Working Smarter with Moldflow Plastics Insight™ 3.0

White Paper

Abstract

This document describes features and enhancements of Moldflow Plastics Insight 3.0 (MPI™ 3.0), a complete suite of advanced plastics injection molding process simulation tools to predict and eliminate potential manufacturing problems and optimize part design, mold design, and the injection molding process. Unlike other plastics CAE simulation software, MPI addresses the broadest range of manufacturing issues and design geometry types associated with the injection molding process. The features and enhancements addressed in this document demonstrate how users of MPI 3.0 can work smarter and more efficiently to reduce or eliminate time delays, improve part quality, and deliver projects on time and within budget constraints.

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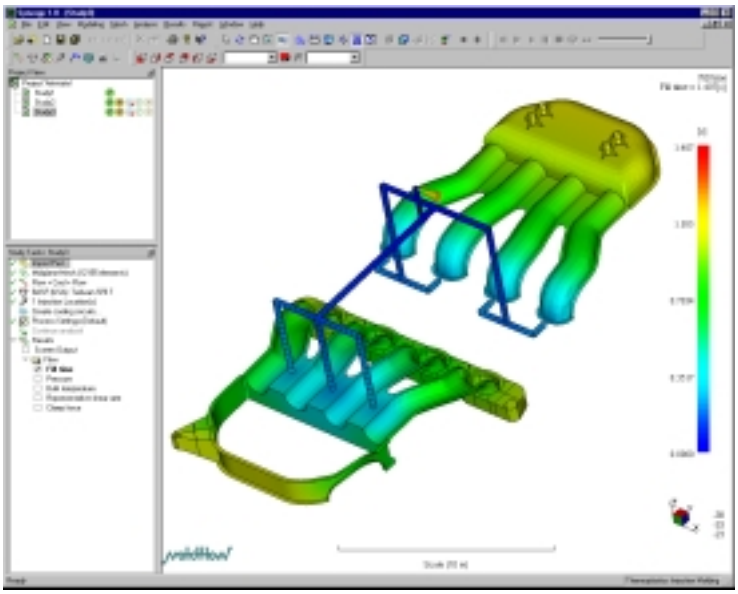
CONTENTS

INTRODUCTION

One of the greatest advantages of the plastics injection molding process is that parts of extremely complex geometry can be produced “net shape” — that is, once a part is molded, cooled and ejected from a mold, it is in the form required for the next step of the manufacturing process. Net-shape parts can be produced in high volumes, in a relatively short amount of time, and with low energy costs. However, the many potential problems associated with manufacturing such complex shapes can result in increased time to market and have a negative impact on profitability.

To avoid the high costs and time delays associated with problems discovered in the manufacturing environment, it is necessary to consider the combined effects of part geometry, material selection, mold design, and processing conditions on the manufacturability of a part. Using predictive analysis tools to simulate the molding process, companies can optimize these variables in the part and mold design phases of a project, where the cost of change is minimal and the impact of change is greatest.



Moldflow Plastics Insight software provides advanced process simulation tools to predict and eliminate potential manufacturing problems and optimize part design, mold design, and the injection molding process. MPI products address the broadest range of manufacturing issues and design geometry types associated with plastics molding processes.

GEOMETRY AND SIMULATION—IT ALL STARTS HERE

Simulation Depth

MPI analysis modules are able to simulate the most comprehensive range of manufacturing processes encountered in thermoplastics and thermoset injection molding. With MPI, you can simulate the filling, packing, and cooling stages of the thermoplastics injection molding process and also predict post-molding phenomena such as part warpage. It is even possible to analyze the flow of fiber-filled materials, predict the resultant fiber orientation, and take that into account when predicting part warpage. You also can simulate more exotic thermoplastics molding processes, such as gas-assisted injection molding, co-injection and injection-compression processes with MPI, as well as reactive molding processes including thermoset injection molding, reaction injection molding (RIM), and microchip encapsulation. Quite simply, MPI software offers the greatest range of molding process simulation tools in the plastics industry, bar none.

Geometry Breadth

While MPI does contain a broad suite of in-depth simulation tools, it is made all the more powerful because of the wide breadth of part geometry that can be easily analyzed.

Traditional Midplane Solutions

For thin-walled plastic part designs, MPI can analyze traditional, midplane finite-element mesh models. To increase your productivity when creating and analyzing such models, the MPI/Midplane Generator can be used to automatically generate a midplane mesh and assign proper element thickness to ensure accurate analysis results.

MPI/Fusion Solutions

MPI/Fusion, which is based on Moldflow's patented Dual Domain™ technology, allows you to analyze CAD solid models of thin-walled parts directly, resulting in a significant decrease in model preparation time. The time saved allows you to analyze more design iterations as well as perform more in-depth analyses.

MPI/3D Solutions

Using a proven solution technique based on a solid, tetrahedral finite-element volume mesh, MPI/3D allows you to perform true three-dimensional flow simulations on parts that tend to be very thick and solid in nature as well as those that have extreme changes from thin to thick.

Together, these three solution methods provide a breadth of geometry support that is unmatched in the plastics industry today.

Enhanced CAD Interfaces and Geometry Representation

Moldflow Design Link (MDL) is completely integrated with the MPI/Synergy pre- and post-processor. MDL provides data integration to leading CAD systems through standard interfaces such as IGES, STEP, and Parasolid™. In addition, imported geometry is now represented in MPI/Synergy as trimmed NURBS surfaces. These surfaces can be independently viewed, grouped, or meshed. NURBS surfaces are supported by the IGES, STEP, and Parasolid file formats.

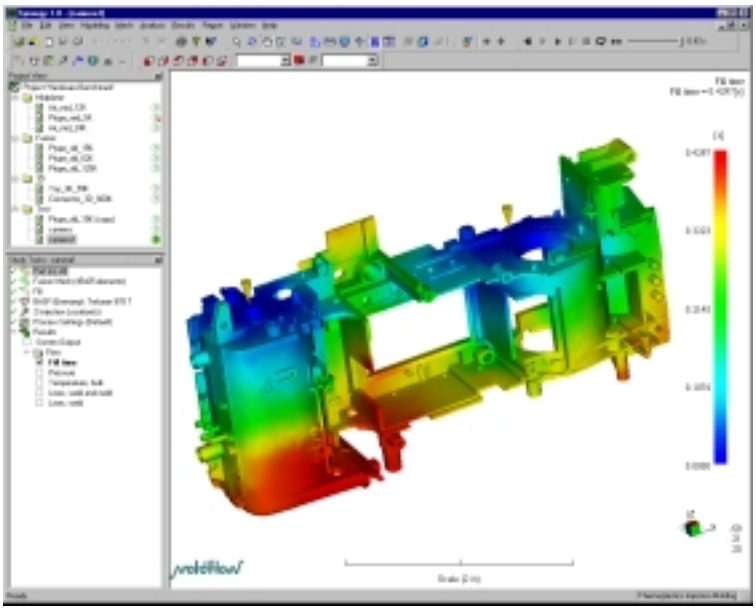
The accuracy of analysis results is just as dependent on having an accurate part model and mesh as it is on having accurate material property data. For this reason, Moldflow is constantly working to improve the level of CAD interfaces available to make it as easy and seamless as possible to read 3D CAD models into our software. Part designers may spend hours, days, or even weeks creating 3D solid CAD models using many of the leading CAD packages available. MDL helps to eliminate the need to duplicate effort in creating a model suitable for finite element analysis inside of MPI.

In addition, within MPI/Synergy, it is possible to import many other types of CAD interface file formats including, IGES, STL, Patran Neutral, Nastran Bulk Data File (BDF), and ANSYS Prep 7 files. Additionally, since many CAD packages are based on the Parasolid geometry kernel, Moldflow introduced MDL to directly read in Parasolid files from CAD programs such as Unigraphics™, Solidworks®, Solid Edge™, and IRONCAD™, in addition to many others.

This level of CAD integration makes it easier than ever to quickly assess the impacts of part and mold design changes on manufacturing using MPI analyses, no matter which CAD environment is used to create the models.

MPI/SYNERGY

The MPI/Synergy module is a pre- and post-processor used for model preparation, meshing, mesh editing, model validation, job setup, job control, results visualization, and report generation. The MPI/Synergy graphical user interface supports all of the analysis modules of MPI. MPI/Synergy also supports midplane, MPI/Fusion and MPI/3D tetrahedral mesh models in a single multi-window, multi-document, Windows-based environment.



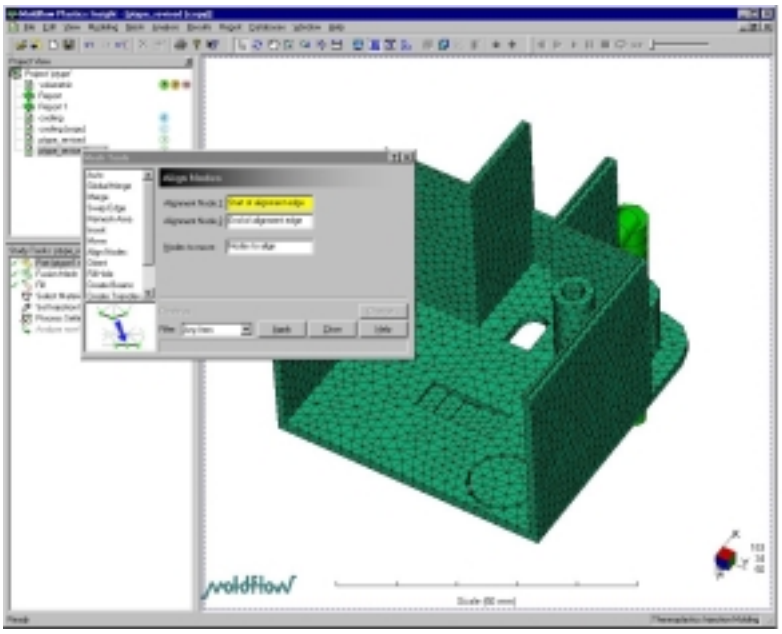
The MPI/Synergy user interface provides a streamlined and intuitive working environment. There are two dockable work panes normally viewed on the left side of the interface. The top pane, Project View, provides a quick visual review of the different studies and analyses that have been performed and is used for organizing projects. The lower pane displays the Study Tasks, which are designed to guide users through the necessary tasks to import a CAD model, and set up and launch an analysis or sequence of analyses.

MPI/Synergy takes advantage of many popular Windows-based, ease-of-use functions, including drag-and-drop and context-sensitive right-mouse-button access for performing common tasks. MPI/Synergy also includes many keyboard command shortcuts which more advanced users may prefer.

Meshing and Mesh Editing

MPI/Synergy provides a complete set of tools to create, edit and validate meshes for midplane, MPI/Fusion and MPI/3D analyses. Moldflow is the only CAE software available today that supports the simulation of the plastic injection molding process with all three of these mesh types.

New in MPI 3.0 is a fully automatic, 3D tetrahedral mesh generator. Unique to this feature is the ability to control the number of elements through the thickness of a part. This complements other automatic meshing capabilities already in the product for creating finite-element midplane and MPI/Fusion meshes.

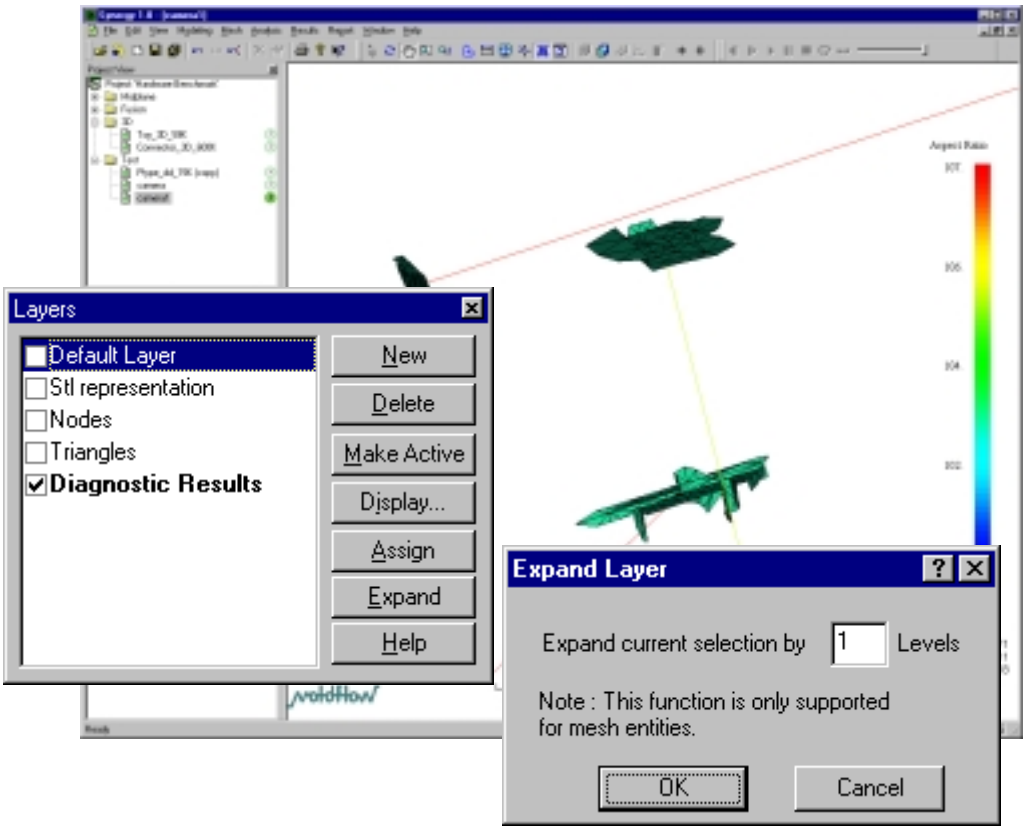


Also new in MPI 3.0 is a comprehensive set of mesh-editing and validation tools. The new Mesh Diagnostics tools provide the ability to easily visualize the quality of the mesh with respect to criteria such as aspect ratio, overlapping elements, connectivity, thickness, free edges, and occurrence number. Several new mesh-editing tools are provided to clean up and refine the mesh. Also, new selection methods are available to allow users to quickly and easily focus on specific problem areas. All these tools allow users to increase productivity by spending less time on model preparation and cleanup and more time on analysis, results interpretation, and report generation.

Layers — Easily Organize Your Analysis Model

MPI/Synergy also includes a very powerful and easy-to-use layers system. Layers are used to group entities together and to limit user interaction to specific model areas. You can create as few or as many layers as needed. There is a default layer, as well as layers for specific model entities such as CAD geometry, nodes, and elements.

Layers can be turned on and off to get a better view of the region of the model where interest is being focused. When a layer is turned off, features on it will not be visible or selectable. Users can also modify entity properties, such as element color or visualization style, layer by layer.

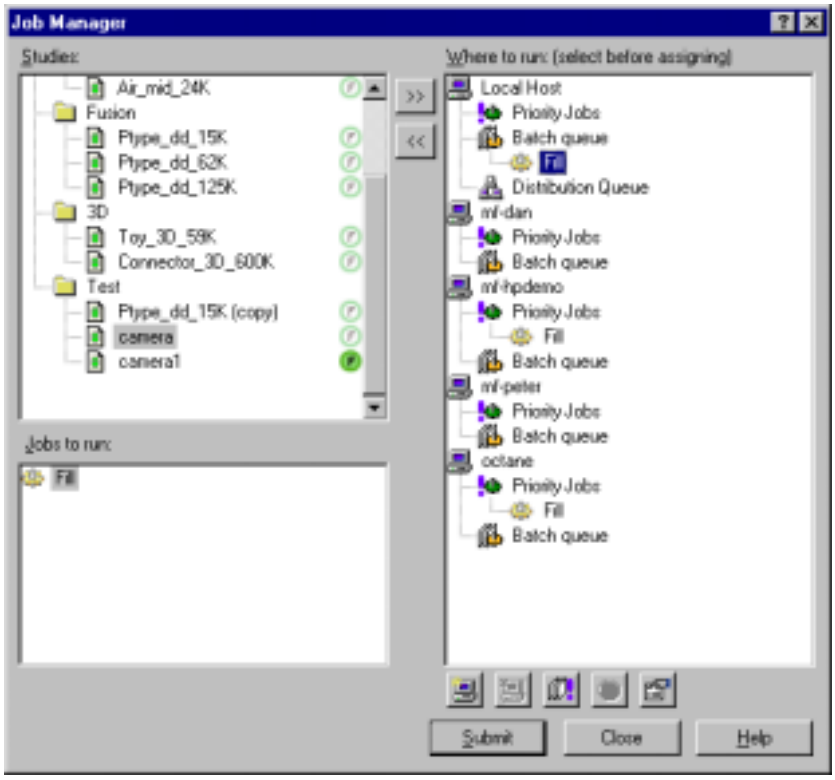


The use of layers is an integral part of efficient model preparation and mesh editing. When using the Mesh Diagnostics tools to reveal problems such as high aspect ratio elements, users may choose to have them placed on a new layer called Diagnostic Results. This allows users to turn off all other layers and visualize and repair only the problem elements.

A new Expand Layer tool allows users to expand an area they have selected to include the next layer of connected elements, by one or more levels of connection. This allows users to edit problem elements easily, since they can quickly and selectively visualize the elements connected to a problem element.

Job Manager

The MPI 3.0 Job Manager has been designed to allow users to take advantage of computing power available over their local area networks (LAN). The Job Manager allows users to submit jobs to available network job servers, without having to manually move any files to the machine actually running the analysis. Once the job is complete, users are notified automatically. While the job is running, an interactive job status window allows users to view its progress. Another enhancement to the Job Manager is the distribution queue. This queue automatically distributes multiple analysis jobs from a design of experiments analysis to available servers on the network. This functionality allows analyses to complete in the shortest amount of time possible.



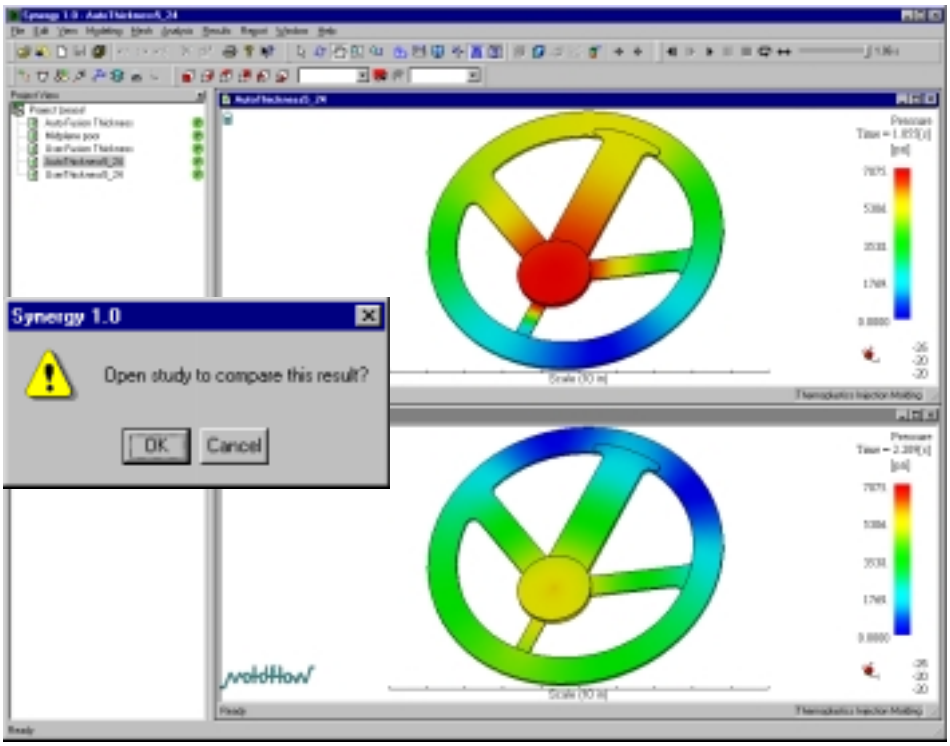
The Job Manager has been developed to work within a heterogeneous hardware network, meaning that all jobs can be distributed among Windows-based PCs and UNIX-based servers from either platform. For example, a user sitting at a PC could launch and monitor several jobs on any UNIX machines that had been specified as available job servers and vice-versa.

Results Interpretation and Reporting

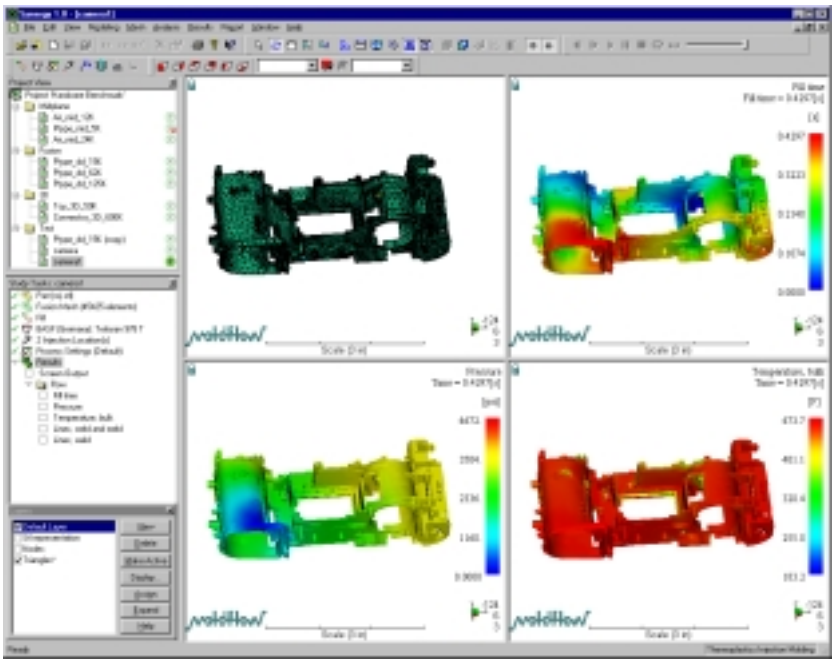
MPI/Synergy contains a number of tools that make interpreting results during post-processing easier than ever. Multiple windows now can be locked together so that manipulations in one window, such as rotating and zooming, will take place simultaneously in all windows. A new results synchronization mechanism allows a user to open results from multiple analyses and view them in the same scale. For example, when viewing colored contour plots of temperature results from two analyses, the colors will scale to the same values in each window. Using these two features together lets users directly compare results of different analyses quickly and easily. Enhancements to the automatic, web-based report generator now let users communicate these results just as easily. The report generator allows different analyses on the same part model and even analyses of different part models to be included in one report.

Results Synchronization and Window Locking

The new Results Synchronization capability for comparing results increases the speed at which users can determine the optimum set of results for any given study. Typically, users will run an analysis, review the results, make some changes, and run another analysis. It is now possible to open the results from the new analysis and display them using the same scale as the results of the first analysis. This not only helps in interpreting results but identifying the analysis that provides the better results.

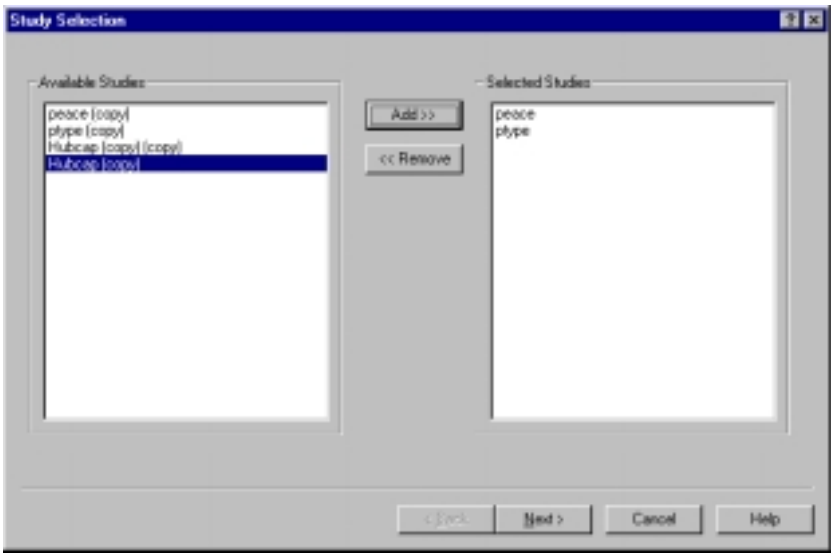


Complementing Results Synchronization is a new Window Locking feature that allows any MPI/Synergy graphical windows to be locked together. Locking links view manipulation operations (pan, rotate, zoom, etc.) such that all window view changes are done simultaneously. This feature is useful during both the pre- and post-processing stages. During pre-processing, users can display the mesh in one window and the Mesh Diagnostic Results in another to simplify mesh editing tasks. During post-processing, users can modify the view of different result quantities displayed in multiple windows at the same time to allow for better interpretation of the results.

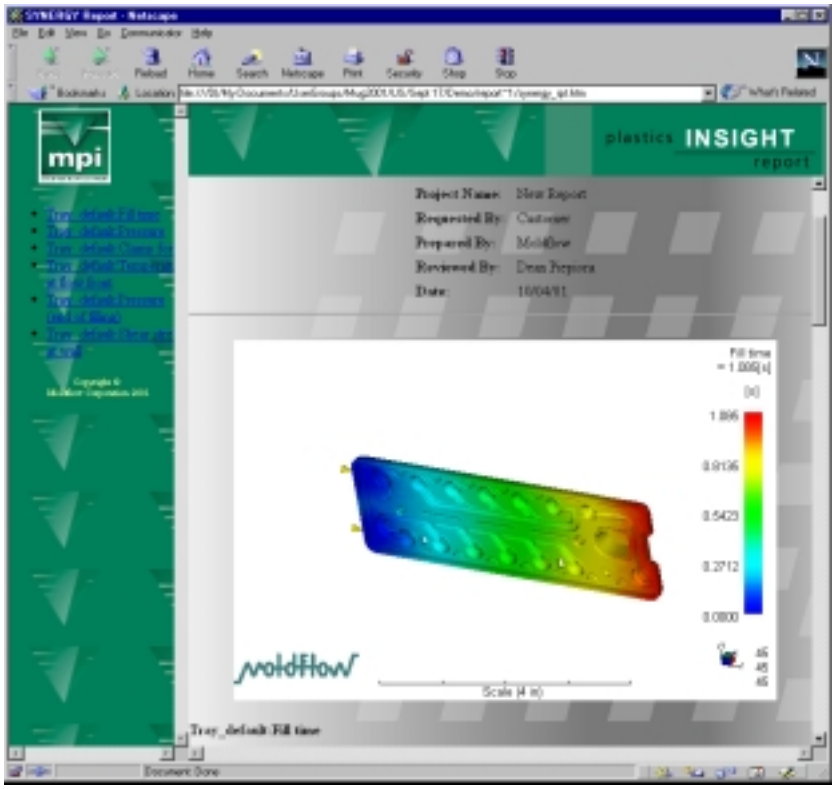


Results Communication

The MPI/Synergy report generator allows users to easily create a single report containing results from multiple analyses from the same or different models. A new report wizard walks a user through the report creation steps and allows the user to select analysis results from the same or different part models.



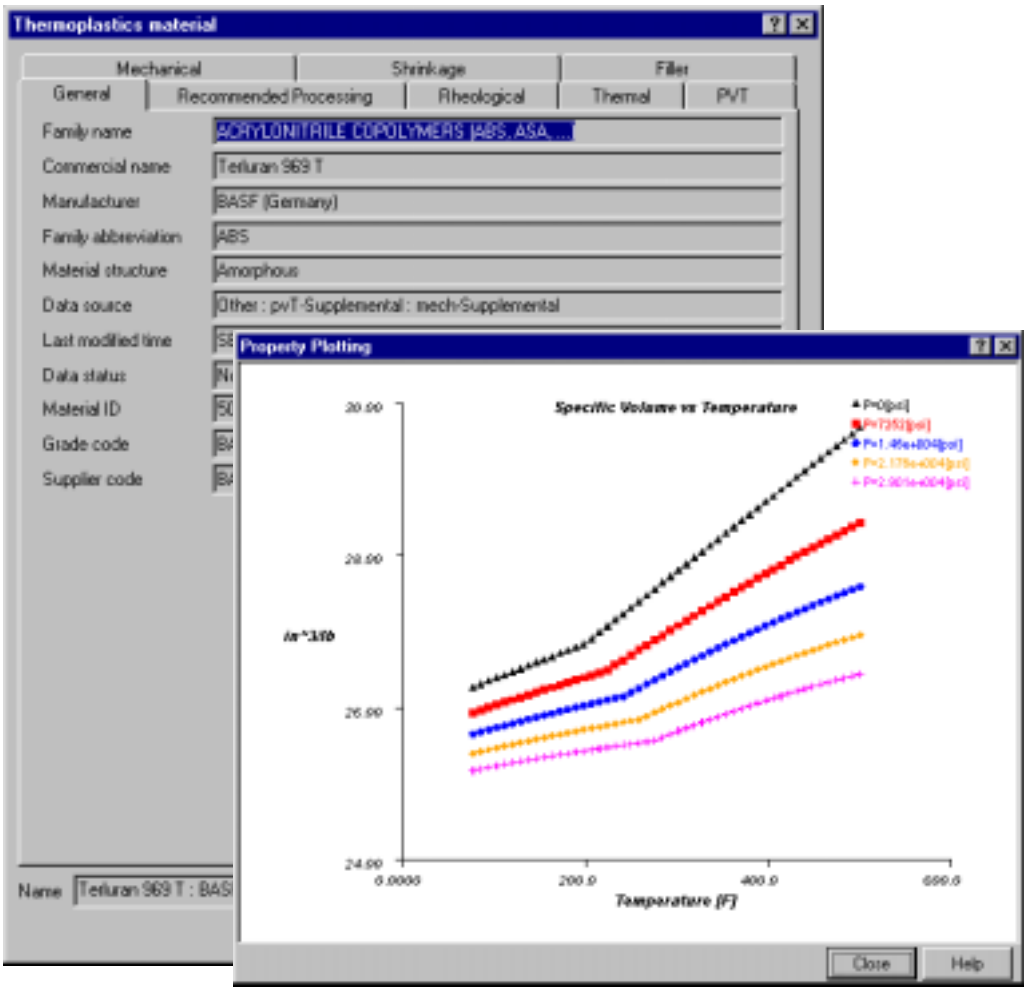
Using the report wizard, a user simply selects the analysis results from the available studies and adds them to the selected studies. The user can then select which results from each study to include in the report, which could be the same or different for each study selected. Finally, when a user creates a report, the option is given to save the report as a template that can be used to create additional reports with the same report layout.



MATERIAL DATABASE

It is well know that predictive analysis products such as MPI are used to simulate the complex behavior of injection molded polymer melts. As Moldflow is constantly striving to assure that analysis results are as accurate as possible, one of our highest priorities is to provide analysis solver algorithms and material data to achieve that goal. Regarding material data, Moldflow has developed some of the world's most innovative testing methods to ensure that the material characteristics used for analysis represent those of injection-molded polymer melts. For example, Moldflow uses instrumented injection molding machines to determine rheological data, which is basic to all flow analyses.

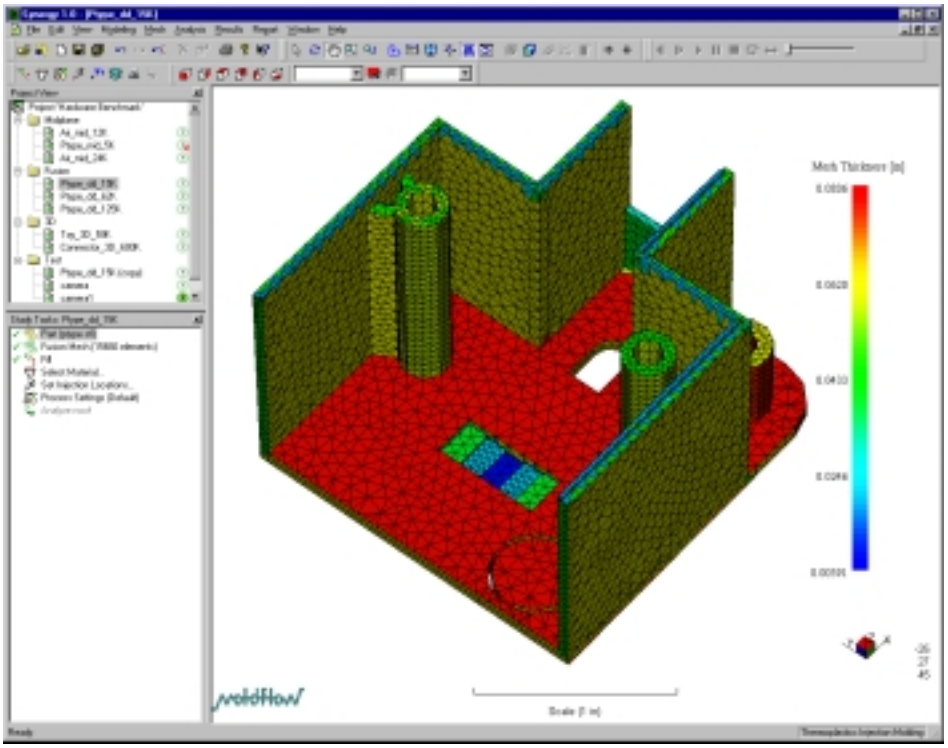
As part of that constant innovation, new in MPI 3.0 is an expanded material database, which includes over 7,500 unique materials and represents the most extensive material database available for plastic process simulation software. The database supports both Moldflow and C-MOLD material models, including the Moldflow second-order viscosity model, the Cross-WLF viscosity model, and the 2-domain, modified Tait pvT model — all of this to ensure that our customers have access to the highest quality material data for plastics simulation.



Along with a comprehensive suite of standardized test methods, Moldflow Plastics Labs are the only providers of many specialized and innovative measurement techniques that yield greater simulation accuracy. Among our unique capabilities are mold shrinkage measurements, injection molding data verification, slit-die thermoset rheology, and proprietary model fitting. The labs are an integral part of Moldflow's software development and testing processes. This ensures a ready exchange of knowledge and skills, which drives the continuous improvement of testing and simulation technology.

MPI/FUSION ENHANCEMENTS

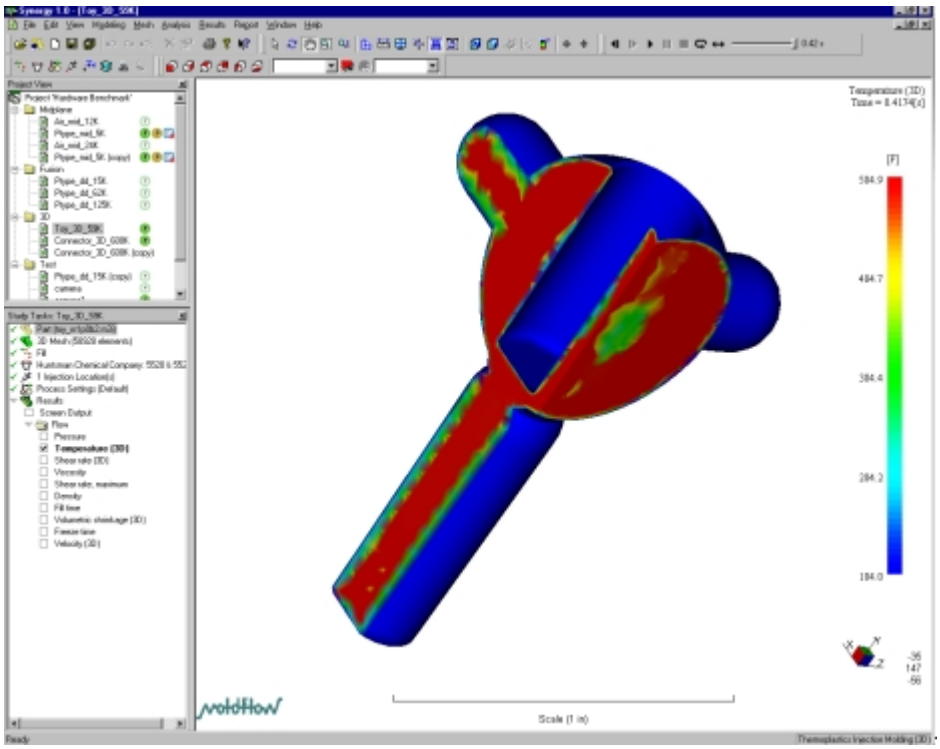
Since MPI/Fusion was first released, the two most often requested enhancements have been the ability to display and change the thickness of the Fusion mesh. MPI 3.0 fulfills these requests and more. Now users can both visualize and modify Fusion model thickness directly within MPI/Synergy and it can be accomplished on either a global or local basis. Mesh generation and editing capabilities are more complete, and more controls are provided to specify mesh density and to better visualize mesh quality. Mesh editing has been extended to better support local refinement and tools are provided to re-match meshes between top and bottom surfaces. Additionally, Fusion technology has been extended to support the MPI/Reactive Molding, MPI/Microchip Encapsulation, and MPI/Underfill Encapsulation analysis modules.



Having the ability to view and change the thickness of a Fusion model means users can assure that the model is as accurate as possible for analysis. It also allows users to more easily modify geometry, such as by adding flow leaders or flow restrictors to improve the part design for manufacturability.

MPI/3D ENHANCEMENTS

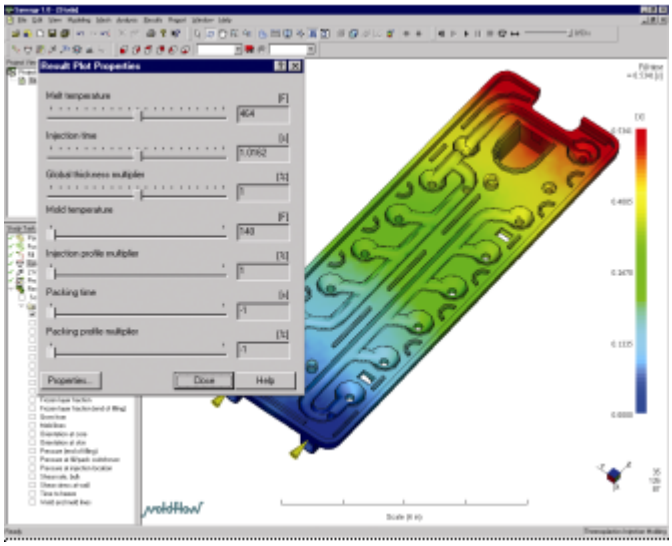
To improve access to 3D simulation technology in MPI/Synergy, Moldflow introduced a proprietary 3D tetrahedral (TET) mesh generator in MPI 3.0. The 3D TET mesh generator allows users to translate a readily available surface volume mesh, such as from an IGES file, into a solid, 3D TET Moldflow mesh with fully automatic mesh refinement through the part thickness for optimal performance. The 3D Flow solver has been enhanced to support compressible flow during the filling stage of the injection molding process, and now produces results for clamp force and shear-rate calculations for beams.



The use of the cutting planes can be very useful during post-processing of 3D analysis results. Since 3D is generally used for thick parts, users will tend to be interested in what is going on inside the thick, center sections of the part. There are default cutting planes as well as user definable cutting planes. The use of multiple cutting planes simultaneously also provides the added benefit of seeing what is going on at intersections and corners.

DESIGN OF EXPERIMENTS

Also new in MPI 3.0 is a Design of Experiments (DOE) solver and analysis manager. This function allows users to automatically setup and perform a sequence of analyses, varying specified parameters. Once complete, interpolated results displays are created automatically to provide quick and simple access to results data. Examples of input parameters include mold and melt temperatures, injection time, packing pressure, packing time, and part thickness. Output data include both single-point quality indicators such as volumetric shrinkage, injection pressure, clamp force, or flow front temperature, as well as interpolated displays of fill time, and pressure and temperature distributions.



In the injection molding process, there is some qualification criteria to measure if a product meets the requirements or if a specific process meets the processing cost and there are myriad parameters for injection molding machine operators to control. What manufacturers are interested in is which parameters affect the qualification most, and given a set of parameters, how they can determine the value or range of those parameters which satisfy or optimize the qualification measures. Sometimes, manufacturers will try many experiments by changing parameters and choose from them the set of parameter values that produce acceptable results.

The MPI DOE Manager provides a logical method to arrange the experiments and statistically analyze the results to optimize the processing parameters and the production of the end product. The DOE analysis requires multiple analyses to run, depending on the number of factors users want to investigate. For this reason, the DOE is closely integrated with the distribution queue within the MPI 3.0 Job Manager to distribute the analyses automatically to available machines listed on the server so users can efficiently manage their computer resources.

GENERAL ANALYSIS ENHANCEMENTS

In MPI 3.0, the analysis modules from MPI 2.0 and C-MOLD 2000 have been merged into a single environment, significantly increasing the overall set of solutions available to the combined customer base. For example, former C-MOLD users now have access to the optional MPI/Fusion (Cool, Fiber, Optim and Warp), MPI/3D (Flow and Cool), MPI/Stress, and MPI/Optim modules, as well as expanded capabilities in the MPI/Warp and MPI/Cool modules. Moldflow users have access to the optional Injection Compression and Co-injection analysis modules, as well as extended capabilities in the MPI/Microchip Encapsulation and MPI/Gas modules. And, all analysis modules are available directly through the MPI/Synergy graphical user interface.

An added enhancement for MPI/Gas users is the ability to simulate fiber-filled gas-assisted injection molded parts through to warpage predictions. This provides the means to understand the effect of the gas on the final part shape and allows users to investigate changes to the design of the gas channels and their effects on the part.

Finally, in all modules there are no pre-programmed limits to the number of nodes and elements that can be analyzed in any given model. As part models increase in complexity and physical size, especially multi-cavity models, the number of elements required to accurately represent them also increases. Having no limits on the number of nodes or elements that can be analyzed for a single model, benefits user who have to simulate these very large and sometimes complex models.

CONCLUSION

There are many companies today across a broad range of industries for which the design and manufacture of plastic injection molded parts is on the critical path to achieving successful and profitable product launches. These companies require a tool such as Moldflow Plastics Insight to become and remain competitive on a global scale. Moldflow Plastics Insight is a complete suite of advanced plastics injection molding process simulation tools to predict and eliminate potential manufacturing problems and optimize part design, mold design, and the injection molding process. Unlike other plastics CAE simulation software, MPI addresses the broadest range of manufacturing issues and design geometry types associated with plastics molding process. To summarize, MPI users have access to:

- Analysis modules able to simulate the most comprehensive range of manufacturing processes encountered in thermoplastics and thermoset injection molding.
- A breadth of geometry support that is unmatched in the plastics industry today, from traditional finite element midplane models, to MPI/Fusion solids-based models, to true 3D models.
- Moldflow Design Link, which provides a level of integration to MPI based directly on the CAD solid model.
- The world's most comprehensive material database for plastics flow simulation.
- Tools to validate the quality of analysis performed.

The features and enhancements presented in this document demonstrate how users of MPI 3.0 can work smarter and more efficiently to reduce or eliminate time delays, improve part quality, and deliver projects on-time and within budget constraints.

For the latest information on Moldflow Plastics Insight and all of Moldflow's products, visit our World Wide Web site at http://www.moldflow.com.