3D Gas-Assisted Injection Molding Simulation Streamlines Concept-to-Production

By Marcia Swan, Editor

For companies involved with gas-assisted injection molding, Moldflow's MPI/Gas simulation software provides know-how needed to understand this complex process and ensure that part designs, mold designs and the molding process itself are optimized before production or even tooling begins.

Mack Molding Company evaluated MPI/3D Gas simulation during the development of this new mass transit seat design.[1]

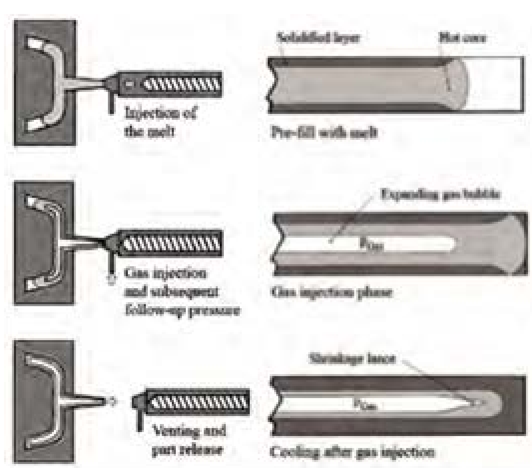
Companies like Arlington, Vermont-based Mack Molding Company are using 3D process simulation to realize more fully the advantages inherent in the gas-assist process to produce the high-quality parts efficiently and economically.

Gas-assisted injection molding is a versatile process that provides tremendous flexibility in the design and manufacture of plastic parts. Compared to conventional injection molding, the gas-assisted process has the potential to produce hollow, light-weight, rigid parts that are free of sink marks and less likely to warp. Additional advantages include material savings, reduced cycle time, reduced pressure and clamp force tonnage requirements, and the ability to consolidate thick and thin sections in a single part.

Because the process involves the dynamic interaction of two dissimilar materials flowing within typically complex cavities, optimizing product, tool and process design for gas-assisted injection molding can be quite complicated. Furthermore, experience with conventional injection molding is not sufficient to address the specialized requirements of the gas-assisted process, especially in designing the gas-channel network, optimizing gas penetration and optimizing the processing window.

Process Overview

The gas-assisted injection molding process begins with a partial or full injection of polymer melt into the mold cavity. Compressed gas (typically nitrogen) is then injected under pressure control or volume control into the core of the polymer melt to help fill and pack the mold. Gas may be injected either through the nozzle of the molding machine, or by direct injection into the mold or into a runner.



Stages and sequence of the gas-assisted injection molding process.[2]

Short-shot vs. Full-shot Techniques

In the short-shot gas-assist process, the cavity is partially filled with plastic before gas is injected to complete cavity filling by pushing the plastic into the unfilled areas of the part. Maintaining gas pressure after the cavity is filled helps to pack the plastic and compensate for plastic shrinkage.

In the full-shot gas-assist process, gas injection starts only after the cavity is completely filled with plastic. A variant of the full shot process incorporates an overflow well (or overspill) at the end of a gas channel. An overflow well is a secondary cavity, typically controlled by a valve gate, into which the gas can displace polymer and thereby penetrate further into the part. The gas packs the cavity by penetrating into the regions where the plastic is shrinking, and the extent of gas penetration is directly influenced by the shrinkage characteristics of the material.

Typical Applications

Typical applications for the gas-assisted process can be classified into three categories:

- Tube- or rod-like parts, where the process is used primarily for saving material, reducing the cycle time and incorporating product function into the hollowed section(s).
- Large, sheet-like, structural parts with a built-in gas-channel network, where the process is used primarily for reducing part warpage and clamp tonnage requirement, as well as to enhance rigidity and surface quality.
- Complex parts comprising thin and thick sections, where the process is used primarily for decreasing manufacturing cost by consolidating several assembled parts into a single part design.

Moldflow Solutions for Gas-assist Applications

MPI/Gas software allows users to study polymer and gas flow behavior within a part model and examine the influence of design and process modifications on the polymer/gas system. Simulation results provide information to optimize product design, including gas channel layout and size; position polymer and gas injection points; and detect and avoid common problems such as gas permeation or fingering, gas blow-through, poor gas penetration and short shot.

The latest release of MPI/Gas software extends 3D analysis capabilities to simulate part warpage. Now part designers, mold designers and process engineers can use simulation results to:

- Aid in material selection, including materials with fibers or fillers.
- Optimize part design including gas channel networks to promote desired gas penetration.
- Evaluate mold design options including gas entrance options and their impact on gas penetration.
- Determine appropriate process conditions to achieve successful molded parts.
- Predict effects of gas channels on the post-molding shrinkage and warpage of the final part.
- Quantify benefits of the gas-assist process compared to conventional injection molding.

MPI/Gas Capabilities		
Analysis Type	Analysis Technology	
Fill		
Fill+Pack		
Fiber Fill+Pack		
Cool		
Warp		
Stress		

Midplane Model  *3D Model* 

Customer Analysis Using MPI/3D Gas Simulation

Mack Molding Company is a leading custom plastics molder and supplier of contract manufacturing services. The company operates six injection molding facilities in the eastern United States, with 120 injection molding machines ranging from 28 to 4000 tons of clamp force, shot sizes from 0.6 to 800 ounces, and expertise in specialty molding processes, including solid injection, structural foam, overmolding, internal and external gas-assist, and two-shot molding.

Dr. Michael Hansen is a Senior Technical Development Engineer at the company's Arlington, Vermont headquarters plant. Hansen is a proponent of molding simulation and supports incorporating the technology into everyday workflow.

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"Using molding simulation allows us to test and verify key aspects of a new product design during development. Results help us to confirm material selection, streamline part and mold design and verify processing parameters, even for our most challenging applications," he notes.

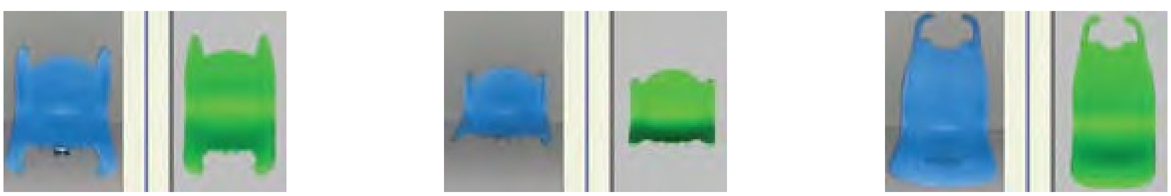
Hansen has been working in conjunction with BASF, the world's leading chemical company, to evaluate 3D simulation capabilities. Here, he presents an analysis that illustrates the utility of the MPI/3D Gas software for an innovative gas-assisted injection molding application.

Mass transit seat

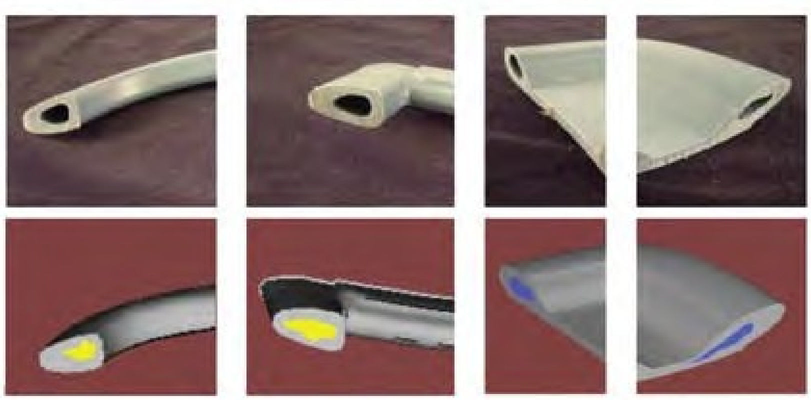
For a new seat design for mass transit vehicles, the gas-assist process using a reinforced composite resin was chosen to meet requirements of efficient use of material, aesthetics, and product structural performance criteria. Tooling considerations included filling the part from a single, central location on the part to avoid knit lines and placing gas pins and overflow wells in locations that would not be visible when the finished product was installed.

Using MPI, Hansen was able to import the 3D CAD model directly, eliminating the need to prepare a special model for molding simulation. Hansen used MPI/3D Gas simulation to investigate gas penetration patterns, gate and gas pin locations, overflow well location and size, as well as processing parameters including gas delay time, gas pressure, plastic fill time and clamp force, among others.

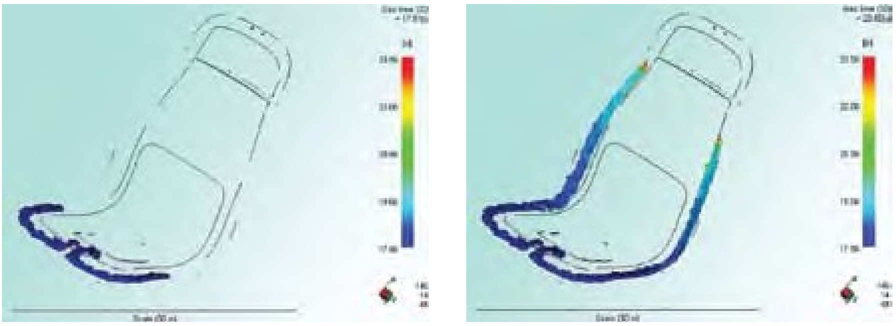
Molding trials showed good agreement with simulation results.



Molded short shots (shown in blue at left in each pair of images) produced at intervals throughout the cycle corresponded closely to the predicted plastic filling pattern at the same times (rendered in green at right in each pair of images).[3]



Cross-sections cut through gas channels showed that the gas penetration in the molded parts (at top in each pair of images) also corresponded closely to the predicted gas penetration (at bottom in each pair of images).[4]



MPI/3D Gas simulation results helped to confirm the design of the gas channel pattern.5

For this application, optimizing part and tool design, material selection and choice of molding technique were essential to assuring manufacturability and durability of the finished product. Hansen emphasizes, "Using CAE tools is a key factor in time-to-market and achieving a smoother transition from concept to real-life production."

Mack Molding Company provides design through FDA-approved manufacturing services to the medical, commercial, computer and business equipment and transportation markets. With 87 years of plastics expertise, the company integrates product development, custom injection molding, sheet metal fabrication, and full product assembly in ISO 9001 and ISO 13485 environments. Product development resources include design, prototyping and extensive engineering services.

Images provided courtesy of Mack Molding Company:

[1, 3, 4, 5] Michael Hansen, Ph.D., Mack Molding Co., "Gas-assisted Mass Transit Seat: Comparing Real-life Molded Part Data with Simulated 3D Numeric Mold Filling Results," Society of Plastics Industry Conference, Memphis, TN, April 2007.

[2] Michael Hansen, Ph.D., Mack Molding Co., "Gas-assist Injection Molding: An Innovative Medical Technology," MD&DI, August 2005.