials are kept in an optimal molten state until injected into the part cavity. This "final control element" guarantees higher yields, reduced cycle times and better part quality. Moldflow now also offers the world's most advanced hot runner control technology.

How Are We Doing Today?

Bringing production equipment into a networked environment does more than just extend the control and monitoring functionality. It provides access to real-time data that can be used for production monitoring, work order management, job scheduling, statistical quality control (SQC), statistical process control (SPC), production scheduling, preventive maintenance, production reporting and part traceability. The instant access to the metrics that define an operation's performance, give it the agility to quickly and confidently respond to changing market conditions and competitive pressures. Can you schedule additional jobs to maximize your capacity? How aggressively can you price your services? Can you provide detailed production quality data and assure part traceability to your customers? Moldflow Manufacturing Solutions™ provide you the capabilities.



Process Simulation

Simulate processing conditions, material choices and expected quality.

Process & Capabilities Knowledge

The validated data serves as source for future predictive modeling and design.

Part Design Optimization

The part is designed using the knowledge of the available manufacturing capabilities and material characteristics.

Risks & Possible Impact

A poorly designed part can cause weld lines, air traps or even overpacking, using up unnecessary material and resulting in longer production cycles.

When a part cannot be manufactered as designed, there are only two options, compromise the design or go back to the drawing board, resulting in weeks or months of lost production time.

Mold Design Optimization

Design the mold that optimally suits the part requirements and the production capabilities.

Risks & Possible Impact

A poorly designed mold with an unbalanced fill can result in longer production cycles and high scrap rates.

Mold design through trial and error can require several mold reworks and delay production release for weeks or months.

Automated Process Setup & Optimization

The part was designed optimally to the manufacturing capabilities, allowing the software to automatically set up the fastest and most reliable process window.

Production Monitoring

The system monitors various production data in real time, including machine efficiencies, scrap causes, job start/stop, lot changes, material consumption, and part quantity adjustment.

Process Monitoring & Control

The system continuously monitors and maintains the optimal process conditions.

Hot Runner Controls

Advanced hot runner controls assure that materials are kept in an optimal molten state until injected into the cavity.

Risks & Possible Impact

Manual process setups can require endless trial runs and can result in unnecessarily long production cycles.
Lack of real time data can compound efficiency problems and capacity under-utilization, resulting in lost production time or marginal efficiency.
Inconsistent monitoring can result in poor product quality.

The Knowledge Loop

To accomplish all of the above, a system needs to be totally integrated and balanced. It has to be a "knowledge loop" that starts with the in-depth profiles of production capabilities and material characteristics that are used to optimally design a part and mold and determine a practical processing window. From there the information is used to control and monitor the optimal settings of the process equipment and the auxiliaries in the manufacturing cell. The knowledge loop is closed with the validated data serving as the source for future predictive modeling and design.

Implementing this knowledge loop requires a technology partner who understands the complex data interfaces needed to communicate with older as well as today's state-of-the-art equipment. Turning proprietary signals from a multitude of sources into a wealth of meaningful and usable information is invaluable.

The knowledge loop needs to be extendable to upstream and downstream processes. This can go from the basic hand-off or exchange of intelligent data between process entities to a superset of centralized control and monitoring functions that start with the supply management of raw materials, through automated assembly, and packaging. The ultimate goal is to create a single continuum that is proactive in that it intelligently determines the fastest and most reliable process steps to produce a product, and reactive to predictably adapt to erroneous behavior, to expand the body of process knowledge and to document product genealogy and quality.

Manufacturing Optimization

Even though design analysis solutions play an important role in this knowledge loop, the focus of this white paper is on the manufacturing optimization segment. Moldflow Manufacturing Solutions products comprise a complete suite of tools that can be used for the setup, optimization, and control of the injection molding process, as well as for the monitoring and monitoring-related tasks associated with injection molding equipment, as well as upstream and downstream auxiliary equipment. The primary objective of manufacturing optimization is to achieve and maintain the best processing conditions, resulting in higher part quality and more efficient use of machine time.

In the next sections, we will cover several important aspects of manufacturing optimization and how Moldflow solutions can help you accomplish them.

Process Setup

Successful process setup requires an operator to determine a machine-mold-material combination of processing conditions to achieve acceptable quality parts. Moldflow's process setup module eliminates the guesswork over process parameter permutations and instead provides an intuitive, systematic method for establishing the best combination of process parameters that produce good molded parts. This scientifically created process results in less time spent on setup and less material wasted on trial-and-error iterations.

Process Optimization

After determining the combination of process parameters that will produce an acceptable quality part, it is important to further determine or verify a robust processing window. Moldflow's process optimization module performs an automated Design of Experiments (DOE) that builds on the foundation established during the process setup phase. The technology allows users to further optimize the combination of processing parameters to determine a robust, "good parts" processing window. The predefined DOE runs automatically, so no special expertise in statistical process control (SPC) is required for a machine operator to determine a robust, "good parts" processing window quickly. Once this robust processing window has been determined, the process is less likely to go out-of-control and produce out-of-specification parts.

Process Control

Assuming a robust processing window has been determined by using the process setup and process optimization modules, users can access Moldflow's process control module to maintain the optimized processing conditions. The process control module allows users to consistently maintain the production process, resulting in reduced reject rates, higher part quality, and more efficient use of machine time.

Hot Runner Process Control

The right machine parameters and the wrong process control of the mold will result in slower cycles, parts out of tolerance, high scrap rates and constant headaches for processing technicians. It is imperative for the best part-price ratio that the core of a mold, the hot runner when used, be properly controlled.

Moldflow's Altanium® hot runner process controls are the industry's first and only modular, small footprint solution that can support from one to 384 zones. Its unique modular control units can be used freestanding, mounted on the mold or mounted alongside, behind, or even inside the injection-molding machine. With advanced technology for auto-slaving, boost control, standby management, mold diagnostics and data collection, Altanium® controls offer the highest degree of temperature control accuracy for existing and future low-mass nozzles, featuring user selectable phase angle or zero cross power control per zone, state-of-the-art "hall effect" current transducers and enhanced diagnostics and control software.

The increased use of temperature-sensitive engineering plastics, hard-to-mold polymers, and co-injected materials demands the ultimate in temperature control to assure dimensional consistency, which is where Moldflow hot runner

controls come in.

High Speed Process Monitoring and Analysis

Once a robust processing window has been established and is in control, it is important to continuously monitor key process parameters to identify any trends in the process. Using collected data, Moldflow's process monitoring and analysis modules analyze the manufacturing processes to uncover hidden or latent problems, as well as collect and archive the data for future part quality conformation.

Statistical Process Control

Fundamentally, statistical process control (SPC) is a method of monitoring a process during its operation in order to control part quality during production, as opposed to relying on inspection to find problems after the fact. SPC involves gathering and analyzing data about the process itself in near real time, so that necessary action can be taken. This is done in order to identify special causes of variation and other abnormal processing conditions, thereby bringing the process under statistical control and reducing cycle-to-cycle or part-to-part variation. Because of the nature of the injection molding process, it is ideally suited for implementing SPC methods. Therefore, a complete manufacturing solutions system should include a method for performing various SPC tasks.

Moldflow's SPC module can be used to apply SPC methods to the injection molding process. Some of its capabilities include:

- Measure and store up to 50 parameters on every machine cycle and then perform typical SPC treatment of the data.
- Activate alarms and part diverters when process limits are violated.
- Display run charts to review process parameters and part attributes for up to 100,000 machine cycles.
- Display histograms, X-bar and R charts, and scatter diagrams for additional analysis capability.

These are just some of the SPC capabilities available to help injection molders improve their process and maintain greater control over it.

Statistical Quality Control

Relative to injection molding, statistical quality control (SQC) is the application of statistical techniques to measure and evaluate the quality of a part or process. Within SQC, there is the concept of acceptance sampling, which is the application of statistical techniques to determine whether a population of items should be accepted or rejected based on a sample inspection. Furthermore, "quality measurements" associated with certain characteristics, such as part weight, part dimensions, part warpage and others, can be assessed. Any or all of these characteristics can be identified as either acceptable or not acceptable. In combination, the measurement of these characteristics, results feedback and the correlation with SPC data offer valuable tools for injection molders who aim to achieve or exceed the highest levels of production quality. Moldflow's SQC module allows SQC data to be entered into the system and recorded in association with shot-numbered process data for correlation purposes in a statistical process analyzer tool.

Production Monitoring Technology

Production monitoring is normally associated with tracking data such as part counts, number of good parts versus number of defect parts, defect causes, machine downtime, and machine efficiencies.

Moldflow's production monitoring module includes the previously mentioned features that allow for the tracking of production data, plus it has mechanisms to input scrap causes, downtime codes, job start/stop, lot changes, material consumption, and part quantity adjustment. This capability allows injection molders to measure and track their operations in real time, thereby enhancing critical decision-making.

Production Reporting

Once a production or process monitoring system is in place, there must be a mechanism for extracting the data collected in a format that is easily communicated to those who require the information. This is accomplished using Moldflow's production reporting module, which provides the following capabilities:

- View production processes with graphic and tabular reports.
- Report real-time status on every job on every machine.
- Customize reports.
- Create dozens of standard reports that summarize performance by job, machine, mold, and part number.
- Graphically illustrate scrap and downtime using Pareto and pie charts.
- Easily and efficiently interchange information with various databases and other software packages, such as ERP/MRP systems.

Production reporting is a valuable and necessary component of any process or production monitoring system as it is the mechanism for providing access to critical information in real time so that informed business decisions can be made.

Production Scheduling

As an injection molder increases the number of machines and molds that are scheduled to run in production, an automated production scheduling system becomes a necessity. Without a production scheduling system, molders will ultimately delay or miss product ship dates. When it happens, the resulting lost time, additional expenses, and dissatisfied customer cost more than money, it costs their reputation. Moldflow's production scheduler module provides fast job creation and efficient schedules. The ability to use previously collected job histories and job templates makes scheduling new jobs or job re-runs easy and efficient. The production scheduler module also allows users to adjust machine workloads to accommodate changes in production or delivery requirements while eliminating scheduling conflicts.

Conclusion

To maximize capacity utilization and production efficiency, while improving quality, manufacturers need integrated manufacturing solutions that facilitate continuous process improvements and ultimately make them more competitive.

Moldflow's "best-in-class" products allow manufacturers to optimize operations, drive down costs and increase profitability with end-to-end solutions that optimize the entire design-through-manufacturing process.

For more information about Moldflow Manufacturing Solutions, visit

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