

INTEMOLDING: A CAD-CAE INTEGRATION SYSTEM FOR PLASTIC INJECTION MOLDING

1. Introduction

For plastic injection molding design, it is highly desirable for design and analysis to be integrated. This is to ensure that a design can be manufactured by the injection molding process. Despite the widespread use of CAD system for design and CAE system for analysis, it is known that the two processes are not well integrated. There is no generic, unified model that allows both design and analysis information to be specified and shared. Although most of the CAE systems provide built-in modeling tools for the users, these tools are only meant for developing analysis model with limited CAD functionality. Similarly, although some CAD systems allow certain CAE systems to run under their environments, they only provide an integrated environment, not an integrated system. Designers still require to create their design or CAD model, and to transfer the CAD model to analysis or CAE model. Analysis-related information has to be specified for the CAE model separately. CAD and CAE models inherently use different data models, hence they are in effect not integrated.

To tackle these problems, our research group develops the strategies and tools for a full integration of injection molding CAD/CAE process. A feature-based, Object-Oriented CAD-CAE integration model has been developed, and a software tool, namely, inteMolding Version 1.0, has been implemented. This project is part of the larger project titled “Optimization of Plastic Injection Molding - An Integrated approach”. The project is jointly funded by Ministry of Education, Singapore and Moldflow Pty Ltd, project number ARC5/98.

InteMolding Version 1.0 is a CAD-CAE integrated system for plastic injection molding design and analysis. It uses Solid Edge® as its underlying CAD platform and Moldflow® as its underlying CAE platform. The software integrates the primary functionalities of these two systems by providing an integrated data model called a *CAD-CAE integration model*, as well as an integrated environment for the injection molding designers. The designers develop the CAD-CAE integration model of their design by creating the CAD geometry and specify information for the CAE analysis. This integration model is then used to invoke CAE subroutines to conduct CAE analyses, to extract CAE analysis results and to modify integration model to improve or optimize the initial design. The process is carried out automatically and iteratively until the pre-specified part quality criteria are met. Figure 1 shows the system framework.

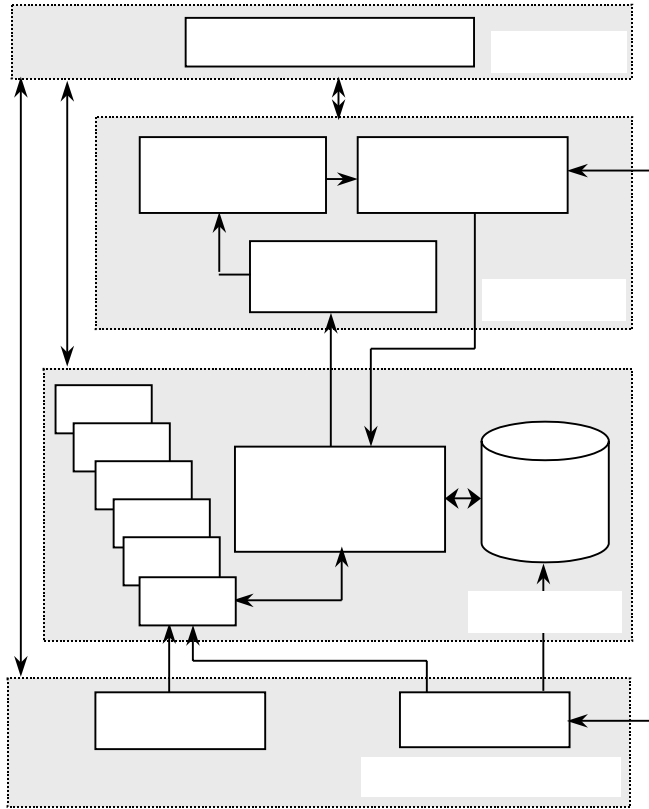


Figure 1. InteMolding Version 1.0 system framework

2. Functionalities of the Developed System

Figure 2 shows the graphic user interface (GUI) of InteMolding Version 1.0. The upper panel shows the system menus and tool bars and the lower panel shows the GUI of Solid Edge system. During the geometric modeling process, the designer uses the GUI of the CAD system. Otherwise the GUI tools provided by the InteMolding system are used.

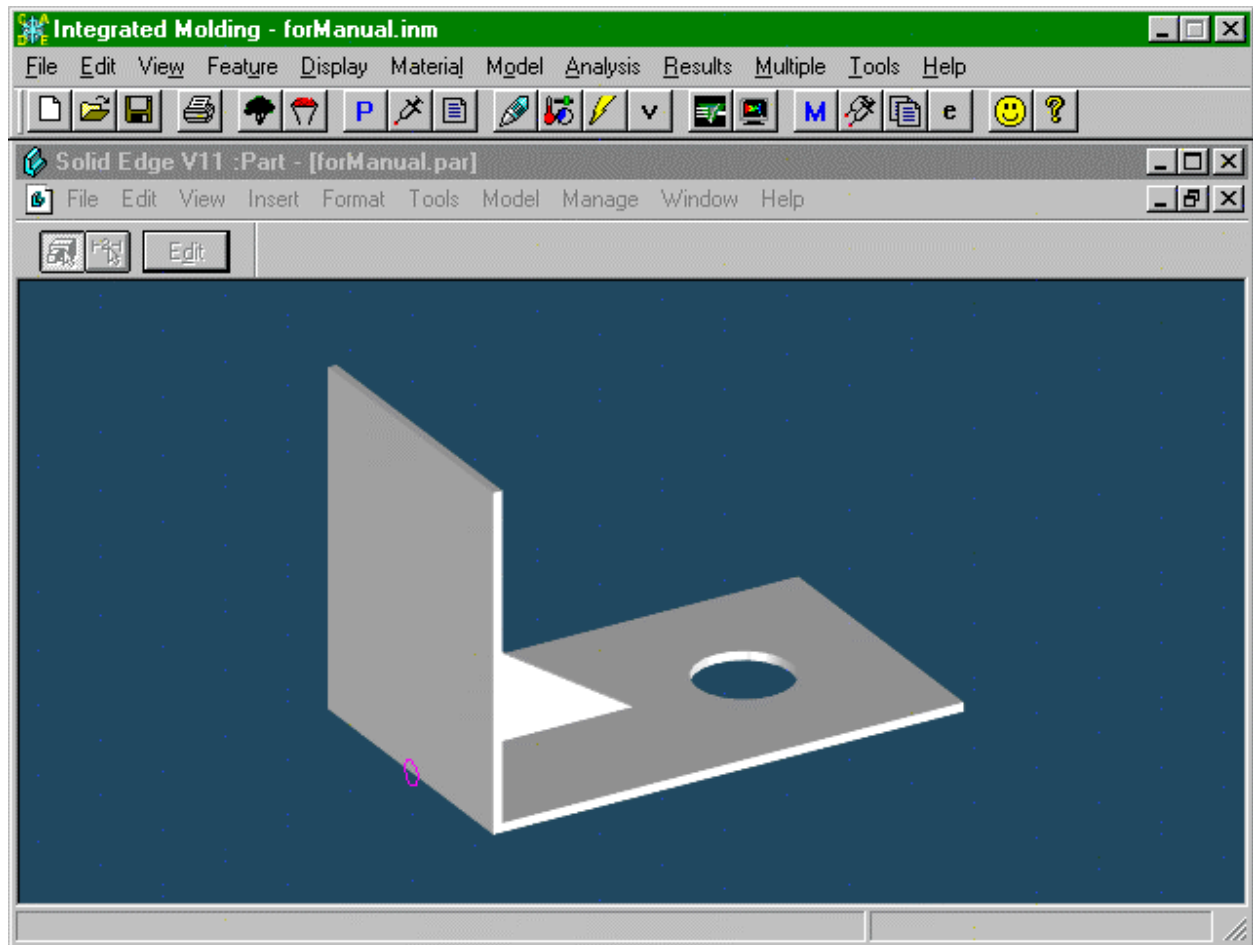


Figure 2. Graphic user interface of InteMolding Version 1.0

InteMolding Version 1.0 can be used for broad aspects of injection molding design and analysis involving integration of the two processes. Some of the most prominent functionalities are :

1. Integration for single CAE analysis. The designers use the system to create the part geometry; specify a material; specify one or more injection locations; specify processing conditions such as melt temperature, mold temperature and injection time; and then to conduct a single CAE analysis. The designers can also specify quality criteria, which can then be used to verify the feasibility of the design.
2. Integration for multiple CAE analyses. Apart from supporting a single analysis, the system can be used to conduct multiple analyses so that a number of designs can be compared to identify the optimal one. The designers can specify a number of material options; specify a number of gate location options; specify a number of options of processing conditions corresponding to each of the specified materials. Subsequently multiple analyses can be performed corresponding to the combinations of all these options. If the designers have specified quality criteria, the system can compare these options and identify the optimal design.
3. Bidirectional CAD-CAE integration. Not only does the system support integration from CAD to CAE, it also supports integration from CAE to CAD, which means the system can be used to modify the part geometry automatically and to conduct the new analyses.

The whole process is iterative until the specified quality measuring criteria have been met. For example, to design a feasible part thickness, the designers can specify which features to vary or rather the whole part to vary; specify variation ranges or number of variations; specify verification and evaluation criteria. The system can automatically vary the specified part thickness and conduct analyses until specified criteria are met. If the designers have chosen to examine all variations of thickness, then the system can be used to evaluate these variations to report the optimal thickness.

4. Optimization of molding conditions. Molding conditions refer to the processing conditions, which characterize the melt behavior at the cavity rather than inside the molding machine, such as melt temperature, mold temperature and injection time. The system supports two methods, namely, exhaustive search method and Genetic Algorithm (GA)/gradient hybrid method. For the exhaustive search method, the system uses a strategy of coarse/refined two steps to reduce the number of CAE analyses involved. For the second method, the system uses GA to derive an initial set of elite molding conditions. These molding conditions are then used to initiate a number of gradient searches so that the optimal molding conditions can be derived.

Figure 3 and Figure 4 show the specification user interfaces for single analysis and multiple analyses respectively. Figure 5 is the user interface for the designers to specify which part features are involved in part thickness design and optimization.

The screenshot shows a 'Part Specification' dialog box with the following fields and controls:

- Part name:** Bracket
- Number of elements for analysis:** 400
- Material:** PP - 1 (Amoco Polymers Inc. [AMOCO]: 10-1246 [AM800])
- Analysis type:**
 - Filling analysis only
 - Both filling and packing analysis
- Boundary Condition:**
 - Gate Location: 1 gate(s) assigned
 - Gate location marker radius: 2.5
- Processing Condition:**
 - Melt temperature: 235 (range: 215 - 255)
 - Mold temperature: 40 (range: 20 - 60)
 - Injection time: 2
- Variables:**
 - v1 = Maximum shear stress (MPa)
 - v2 = Uniform cooling time (SD)
- Verification and Evaluation Criteria:**
 - Min: v1 (0.5)
 - Min: v2 (0.5)
 - v2 < 1

Figure 3. User interface for part model specification

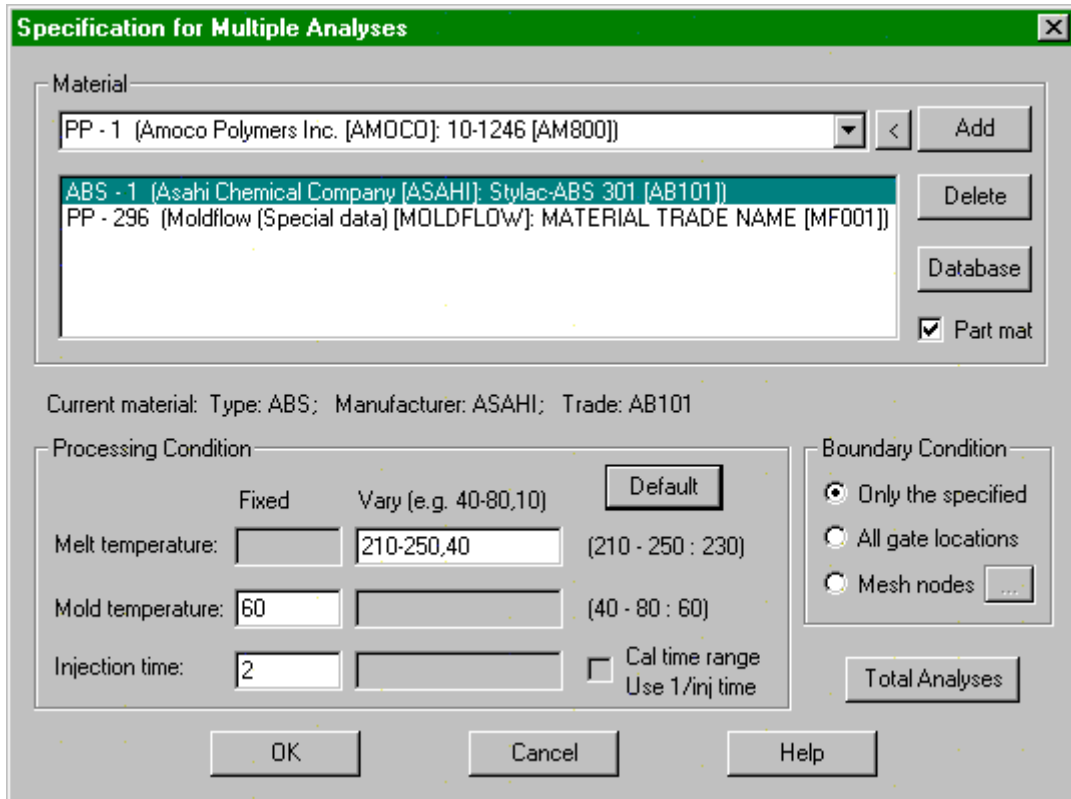


Figure 4. User interface for specification for multiple analyses

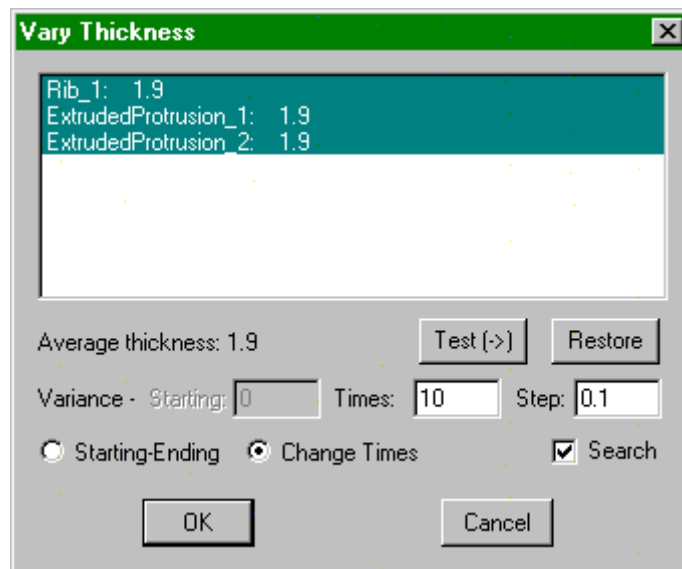


Figure 5. User interface for specification for part thickness variation