iQ hold control Determines the Optimum Holding Pressure Time

Holding out for Higher Quality

The iQ product family from Engel will gain a new member at K 2022. *iQ hold control* automatically determines the optimum holding pressure time for the particular mold with no input from the operator. This saves the processor a lot of time for mold trials while also increasing both productivity and energy efficiency.

The optimum holding pressure time is often lower than that established at the beginning. In these cases, the cycle time is shortened.

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Ten years ago, Engel launched *iQ weight control* and laid the foundation for a whole range of intelligent assistance systems [1–3]. The abbreviation "iQ" stands for intelligent quality, meaning the integration of expert knowledge into the injection molding machine control.

The aim is to improve the quality of the production process and thus also of the manufactured products. The iQ product family has grown steadily in recent years (**see Box**). All iQ software products support the practitioner through at least one of the following factors (**Fig. 1**):

- Transparency – making the process status intelligible by means of meaningful parameters and a clear presentation.
- Assistance – the automated determination and setting of process parameters.
- Efficiency – increasing the productivity and reproducibility and reduction of rejects through the continuous automated adaptation of process parameters while the process is running.

The new i*Q hold control* falls into the group of set value assistants. The software serves for automatic objective determination of the optimum holding pressure time. The innovation brings us a little closer to fully automated optimization of the entire injection process.

Saving Time and Raw Material

The holding pressure time is a key process parameter for the part quality. It takes effect at the end of the injection step, in a phase of the injection molding process at which the cavity is completely volumetrically filled. Due to the cooling of the melt and the resulting volume shrinkage, surface defects such as sink marks and voids, but also invisible negative effects on quality, such as internal stresses, may arise in this phase. These quality reductions can be prevented by applying holding pressure to the melt for a specific time.

However, the holding pressure prolongs the cycle time and thereby has

an unfavorable effect on the cost-efficiency and energy consumption. The question is thus the minimum time for which the pressure must be applied to ensure high part quality. From the point of view of processing, the holding pressure can be ended when the sealing point is reached. The sealing point is the time at which the material solidifies at the gating point of the cold runner or in the region of the nozzle when a hot runner is used.

The conventional method for identifying this point is described as the sealing point determination in the literature. With this technique, the holding pressure time is increased in successive cycles until the weight of the parts no longer changes (**Fig. 2**). However, the disadvantages are the high time consumption and susceptibility to defects. The machine operator must manually adjust the holding pressure time in the injection molding machine control system, remove the produced parts and weigh them in the quality lab. A faster method for determining the sealing point is to observe the curve of the screw position or screw velocity in the holding pressure phase. The (approximate) halting of the screw corresponds to the sought sealing point. However, since the curves approach this point asymptotically and the leakage via the locking ring may fluctuate from shot to shot, the method requires experience and is less precise.

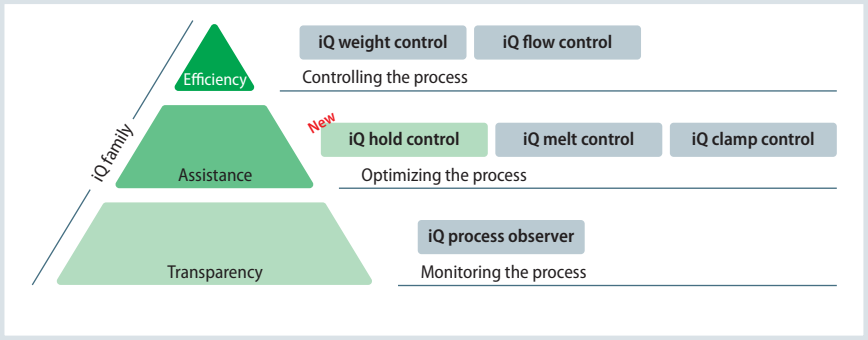

Fig. 1. The iQ products can be subdivided into the stages transparency, assistance and efficiency depending on the type of support. The new iQ hold control set value assistant serves to optimize the holding pressure time. Source: Engel; graphic: © Hanser

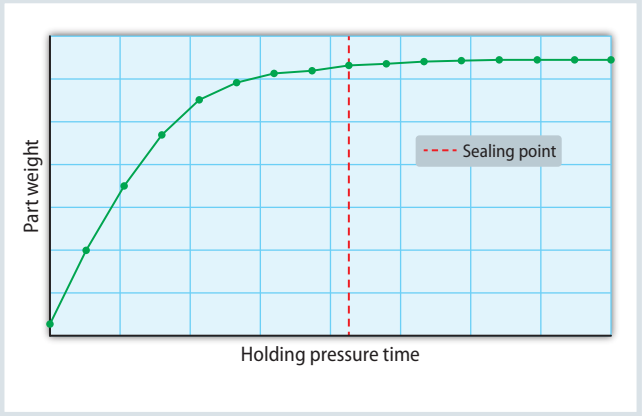

Fig. 2. Sealing point determination by weighing the molded parts while varying the holding pressure time: the sealing point corresponds to the time from which no weight gain can be ascertained as the holding pressure time is increased. Source: Engel; graphic: © Hanser

Optimum Holding Pressure Time with One Click

With *iQ hold control*, fully automatic determination of the holding pressure time is performed with just one click. The software operates in two steps. In the first step, the screw position is analyzed to determine a rough start value. In the second step, this start value is used as the basis for cyclically varying the holding pressure time, cooling time and plasticizing delay, and the optimum holding pressure time is determined by analyzing the mold breathing signal.

Since, for the sake of simplicity, often only the holding pressure time is varied in practice, the cycle time and residence time of the melt in the melt cylinder are undesirably prolonged. With *iQ hold control*, on the other hand, the holding pressure time, cooling time and plasticizing delay are altered cycle by cycle so that the cycle time can be kept constant during the optimization phase and, on the other hand, the plasticizing can be started at the identical point in the cycle in each case (**Fig. 3**). In this manner, it is possible to create a constant process by evaluating the holding pressure time as independently as possible from other influences.

In summary, automatic holding pressure time determination with the aid of the assistance system offers a combination of both of the methods that have been used until now. The difference is that the mold breathing signal is used instead of weight information. Although this does not provide any information about the absolute value of the part weight, the comparison of the mold breathing signal of two cycles indicates whether the weight has changed from one cycle to the next, or not. This, too, can be used to determine the optimum »

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Service

Engel is presenting the system to the public for the first time at K 2022:
Hall 15, booth C58

References & Digital Version

You can find the list of references and a PDF file of the article at
www.kunststoffe-international.com/archive

German Version

Read the German version of the article in our magazine ***Kunststoffe*** or at
www.kunststoffe.de

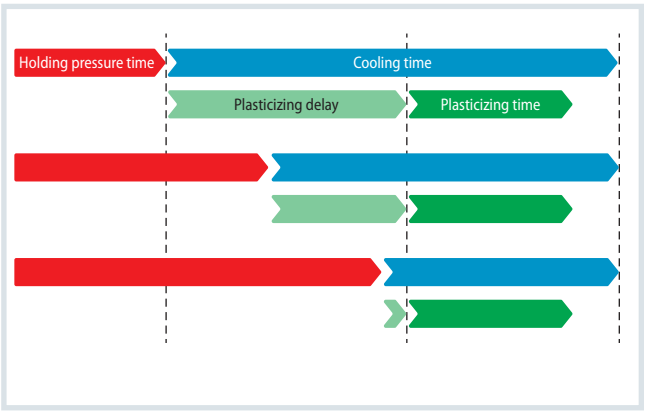

Fig. 3. Variation of the process parameters during optimization of iQ hold control: the cycle time remains constant during optimization and feeding starts at the same time in the cycle. Source: Engel; graphic: © Hanser

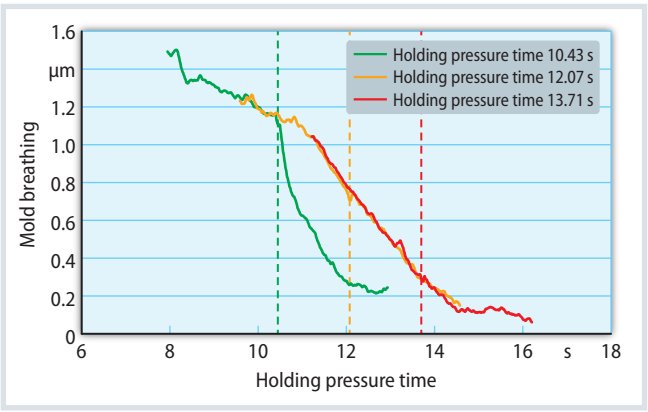

Fig. 4. Mold breathing over three cycles with different holding pressure times: if the holding pressure time is reduced and the part is not yet sealed, mold breathing stops. If the holding pressure time is prolonged beyond the sealing point, mold breathing remains unchanged. Source: Engel; graphic: © Hanser

Intelligent Assistance

The ancestral gallery of the iQ product family for injection molding machines:

- 2012 iQ weight control: automatic real-time control of the injection process for constant shot volume [1–3] despite fluctuations in the raw material and in the ambient conditions
- 2015 iQ clamp control: automatic setting of the clamping force via determination of the mold breathing directly at the machine [4, 5]
- 2016 iQ flow control: automatic single-circuit flow control for constant temperature-control conditions and energy saving in mold temperature control [6]
- 2019 iQ melt control: automatic adjustment of the screw rotational speed for reduction of wear and material stress by exploiting the available cooling time [7]
- 2019 iQ process observer: comprehensive automatic process data analysis including an AI-based platform for optimizing the process [8]
- 2022 iQ hold control: automatic determination of the optimum holding pressure time for potential cycle-time reduction

holding pressure time, as with conventional sealing point determination.

Mold Breathing as Basis

In an experiment, the mold breathing signals at different holding pressure times are shown (**Fig. 4**). In the cycle describing the green curve, the holding pressure phase is terminated one second before the sealing point. The result is that material from the cavity is forced back into the space in front of the screw, which leads to a reduced part weight and smaller integral of the mold breathing compared to a cycle with sufficient holding pressure time. If the holding pressure time is prolonged beyond the sealing point, no more material can flow into the cavity due to the solidified gate region. Consequently, neither the part weight nor the integral mold breathing is changed, as described by the red and orange lines. Thus, by means of mold breathing and its cyclic variation, it is possible to automatically determine the sealing point, which once again highlights the great benefit of this process signal [5].

In a practical example for determining the optimum holding pressure time, the conventional sealing point determination is compared with the new set value assistant *iQ hold control* (**Fig. 5**). For better comparison of the two parameters part weight and integral of the mold breathing, the values were standardized to the maximum value in each case.

The sprue requires special attention here, since there are several possible sprue versions. With the cold-runner gate, it is possible, with careful observation, to distinguish between the sealing point of the part and the sealing point of the sprue rod or sprue runner system.

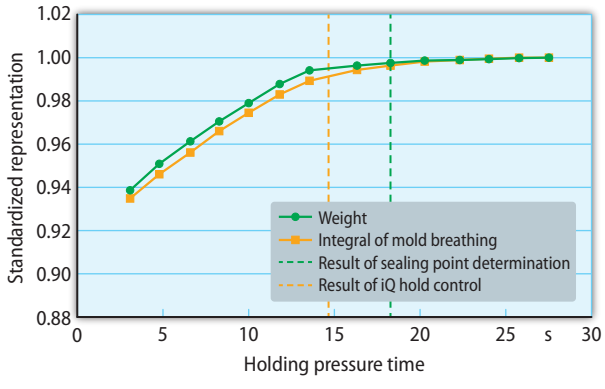

Fig. 5. Comparison of conventional sealing point determination with the result of iQ hold control: for a visual comparison, the maximum values of weight and integral mold breathing were standardized to 1. Source: Engel; graphic: © Hanser

The height of the mold breathing signal is the result of the integral of the cavity pressure over the projected area. Since the projected surface area of the sprue is usually very small compared to the part surface area, the deviation can usually be neglected.

The same argument applies in hot-runner applications with open nozzle since the molten region in front of the hot-runner nozzle usually has a very small area.

Production of Plugs Clarifies the Mode of Operation

At the Engel booth, visitors to K 2022 can see the new *iQ hold control* in action. An all-electric e-mac injection molding machine is producing plugs for vehicle electronics. The machine is equipped with all the assistance systems available in Engel's "inject 4.0" program. They can be individually activated and deactivated so that the visitors can follow the mode of operation live.

It becomes clear what additional benefit the new assistance system can provide processors. The fully automated set value assistant determines the optimum holding pressure time objectively and reproducibly with minimum time outlay. The process engineer can start the optimization at the touch of a button. The automatic process saves time and in many cases can also shorten the cycle time. The automatically determined holding pressure time is often lower than that previously determined manually. Overall, productivity, energy efficiency and cost efficiency are increased. Even if qualified specialists are not present in every shift, a high product quality can be obtained throughout.

Completely Exploiting the Machine's Potential

Intelligent assistance is a key feature of the Smart Factory. Assistance systems determine the optimum production parameters while production is running, suggest them actively or automatically establish them. In this way, the full potential of the injection molding machine can be tapped. With the strictly modular approach to its "inject" 4.0 program, Engel makes it easy for plastics processors to take advantage of the opportunities of digitalization. Individual solutions like *iQ hold control* provide a high benefit. ■