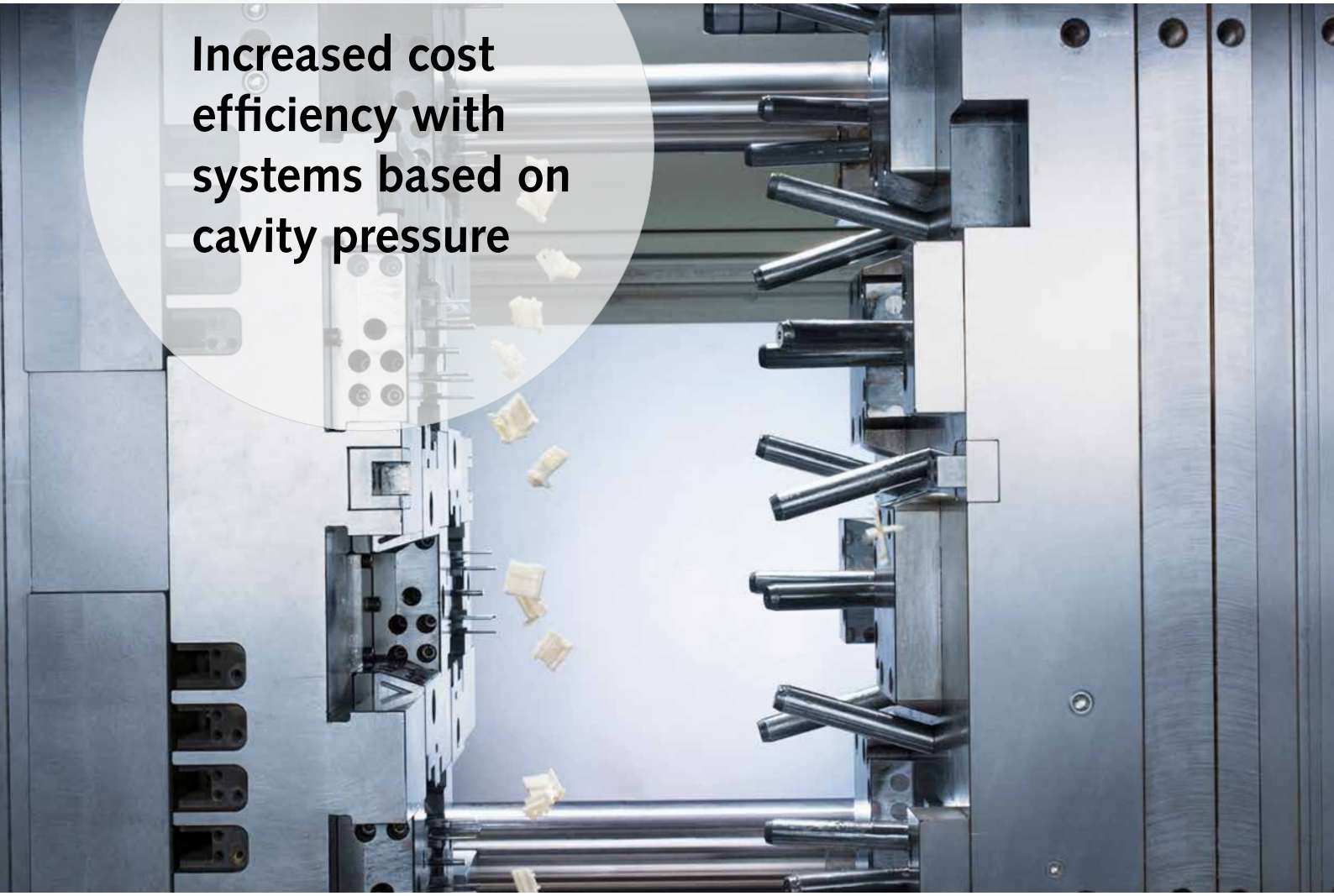
KISTLER

measure. analyze. innovate.

Increased cost efficiency with systems based on cavity pressure

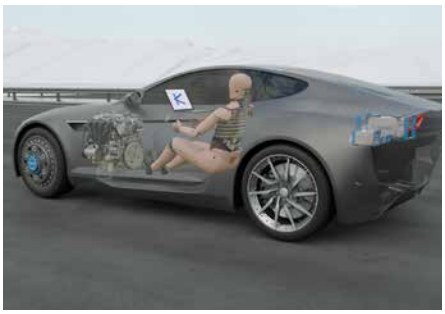


Plastics processing

Optimized process transparency for injection molding

Absolute Attention for tomorrow's world

Kistler develops solutions for challenges in measurement technology with a portfolio that comprises sensors, electronics, systems and services. We push the frontiers of physics in fields such as emission reduction, quality control, mobility and vehicle safety: our products deliver top performance to meet the standards of tomorrow's world, providing the ideal basis for Industry 4.0. This is how we pave the way for innovation and growth – for our customers, and with our customers.



Kistler: the byword for advances in engine monitoring, vehicle safety and vehicle dynamics. Our products deliver data that plays a key part in developing efficient vehicles for tomorrow's world.

Measurement technology from Kistler ensures top performance in sport diagnostics, traffic data acquisition, cutting force analysis and many other applications where absolutely reliable measurements are required despite extreme conditions.

By supporting all the stages in networked, digitalized production, Kistler's systems maximize process efficiency and cost-effectiveness in the smart factories of the next generation.

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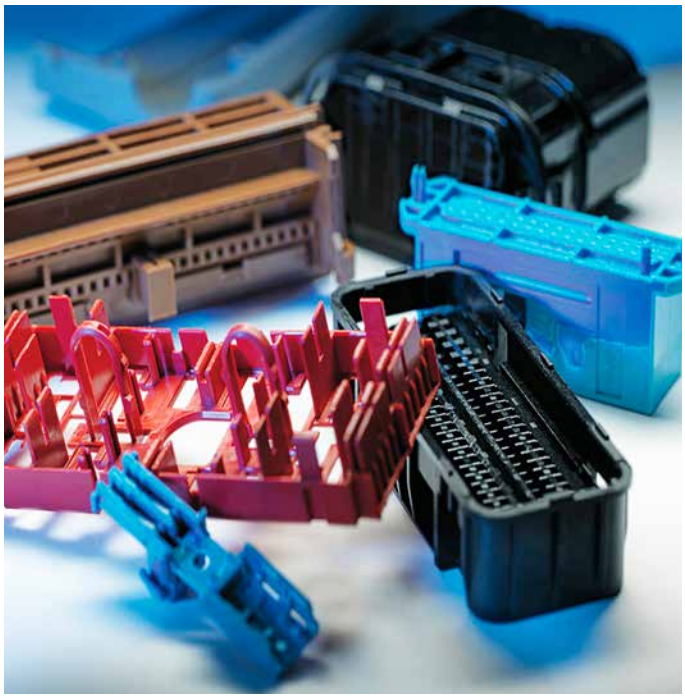
Focusing on your company's success

Our high-performance systems based on cavity pressure measurement monitor part quality and optimize the entire injection molding process. But that's not all: they also ensure sustainable Return on Investment (RoI).

The processes that take place in the mold determine the quality of the molded parts. But because they cannot be observed directly, frequent attempts were made in the past to describe the process phases with the help of machine-based parameters. The majority of these attempts failed – not least because they failed to capture important effects such as gate freezing or melt compression.

Cavity pressure: the key process variable
For four decades, we have known that cavity pressure correlates to quality-relevant part features such as dimensional accuracy, surface, weight or molding degree. Run on pressure fully describes the formation conditions of the injection-molded part, so it provides insights into the mold – regardless of machine settings and other parameters.

Benefits of cavity pressure-based systems
- Zero-defect production
- Reduced quality costs
- Optimized process efficiency
- Rapid amortization (RoI)
- Optimized cycle times
- Savings on staff costs
- Lower energy costs
- Data backup and optimization



100% quality assurance with systems from Kistler
Cavity pressure systems from Kistler represent a closed control loop – from measurement and control of the process through to comprehensive documentation of the process parameters. As well as providing proof of quality for the produced part, this documentation also permits targeted monitoring of tolerance limits and early detection of process deviations.

Focusing on business success
Our efforts to achieve zero-defect output in series production focus on one goal: business success for our customers. Consistently enhancing process reliability and optimizing the use of resources to boost productivity – this is the only sure formula for lasting improvements to process efficiency.

Injection molding with Kistler – now online!
View our animation to experience convincing, first-class solutions from Kistler – the surest route to 100% quality in your production:

Courtesy of TE Connectivity

Higher productivity – lower costs

Kistler systems to measure cavity pressure deliver benefits throughout the production chain. Exceptional added value: increased productivity and lower operating costs.

In series production, cavity pressure is used for continuous monitoring of part quality. The cavity pressure profile accurately mirrors the conditions under which the part is molded. The scrap gate can separate non-conforming parts automatically if part quality does not meet (or ceases to meet) quality standards due to process anomalies.

Boosting productivity and cutting costs
This process-integrated quality assurance means that scrap is detected at the earliest possible stage – an essential prerequisite for lean production. The results of zero-defect production achieved in this way: increased productivity due to improved machine utilization, lower production costs – and, therefore, lower operating costs.

Real-time control and regulation
ComoNeo, the process monitoring and control system from Kistler, allows comprehensive control of the entire injection molding process, helping users to achieve the goal of zero-defect production. The system can be used to determine the switchover point according to the fill level. This can be achieved with a pressure threshold or a special algorithm that automatically identifies the abrupt pressure increase in case of volumetric mold filling. Additionally, the needle valve nozzles can be opened exactly on a pressure threshold – for example, during sequential injection molding. The start signal for fluid-assisted injection during water and gas injection molding (WIM, GIM) and the start signal for the embossing stroke during compression molding are further examples of high-precision control functions based on the cavity pressure profile. Hot runner balancing is another function based on the pressure information from the mold: automatic balancing synchronizes the pressure profiles by individually controlling the nozzle temperatures on the hot runner.

Documented proof of quality
Cavity pressures measured during production clearly reflect the quality of the produced parts, so they can be used for documentation purposes. This results in 100% quality assurance on the basis of cavity pressure measurement, using tests in accordance with statistical process control (SPC). This measuring method cuts the costs of part testing and supplies automatic documentation of the process data – which is still available to manufacturers and customers years after the part was produced.

Benefits throughout the process chain

During the mold trial:
- First machine settings without fill studies
- Time gained thanks to process optimization
- Significant cost reductions during the mold trial
- Overall project acceleration

During optimization:
- Automatic detection of the switchover point
- Optimal cavity pressure profile
- Minimal cycle times

During startup:
- Optimal part quality even after machine changes
- Costly and time-consuming part testing is eliminated
- Automatic hot runner balancing

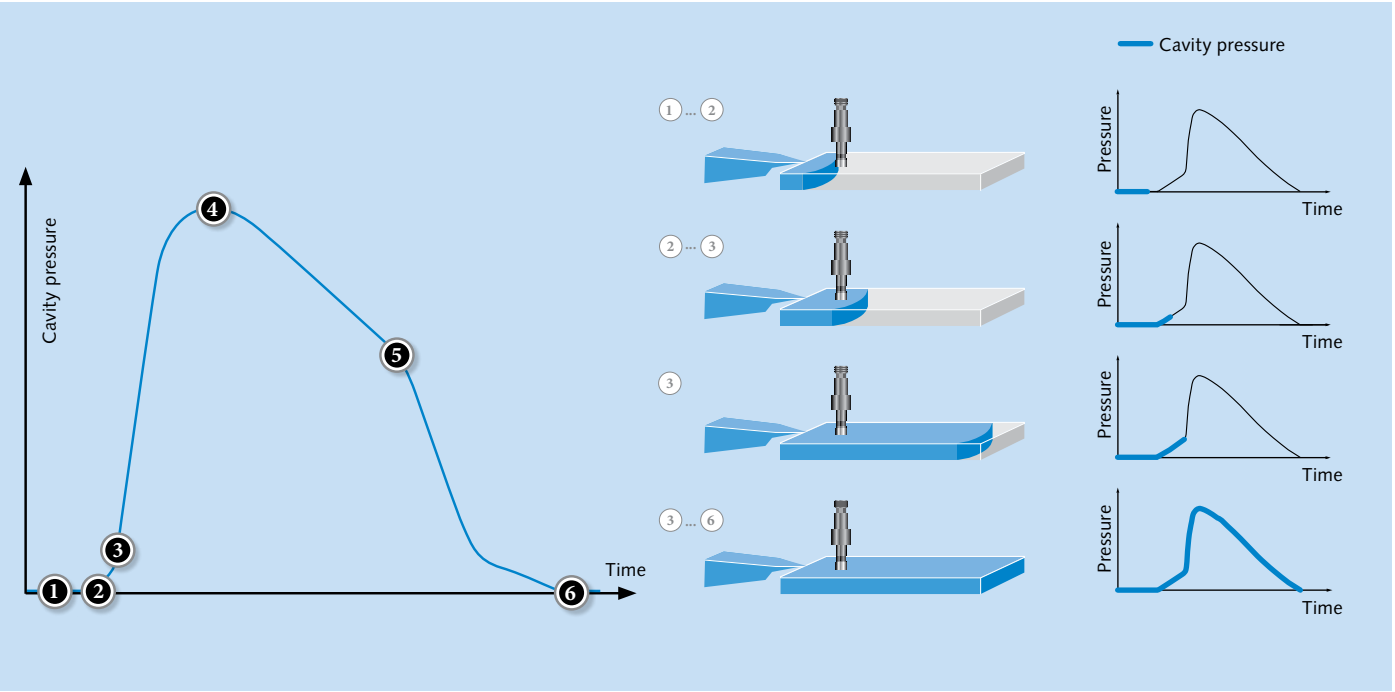
In series production:
- 100% control
- Automated scrap separation
- Process control in real time

For quality assurance:
- 100% proof of quality for every part
- Lower part testing costs
- Automatic quality data documentation

Cavity pressure: the yardstick for quality

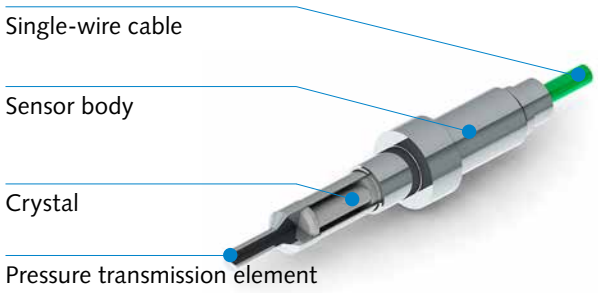
The cavity pressure profile provides information about the quality of each individual part. If correctly controlled, it guarantees sustained improvement of quality in the cavity, so scrap is reduced.

Cavity pressure can very accurately describe the filling, compression and holding pressure phases of injection molding. Knowledge of the fundamental physical relationships makes it easy to evaluate and interpret the pressure profile.



The four phases of cavity pressure
The melt enters the cavity at the start of the injection phase (1). A pressure can be measured as soon as the flow front reaches the sensor (2). The pressure should show an almost linear increase as the injection time increases. The end of the injection phase (3) is reached on volumetric filling of the cavity. The melt will be compacted during the compression phase to guarantee molding of the part contours. The holding pressure phase starts after the maximum cavity pressure has been reached (4). This phase compensates the high volume shrinkage of the plastic material – i.e. the reduction of its volume due to cooling – by adding material. In the holding pressure phase, up to 10% of the part volume will be pressed into the cavity. When the melt freezes near the sprue (5), the pressure in the cavity drops to ambient pressure due to continued thermal contraction (6).

Direct pressure sensor 6183



How pressure measurement works
The directed deformation of a piezoelectric crystal creates an electrical charge. The charge signal, which functions in proportion to the pressure, is converted into electrical voltage using a charge amplifier.
Highly dynamic pressure progressions can be measured exactly using this technology.

100% quality – from measured values through to documentation

Throughout the entire measuring chain, Kistler offers everything you need to achieve optimum results from the first measurement until your documentation is completed: high-precision sensors and a process monitoring system that is easy to configure, as well as the related connection technology and networking software.

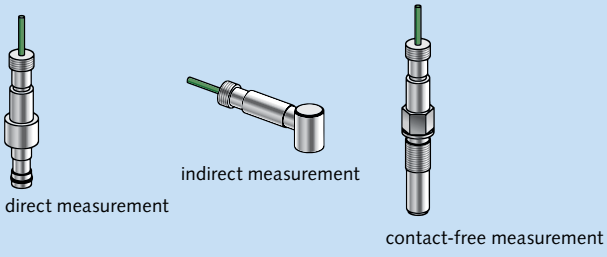
Sensors
Exact, reproducible pressure measurement values can only be obtained with reliable sensors that measure precisely. Kistler supplies optimal sensors for all part geometries, mounting conditions, injection molding processes and plastic materials.

Sensors from Kistler offer virtually unlimited service lifetimes; they deliver highly linear measurement results, and they operate independently of temperature. They provide high-resolution measurements of minimal pressure variations (range up to 2,000 bar) and/or temperature changes of up to 300°C.

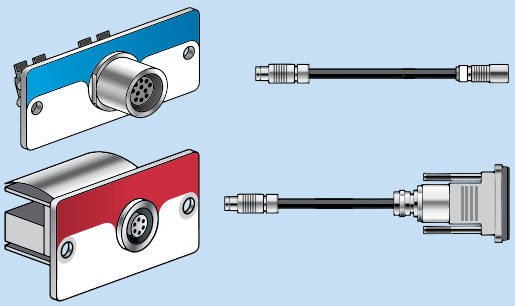
Connection technology
Increasing numbers of cavities and more sophisticated temperature conditioning concepts: these factors mean that the structure of injection molds is becoming more complicated. But at the same time, molds should be easy to maintain and remove. Kistler has consistently responded to these changes with its connection technology for pressure and temperature sensors.

Single-wire and multi-channel cable technologies from Kistler ensure accurate and reliable transmission of the sensor signals to the monitoring and control systems. Signals from combined pressure/temperature sensors can also be transmitted using multi-channel cable technology and a thermocouple amplifier.

Measure



Connect



Analysis systems
ComoNeo is Kistler's process monitoring system for cavity pressure-based optimization, control, monitoring and documentation of injection molding, with separation of good and bad parts. The system is suitable for every application and it cuts quality costs because faulty parts are detected automatically.

ComoNeo is compact, meets industry standards and is easily configurable. It features a process-oriented operating philosophy and integrates flexibly into various production environments. The system has up to 32 inputs for piezoelectric cavity pressure sensors, up to 16 inputs for temperature measurements, and four analog voltage inputs for machine signals (screw drive, machine pressure, etc).

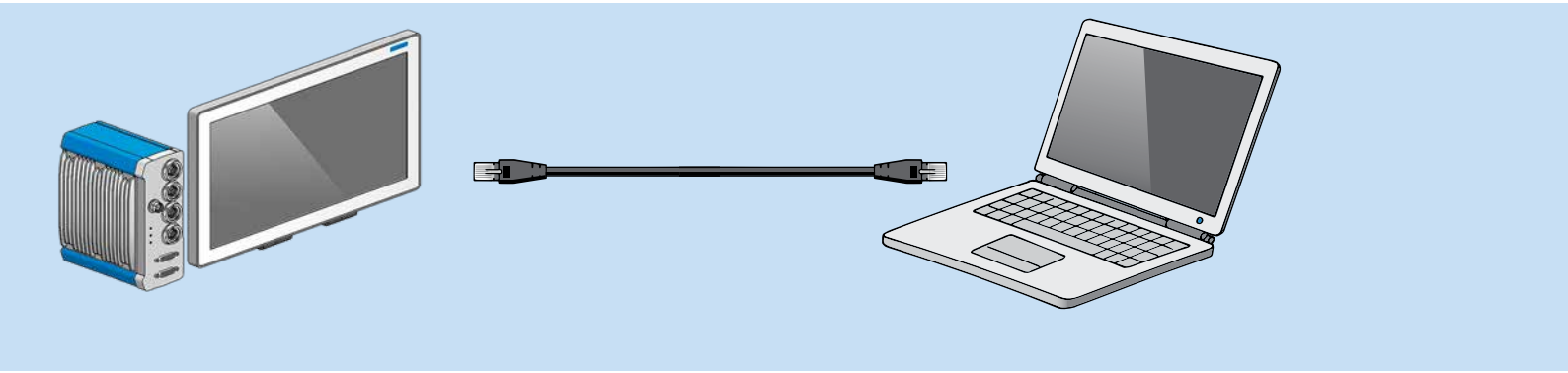
Software
Optional software products are available as extensions to ComoNeo.

Available features
- ComoNeoGUARD
- ComoNeoRECOVER
- ComoNeoMULTIFLOW
- ComoNeoSWITCH
- ComoNeoMERGE
- ComoNeoCOMPOSITE
- ComoNeoPREDICT

ComoDataCenter
All ComoNeo devices can be networked in the ComoDataCenter. Data can be viewed in real time or as archived historical data.

Monitor and control

Document and analyze



High-precision sensors for enhanced process reliability

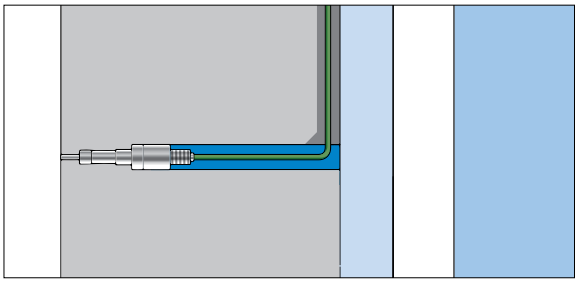
Exact, interpretable pressure measurements enhance process reliability and ensure greater efficiency throughout the production process. High-precision cavity pressure sensors from Kistler offer the ideal solution to achieve these goals.

Measurement of pressure and temperature during injection molding calls for reliable and durable measuring technology with high resolution – and no need for maintenance. Suitable measuring systems must be able to capture and resolve the smallest pressure variations, even at pressures of 2,000 bar.

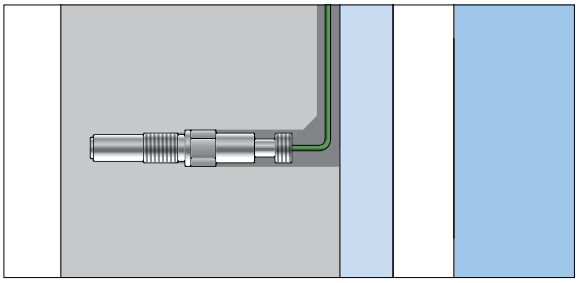
Piezoelectric cavity pressure sensors from Kistler offer virtually unlimited service lifetimes, and they operate reliably – even in case of high temperature variations. They can be used at mold temperatures of up to 300°C and for any melt temperatures. Kistler offers a series of cavity pressure sensors with standardized uniform sensitivity. Each sensor equipped with Unisens technology will be delivered with this standard sensitivity. This eliminates the need for individual settings on electronic equipment.

Benefits of Kistler sensors

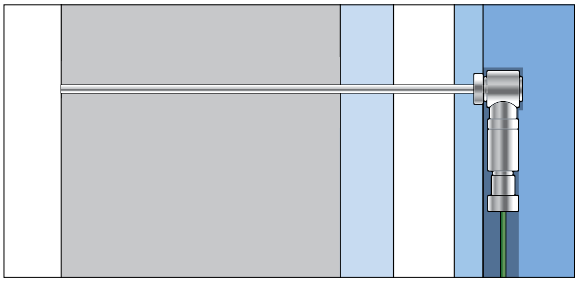
- High-resolution, reliable measuring instruments with long service lifetimes
- Even the smallest pressure variations are captured
- Measurements are independent of temperature
- Sensors for direct, indirect and contact-free measurement
- Combined pressure and temperature sensors



Direct measurement: the melt pressure acts directly on the front of the pressure sensor.



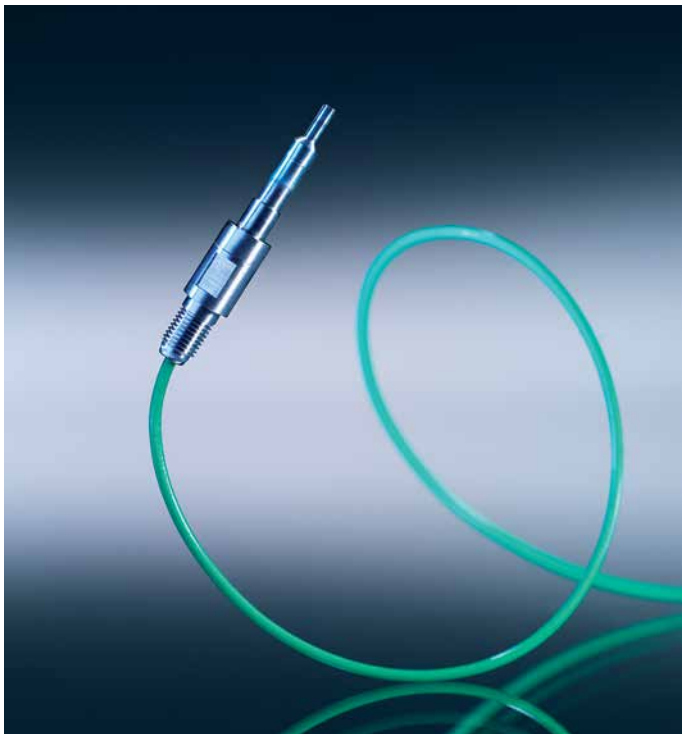
Contact-free measurement: measuring pins capture the mold compression caused by the pressure



Indirect measurement: the ejector pin transfers the pressure to a force sensor.

Direct, indirect and contact-free measurement
With the direct measuring method, the sensor contacts the melt in the cavity to measure the pressure directly and without pressure loss. For most sensors, the front of the sensor can be matched to the surface of the cavity, which means that virtually no marks can detected on the part. Direct-measuring sensors are available in different dimensions.
The indirect measuring method is recommended if there is not enough space for a direct-measuring sensor. Optical components – such as lenses or light conductors and parts with Class A surfaces for automotive engineering – must not show any marks left by the sensors. The cavity pressure for these applications can also be measured contact-free with measuring pins.

Combined pressure and temperature sensors
For monitoring of parts that tend to shrink and deform, it is advisable to measure both the temperature and the cavity pressure. Combined pressure/temperature sensors measure the cavity pressure and the contact temperature at the same point on the part. The thermocouple is positioned directly at the tip, so the sensor measures the contact temperature with the melt. Combined pressure/temperature sensors from Kistler are compatible for installation with standard cavity pressure sensors.



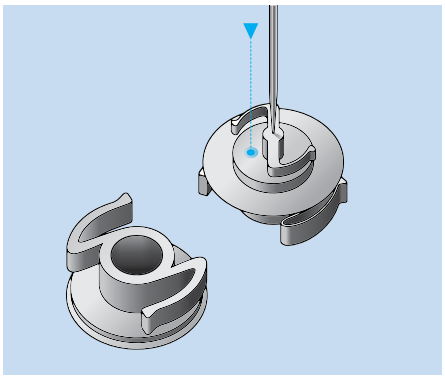
Correct positioning is critical

Correct positioning of the cavity pressure sensor is critical in order to obtain meaningful measurements. Particular attention must be paid to the position of the sensor relative to the flow path of the melt and the wall thickness of the part at the installation point.

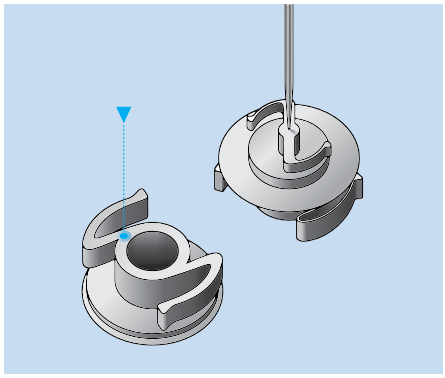
Measurement near the sprue
The pressure progression in the mold will be captured during the injection phase as soon as the flow front of the melt reaches the sensor. A meaningful and more sustained measuring result is usually obtained near the gate and in the area of the greatest wall thickness. This is because thick-walled points are the last to solidify. When positioning the sensor, the points where the melt freezes first and last must be estimated. For cavities with several gates, the measurement should be taken in critical areas of the part.

Measurement away from the sprue
The further from the sprue the measurement is taken, the later the flow front of the melt will reach the sensor. This also means that the pressure measurement starts later, so the fill level must be higher in order to measure a pressure. For this reason, the injection phase cannot be visualized until the sensor is reached. During a measurement at the edge of the part – i.e. away from the sprue or at the end of the flow path – a signal will only be measured when the pressure rises steeply in the compression phase. Measurement positions far from the sprue offer benefits if special quality problems need to be monitored at the end of the flow path.

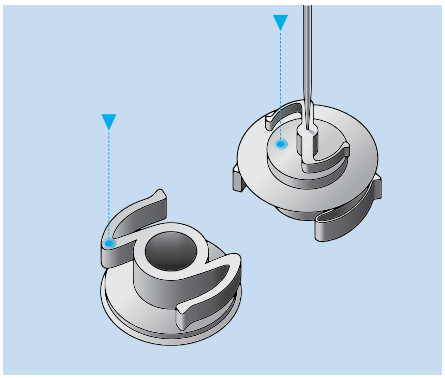
Basic rules for correct sensor positioning



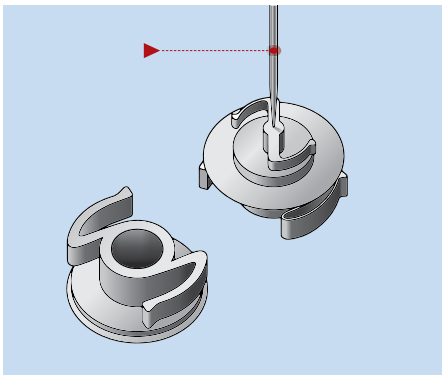
1. Placed near the sprue for optimal measurement results



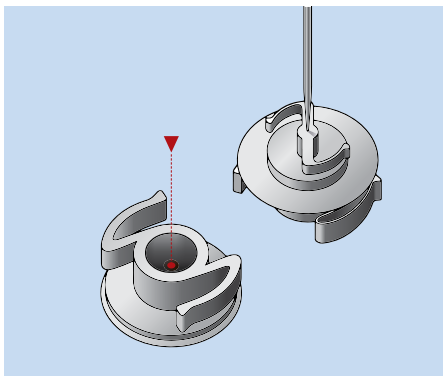
2. Positioned in the area where the wall is thickest



3. Second sensor for large parts



4. Sensor is not positioned in the sprue



5. Sensor is not positioned opposite the gate

Connection technology: reliable equipment for injection molds

Single-wire and multi-channel cable technology from Kistler has greatly simplified the way sensors are connected to systems. And with Kistler technology, connections are more secure because proof of correct signal transmission can be provided.

Single-wire technology consists of a cable with one conductor and a very small cross-section. This technology reduces the space requirements in the mold; installation is easy and cables can be repaired by the user.
For complex and modular molds, contact elements connect cables in different mold elements.

Multi-channel cable technology
On the basis of single-wire technology, up to eight different sensors in the mold can be connected to analysis systems with one single cable. A multi-channel connector and a multi-channel cable connect all sensors in the mold with the ComoNeo process monitoring system. Multi-channel cable technology reduces space requirements in molds, and it also cuts cabling costs. As standard, the multi-channel connector is fitted with a chip to allow automatic mold identification. ComoNeo measurement and analysis systems automatically identify the mold and load the corresponding settings and parameters. This prevents errors and allows significantly faster mold changes.

Cable technology for pressure and temperature signals
Multi-channel cable technology also enables combined pressure/temperature measurements. One single cable secures the connection to the ComoNeo process monitoring system for up to eight temperature signals. The amplifier supports combined pressure and temperature sensors from Kistler as well as all commonly used temperature sensors.

Benefits of single-wire technology:
- Cables can be shortened as required
- Cables can be repaired by the user
- Space-saving cable installation

Benefits of contact elements:
- Easy integration and installation of sensors and cables in complex, modular molds
- Simplified installation and maintenance of molds
- No cable damage during installation/removal of molds

Benefits of multi-channel cable technology:
- Only one cable from the mold to the monitoring system
- Simpler/faster installation than with single-channel cable technology
- Mold identification for fast and reliable mold changes

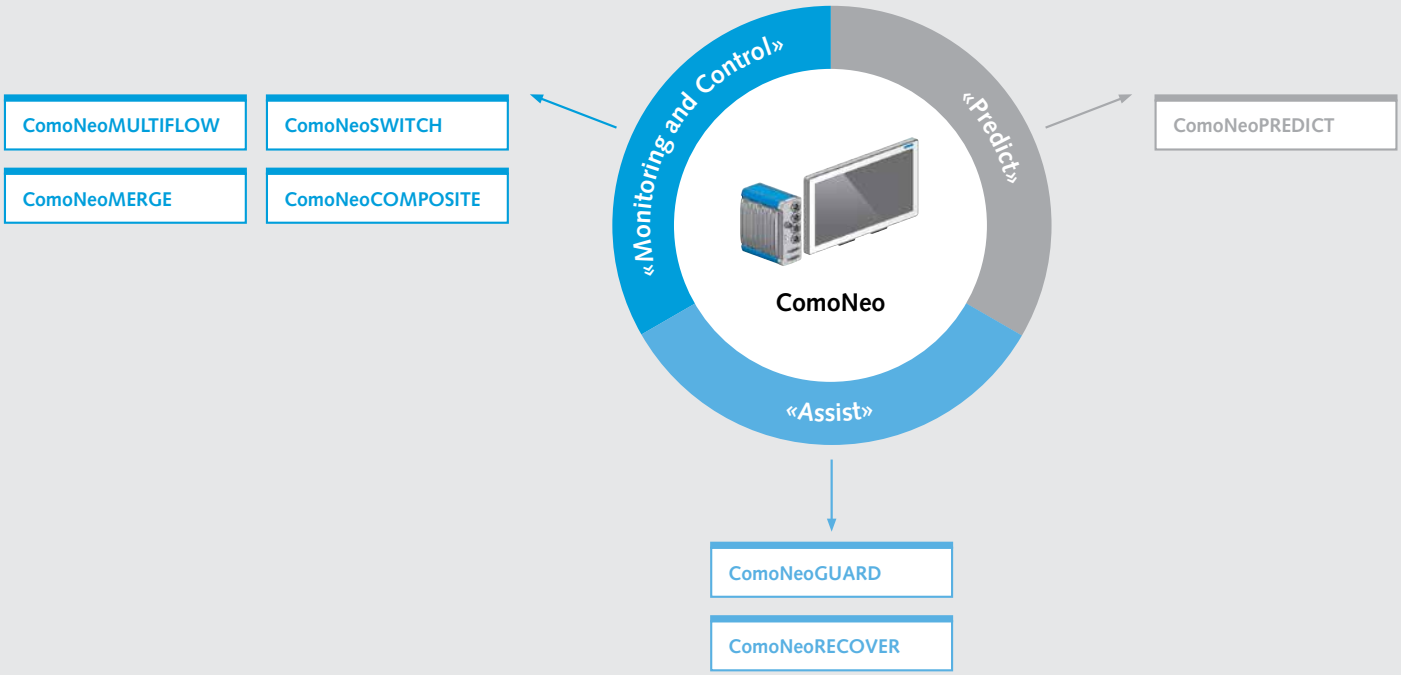
Process monitoring with ComoNeo

All efforts to monitor injection molding processes are aimed at cutting costs. The ComoNeo process monitoring system is the method of choice to achieve this goal because it detects scrap automatically.

ComoNeo is the process monitoring system from Kistler for cavity pressure-based analysis, optimization, monitoring and documentation of injection molding, with separation of good and bad parts. This compact system meets industry's needs and is easy to configure. It also features simple connection technology and integrates flexibly into different product environments.

Simple to operate – crystal-clear display
Operating ComoNeo is simple: the cavity pressure progression can be followed in real time, and visualization on the capacitive Multi-Touch Display makes it easy to understand process fluctuations. Integrated data storage allows recording of curve histories with at least 50,000 cycles. Curve superimposition and a host of other useful functions (changeable color schemes for the curve display, cycle comments, cursor functions, etc.) allow detailed analysis directly on the injection molding machine . Production mode includes clear displays showing production progress and scrap rate, as well as intelligent mechanisms (e.g. automatic detection of interruptions to production and declaration of a defined number of cycles as scrap on restarting). As well as tracking part quality, ComoNeo can monitor process stability and trigger warning signals in case of process fluctuations.

Benefits of ComoNeo:
- Separation of good/bad parts
- Costs are cut because process efficiency is boosted
- Process stability is monitored and optimized on the basis of cavity pressure
- The integrated process dashboard provides a quick overview of the status and progression of production
- User-guided generation and definition of monitoring functions for part separation



Assistance systems

ComoNeoGUARD
ComoNeoGUARD is a tool that generates and positions the monitoring boxes for good/bad evaluation itself – guiding users quickly and seamlessly to the scrap limits. The results define the evaluation types and the relevant limits. Thanks to this approach, components can be monitored and sorted into good and bad with high precision – and pseudoscrap (i.e. "presumed" scrap) is reduced. By using ComoNeoGUARD for user-prompted generation of the EO limits, users are guided through the procedure for defining the correct scrap limits. This eliminates the need for specific previous knowledge when setting up full process monitoring.

ComoNeoRECOVER
ComoNeoRECOVER makes it possible for users to transfer pre-established processes from one machine to another with no problems at all. This makes it easy for users who have no previous specialist knowledge of cavity pressure to optimize processes and improve part quality. The Restart module has been integrated into the system since version 2.0 of ComoNeo. The purpose of this module is to reproduce the quality of an established injection molding process identically on a new machine. The Restart Assistant is therefore used as a tool to optimize injection molding processes, rather than as a monitoring instrument.

Process control systems

ComoNeoMULTIFLOW: automatic hot runner balancing
ComoNeoMULTIFLOW synchronizes the pressure profiles by individually controlling the nozzle temperatures on the hot runner. It stabilizes the process and adjusts for batch fluctuations as well as other process disruptions. ComoNeo combines the advantages of automated hot runner balancing with 100% quality assurance based on cavity pressure. The purpose of hot runner balancing is to ensure identical injection and pressure conditions in all the mold's cavities. The control variables used by ComoNeoMULTIFLOW are the cavity pressure profiles in the individual cavities. The actuating variables are the temperatures of the hot runner nozzles.

ComoNEOSWITCH
ComoNeoSWITCH actively provides machine feedback. This allows ideal timing for the switchover from speed control to pressure control in response to cavity pressure. The automatic switchover control can be used in two different ways. The first option involves manual setup, and control behavior is only changed after the user intervenes. For example, a user can specify the defined level of cavity pressure at which the switchover should take place. The second option is called SLP (Switch Level Process): setup in this case is fully automated, and control behavior is automatically optimized from one cycle to the next. For molds with multiple cavities, behavior during automatic switchover has been optimized for the specific purpose of compensating for different behavior patterns during the production sequence. When conditions are set manually, additional dependencies across multiple cavities are available as control criteria.

ComoNeoMERGE
ComoNeoMERGE is especially helpful with the production of multi-component parts such as toothbrushes, screwdrivers and grips for cordless screwdrivers. All the cavity pressure data measured in the manufacturing process is merged to provide a clear visual overview of the complex multi-component injection molding process. In multi-component injection molding, multiple mold types are used with different sensor positions. ComoNeoMERGE maps all the components and the individual process steps for each cavity as a curve. The benefits: precise monitoring of the complex process sequence for multi-component injection molding, and a corresponding reduction in quality costs for the production process. This allows users to make use of ComoNeo's full functionality as a process monitoring system for multi-component injection molding.

ComoNeoCOMPOSITE
As is the case with other filling processes (such as injection molding), the pressure curve is a critical factor in process optimization and production monitoring. ComoNeoCOMPOSITE ensures that users can easily recognize the characteristic phases of the process such as evacuation, filling and curing in the pressure curve – so process parameters are optimized and production becomes more cost-efficient. The pressure signal is also used as a control variable for individual steps of the process – so online process control becomes possible. At the same time, anomalies in the pressure curve indicate whether faults can be expected in the finished part and, if so, which ones. Capture and recording of the pressure signal with ComoNeoCOMPOSITE also allow traceability of the individual process steps. For these reasons, the pressure curve is indispensable as a quality assurance tool.

Prediction systems

ComoNeoPREDICT: specific quality criteria with online prediction

Online quality prediction is the basis for reliable statements about every manufactured part – ahead of time. Taking the current cavity pressure profile as the basis, ComoNeoPREDICT forecasts the part's eventual dimensions. ComoNeoPREDICT is based on models that make it possible to calculate the characteristics of molded parts. The statistical DoE (Design of Experiments) process for test planning helps to determine relationships between pressure / temperature profiles and defined quality features. To carry out online quality prediction, users need the machine and the part, plus the ComoNeo monitoring system and the software (PC software) to generate the DoE and the prediction model.

The functions of the ComoNeo process monitoring system are complemented by a module that includes curve analysis, statistical functions and reporting.

Quality documents from ComoDataCenter

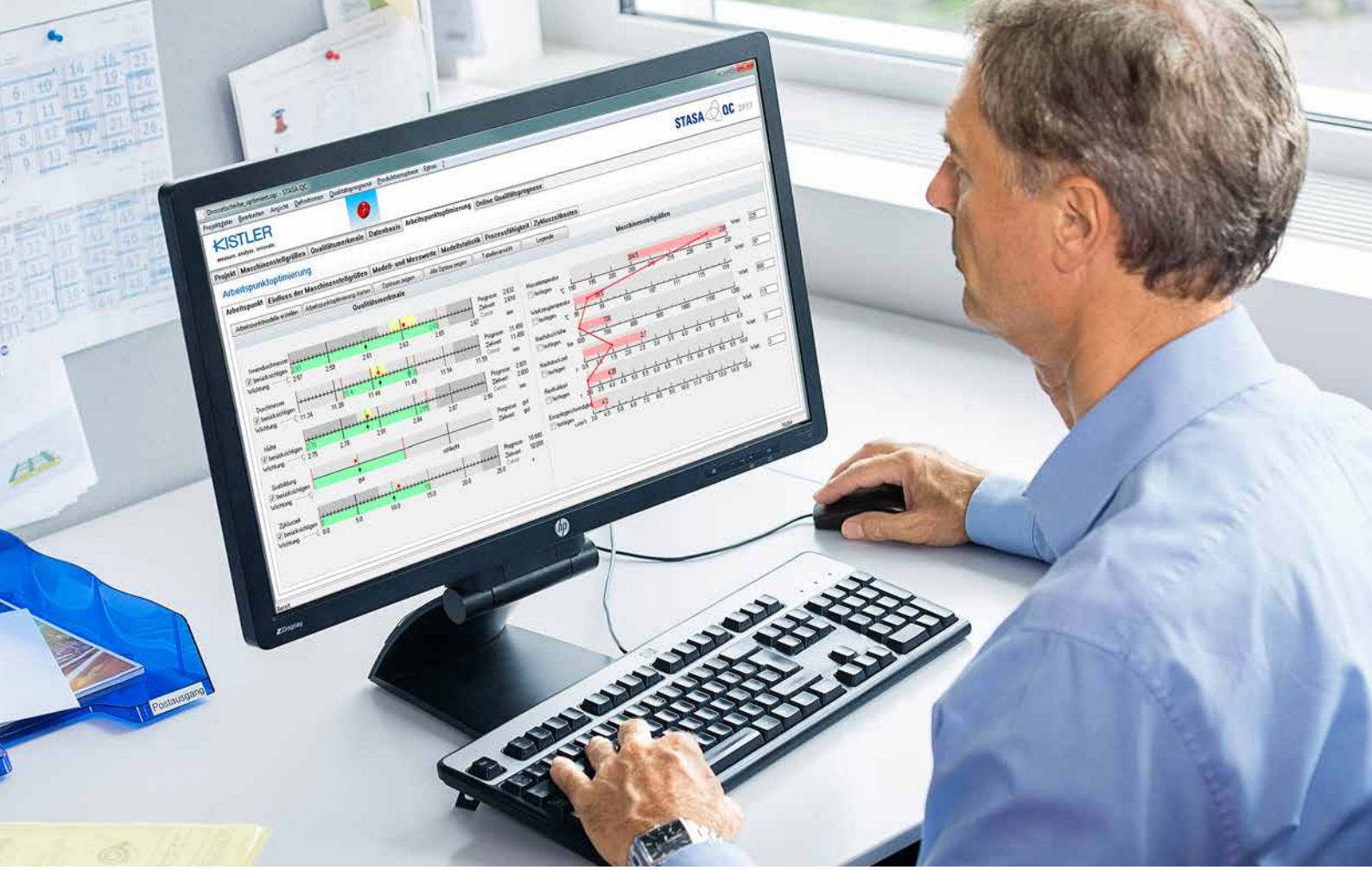
ComoDataCenter links all the user's ComoNeo systems to combine process- and quality-related production data for both live and completed orders in one database.

ComoDataCenter provides users with an overview of the status of each injection molding machine, and also allows cross-plant production monitoring and process analysis. For example, users can see which machine is generating particularly good or poor performance values by comparison with the other machines. Data can be accessed at any time via a web browser – even from a mobile end device.

ComoDataCenter's extensive data history is quick and easy to search with the help of various filters.
This means that users can easily carry out multi-level searches for production orders and batches. To perform detailed analyses of process fluctuations and scrap cycles, ComoDataCenter comes with a varied range of evaluation functions. The Expert version (available as an option) also allows integration of the data into the user's IT infrastructure. All production data can therefore be pooled to guarantee unlimited data comparability.

Benefits of ComoDataCenter

- All recorded process data is stored centrally
- Simple, speedy searches for production orders (filter option)
- Production efficiency can be compared across multiple batches
- Process fluctuations are detected quickly
- Recording and comparison of machine capacity utilization and efficiency
- Integrates ComoNeo and CoMo Injection devices



ComoNeoPREDICT operation point navigator – for stable part quality

The ComoNeoPREDICT operation point navigator makes it possible to determine the optimum operation point. The results of a stabilized process and reduced cycle times: increased productivity and significant cost reductions.

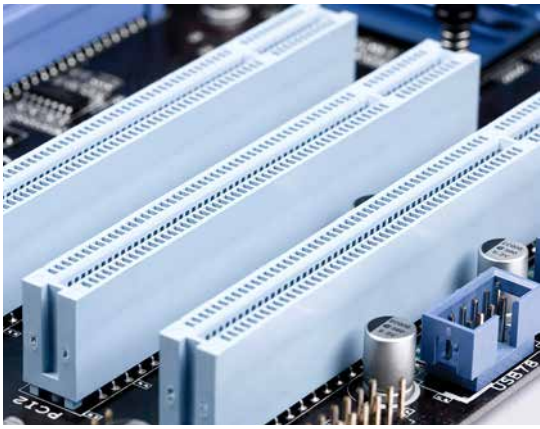
During setup and makeready, operators typically adjust the operation point of the injection molding machine by successively changing the parameters until all quality specifications for the part are met. In the setup phase, operators work by trial and error, largely on the basis of experience.

The Operation Point Navigator is the alternative to this approach: based on the freely definable setting parameters, it proposes a minimum number of trials. All parts in all trials will be measured and features such as surface quality or flash will be evaluated.

Determining the operation point
Using this data, the Operation Point Navigator establishes a relationship between the machine settings and the part's quality. The program determines the optimum operation point based on the relationship between these two parameters.

Benefits of the ComoNeoPREDICT Operation Point Navigator:

- Determines the optimal operation point
- Consistent part quality thanks to process stabilization
- Simulates the relationship between actuating variables and quality in injection molding
- Ideal for optimizing live production processes



Kistler – your partner for innovation

Kistler is a leading manufacturer of sensors and systems for quality assurance in injection molding for plastic parts. Kistler pioneered the fundamental developments in this field during the 1970s.

Today, processing companies worldwide rely on Kistler when it comes to process monitoring: they put their trust in Kistler's four decades of expertise and experience, technology leadership and our innovative strength. Major application areas in the plastics segment include electrical, medical and automotive technologies.

Visit www.kistler.com to view selected application examples such as:

- Boida Kunststofftechnik
- Fischer
- F. Morat
- HEWI
- Neo Plastic
- Brose
- and many more.

"As Head of Production, I'm familiar with all the pitfalls of injection molding for technical parts. Thanks to sensors and systems from Kistler, I can be certain that my connectors and cases to house electronic equipment for the automotive and electrical engineering sectors are fully molded."

Statement by Erich Fischer, Head of Production at Fischer GmbH & Co KG of Sinsheim

At our customers' service across the globe

Thanks to Kistler's global sales and service network, we are always close to our customers. Some 2,200 employees at more than 60 locations are dedicated to the development of new measurement solutions, and they offer customized on-site support for individual applications.

Find out more about our applications:
www.kistler.com/applications

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