smart machine

iQ weight control | iQ clamp control | iQ flow control





Self-adjusting assistance systems for machines and robots

Leverage the full potential of your production – from the machine through integrated robots to the entire machine floor. Smart assistance systems by ENGEL ensure greater process stability, superior and reproducible quality, significantly fewer rejects and optimised energy efficiency.

Our intelligent smart machine solutions determine the optimum production parameters during operation, actively suggest them or even set them automatically. As a result, ENGEL inject 4.0 offers you ideal support for increasingly complex production processes.

- iQ weight control
- iQ clamp control
- iQ flow control



iQ weight control Intelligent compensation of process fluctuation

Your objective is to deliver best-in-class quality.

ENGEL iQ weight control helps you keep control over all external production conditions. This smart piece of software does the thinking for you - shot by shot. It compensates for fluctuations in both material quality and the injection moulding machine environment – without any manual intervention, in a fully automated way, and in real-time.

The challenge: producing 100% good parts

The quality of the manufactured parts can suffer from:

- material batch and moisture fluctuations
- changes in ambient temperature and humidity
- different shut-off behaviour of the non-return valve
- fluctuations in the utility supply
- long start-up phase after production downtime
- over-injected cavities, or cavities that short shot



The solution: ENGEL iQ weight control

Best-in-class quality shot for shot:

- detecting and monitoring the injection volume and viscosity
- controlling the injected melt volume in real-time
- automatic holding pressure correction
- optimised process stability

How does iQ weight control work?

Maximum precision for your production

ENGEL injection moulding machines are perfectly equipped for your production requirements. They achieve optimum process precision thanks to accurately repeatable screw position and speed. ENGEL iQ weight control takes this one step further and ensures a constant fill volume shot for shot - independent of external influences - therefore guaranteeing constant part quality.

This is how ENGEL iQ weight control works

The actual fill volume can vary in the injection process due to external influences: the smart ENGEL iQ weight control software constantly evaluates the pressure characteristic curve during the injection and compares the measured values with a defined reference cycle. If the system detects changes in the viscosity or material volume, it modifies the injection profile and the switchover point in the same shot to reflect the current situation.

ENGEL iQ weight control also corrects the opening and closing of the individual shut-off needles to reflect the filling progress for moulded parts which are filled in progression via several injection points. These measures in the filling phase increase repeatability, especially for moulded parts with a high flow length to wall thickness ratio (L/T).

Changes in melt viscosity have a negative effect on part quality in the holding pressure phase; this applies especially to thicker-walled parts. To counteract this, iQ weight control automatically adjusts the holding pressure level when the viscosity changes.

iQ weight control graphical display

This standard function of the iQ weight control software paints a clear picture of the current processes and sharpens your view for essential data:

Calculation of the parameters by iQ weight control: You can see injection pressure curves and the reference curve determined by iQ weight control as a function of the screw stroke. Deviations are detected more quickly: By directly comparing the current injection pressure curve with the reference curve, differences can be precisely identified. The most important process data (actual values) at a glance: iQ weight control provides you with a summarised view of the selected injection pressure curve.





The chart shows the injection pressure curve plotted against the screw position during the speed-controlled injection phase. This curve is a fingerprint of the mould filling property changes to the current pressure curve in comparison with the stored reference curve can therefore provide essential insights into process changes.

Fluctuations in the fill volume show up as displacements of the pressure curve in x direction. Viscosity changes compress or stretch the pressure curve in p direction. In practical applications, it is always a combination of the two effects that occurs.

Thanks to sophisticated mathematical transformations, iQ weight control "decrypts" the curve progression and references it to calculate the volume and viscosity deviations pertinent to the process.

What benefits does iQ weight control offer?

Constant mould filling even with fluctuations in the material

In case of batch changes or changes in the moisture content of the material, flashed or short shot parts often occur. Injection parameters would need to be manually readjusted. iQ weight monitor reliably detects viscosity fluctuations and iQ weight control automatically compensates for them.



Permanently consistent moulded part weight

iQ weight control compensates for fluctuations shot by shot, and reduces the moulded part weight variance by up to 85%. The intelligent software still pays dividends even if processes are already stable: It monitors every injection process during production and corrects the holding pressure profile and changeover point immediately if necessary. As a result, iQ weight control ensures process stability in the long term - even if external influences change over time.



85% reduction in weight variance for a vibration element from a razor made of PPS (machine: e-victory 160 combi)

Achieve good parts faster after production interruptions

After downtime or interruptions, it can take a while for the thermal equilibrium to be achieved again. iQ weight control corrects the injection and holding pressure parameters in each cycle so that good parts are produced again immediately.



Shorter start-up phases for a thin-walled PP component (machine: victory 120)

Your benefits

Improved cost-efficiency in your production

- improves productivity
- significantly fewer defective parts
- faster start-up after machine downtime

Reliably high part quality

- enhances process and weight repeatability
- makes the process independent of environmental influences
- compensates for fluctuations in the raw material
- removes the need for repeated manual readjustment

Major benefits with a low overhead

- available for all ENGEL machines
- simply enable, and reduce defective parts
- smart, state-of-the-art control solution
- no additional hardware required
- Integration with CC300, easily retrofitted



What our customers say

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The results of the test series are clear-cut and repeatable. Thanks to the iQ weight control software, we were able to reduce weight fluctuations from 0.02 g to 0.003 g. This is equivalent to a weight consistency improvement of 85%. We are now totally satisfied with a reject rate of 0.047%. Based on this, we have been able to reduce the quality control overhead, and improve the efficiency of the manufacturing process."

Frank Breunig, Initiative, Project & Process Engineer Procter & Gamble Manufacturing GmbH Schwalbach am Taunus, Germany

Reduction in weight variance from 0.02 to 0.003 g

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In the past, parts that were not completely filled had repeatedly been a problem with our thin-walled polyolefin products. Since we introduced iQ weight control as a monitoring and control solution in this area, complaints have dropped by 100%. And operations are easy and intuitive. Our investment in iQ weight control really paid dividends which ever way you look at it."

Rolf Schaupp CEO LAWAL Kunststoffe GmbH Langenau, Germany

Complaints 100% dropped by





iQ clamp control Intelligent clamping force optimisation

The tiniest details, such as mould breathing, can substantially influence the quality of your production. In mould breathing, the opening pressure of the melt partially compensates the compression of the mould due to the clamping force.

If the mould breathing is too great or to small, this can cause rejects due to burn marks (diesel effect) or flashes. ENGEL iQ clamp control determines the optimum clamping force quickly and therefore automatically keeps mould breathing within the ideal range. In this way, the intelligent software supports the operator and ensures the quality of your products for every shot.

If mould breathing or the clamping force are not suitable, quality will fluctuate

- if too much breathing occurs, that is, if the clamping force is too low, this leads to overfilled cavities and visible flash
- if the clamping force is too great, the mould and clamping unit are subjected to unnecessary stress
- clamping force that is too great causes burn marks because not enough air can escape
- clamping force that is unnecessarily high means increased energy consumption

iQ clamp control automatically regulates the clamping force and guarantees component guality

- automatically determines the optimal clamping force
- provides quality-relevant information about each shot
- prevents rejects due to burrs or burn marks
- reduces wear on mould and clamping unit
- improves energy efficiency thanks to optimised clamping force

An explanation of mould breathing







The starting point is closure of both halves of the mould without pressure (Fig. 1).

When the clamping force

is built up, the mould is de-

formed. The volume of the

mould cavity is reduced

slightly as a result of mould

compression (Fig. 2).



Fig. 2



Part of the deformation is compensated for by the opening pressure exerted by the melt during injection. This increase in the mould cavity size is referred to as mould breathing. The resulting change in the mould height, which is approximately equivalent to the mould breathing, can be determined by iQ clamp control (Fig. 3).

13

Automatically achieve optimal clamping force





Transmitted light microscope pictures of the edge of a moulded part. Left: burr formation without iQ clamp control Right: with iQ clamp control.



Product: Engine cover; Material: PP ENGEL duo 4400/700 Clamping force 4000 kN

Injection unit 4400 Shot weight 510 g

The full clamping force is not always needed

In practice, optimising the clamping force is a subjective matter: The result is heavily dependent on the experience of the operator. Setting an unnecessarily high clamping force leads to a slight increase in mould wear as well as energy consumption and cycle time. In addition, if the clamping force is too high, the air cannot escape from the cavities fast enough during filling - this can result in burn marks on the surface of the formed part.

Automatically determine the correct clamping force with ENGEL iQ clamp control

Achieve top results independent of operator experience: ENGEL iQ clamp control is an efficient tool for optimising clamping force. Only a few start-up cycles are needed to determine the amount of clamping force actually needed, and the ideal mould breathing value. This ideal value is then determined by automatic adjustment of the clamping force even if process changes occur.

Critical changes to the process can damage the mould

Changes, for example, of the switchover point, holding pressure or adding individual gates also result in changes in mould breathing. In the worst case, the cavities could be overfilled. That means that the mould is pushed apart so far that the melt flows out of the cavity at the parting line and forms a burr on the formed part. The burr is pressed between the mould halves - and the result can be damage to the mould.

Reduce wear on mould and clamping unit with ENGEL iQ clamp control

The existing monitoring packages for the Engel CC300 control unit make it possible to monitor mould breathing with thresholds for alarms and intervention. This helps to significantly reduce the risk of quality issues such as flash, and reliably protects the mould against overfilling.

Your iQ clamp control benefits

- automatically adopts the optimal clamping force shot for shot
- keeps the mould breathing within the optimal range
- reduces wear on the mould and the clamping unit
- provides optimal operator support
- protects the mould against damage due to overfilling
- ensures consistent quality for your products and significantly reduces the reject rate

Process optimisation without sensors on the mould

Common process parameters like injection pressure or melt cushion only provide limited information about the processes in the mould. Sensors on the mould deliver important data for process optimisation. However, they cause high additional costs and therefore only a fraction of all injection moulds are equipped with them. With iQ clamp control, we provide a reliable and economic alternative.

Determine quality-relevant information economically with ENGEL iQ clamp control

Receive relevant information for process optimisation and monitoring directly from the machine without expensive hardware or sensors. The machine control unit determines mould breathing through intelligent use of existing sensors. The mould breathing curve provides quality-relevant information about the formation of the moulded parts from the injection to the cooling phase and delivers a "fingerprint" of each individual shot.



Comparison between the mould breathing and the cavity pressure curves. Because mould breathing originates from the opening pressure of the melt, the curves of the two signals show very similar characteristics.

The extra bonus

You can immediately utilise the features of iQ clamp control for all moulds because there is no need to add equipment to the mould.

Supports the operator in the best possible way

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Thanks to our years of experience in injection moulding machine manufacturing, we understand our customers' concerns. We have also continuously developed a fine sense for details. With iQ clamp control, we have now succeeded in taking another large step towards intelligent machine controls. For the first time, it can now independently determine a process-relevant set value and make automatic adjustments to adopt it - without the risk of damage to the mould but still maintaining good mould breathing. Our goal is zero-fault production: With iQ clamp control, we have accomplished a crucial step in this direction."

Dr Georg Steinbichler | Senior Vice President Research & Development Technologies, ENGEL AUSTRIA

10

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iQ flow control Dynamically controlled temperature control

A large amount of reject parts produced by injection moulders around the world are the result of temperature control errors. An application-oriented temperature control process is therefore an essential prerequisite for stable processes and high product quality. But not only that: Energy savings and lower maintenance costs as well as a longer service life can be achieved by intelligent temperature control. Temperature control has been in the ENGEL development team's focus for years. iQ flow control sees a further step taken towards intelligent and self-regulating temperature control, with significant increases in process stability.

Negative influences in cooling and temperature control management

- environmental influences
- clogging of circuits
- deposits in flow channels
- dirty inspection glasses
- fluctuations in temperature and flow rate in the supply
- □ lack of connection with the machine control
- no visualisation, monitoring or process documentation
- lack of information about the return flow temperatures in the individual distribution circuits

Exact measurements for precise temperature settings

For a long time, mould temperature control was a process which was mainly orientated on the defined flow temperature at the mould and which was adjusted with a great deal of experience and patience, ENGEL flomo was the first major step towards intelligent temperature control. The intelligent water distribution system measures, monitors and documents the temperature control process.

With e-flomo it was not only possible to measure the temperature and process parameters, but also to actively control the flow rate. The revolutionary iQ flow control software also dynamically and independently adapts the temperature control process and keeps the process conditions constant.

iQ flow control – the solution

- permanent process monitoring
- active compensation of process fluctuations
- steady temperature control parameters
- intelligent speed control of the ENGEL e-temp temperature control unit pump ■ fully integrated into ENGEL CC300 machine control
- visualising, monitoring, controlling and logging of process parameters



ENGEL flomo family constant processes and complete documentation

The optimum water distribution system for cooling moulds and managing their temperature: ENGEL flomo. These compact modules, which are fully integrated into the ENGEL CC300 machine control, replace traditional cooling water distributors with floatation body flow metering. You can use ENGEL flomo to measure, monitor, log important temperature control parameters of the temperature control process; e-flomo even features a closed loop control. All of this enables you to manage the temperature control processes of your moulds in a safe, repeatable, time-efficient and convenient manner.

ideal operating conditions

- no water-filter required
- media temperature of up to 120 °C
- operating pressure of up to 10 bar

flomo

The innovative flomo water distribution system monitors and documents the most important parameters of all cooling and temperature control circuits; vortex sensors constantly measure the flow rate and temperature. These do not include any moving parts and filters; consequently removing the need for maintenance work. The measured values are displayed in a clear-cut way in real-time on the ENGEL CC300 control unit.



e-flomo

The smart temperature control water manifold system: e-flomo allows every batch to be produced under constant process conditions thanks to its active closed loop flow control. With just a click you can load part data sets, which you then manage via the CC300 control unit. This not only ensures greater process reliability, but also reduces setup times.



e-flomo premium

The smart water distribution system that can be fully remotecontrolled: e-flomo premium lets you operate all its features via the CC300 control unit. Direct access to the manifolds is no longer necessary. All features and data are being centrally managed through the control unit which means that forgetting or confusing temperature control circuits is a thing of the past!

Technical features

- measurement of flow rates, pressures, temperatures
- distributor versions: e-flomo/e-flomo premium: 2 / 4 / 6 / 8 circuits flomo: 4 / 6 / 8 circuits
- maximum temperature: e-flomo/e-flomo premium: 120 °C, flomo: 90 °C
- flow rate measurement range per circuit 1 15 l/min
- integrated with the ENGEL CC300 machine control unit
- retrofit available for ENGEL CC200 machine control unit
- thermal decoupling of the distribution circuits

	Monitor	Optimise	Document	Active control	Fully remotely controllable
flomo					
e-flomo					
e-flomo premium					



Compact design and carefully considered layout



Automatically achieve constant process conditions

Based on the measurements provided by the e-flomo optimised water distribution system, iQ flow control enhances the temperature control process. Together with the temperature control unit ENGEL e-temp, iQ flow control independently regulates the pump output and water volumes, thereby creating constant conditions.

- If thanks to iQ flow control, only one parameter needs to be set (ΔT^*)
- simplified and clear-cut operating condition with a single operator window
- uniform temperature distribution even in case of process fluctuations
- for precise ΔT control behaviour in each distribution circuit
- simplified problem detection (alerts)

*Difference between a temperature control circuit's supply and return temperatures

	Overview screen	ΔT control	Speed optimisation
e-flomo			
e-flomo premium			
e-temp + e-flomo (premium)			

Integrated with CC300

- visualisation
- monitoring
- closed loop control
- process documentation
- data set management for parts
- plug & play



e-temp temperature control units perfect integration with iQ flow control and e-flomo

e-temp units are ideally tailored to ENGEL injection moulding machines; they have an OPC UA interface and are supplied preconfigured and with piping for immediate use. They are also characterised by their high quality, compact design and low-maintenance operation for a long service life. Depending on the machine model, they can be positioned in a particularly space-saving manner and do not increase the system's footprint.

Configurations perfectly tuned to your application

Unit	Temperature	Heating power	Pump capacity	Cooling capacity
a tamp 119	100 °C	0.1707	60 l/min, 70 m*	30 kW @ 60 K
е-тептр по	120 °C	O KVV		
a tamp 1/16	100 °C	16 1/1/		
	120 °C	TO KVV		

*Values based on information gained from experience: Ø 30 - 40 l/min

Included as standard:

- complete piping from the machine supply to the e-flomo (up to max. 120 °C)
- electrical connection
- control connection via OPC UA
- iQ flow control

Available as options:

Clean room design

e-temp temperature control units are the perfect choice for an intelligent temperature control process. You can manage them via the CC300 removing the need for an extra control panel. Since they are supplied with piping in place and preconfigured, you only need to switch them on to use them. In production, you will be impressed with low energy consumption and a space-saving design. A clean room version is also available on request.

Heating elements without direct heat transfer medium contact

- no deposits on the heating rods
- longer service life
- fast heat-up times

Optimised indirect cooling

- minimal calcification thanks to controlled bypass
- avoids vapour formation

Communication via OPC UA

- next generation data interface
- operation via CC300
- data and alert management on the CC300

Tank-free system

- compact design
- minimal circulation volume
- efficient and fast heat-up/cool-down

Variable speed pump

- gasket-free pump with magnetic coupling
- no failures due to leaks or corrosion
- speed control allows for energy-efficient operation



■ flow rate measurement

The benefits of intelligent temperature control Energy and cost savings thanks to iQ flow control

Using a practical example, the energy cost saving potentials that can be achieved by the intelligent temperature control of the mould can be clearly demonstrated. In this specific case, the temperature control unit alone accounts for 37% of the total energy requirement of the production cell with conventional temperature control. With iQ flow control this requirement can be significantly reduced.

Process data for the production of the component:

- machine: ENGEL e-motion 170/80TL
- component material: ABS
- shot weight: 7.1 grams
- cycle time: 10 seconds
- temperature set on both temperature control units: 50 °C







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