Kalypso Ultra Technologies relies on SIGMASOFT® to get the “big picture” in their business

Specialized in mold design and process optimization, Kalypso profits from the ability of SIGMASOFT® to consider all variables in injection molding, delivering first-shot success in new projects and bringing new parts into the market more quickly.

Kalypso Ultra Technologies, an engineering service provider of new product development, product design for manufacturing, mold development and process optimization in injection molding, has succeeding in a highly-competitive marketplace by applying comprehensive analyses to each molding system. As an expert in the use of conformal cooling via DMLS (Direct Metal Laser Sintering) and 3D printing, Shawn Schnee, Kalypso’s CEO, is committed to taking mold manufacturing and scientific process engineering to an entirely new level.

A seasoned plastics engineer with over 20 years molding experience, he had decided against using simulation after several failures. Schnee said, “I just stopped using simulation software and returned to trial-and-error practices.” After learning about the capabilities of SIGMASOFT®, however, he decided to give injection molding software a second chance.

The comprehensive approach of SIGMASOFT® provides users with a new way to simultaneously analyze the melt flow and the mold component interactions. The accurate reproduction of real-life processing allows Kalypso an unmatched insight while avoiding costly mistakes and minimizing failure risk. The individual selection of component materials for thermal management in new molds is guided by a complete analysis of the entire system, based on the physical design, material properties, and process interactions. Schnee was able not only to include water line strategies but also hot runner heaters, heater wattages and thermocouples. According to Schnee, “If we don’t consider all of these critical variables it will lead to costly mistakes and inaccurate assumptions.”

In one project, Kalypso was confronted with the challenge of developing a motor mount product, made from 30% glass-filled nylon 6,6. The part had several critical dimensions on the position of the five outside holes. Being a semi-crystalline, fiber reinforced polymer, it was paramount to detect warpage and shrinkage issues related to fiber orientation and post-molding crystallization, especially considering the thickness variations. Because the geometry was exceptionally complex, consisting both of very thick and very thin sections, prior experience with similar shapes was limited.

The initial design was the simplest; a single injection point on the side of the part and a single fountain cooling line at the center of the core. As seen in Figure 1a, some early filling areas create high pressure within the cavity before end of fill. A 15 minute simulation identified this. “Multiple mold iterations and expensive tooling modifications were completely avoided,” according to Schnee. A second gating concept was conceived, as shown in figure 1b. “The new design approach was a suitable alternative with acceptable pressure deltas within the cavity,” he explained.

Figure 1a: The single edge gated design produces an unbalanced cavity filling resulting in higher plastic pressure inside the cavity.

Figure 1b: The new design reduced the plastic pressure inside the cavity by half.
To maximize the efficiency of the production process, the maximum shear rate was investigated for both designs. Figures 2a – 2d display the resulting shear rate and corresponding temperature rise from both designs. The higher shear rate can degrade the fibers in the polymer, resulting in lower mechanical properties. “It is not going to be an issue at the proposed filling time; however, we aim to maximize process flexibility to the customer.” The new design reduces the shear rate by over 50%, allowing a wider range of injection profiles.

Once the gating system design was completed, the thermal dynamics of the mold in operation were considered. The Virtual Molding trial of 20 consecutive production cycles indicated a strong thermal gradient (hotspots) in the tool at the center of each cavity. This was to be expected but the high degree of temperature difference was not anticipated. “We already had cooling in these areas but it wasn’t enough for the desired cycle time.” The temperature distribution in the mold (Figure 3a) shows how the cores were overheating. “With each cycle, the temperature difference became more significant,” reported Schnee. These hot spots would have forced an unacceptable cycle time due to their undesirable effect on the thermally induced stresses responsible for warpage, negatively affecting profitability or part quality.

A new cooling approach was considered using conformal cooling in the cores. This was not the final implemented design but is used here to exemplify the approach and its benefit. As a result, the hot spots were eliminated and an exceptionally even mold temperature was achieved (Figure 3a-b). “SIGMASOFT® provided reliable data that helped our company optimize runner balancing, water placement and water strategy – using conformal cooling instead of traditional cooling methods,” stated Schnee. “We had successful first shots with minimal tool adjustment on the actual molding machine.” The process set-up sheets were formulated based on SIGMASOFT® output results and were provided to the molder.

Having now used SIGMASOFT® for three years, Schnee is fully convinced that Virtual Molding Technology is a truly different approach and has integrated it in the company’s design and production processes. “I do not believe there is any other software on the market able to match SIGMASOFT®,” he said. “SIGMASOFT® is a tool that no serious molder or mold designer should be without. It’s an exceptional tool with exceptional results that enables users to have a ‘big picture’ perspective of many competitive aspects of their business.”

**COMPANY PROFILE**

Kalypso Ultra Technologies, started in April 2011, was created as a full-service engineering provider, to develop plastic devices and molds for thermoplastic injection molding and specialized processes such as LSR, metal injection molding and micro-injection molding. Kalypso differentiates itself from other engineering service providers through the approach of delivering accurate process set-up sheets, photorealistic models, 3D printed components and full motion simulation.

Shawn Schnee, CEO, Kalypso Ultra Technologies
ASPEM Ferramentaria obtains first shot success in 48-cavity rubber mold

“We have reduced the time required in meetings and discussions to decide about mold layouts, cavity distribution and runner dimensioning. We have also increased productivity because the molds built based on information delivered by SIGMASOFT® hardly ever return for adjustments after initial trials.”  
Sandro Junior Paulino, Technical Director at ASPEM

ASPEM Ferramentaria, based in Nova Vinhedo, State of Sao Paulo, is one of the best known rubber mold manufacturers in Brazil. With more than 14 years’ experience, they have successfully completed thousands of projects for the automotive, medical, electric and consumer industries.

In 2012, ASPEM invested in SIGMASOFT® to improve the profitability of their operation. Currently the software is being used in over 90% of all new developments. Through a real industrial application, ASPEM demonstrates how SIGMASOFT® was used through the mold development stage, supporting decisions such as gating, runner design and mold tempering system. Following an iterative process of four days in the Virtual Molding environment, the mold delivered first shot success. The company was able to reduce the runner volume by 47% and the curing time by 9%.

Testing concepts with a systematic approach

ASPEM was confronted with designing a 48-cavity mold, with dimensions 700 mm x 550 mm, as seen in Figure 1. The objective in this case was to maximize profitability, while minimizing scrap and cycle time, without negatively affecting part quality.

At the start, following previous experiences, two ingates were conceived for the parts. However, to optimize the runner geometry and to simplify part ejection, it was proposed to use a single ingate per cavity. A simulation was used to validate this approach. Two criteria were evaluated: shear rate and scorch.

In Figures 2 and 3, the shear rate and the scorch are presented at 95% filling. The shear rate, even for one single ingate is...
With the volume reduction of 47%, the shear rate was still below the recommended level (the maximum value was 1500 s\(^{-1}\)) while the scorch levels remained almost unchanged. The available machine had a maximum injection pressure of 1800 bar while the redesigned channels required a pressure of only 1064 bar. Foreseeing future wear in the mold and possible contamination during the production life, the runner channels could change somewhat over time, leading to higher required pressures. Further volume reduction could produce more risk, and was not pursued. Both runner configurations are presented in Figure 6.

With this new runner volume, material consumption was reduced by 89 g per shot; with a total cycle of 360 s. The mold operates over three production shifts, and, with the rubber price at $6.40 per kg, the annual savings were calculated to be $33,108, for the decrease in material consumption alone (without considering the extra costs to discard this material).

**Strengthening the competitive edge**

The implementation of SIGMASOFT® has positively impacted the productivity and shortened the time for project execution. SIGMASOFT® is used throughout the complete mold design, supporting the decision making process in aspects such as injection pressure, cavity number and thermal efficiency. "Simulation is not only limited to the filling analysis in the cavity," Sandro Junior Paulino stated. "It is possible to analyze the complete process in advance, from warming up the mold all the way through the part vulcanization. In this way, the development team and the molder have more information to quote a new project, with reliable details about curing time and optimum cavity number."

Another positive aspect of using SIGMASOFT® has been the possibility to develop know-how internally. "We have increased the knowledge of our team, and we run experiments in the software for application in future projects", adds Paulino. Furthermore, virtual molding has strengthened the company’s competitiveness. "SIGMASOFT® allows us to increase the profitability of our customers’ molds", he states. "We have also gained credibility with our clients, as design decisions now are not only based on the experience of our team, but are also backed up by simulation results."
Improving the accuracy in the composed mesh

With the new SIGMASOFT® version 5.0, the traditional Cartesian mesh was replaced by the unstructured mesh. This mesh automatically merges dense regions of elements together to save calculation time. While a large number of mesh elements are saved (particularly in the mold), there are some regions where it is not desirable to reduce the mesh and have the maximum accuracy possible.

Particularly at the part-non part interface, where the most important thermal and fluid phenomena take place, it is advisable to prevent such coarsening. An option is available to prevent such coarsening at the boundaries via “Solver > Project Configuration> Mesh”, as seen in Figure 2. This box should be checked when reduction in accuracy are not permissible.

It is important to keep in mind that when preventing coarsening, the number of elements is increased, as is the calculation time.

Preprocessor: Getting the most of Boolean Operations

A Boolean operation in the preprocessor is used to join or subtract geometries to create new ones. This can be used, for example, to extract a solid runner system from an existing mold.

The order of geometries in the geometry tree is used to determine which intersecting areas “disappear” and which remain to be meshed in the final model.

The general rule is that geometries in the bottom of the tree cut geometries above it, following the principles of “Boolean operations”.

In Figure 1, geometry A and geometry B are shown. In the first case, B cuts A, because B is listed below A in the geometry tree and has therefore a higher hierarchy.

In general, Boolean operations only apply to intersecting areas. For example, they will take place if the part geometry intersects with the mold cavity. You can decide how to accomplish Boolean operations selecting one of the following options:

- **Manual Booleans** – The geometry is cut by every geometry that is below it in the geometry tree.
- **Skip Booleans** – The geometry is not cut by geometries below it in the geometry tree but can cut geometries that are above it.
- **Block Booleans** – No Boolean operations will be performed on the geometry.
- **Up to Limit** – It works the same as manual Booleans, except that geometries are only cut if they have 20,000 triangles or less (this value can be adjusted in the solver configuration.) 20,000 is the default. If they have above 20,000 triangles, the Boolean operation is not performed. If there are no intersecting areas in the model and care is taken to have the geometries aligned properly in the geometry tree, Boolean operations are not required. is relevant for the Boolean operations.

Did you know...

- When pressing the middle-mouse button over the geometry in a preprocessor the number of faces and triangles present in the selected geometry is shown. The more triangles and faces, the longer it will take to perform Boolean operations on the geometry or to generate a geometry view for the postprocessor.
- Each material ID assigned in the preprocessor can be defined with different properties later on in the enmeshment and definition. For example, if two tempering channels with different temperatures are used, it makes sense to assign them two different tempering IDs: Tempering ID 1 and Tempering ID 2.
- The volumes of the geometries can be calculated by clicking on tools > calculate volumes. The volume can be displayed under info > material. This functionality can be especially helpful to determine a reasonable filling time for a new part.
Bringing a fresh insight has always been paramount at SIGMA. Beyond having a robust and reliable simulation product, a major priority has been to build a team with a sound technical background. This year, two interns from the prestigious University Massachusetts Lowell joined the company and supported the regular activities involved with SIGMASOFT®. After three months, both appreciated the working culture and the technical value of SIGMASOFT®.

Cormac McCarthy, born in 1993, is majoring in Plastics Engineering at the University of Massachusetts Lowell. Between May and August 2013 he joined SIGMA for an internship. “I did not expect the magnitude of experience I received from SIGMA,” he said. “I really got to see first-hand how things worked between SIGMA and the customers.” Cormac valued the working environment, and that everyone in the company took time during every project to explain things thoroughly.

Looking back, Cormac recalls that the most interesting work he was assigned was working on a live project. “There were problems with the part twisting, and immediately after the call, we pulled up the project in SIGMASOFT®. As a team, we broke down the problem and realized there was a crystallization issue. We then discussed some possible changes that could be made.” After the discussion, different solution approaches were evaluated. The main issues were identified and different proposals were made, to solve these issues as cost effectively as possible.

Cormac would recommend working at SIGMA. “If you are interested in advanced molding technology I can’t imagine there is a better place to go to. The coworkers are great and the software from what I’ve seen is unparalleled.”

Harshal Bhogesra was born in 1990 and was a senior plastics engineering student at the University of Massachusetts Lowell. Since 2010 he has been gathering experience as an assistant process engineer and teaching assistant for plastics engineering. Between May and August 2013 Harshal joined SIGMA for an internship. What he enjoyed most was the work culture and the staff; in addition, he valued the level of responsibility he was assigned. From his point of view, “The software has a great potential to revolutionize the injection molding industry in the near future.”

After obtaining his Bachelor degree, Harshal joined SIGMA Inc. in April, 2014.

Seeds for the future

Two interns share their views about the working experience at SIGMA Inc.

SIGMASOFT® EVENTS

<table>
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<tr>
<th>Event Date</th>
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| May 18-22, 2014 | EXHIBITING AND PRESENTING AT PM 2014 WORLD CONGRESS  
Walt Disney World Dolphin Hotel  
1500 Epcot Resort Blvd.  
Lake Buena Vista, FL 32830 USA  
www.mpfi.org/Meetings/2104/early_gate.htm |
| June 11-12, 2014 | EXHIBITING AND PRESENTING AT AMERIMOLD (PANEL TOPICS)  
Suburban Collection Showplace  
6100 Grand River Avenue  
Novi, MI, 48374 USA |
| June 18-19, 2014 | EXHIBITING AND PRESENTING AT INNOVATION AND EMERGING PLASTICS TECHNOLOGIES CONFERENCE  
Penn State Erie, The Behrend College  
Erie, PA USA |
| September 10 – 12 2014 | SIGMASOFT NORTH AMERICAN USER GROUP MEETING  
Westin Chicago Northwest  
Itasca, IL 60143 USA  
www.sigmasoft.com |
| September 29 – October 3 | EXHIBITING AT FERIA INTERNACIONAL DE BOGOTA  
Pabellón Alemania, Corferias, Bogota, Colombia  
www.feriainternacional.com |
| October 10 – 18 2014 | EXHIBITING AT FAKUMA  
Messe Friedrichshafen  
Neue Messe 1, 88046 Friedrichshafen, Germany  
www.fakuma-messe.de |
| October 21 – 22 2014 | SIGMASOFT INTERNATIONAL USER MEETING  
Kongresshotel Potsdam am Templer See  
Am Luftschiffhafen 1 – 14471  
Potsdam, Germany  
www.sigmasoft.de |
Reducing cycle time by selecting the right mold material

With the aid of SIGMASOFT® Virtual Molding, an automotive supplier was able to select a new mold alloy for a challenging application, reducing the molding cycle by 20% without changing the part design.

The pressure to reduce cycle time is common for every molder. In this struggle, there are several actions that can be considered: changing the mold tempering concept, reducing wall thickness in the molded part, changing the processing parameters or modifying the resin formulation. There is also another possibility that is not always considered: changing the mold material for an alloy with a higher thermal conductivity. This article’s example illustrates the advantages of this approach. Here the mold material was only locally modified, while a substantial reduction in cycle time was achieved.

Notably, higher thermal conductivity sometimes results in lower hardness values and care should be taken to select the appropriate material.

In Germany, an automotive supplier was molding a technical product that required a cycle time longer than expected. SIGMASOFT® Virtual Molding was used to analyze the current production and find a solution. The desired mold temperature was 80°C, and the tempering channels were running in a range from 60 to 80°C.

After simulating 20 consecutive molding cycles the hotspots in the mold, responsible for the extended cycle time, were evident. Due to the complicated part geometry, it was not advisable to machine new tempering channels (which could compromise the mechanical integrity of the mold). A part redesign was also out of the question.

SIGMA suggested changing the mold material. Two alternatives were considered: a copper-beryllium based alloy and a hot-work tool steel. “In both cases the objective was to reduce the cycle time, ensuring the required part quality and a long tooling life,” stated Manuel Schmellenkamp, SIGMA Engineer responsible for the project.

A first evaluation using a copper beryllium-based alloy was chosen for its very high heat conductivity (close to 100 W/m²K). The ability of the mold to transport the heat energy from the melt to the cooling channels is greater, leading to a smooth temperature distribution in the mold.

The temperature in the hot spots dropped from 147°C to about 92°C, and the mean mold temperature reduced from 95°C to around 85°C. “It was a substantial improvement in the mold temperature,” Schmellenkamp explained. “However, the molder was concerned with the lower hardness of the alloy, which may lead to wear and reduce mold life.” The typical hardness for this type of material is 33 HRC.

A second analysis considered the possibility of using special hot-work tool steel. This material has a higher thermal conductivity than regular tool steel (60 W/m²K), and though the ability to remove energy from the melt is not as high as with the copper-beryllium alloy, it delivers a higher wear resistance, due to its improved hardness (around 44 HRC).

The SIGMASOFT® Virtual Molding analysis proved that the hot spot temperature could be reduced from around 147°C to 120°C and in some regions from 119°C to 102°C, as shown on the right side of Figure 1. “This material selection delivered the best compromise between both alternatives: high wearing resistance and high thermal conductivity,” concluded Schmellenkamp. “The molding cycle was reduced by 20% without changing the mold design.”

According to Schmellenkamp, this increase in productivity is easily achievable in existing molds. “It is not uncommon to accomplish this reduction in cycle time for several existing molds within a single company, resulting in up to 15% more parts produced in the same period of time.”

Figure 1 - SIGMASOFT® Virtual Molding Technology reproduces exactly the same temperature conditions in the mold during production. Left: With conventional tool steel (thermal conductivity of 45 W/m²K) hot spots delay part solidification. Right: Hot-work tool steel (thermal conductivity of 60 W/m²K) eliminates hot spots and reduces cycle time by 20%.
Coupling fiber orientation and rheology improves simulation accuracy in highly-filled plastic applications

A new model that considers the influence of fiber orientation on the viscosity has been integrated into SIGMASOFT®, improving the prediction of shrinkage, warpage and mechanical performance of highly filled plastic parts.

Following the trend to reduce the polymer while increasing product strength of molded parts, the demand for highly-filled polymers, such as thermoplastics or thermosets with 50% or 60% of fiber content, has increased in the last few years. However, the rheology of these polymers cannot be described with classical viscosity models, such as Cross-WLF or Carreau-WLF.

The modified rheology of highly-filled polymers influences the filling behavior of the melt, as well as the resulting fiber orientation and thus the predicted warpage and mechanical behavior. If the injection molding simulation ignores these factors, the accuracy of the produced results is questionable and only of limited application and value.

In the German research project Mises FOK, Robert Bosch GmbH, Faurecia and EADS Deutschland GmbH Composite Technologies, partnered with MAGMA Gießereitechnologie GmbH (developer of SIGMASOFT®) and Volume Graphics GmbH, as well as with the Fraunhofer Institute, to develop a better model to simulate the fiber orientation in automotive applications using highly fiber-filled polymers.

As a result of this project, new models were integrated into SIGMASOFT® to reproduce the non-stationary interdependence between the fiber orientation and the viscosity. In this way, the accuracy of the calculated flow behavior is greatly improved for highly-filled polymers. A further advantage of this expansion lies within the improved accuracy of the prediction of the final fiber orientation, particularly in the middle-layer of the polymer, where fibers are predominantly oriented randomly compared to the flow direction, because the actual interaction between viscosity and orientation is considered.

In Figure 1, the random fiber orientation in the center of the wall thickness predicted by the simulation is compared with and without consideration of the interaction between fiber orientation and viscosity. The differences in the prediction of the middle-layer are clearly visible.

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