

Introduction of the CAE System

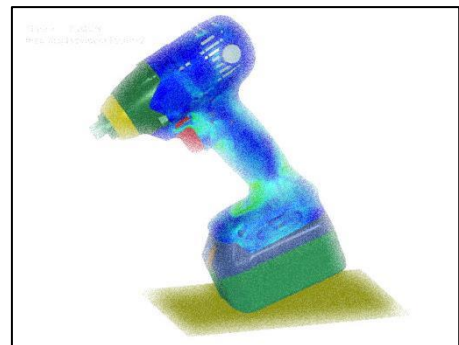
R&D Center

1. Introduction of the CAE System

The CAE(Computer-Aided Engineering) checks the performance, manufacturing process, and suitability of materials for the models which is made by the CAD(Computer-Aided Design) in details. It also can be a tool to optimize the design, a manufacturing process, and the material through its results. By using this tool, it can predict the problems that can occur through the manufacturing process (cost, molding troubles, etc.) and a product usage process (performance, design, etc.) As such, it can both provide optimum design and minimal cost by cutting the development period.

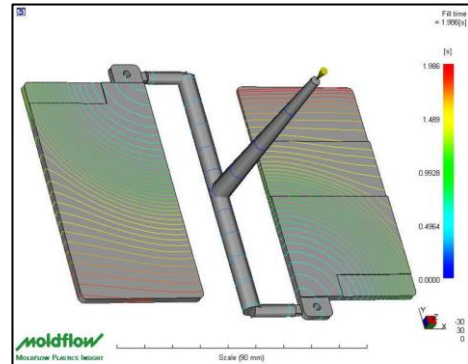
The CAE offered by Korea Engineering Plastics (KEP) can be classified as molding analysis and structural analysis, and can be applied according to the type of application. Optimal design for molding can be determined by molding analysis. Also, the number and spots of the gate, runner layout, and cooling lines can be optimized in mold design. For a real production process, it can help to optimize the process (Cycle time, injection spec, etc.) and increase yield. In particular, it is useful for solving and minimizing problems in the manufacturing process (deformation, gas vents, weld lines, etc.).

Structural analysis can also optimize the design for environmental and other conditions before making a mold. By using this function, a designer can create plastic products with performance comparable to existing steel products and evaluate the performance of the whole assembly including plastic components. In addition, it can root out the source of issues and even solve problems that can occur during the real product usage (cracks, whitening, noise, vibration, etc.).



Parts of the KEP CAE Analysis	
Parts of the Analysis	Application
Molding analysis	Flow, Packing, Cooling, Warpage analysis
	Runner balancing, Gate location
	Fiber orientation, Experiments design, Process optimization
	Core shift, Insert molding
Structural analysis	Linear, non-linear(large deformation, material, contact) analysis
	Vibration analysis (Normal mode, Transient response)
	Thermal analysis, multi-body dynamics
Molding-structure coupled analysis	Structure analysis considering the Fiber orientation, Weld line and residual stress
Crash/Impact analysis	Crash, impact, dropping, airbag analysis

KEP continuously has supported the CAE, beginning with the introduction of the Moldflow molding analysis S/W in 1992. Today, we have the analysis facilities and ability for checking the vibrational property, crash/impact analysis, etc. as well as molding and structural analysis. Through these, we have supported our customers to make reasonable decisions in regards to products and molds (gates, runners, cooling channels, and so on) design, material selection, and optimal process(molding condition). We measure the data of the common properties, special properties, and property changes by temperature which impact the result of the analysis. In addition, we build a material DB of injection molding and structural analysis and improve the accuracy of analysis results by using the material DB. We have cooperative relationships by sharing our DB with customers who want to analyze CAE by using our company's materials.



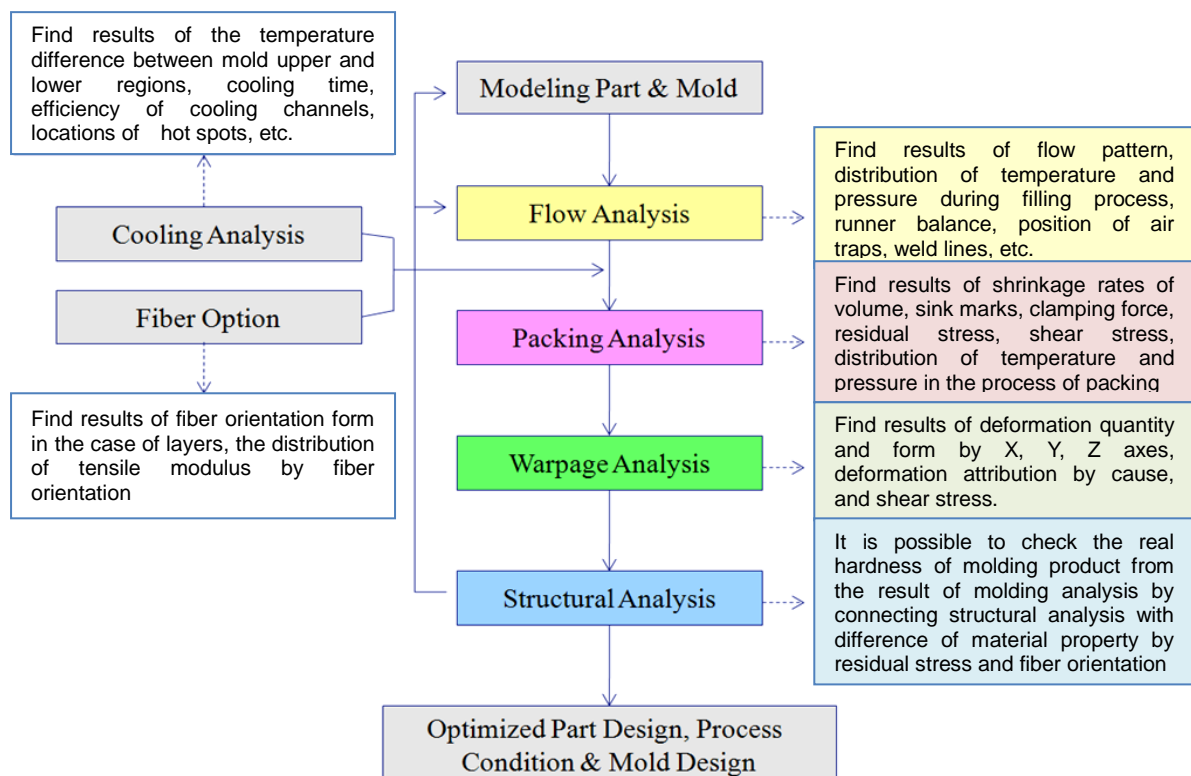
2. Injection Molding Analysis

Injection molding softwares which are widely used in domestic are Moldflow, Moldex3D, Timon, MAPS 3D, Simpoe-Mold. Among them, KEP have Moldflow & Moldex3D. Most softwares operate under the same analytical theory and have similar product composition. Therefore, this document will follow the standards of Moldflow, as it was a pioneer of the commercial software.

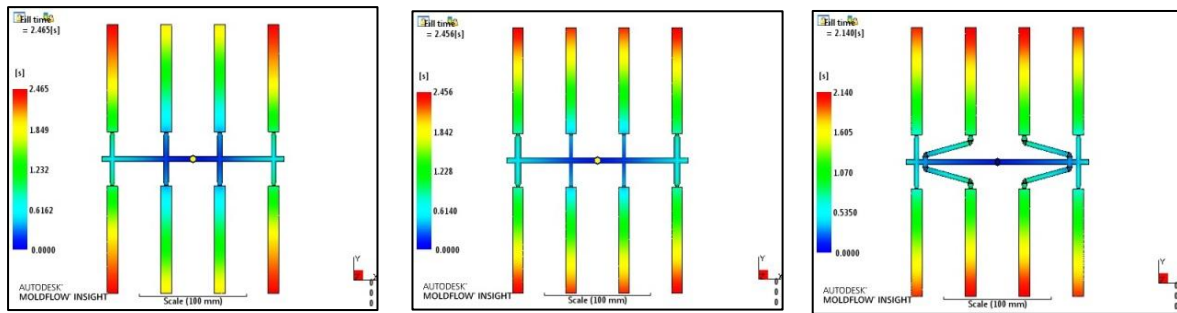
The S/W for molding analysis have basically 4 steps. Those are Filling, Packing, Cooling, and Warpage. In addition, it contains the core shift, insert, fiber orientation, structural analysis, and structural interface. There is also a different module commercialized for analyzing gas injection, co-injection, injection-compression, and Mucell injection excluding common injection molding.

The process of molding analysis and the result of the each step are outlined in the diagram below.

<The flow of molding analysis >



In a flow analysis, we first need to check whether there is a short-shot, air traps, weld lines, warpage, flash or not. Also, should check filling balance which is the cause of flash, warpage. In case of a Multi-cavity mold, need to check in regards to runner balance, and need to be designed to fill each cavity at the same time. It is possible by changing runner lay-out and runner size.

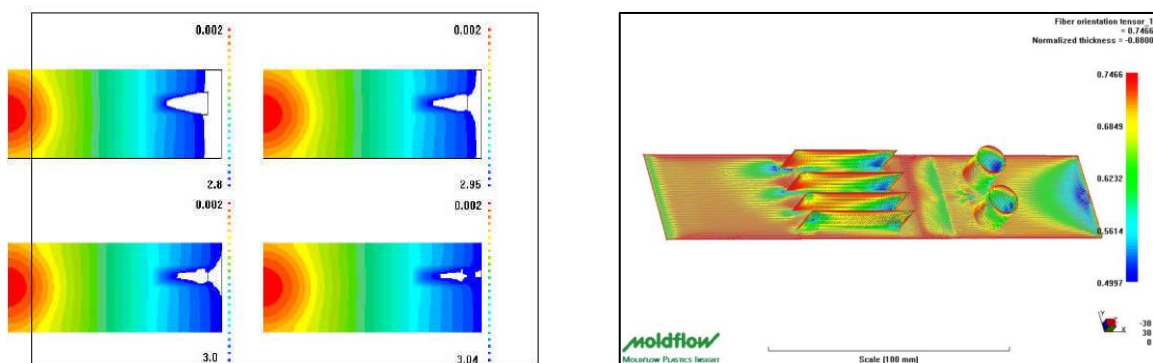


The next step is a packing analysis. We need to check whether there is flow hesitation or race track. If flow hesitation exists, weld lines as a result of resin concentration in the direction to the thicker part due to the thickness difference and exterior defects like a flow marks by solidifying resin and race tracks, and generation of short-shot occur. To avoid these, the molding conditions and design have to be changed like a gate additions or gate position, rib thickness or additions, and so on. In particular, product for exterior or products which have a significant load, the position of the weld line is important. To this end, the position of gate needs to be considered.

Gas traps are also generated because of exterior defects. As such, need to make the mold have the gas vents to the positions which have the gas traps.

The shear stress and shear velocity cannot exceed maximum shear stress and shear velocity of the material.

The main directions, and distribution of the fiber orientation are important. In the process of filling, fiber has a consistent direction to minimize flow resistance. The direction and degree of orientation create deformation by a difference of shrinkage rates. However, it improves product hardness in that orientation direction because of powerful fiber orientation.



3. Cooling analysis

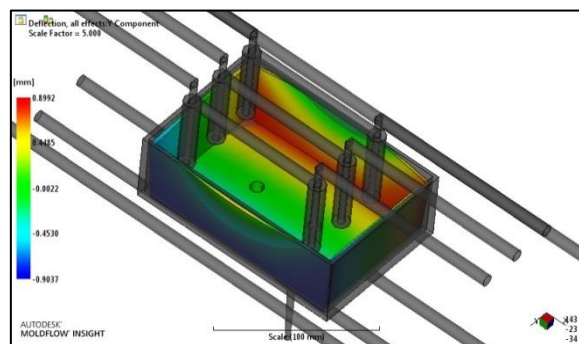
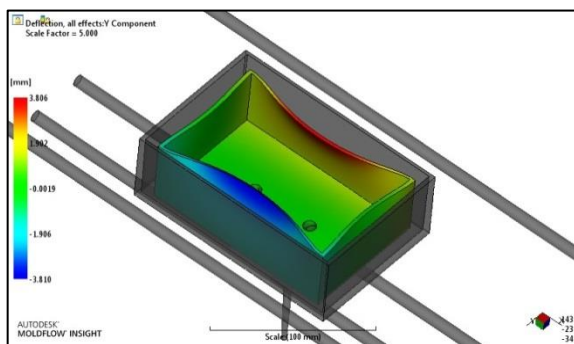
The following process is cooling analysis:

First, check whether hot spots occurred and their positions. Hot spots cause the delay of cycle time, gas pocket, and sink mark. To solve these problems, cooling is reinforced or the product thickness needs to be slimmer for fast cooling. Deep mold products can also have hot spots because it is hard to release the heat.

Second, check the temperature difference between the upper and lower mold. If it is a large difference, it will result in deformation. To this end, we need to make up for cooling lines in order to minimize the difference.

Third, check parts which make the delay of cycle time by seeing the result of the time to reach ejection temperature, frozen layer percentage, and solve the problems by making the mold slimmer.

Fourth, examine the cooling efficiency of each channel by the result of the circuit coolant temperature, Circuit Reynold`s Number, circuit flow rate, and circuit heat removal efficiency. And then revise channel size and layout, pump capacity, types of refrigerants, if there issues exist in regards to cooling efficiency.

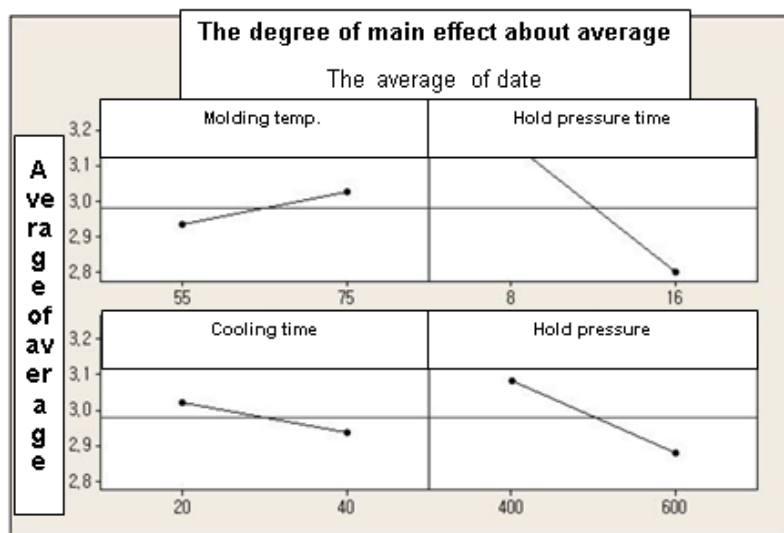


4. Warpage analysis

Warpage analysis calculates the amount of deformation in the X, Y, and Z axes using shrinkage by residual stress and PVT properties occurred in the filling and packing process. It can also check causes of deformation by calculating each factor's degree of attribution to the whole deformation. The major causes are differential orientation, differential shrinkage, differential cooling, corner effects, and so on.

Deformation by orientation can be resolved by shifting, adding, or sometimes eliminating gate positions and changing material. Deformation by shrinkage difference can be solved by changing rib thickness, rib addition, or other changes of the ribs. Deformation by cooling can be fixed by supplement of cooling lines or controlling the mold temperature.

You can take into consideration the effect of inserts excluding flow, hold pressure, cooling, and deformation analysis above. Also, you can analyze the flection of thin and long mold cores by differential injection pressure. Some structural analysis is possible to connect molding analysis with the differential material properties caused by residual stress and fiber orientation occurred in Filing process. Finally, it is possible to predict causes of trouble by carrying out an experiments design which includes molding conditions or design as a factor and suggest solutions.



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