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**Technical article**

**Injection molding**

**How to find the optimum cycle time?**

**SIGMASOFT® Virtual Molding helps finding the most profitable process window**

*In injection molding, cycle time is decisive for the cost of the molded part. However, due to production pressure, sometimes processors settle for less-than-optimum cycle times, which compromise the profitability. This article illustrates how SIGMASOFT® Virtual Molding helps molders to find the optimum process window.*

Cycle time is one of the most important variables to determine the cost of an injection molded part. However, as the complexity of the molded components increases, so does the molding difficulty. And sometimes, due to the pressure to enter the market, once the required quality is achieved in the parts no further modifications are done to the injection molding parameters, even if the optimum cycle time has not yet been found.

A complex part, a winged wheel, was to be produced in PA66 GF35. Due to the intricate design of the component, several slides and inserts had to be used as well as a sophisticated ejection system. The part was thin; however, the cycle time required for production in acceptable quality was 41.5 s, as seen in Figure 1.

The production team reached out to SIGMA Engineering GmbH to reduce cycle time. The objective was to identify the optimization potential of each phase of the production cycle, while ensuring part quality, with the software SIGMASOFT® Virtual Molding.

The complete mold was introduced in the simulation as an assembly, with all its components. The cavities, cores, ejectors, plates and tempering channels were considered in the analysis, each one with its own physical properties. The actual production process was reproduced with all its steps, exactly as seen in Figure 1, for 20 production cycles. The parts were “virtually molded” on the computer, and the results in the part were analyzed.

The starting point was that at the ejection time, the temperatures in the part were well below the ejection temperature recommended for this material (200°C). This was clear evidence that the cycle time could be shortened.

To propose a shorter cycle time it was important to control the part deformation and thermal load on the movable cores. A detailed analysis of the cooling behavior of the part showed that the critical areas achieved the recommended ejection temperature 16 s before the current ejection time. Furthermore, it was found that the handling times between cycles could be reduced, as seen in Figure 2. In total, the cycle time was reduced with the help of the simulation from 41.5 s down to 20.5 s.

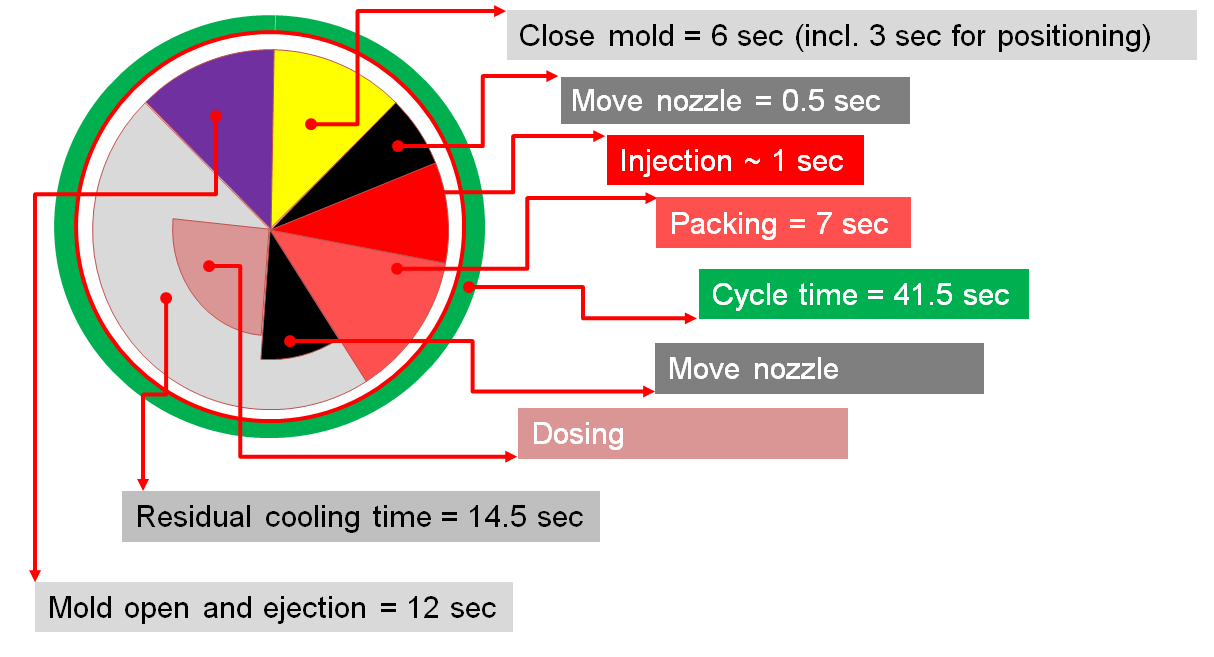
The new proposed cycle time was tested virtually as well. Instead of running it on the machine, it was necessary to first try it on the computer, to avoid possible damage of the mold cores due to thermal deformation or high shrinkage. A virtual temperature sensor was installed in the mold to analyze the temperature behavior during start-up of the new process window. The results are shown in Figure 3.

When shortening the handling times and reducing the ejection time, the mean mold temperature is increased. The first observation was that the maximum temperature achieved during molding was increased by 5°C. Also, 15 instead of ten cycles were required during start-up to achieve a thermal steady state. The temperatures in the part surface were increased by 20°C to 40°C, and the part was ejected at a higher temperature, as seen in Figure 4.

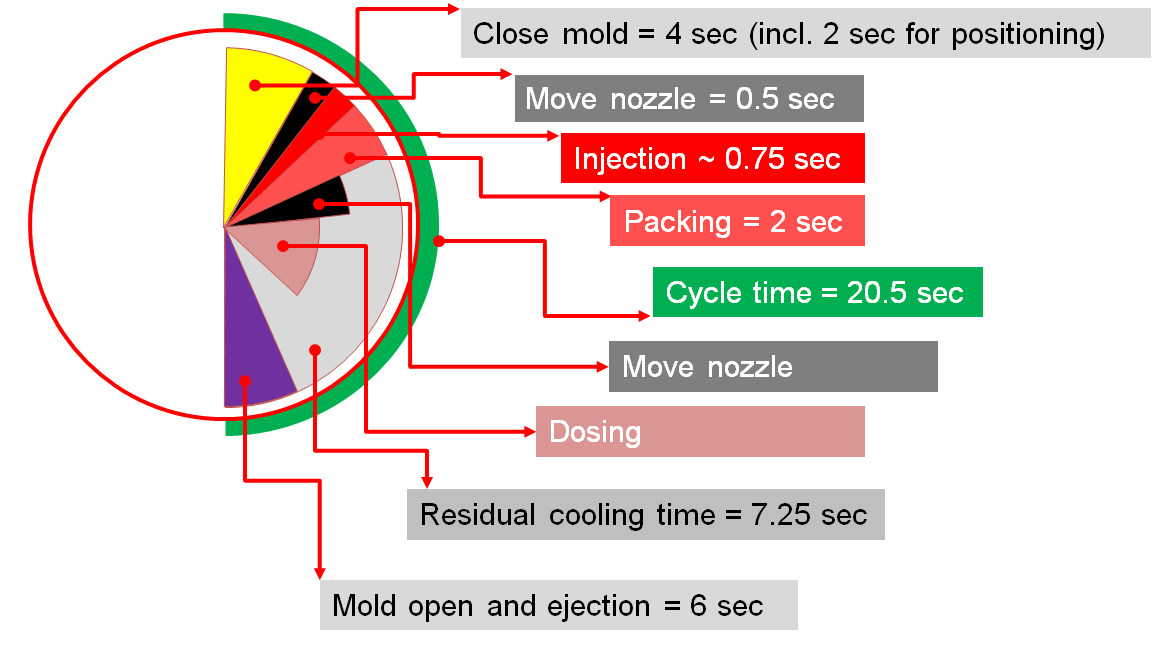
Due to the higher thermal stresses the deformation was increased up to 10%, but it was still within the specified tolerances. The residual stresses in the contact regions between part and cores increased by almost 15%, but its magnitude was low enough to ensure a safe ejection.

SIGMASOFT® Virtual Molding allowed finding an optimized process, and made it possible to verify that the part quality and mold performance were within specifications before going to the machine. This approach saved both development time and production costs in comparison with the traditional trial and error method on the injection molding machine. The molder gained a higher credibility towards its customer and a deeper understanding of the phenomena occurring within the mold. Thus, the production team’s confidence in producing the part and their know-how for processes were strengthened.

CAPTIONS



*Figure 1 – Current molding cycle of 41.5 s*



*Figure 2 – Optimized molding cycle, shortened down to 20.5 s*



*Figure 3 – A virtual temperature sensor showed that the shorter cycle time increased the maximum temperature and the number of cycles during start-up.*

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*Figure 4 – The ejection temperature in the part is increased due to the shorter cycle time. However, it is still below the recommended ejection temperature of 200°C.*

SIGMA® (www.sigmasoft.de) is 100% owned by MAGMA® (www.magmasoft.de), the world market leader in casting process simulation technology based in Aachen, Germany. Our SIGMASOFT® Virtual Molding technology optimizes the manufacturing process for injection molded plastic components. SIGMASOFT® Virtual Molding combines the 3D geometry of the parts and runners with the complete mold assembly and temperature control system and incorporates the actual production process to develop a turnkey injection mold with an optimized process.

At SIGMA® and MAGMA®, our goal is to help our customers achieve required part quality during the first trial. The two product lines – injection molded polymers and metal castings – share the same 3D simulation technologies focused on the simultaneous optimization of design and process. SIGMASOFT® Virtual Molding thus includes a variety of process-specific models and 3D simulation methods developed, validated and constantly improved for over 25 years. A process-driven simulation tool, SIGMASOFT® Virtual Molding provides a tremendous benefit to production facilities. Imagine your business when every mold you build produces required quality the first time, every time. That is our goal. This technology cannot be compared to any other simulation approach employed in plastics injection molding.

New product success requires a different communication between designs, materials, and processes that design simulation is not meant for. SIGMASOFT® Virtual Molding provides this communication. SIGMA® support engineers, with 450 years of combined technical education and practical experience, can support your engineering goals with applications specific solutions. SIGMA® offers direct sales, engineering, training, implementation, and support, by plastics engineers worldwide.

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