Intelligent Assistance Relieves the Strain on Production Staff

The plastics industry has been hard hit by the shortage of skilled staff, as fewer and fewer young people are choosing to enter the profession in this industry. Measures are available to increase the attractiveness of the plastics industry as an employer, but until they have an appreciable effect, the efficient deployment of the available human resources is becoming a survival issue for many companies. Here, digitalization opens up opportunities for supporting the well-trained technical staff and reducing the pressure on them.

Intelligent assistance systems in the injection molding machine control help the machine operator to perform the work more efficiently. © Engel

With the development of the iQ product family, the injection molding machine manufacturer and system supplier Engel Austria has been pursuing the goal for over ten years of equipping injection molding machines with a steadily growing number of assistance systems. It is thereby giving the users tools that will relieve them of time-consuming activities and help them to perform their work more efficiently. Software-aided assistance now spans the curve from the initial setting of the machine, through the elimination of process fluctuations, through to continuous monitoring and analysis of the production process.

Automatic Adjustment, Control and Analysis

The process setting for a new mold, besides technical expertise, principally takes time. After all, machine operators often proceed by trial and error. The quality and robustness of the operating point determined in this way lay the cornerstone for making production as trouble-free and therefore economical as possible. The disadvantage of this established method is that unfavorable process settings often only become apparent later in the current process in the form of frequent interruptions or the production of rejects.

Intelligent assistance systems, on the other hand, automatically determine the optimum process settings within the limits set by the user, such as clamping force or holding time. If the production process runs with the objectively determined optimum process parameters, the energy input, and often the raw material consumption, too, can be reduced, the cycle time shortened and thereby money saved. That is particularly true when the assistance systems not only determine the appropriate setpoint values, but also keep the process parameters relevant to quality and efficiency constant even during the production process. Digital process controllers automatically adjust the setpoint values determined for the cycle, such as the changeover point and the holding pressure level, to the current conditions. In this way, for example, the injected melt volume remains constant, even if the material properties change or the ambient conditions fluctuate. This actively prevents rejects.

Controlled conditions are also advantageous for mold temperature control. High-end cooling water manifolds optionally control either the flow rate or the temperature difference between the feed and return, and thereby ensure a constant cooling process irrespective
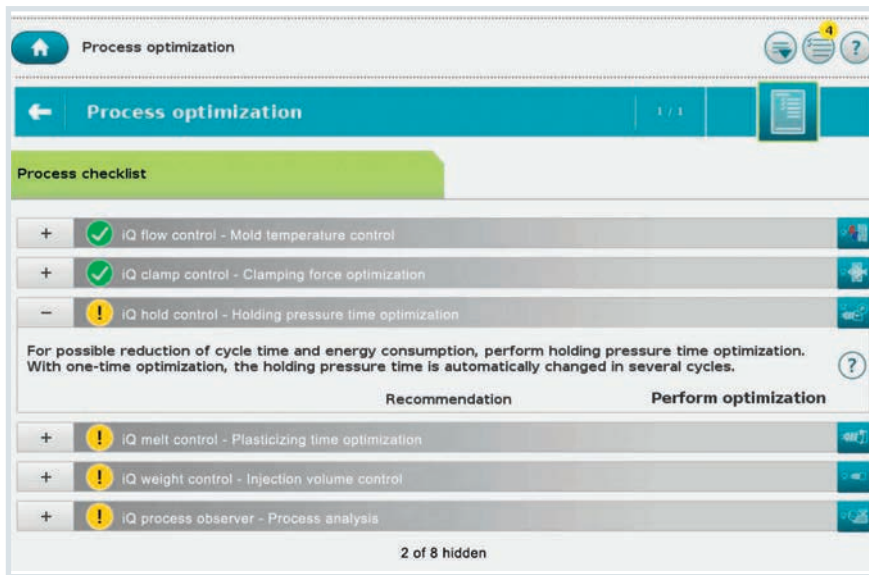
Fig. 1. In the process check list, a brief explanation, a recommendation for the next necessary step, an icon for jumping directly to the respective screen page and a status icon can be found for each assistance system. © Engel

of fluctuations in the water supply. Combining these water manifolds with temperature-control units operating with a speed-regulated pump even allows the pump speed to be controlled according to demand. This leads to energy savings of up to 85%.

Last but not least, it is worthwhile keeping an eye on the process during production. For this, too, the iQ product family has a digital helper. The software analyzes the process data shot by shot and recognizes independently occurring changes, deviations and current improvement potential.

The machine assistants for the injection molder, if used consistently, prove to be a comprehensive carefree package: They support the optimization of setpoint values and automatically adjust process settings to compensate for fluctuations. All the user has to do is to decide how and in what sequence the now diverse assistance systems are used to obtain an optimum result (**see Box p. 36**). The new process check list in the Engel control system helps with this.

Process Check List Supports the Use of Smart Assistance Systems

The process check list shows the user what potential can be unleashed by means of the assistance systems in the Engel injection molding machine. It gives injection molders greater reliability in the selection and use of smart assistance systems. It will be presented for the first time at Fakuma 2023, and from then on will be the cornerstone for the use of digital assistants. Integrated into the injection molding machine control, it supports the user with a simple, clear display (**Fig. 1**). The user learns

- which assistance systems are available in the machine or can be easily tested by means of a preinstalled trial version,
- in which sequence they must be activated for an optimum result, and
- whether an action is necessary at the current time.

The process check list thus makes the available optimization potential transparent. The user can immediately see with a notification icon how many optimization possibilities the process check list currently holds for him. It supports the technical staff in rapidly and efficiently saving both energy and valuable working hours.

30 Minutes instead of Eight Hours

The production of 4-pin plugs for automotive electronics (**Fig. 2**) on an Engel e-mac 100 injection molding machine, which is equipped with all available iQ systems, makes clear the great benefit of the process check list. Before process optimization, the cycle time was 13 s, and the production cell required 0.8 kWh to process 1 kg of raw material. After all the optimization steps recommended in the process check list had been implemented, the cycle time was only 12.5 s and the energy consumption of the production cell was 15% lower. In addition, the clamping force could be reduced by 50%.

iQ hold control reduced the holding time from 4 to 3.5 s. As a result, the energy consumption could be reduced by 5%. *iQ flow control* saved a further 10% energy by reducing the speed in the temperature control unit and automatically adjusting the flow rates based on the temperature difference. Last but not least, *iQ clamp control* was able to reduce the clamping force from 500 to 250 kN.

With the activation of the *iQ weight control*, the machine automatically performs process adaptations in the event of fluctuations and relieves the pressure on the technical staff during process adjustment – for example during the night shift or on batch exchange.

Finally, the current operating point is determined as a reference for a sub- **»**

Fig. 2. The production of plugs illustrates the benefit of the check list. © Engel

| Process data | recording | display | preparation | interpretation |

Commercial analysis software

iQ process observer (process change / reference deviation)

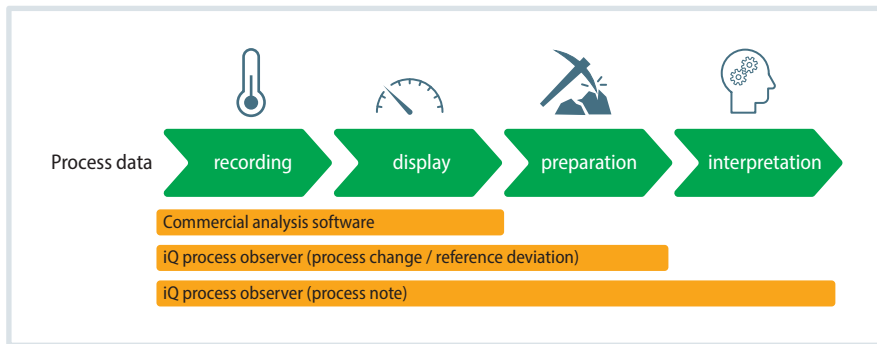iQ process observer (process note)

Fig. 3. Unlike conventional data analysis tools, the iQ process observer is not only capable of gathering data. Rather, it also prepares the data so that the user recognizes weaknesses in the process. The software automatically recognizes a large number of typical errors and optimization possibilities. © Engel

sequent process analysis. For the plug housings, the time required for optimization was a total of 30 minutes. Without the assistance systems and without the guidance provided by the check list, this would have occupied a skilled staff member for an entire working day.

Machine with Analytical Capabilities

Is software the better injection molder? Some experienced injection molders worry about this question. The situation is comparable to the early days of automation. Then, too, it was feared that

robots could rob people of their jobs. Today, hardly any machine operator in injection molding would want to do the work of the removal robots again. But it is correct to say that we have reached the point in injection molding technology where the machines can perform not only manual but also analytical activities, such as process data analysis.

Injection molders often face the following questions: The machine produces more rejects than yesterday – what is different now? When will my process be stable again after a production interruption? What undesirable side effects are there if I change the speed during metering?

Can the machines really answer all these questions?

The fact is that, until now, a large number of measurement values have been available in daily injection molding practice, but only a handful of selected parameters are usually used for monitoring and analyzing processes. This is partly because it is laborious to choose suitable parameters and determine suitable warning or monitoring limits. On the other hand, with increasing numbers of analyzed process parameters, it is increasingly difficult to keep track of what is essential at the moment. Against this background, many injection molders are content with a restricted view of the process.

The software shows its strengths in identifying deviations arising from hundreds of process data. But humans have a clear advantage when it comes to finding the cause.

Automatic Interpretation of the Data

But regarding this point, too, there have been pioneering developments in recent years. The *iQ process observer* from Engel goes two steps beyond monitoring and recognizing deviations (**Fig. 3**). The first step consists in the fact that the process as a whole is considered and, instead of some selected process data, hundreds of them are now automatically processed so that they can be read by the expert user like a story in pictures. This picture story narrates the sequence of changes over time (**Fig. 4**). The trigger for the deviations can often be quickly read from this (**Fig. 5**). With data processing, the software relieves the user of the

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Intelligent Assistance with iQ

Assistance systems provide support for a large number of tasks: in setting, controlling and analyzing quality and efficiency-determining process parameters.

Set-up Assistants

- **iQ clamp control** automatically determines the optimum clamping force. Effect: no burn marks, no flashing, good venting, reduced mold wear and often also a lower energy demand, since the optimum clamping force is usually lower than the one set manually.
- **iQ hold control** is the automatic and rapid alternative to complicated sealing point determination to determine the optimum holding time.
- **iQ melt control** reduces the screw speed during metering if possible, so that the available cooling time is optimally utilized. This reduces screw wear.
- **iQ motion control** optimizes the acceleration phases of movement sequences, such as the opening and closing of the clamping unit or the movement of the robot arm, and thereby shortens the cycle time.

Control Assistants

- **iQ weight control** individually adapts the injection profile, the changeover point and the holding pressure to the current conditions for each cycle. This ensures consistently high product quality even in the event of fluctuations in the ambient conditions and raw material.
- **iQ flow control,** based on the measured values of the e-flomo temperature-control manifold, ensures uniform temperature-control conditions in the mold and high energy efficiency by actively controlling the temperature difference in all individual temperature-control circuits. In addition, iQ flow control regulates the speed of the Engel e-temp temperature control units according to demand, which further reduces the energy demand of the production cell.

Analysis Assistant

- **iQ process observer** continually analyzes hundreds of process data, recognizes changes and deviations, and provides information about optimization possibilities. The software automatically determines the warning limits for all parameters.
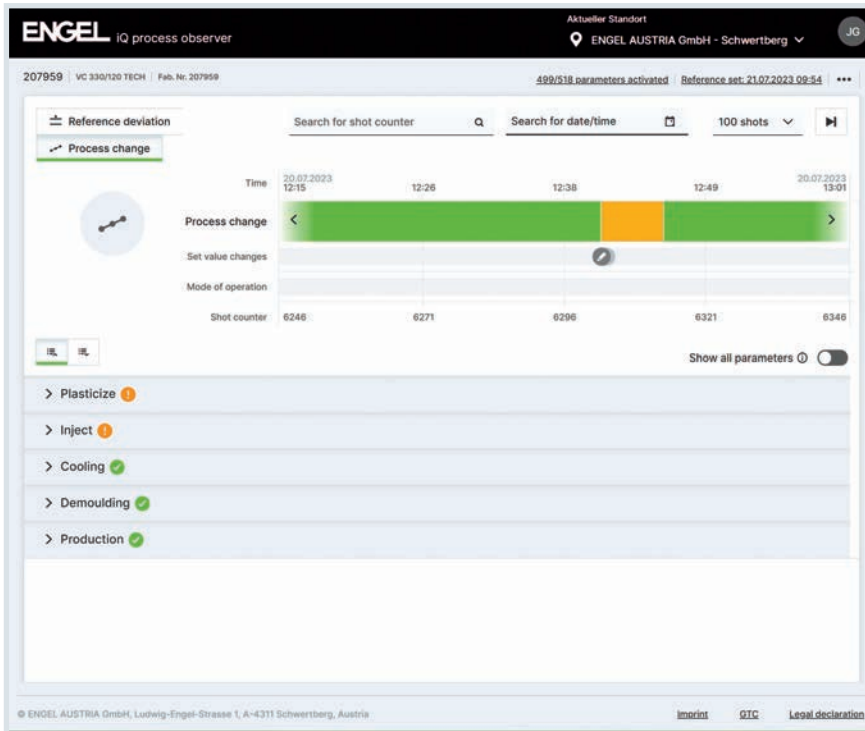

Fig. 4. In this example, the iQ process observer lists the incidents within 100 cycles. The yellow region in the timeline shows process changes. The pencil symbol at the beginning of this phase also provides the reason for this: settings have been changed. In the still-collapsed detail range below, it can be seen that the changes affected the process steps "plasticizing" and "injection." © Engel
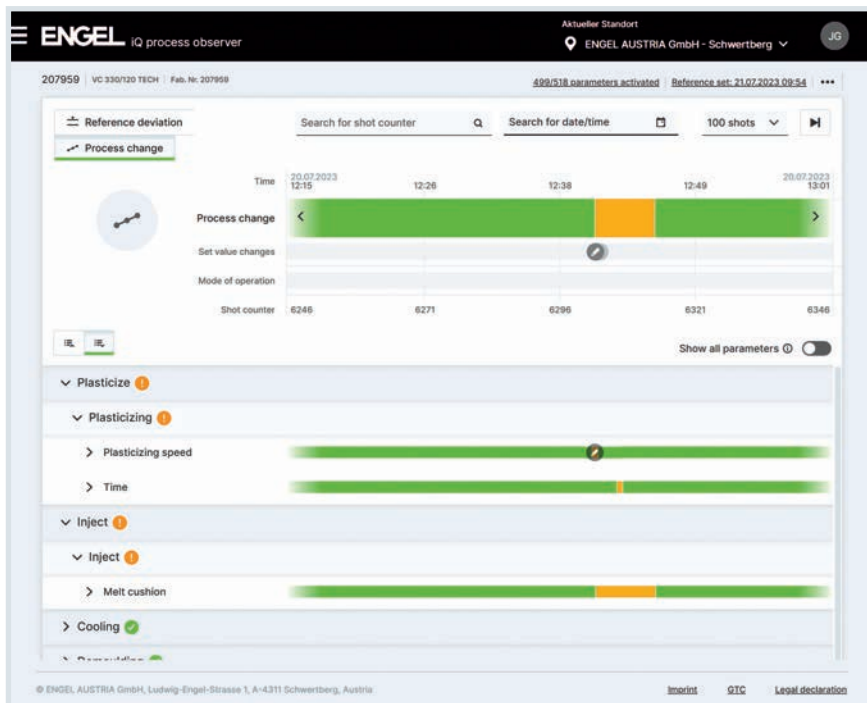

Fig. 5. Further information can be found by expanding the detail range: A user has changed the metering rate (recognizable by the pencil symbol). The desired effect was the change of metering time (marked yellow in the "time" line). However, the assistant also indicates a different consequence of this change: The melt cushion, i.e. the screw position at the end of the injection operation, has also changed (marked yellow in the corresponding line). This may indicate that, from this point on, a different amount of material was injected. All the other process parameters analyzed are unchanged. © Engel

complicated task of searching for deviations, filtering the relevant data and presenting the data in a form that makes interpretation possible in the first place.

The second step consists in the assistant also taking over the interpretation of the data. For this, Engel has packaged a large number of known error and optimization scenarios in smart algorithms. Using the setpoint and actual values, they check for each cycle whether one of the known errors is present or there is optimization potential. If this is the case, the system gives indications of the problem, the possible cause and the specific solution.

The Data Network Is Becoming Ever Tighter

The *iQ process observer* is a living system. That means the stored algorithms for identifying faults and optimization possibilities are continually being expanded and developed. Since the know-how is not held locally on the machine, but is made available via the cloud, the system is always up to date. This makes the net with which the *iQ process observer* fishes in the sea of data for optimization possibilities ever tighter. ∎

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Editorial Note
The third part of the "Carbon Busters" series for greater sustainability in injection molding planned at this point must be postponed for technical reasons. It will appear at a later date.