Confluence of Rapid prototyping manufacturing and CAD Software's for Mold design

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ABSTRACT

This research focuses a new method of using CAD software combined with rapid prototyping (RP) for mold design. CAD software and RP reduces the time required to generate the internal and external features of a tool by automating frequent or repetitive tasks, importing pre-configured standard components, and avoiding errors by following user-specified rules of mold design.

Keyword: *Rapid Prototyping (RPT); Rapid tooling (RT); CAD software.*

1. Introduction:

Now a days variant mold-design CAD package features programs or modules to build and view a full representation of the mold, which includes generating core and cavity from the part model, Split-line splits, minimization of parting surfaces, mold-base selection, and addition of shutoffs, cooling lines, runner systems, gates, slides, lifters, ejectors, columns, spacers, guides, nozzles, screws, and pins. This type of software of mold-design software may also contain or link up with on-line libraries of standard mold components. After that these parts from software can then be imported directly into a 3 Dimensional solid or surface program. By using mold CAD software suppliers have not only improved many of these mold-planning functions, but also are bringing in a host of additional or enhanced capabilities, such as more graphical representation of visualization tools, preliminary mold designs for "quick quoting," rapid modeling of EDM electrodes for special part features, and the ability to create and manipulate holes, pockets, cavities, or side actions.

By giving examples of features which are being added to tooling CAD packages are mold "feasibility" tools that evaluate the overall quality and moldability of a tool; flow and cooling simulation technology as a means to check material flow problems, cycle times, or potential stresses and warpage; and new ways to handle tooling data, such as user-created templates that set rules or constraints. For example draft angles, limited steel thicknesses which can be moved from one model to another. Mold designers may work with part models created in other CAD software, which can create to problems in an importing data or generating correct dimensions or tolerances. Due to errors it produces the gaps between surfaces of the part or tool, which can be solved by data translators, healing programs or more "tolerant" mold-design modules.

One of the most typical or we can say critical areas of the mold model are the creation of the core and cavity and the parting-line split. By core and cavity parting line the complexity of the geometry coupled with the need to create the most simple and effective design for part removal and overall tooling cost. By using previous software, mold designers would divide the surfaces of the part model manually and place them on separate levels to create the core and cavity. The parting surfaces were created piece by piece from the edges of the model, and then a complete split surface was generated by filling in any gaps and trimming back. New generation software does more to help the modeler create better quality parting lines faster and with built-in "intelligence" that can suggest the geometry and position of the split

1.1 Consideration in Injection Mold Design

Molding conditions have a consequential influence on the final properties of the material regardless of the part design. Two of the process conditions that have a meaningful influence on the behavior of the polymer are the melt temperature and mold temperature .Initially it is necessary to compare between these process conditions and the true points that that are required to control over them. Melt temperature is the actual temperature of the polymer as it leaves the nozzle and enters the mold. The barrel true points represent the tools that are necessary to arrive at the desired melt temperature, but in actual they are not same.

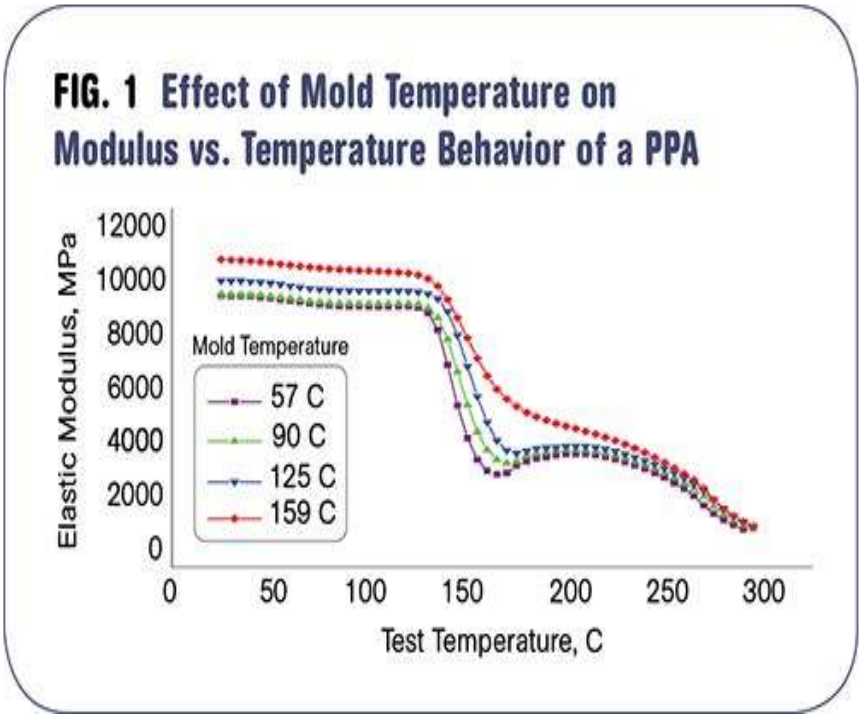

Fig-1 Effect of Mold Temperature on Modulus vs. Temperature

The mechanical stress, strain that work transfer to the material, the residence time, and the condition of the screw and barrel all are likely to have influence or effect in determining the actual melt temperature. In the same way the actual surface temperature of the mold cores and cavities are related to each other, but not necessarily the same as, the temperature of the fluid passing through the channels in the mold. Mold temperature has possibly a less easily seen but often more profound effect on final properties. In having no pattern or structure i.e (amorphous) polymers such as Acrylonitrile butadiene styrene and polycarbonate, higher mold temperatures produce lower levels of molded-in stress and consequently better impact resistance, stress-crack resistance, and fatigue performance. In case of semi-crystalline materials the mold temperature is considered at very important factor to find the degree of structural order in the solid. The degree of structural to control many performance parameters, including creep resistance, fatigue resistance, wear resistance and dimensional stability at elevated temperatures. Crystals are created at temperatures below the melting point but another temperature falls below the glass-transition temperature (Tg) of the polymer.

1.2 TIME TO CRYSTALLIZE

The materials having high ordered molecular structure materials will have temperature above the glass-transition temperature in order to give the polymer enough time to crystallize. Figure 1 compares the actual behavior of high-temperature nylon (PPA) when molded at the proper mold temperature and at lower mold temperatures. By graphically representation on plot the modulus of the material is a function of temperature. The stiffness of the material at room temperature increase when mold temperature increases.

The most particular difference between the samples molded at the proper temperature and at the lower mold temperatures can be found at the elevated test temperatures. When the material approaches the glass-transition region at 130 to 140 C, the modulus begins to decline in material molded at lower temperatures and falls quickly at even lower mold temperatures. This behavior is in the hands of the processor.

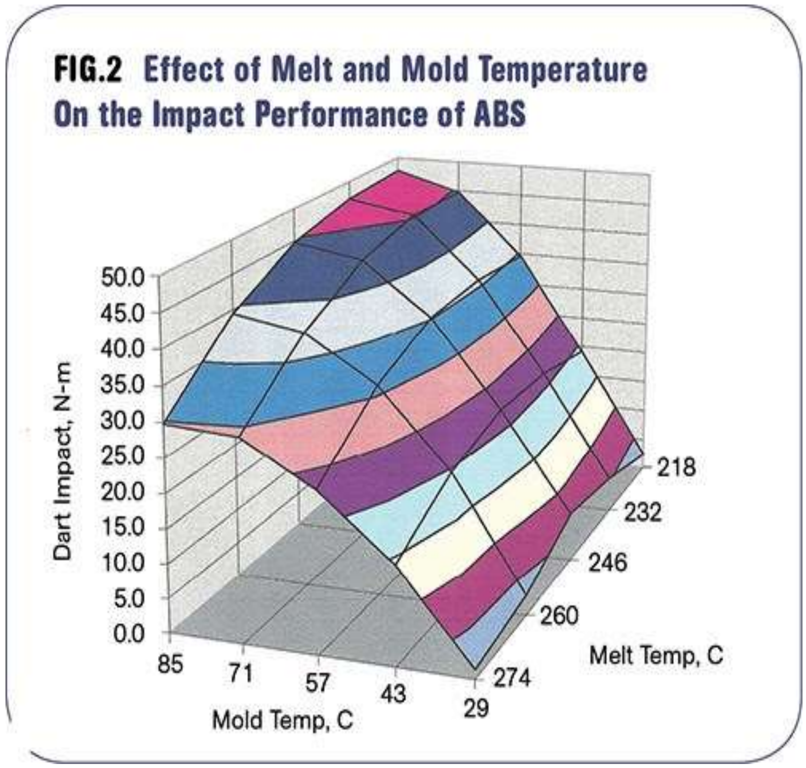

Fig.2 Effect of Melt and Mold Temperature of ABS

Figure 2 shows the interaction of mold and melts temperatures in determining the impact performance of ABS, an amorphous polymer typically selected for its toughness. The contour plot captures falling-dart impact resistance as the mold temperature is varied from 29 to 85 C (85 to 185 F) and the melt temperature is adjusted from 218 to 271 C (425 to 515 F). It may be surprising to some that the impact resistance ranges from less than 2 N-m (1.4 ft-lb) to almost 50 N-m (36.5 ft-lb) simply as the result of these process changes. The mold temperature is the dominant factor; however, the best results are obtained when higher mold temperatures are combined with lower melt temperatures. The ideal range of processing conditions, as well as those conditions that should be avoided, are very apparent in this plot. This behavior is characteristic of all polymers. In general, optimal performance is produced by combining a lower melt temperature with a higher mold temperature. Unfortunately, this is the opposite of what we usually find on the production floor. Typically melt temperatures are running higher than is ideal because melt temperature is often considered to be the only available tool for reducing the melt viscosity. Higher melt temperatures increase energy consumption, degrade the polymer, and extend the cooling time needed to create a dimensionally stable part. To compensate for this extended cycle time, processors will rely on reduced mold temperatures to gain back lost productivity. Yet a reduced melt temperature combined with a higher mold temperature often produces a part with the same or shorter cycle time and a better set of mechanical properties. When processors understand their role in establishing the properties of the polymer, they approach process development in a very different manner that ultimately reduces cost and improves quality.

2. INDEPENDENT VS. INTEGRATED

Mold making CAD software comes from a variety of sources. There are independent packages from companies Mold and Die Design Solutions. In truth, they do not run on their own, but as an add-on to other vendors' CAD packages.

Alternatively, a mold-design module may be part of a CAD package designed primarily for part design. Mold-design modules are also part of software packages whose main focus is on CAM for machining.

Tying the mold-design software to upstream part modeling or downstream CAM can help reduce errors in understanding the design or manufacturing intent, avoids data-translation issues, and can allow for more rapid adjustments to revisions.

The key point for integrating the different aspects of design is that a mold maker is usually not doing the part design, CAM software specifically for plastics molds. If both the part designer and mold designer are using the same software, it creates a more seamless data environment. When there is a change to the product, it also changes the mold plan. Not being integrated can mean lost time in data translation and reprogramming. So having an integrated solution and working within the same data structure is important.

2.1 PARAMETRIC OR HISTORY-FREE

Mold designers can create their tool models using 3D solid modeling or surface-modeling software, or they can use programs that provide both types of functionality within one program. Solid modeling typically involves part features that have a thickness, while surface tools make shell-type geometries. Exterior mold surfaces like the core, cavity, or parting line, and interior components such as a runner system can be designed with either system, though they may handle the tasks in different ways and be easier or more difficult to use.

Data developed in a solids or surface environment can be managed two ways. A parametric model keeps a history of the chronology of the mold design and also has intelligence allowing for relationships to be formed ("associativity") between different patterns or features. For example, if a designer selects a mold base of a certain size, it is associated with a certain number of drilled holes, created with certain spacing on the plate, and having a certain diameter and depth. The advantage of a parametric modeler is its automatic updating of groups of related objects when an item associated to it changes. It also allows the designer to save and reuse all of the settings again in another tool plan, saving time.

A disadvantage of parametric software is that the designer cannot make even a small change to a feature without impacting all related groups of objects. So expanding one hole in the mold base may cause all the holes in the base to change—even if that is not what was intended.

So-called "history-free" modelers (also called explicit, dynamic, or direct modelers) do not associate one pattern or feature with another, do not create a history tree, and do not link associated components, allowing individual features to be changed independently. Users can thus create unusual geometries for components or patterns without affecting other standard components. Users can update the mold design quickly when just a few features are adjusted.

The downside is that changes to a duplicated element or feature such as a hole, column, or pin—which would be repeated for each element automatically by a parametric modeler—must be done one at a time in a history-free environment. And the designer must remember to change any components relating to that component—such as remembering to change the hole size if a pin is resized. Parametric modelers reduce some risk of errors—and save time in such circumstances—by updating associated features automatically.

One fairly new development is that some CAD packages allow users to assign parametric and non-parametric functionality to different features in the same model. This is growing more common as some vendors of parametric modelers are now adding history-free direct modeling commands to their software.

2.2 INTEGRATED SYSTEMS ADVANCE

Software is coming out with new analysis tools for its Top Solid Mold parametric module that will allow users to complete complex parting-line splitting with less frustration. The new Parting Line Verification tool helps designers find the position and geometry of the parting line. It separates the mold block into two associative shells (surfaces) and then provides information about the quality of the parting line such as interferences with features on the surface. The new Invalid Parting Line analysis tool can determine misaligned parting surfaces or otherwise inaccurate parting faces and can help the designer heal such flaws.In addition, the new Predefined Mold Sub-Assemblies tool allows designers to create and organize assemblies in their tool by hardware, bolts and screws, ejector pins, standard components, and machined elements.

3. COMPLEMENTING CAD

There is also news from CAD vendors that have extended their part-design packages with mold-design functions. It has enhanced the cut-and-paste (“prune and graft”) feature in its software that allows mold designers to add or remove features such as pockets or side actions more easily than before. The software also has improved its mold-parting command for generating parting-line surfaces. It added a new validation program that can compare different versions of a mold design and highlight even the most subtle changes. Mold wizards can help designers create cooling lines. Users can create their own templates that can be applied to multiple models.

3.1 THE CAM CONNECTION

The program applies history-free surface-modeling intelligence to core and cavity generation, while the remainder of the mold design is completed in 3D solid geometry. All parametrically designed components and related dimensions and tolerances can be modified using a single “global” edit for multiple groups of components, or they can be modified individually. Since most mold components are made up from fairly simple prismatic geometry, solid modeling is the most appropriate method for the overall mold. But cores, cavities, and slides require surface-modeling tools.

CAM package, provides integrated mold-design modules that enable users to add, extend, or modify surfaces, automatically generate parting surfaces, and create internal mold components. There are also visualization tools to check draft angles and backdraft conditions. Mold makers also have the ability to design electrodes themselves within the system. The intelligence on the CAD side comes together with the CAM functions for more automatic feature recognition and tool-path generation.

Another fundamental concept is bringing a key element of Industry 4.0—data-driven decision making—to smaller shops. Data-driven decision making,is a quantum shift in how people run their business.

its process-monitoring and control system for injection molding that now includes integrated part-quality prediction. The integrated software calculates the optimal process parameters to ensure higher quality, especially in demanding applications.

3.2 Autonomous optimization

It is coupled to injection molding simulation to help molders make more informed decisions with less manual labor. The concept is to automatically create and calculate hundreds or thousands of simulations within a predetermined design space of millions of possibilities to learn about the relationship between final part quality and the material, mold, process, and molding machine.

With a larger sample size, there is a much clearer understanding of the relationship between the part/mold design and the process. This approach provides even more value to the molder because the software is completing a much larger portion of the work. It’s also completed well in advance of building a mold.

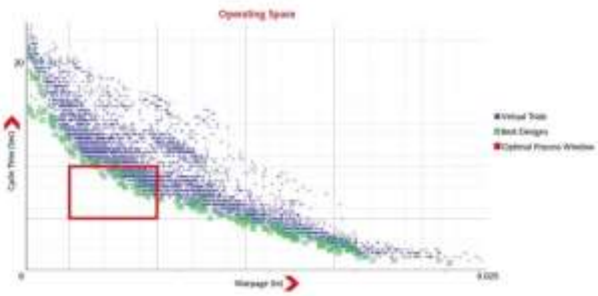

Fig.3.WarpageVs cycle time

3.3 RP interface and Cad Software:

Why Rapid Prototyping manufacturing:-

- **Rapid mold gating iteration**: Enables quick selection of optimized gate locations, especially for large parts, before committing to a comprehensive design validation analysis. Helps eliminate weld lines in early analysis stage.
- **Enhanced accuracy in simulating composites and special molding processes**: Expands current simulation capabilities for resin transfer molding (RTM), polyurethane (PUR) chemical foaming, fiber-reinforced plastic injection molding, hot-runner molding, and more.
- **Automated simulation workflow**: Allows you to customize and automate simulation workflows through integrating Moldex3D with your product design systems.
- **Faster simulation**: Reduces filling/packing simulation processing time by up to 30%. Supports automatic generation of non-matched solid meshes for the entire moldbase and its components, including the mold plates, inserts, etc.

3.3 OPTIMIZING CONFLICTING GOALS

- Common thermoplastic molding challenge is cycle time (specifically cooling time) vs. distortion. These goals are conflicting: Shorter cooling time makes for a hotter part at mold open and likely leads to greater shrinkage outside of the mold (where there is no mold to hold it in shape), which results in a distorted part. A longer cooling time allows the part to cool more inside the mold, where it's constrained (mostly), holding the part in place until it has higher strength. It shrinks less outside the mold and typically has less distortion. The objective is to find a way to reduce the part temperature at ejection and *also* reduce the cooling time in the mold.
- The new, automatic approach is quite different. The software operator sets up the initial design, which includes objectives, variables, and constraints. The software automatically produces each future variant (simulated design) by changing the process and/or geometry in milliseconds, generates the mesh, queues it up for calculation, runs the simulation, and plots the results of the objectives. The results of all variants are plotted in a single chart so the operator can easily determine which of the variants produce the results that most closely meet their objectives. Two very common problems molders encounter are determining the best gate location and the fastest possible cycle time. But there are other objectives too, all involving part quality. Parts must meet dimensional, aesthetic and mechanical requirements. With autonomous optimization, multiple objectives are used simultaneously to ensure molders don't end up with undesirable outcomes, such as finding the lowest pressure to fill a cavity but also finding that it creates weak weld lines,

or determining the route to the least amount of trapped air but finding that it requires the highest melt pressure

4. CONCLUSIONS

Rapid prototyping process indicates the possibility of its application in various fields. It can be concluded that RP printing technology is the most fascinating for mold design, especially in the development of plastic mold design.
RP technologies are definitely widely spread in different fields and show a great potential.
Applications of CAD software and rapid prototyping combine improves efficiency, saves time and man ,machine and material.

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