Special reprint from Kunststoffe international 6-7/2017

HANSER

Erwin König

A Quantum of Relevant Data

"Quality of Things": Process Monitoring and Control Systems as Basic Building Blocks for the 4th Industrial Revolution

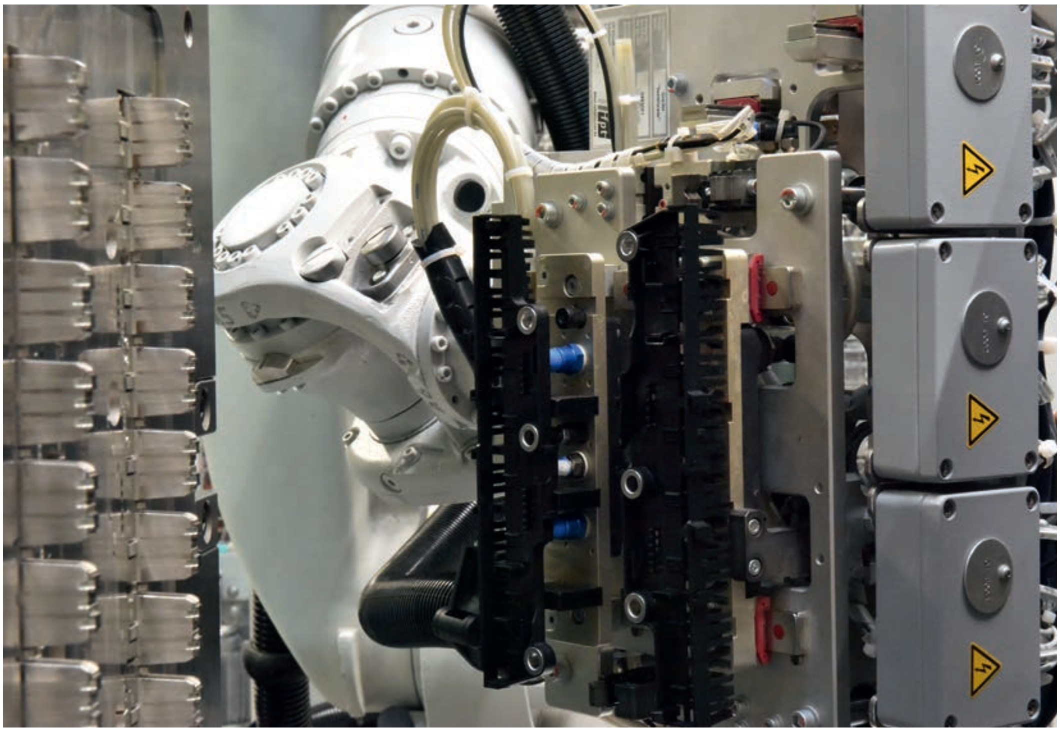
PRIAMUS
A business of BARNES GROUP INC

PRIAMUS SYSTEM TECHNOLOGIES AG
Rheinweg 4
CH-8200 Schaffhausen / Switzerland

Tel. +41 (0)52 632 2626
Fax +41 (0)52 632 2627
info@priamus.com
www.priamus.com

Special reprint

Masthead
Publisher: Carl Hanser Verlag GmbH & Co. KG, Kolbergerstr. 22, 81679 München



Plug-in connectors being automatically removed from the mold by a robot (© Priamus)

A Quantum of Relevant Data

"Quality of Things": Process Monitoring and Control Systems as Basic Building Blocks for the 4th Industrial Revolution

The use of cavity pressures and cavity temperature signals to control, monitor and regulate the injection molding process is the state of the art in the production of technically sophisticated plastic parts. The 4th industrial revolution is opening up untold possibilities in the automation of administrative, technical and planning processes. Such control systems are an ideal source of data of the highest relevance and information density.

Utilizing and evaluating data obtained from production systems entails networking all installation components and possibly additional sensors with each other under all kinds of outlay and merging as much data as possible, mostly in manufacturing execution systems (MES). Interfaces often cause difficulties because they are so varied and because there is a lack of standards. What is more, not all device manufacturers have gotten around to offering a digital communication interface.

A further hurdle is data synchronization, which usually requires the use of a time-stamp and in many cases does not proceed satisfactorily. Vast data sets are generated because often too much information is collected. And the more data that is available, the more complex and unreliable the evaluation becomes. It is probably safe to say that the bulk of the data is not very useful, complicates the analysis and leads to wrong conclusions.

The question then arises as to which evaluations are necessary and useful, how they can be improved if necessary, and whether it might not be more effective to employ the open- and closed-loop control systems that are already established. After all, these can deliver already evaluated data with a high information content from an optimized production setup. That would obviate the need for acquiring additional data, the usefulness of which is doubtful in many cases (**Fig. 1**).

Advantages of Data from the Cavity

Sensor-based monitoring and control systems visualize and analyze the injection molding process and initiate corresponding open- and closed-loop control steps to improve parts quality and production consistency. They help users to identify and eliminate production problems and to document the measures and

Fig. 1. The Fillcontrol process control system as a central component in the "Quality of Things" (source: Priamus)

the successful outcome. They not only furnish reliable data on the quality of each individual molded part virtually in real-time (**Fig. 2**) but also provide information about production indicators that serve as the basis for analyses and further optimization measures.

Unlike statistical methods, which are based on random samples and are not available in real time, these are results which have been obtained from all the parts which have been manufactured. As such, this already constitutes a high-quality evaluation and pooling of information that can be used further. Users should not forgo this in favor of cheaper and less useful information which is not process-based. That would be inconsistent, inefficient, and uneconomical.

Quality Assurance and Control Systems Provide Important Information

KE Elektronik GmbH in Kressberg-Marktlustenau, Germany, is a member of the Amphenol Group of companies. Its core competences lie in polymer engineering, pipe processing, and construction and joining technology. KE Elektronik directly supplies the leading tier 1 electrical and electronic subcontractors from the automotive and aerospace industries whose systems are shipped to nearly all vehicle and aircraft manufacturers around the world. For the production of plastic connector strips (**Fig. 3**), the company relies on Fillcontrol systems (supplier: Priamus System Technologies AG, Schaffhausen, Switzerland). Unlike machine control systems, these have a variable response to process fluctuations triggered by changes in material, material preparation, ambient conditions or temperature control in the injection unit, hot-runner and mold.

The key characteristics determining the quality of the PA66-GF25 connector strips are the overall length, the spacing of the connector chambers and the warpage of the strip, which must be maintained over temperatures of -40 to 150 °C in accordance with the auto maker's specification. Process approval requires that the parts be measured under standard conditions in order that compliance with tolerances may be assured across the full temperature range.

The Fillcontrol system keeps the process constant during production. Specific machine parameters have no bearing on the quality of sophisticated molded parts and so are of little use where the process reliability of each individual cavity is required. At KE Elektronik, the melt flow in multiple hot-runner molds is almost continuously automatically balanced and evaluated via the Priamus system – with additional process controls available for measuring viscosity, compression and shrinkage if required by the specification. Sensor-based process visualization alone is capable of immediately identifying weak points or faults so that they can be rectified.

This also applies to all systems of relevance to the process. Measurement of cavity pressure and temperature or communication with these peripheral systems within the control systems enables weak points or faults to be detected. For example, a temperature control device failing to reliably maintain the required temperature will be detected either by a change in cavity temperature or by actual readings at the interface. With regard to cavity temperature control, it is also unnecessary to monitor the setpoint and actual value, flow rate and tubing in order to gauge the correct mold temperature.

A temperature sensor is installed in the cavity wall wherever a certain temperature must be ensured and is sufficient to indicate changes in the entire temperature control system. The Fillcontrol system even makes it possible to correct deviations within predefined limits and to keep shrinkage at a constant level [2–4]. Another of the numerous features of this system is melt-front-dependent switchover to holding pressure [6] as a way of smoothing out viscosity fluctuations and thus always en-

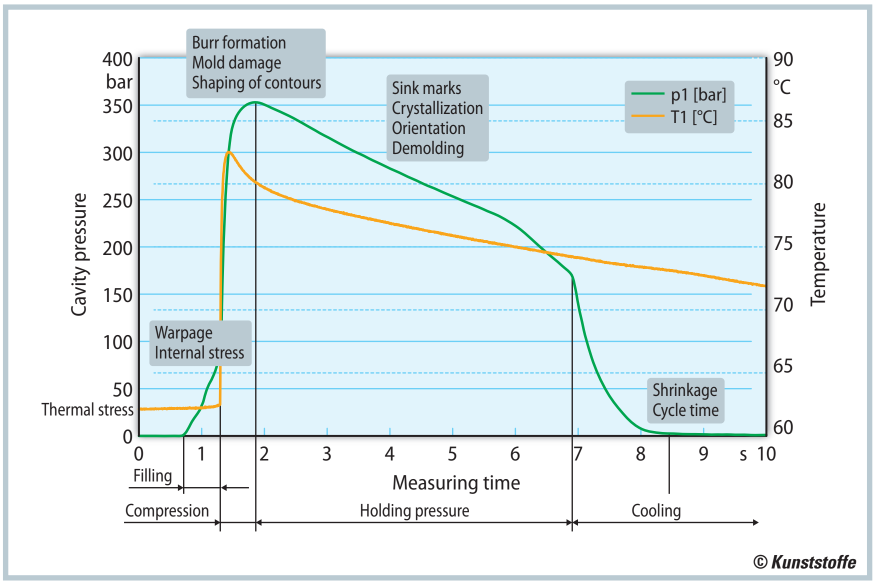


Fig. 2. The characteristic curve of the signals from the cavity pressure and cavity temperature sensors can be used to evaluate and monitor almost all quality characteristics in each cavity (source: Priamus)

suring the optimum switchover point. Yet another is automatic hot runner balancing [1–4], which ensures that the cavities in multiple molds are always filled simultaneously.

All Deviations Reveal themselves in Pressure and Temperature Readings

Sensors in the cavity help to determine start-up scrap. The system detects when the cavity temperature lies within the specified limits after startup or a downtime (**Fig. 4**). The same applies to all other monitoring functions, and even combinations thereof. Any change in material charge or other input condition can be reliably detected by monitoring the viscosity inside the mold by means of cavity pressure and temperature sensors (**Fig. 3**) – the deviation can be regulated accordingly as well [7]. The degree of compression in the molded part provides information about the strength, fill and dimensional stability, and the same considerations apply here.

Nearly all deviations in the systems in the injection molding process reveal themselves in the cavity pressure and temperature readings. It therefore makes most sense to largely base process validation on these readings. This approach saves a great deal of effort, manpower and costs and is at the same time self-monitoring, as failure of one component immediately leads to the identification of a bad part.

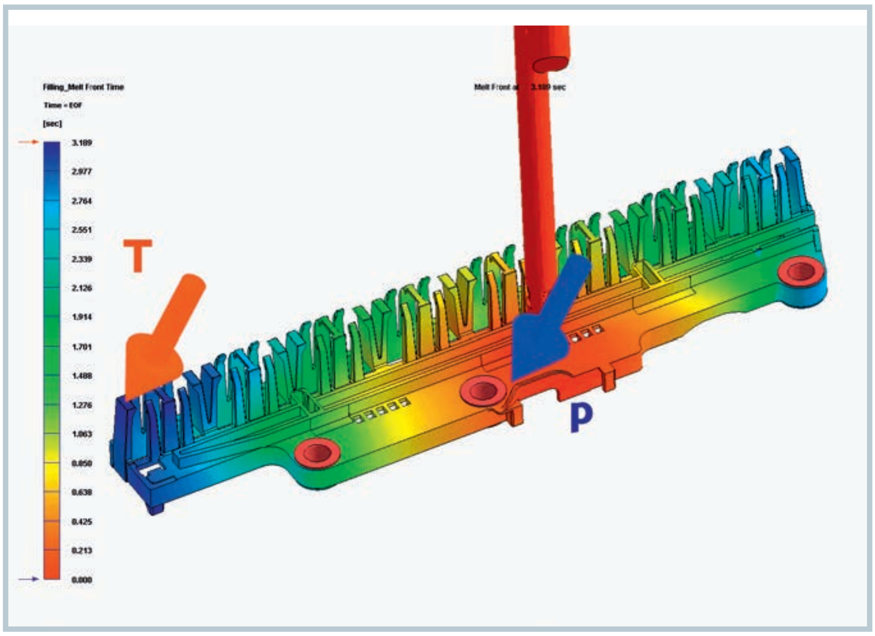


Fig. 3. Correct positioning of the cavity pressure and cavity temperature sensors offers plenty of scope for controlling and regulating the injection molding process in order that sophisticated parts may be produced in consistently good quality (© Priamus)

Networking with Interlocked Process

System networking and the security of all relevant data are of great importance to KE Elektronik. The primary goal is to interlock the process so as to avoid errors from the outside and to ensure maximum process reliability. For example, only approved machine configurations and, where possible, approved peripheral devices for the production of a particular molded part are made available on the master computer interface. The prepared material is compared with the specifications and checked. The production data from the molding machine, the hot-runner controller and the Fillcontrol system are fed to the MES via various interfaces, and the package units – in some cases the very molded parts themselves – are labeled or coded for the sake of traceability.

Attempts are made through individual assessments to keep data volumes as

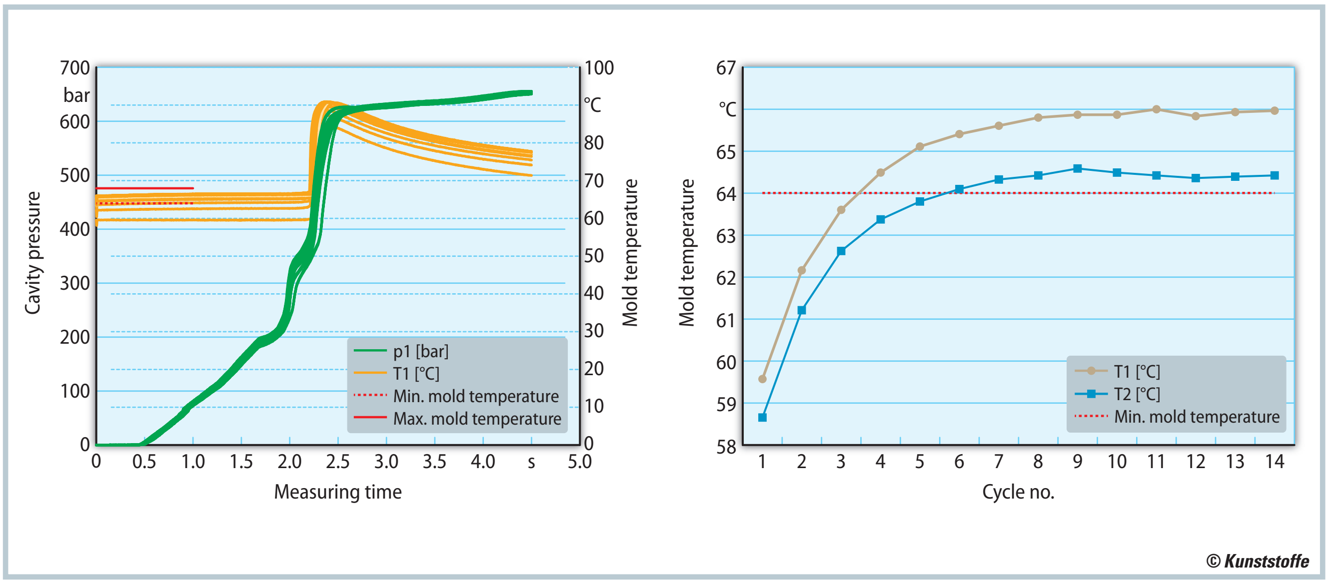


Fig. 4. The trend data (right) for the cavity wall temperature clearly reveal when the process is in thermal equilibrium after startup or a downtime. Scatter is clearly indicated by the overlapping of the curves (left) (source: Priamus)

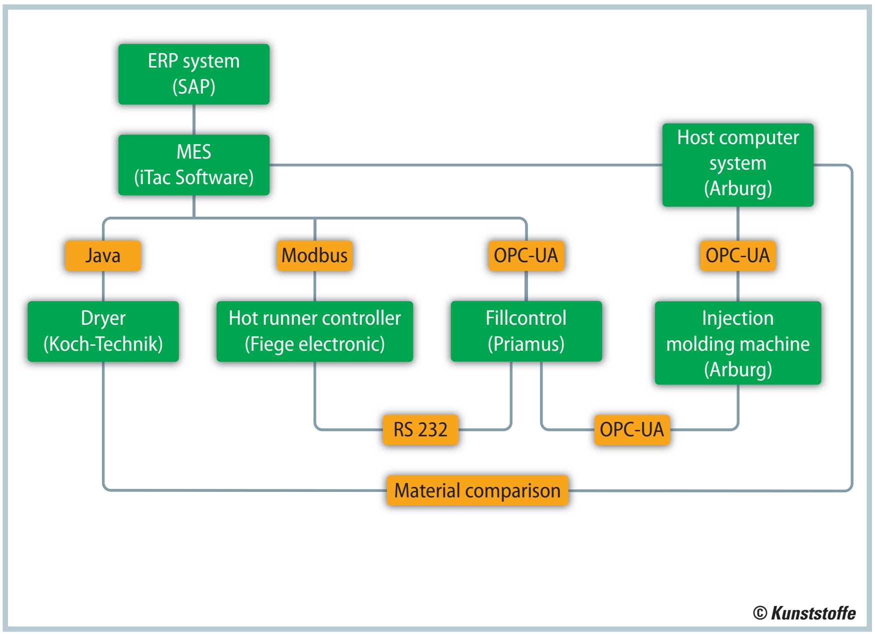


Fig. 5. Networking of plant components in the production cell for connector strips at KE Elektronik (source: Priamus)

low as possible and to use only data of high relevance. But it is not just the data volume which can cause problems. There are so many different system interfaces and these can sometimes be incompatible. This leads to complex structures which cannot be mastered without specific specialist knowledge and can give rise to barriers (**Fig. 5**).

Yet there are also huge upsides to recording the relevant data. In the event of a complaint, the Quality Assurance department can access it quickly and prove that no bad parts passed through quality control undetected. This slashes the outlay required for verification. For example, it is possible to show how material fluctuations have evolved over a longer period of time and what corrective action was taken.

Conclusion

The goal of networking in production must be a simple networking structure with powerful interfaces. There must be no restrictions imposed on the information forwarded to various visualization and evaluation systems. The entire system must lend itself to expansion at any time so that it is future-proofed. It is important to generate process-relevant data which supports further analysis and optimization. In this connection, it is advantageous to have a central component in a production cell which collects the data from the participating systems and forwards it to the higher-level systems (**Fig. 6**).

For maximum efficiency, these solutions should be tailored to the injection molding company. The past has shown that large, general-purpose systems are rejected by users because they are too complex. Proceeding on the assumption that each injection molding machine will be networked in the future, it is expedient to have a quality assurance and control system such as Fillcontrol in place as a way of keeping data volumes small and relevant. At Priamus, this is called "Quality of Things". ■

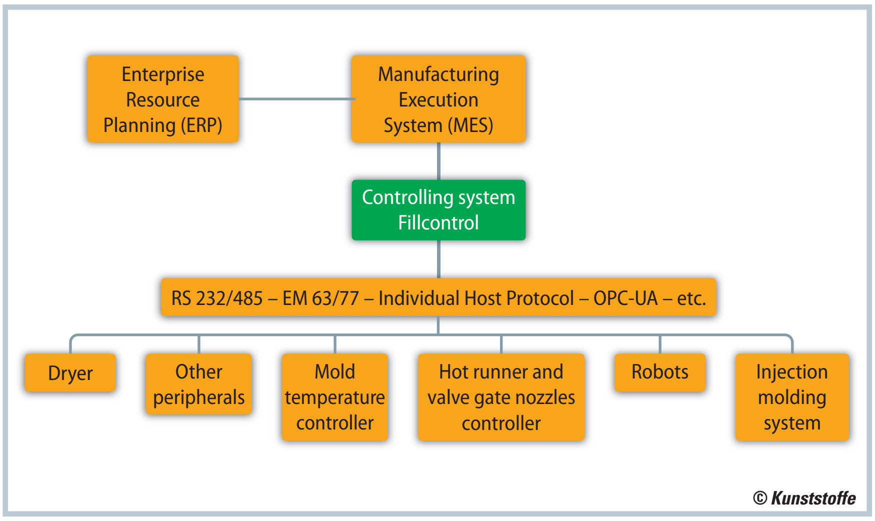


Fig. 6. Future-proofed, simple networking structure, with Priamus Fillcontrol acting as the central filter for quality-relevant data (source: Priamus)

The Author

Dipl. Ing. (FH) Erwin König has been Managing Director of Priamus System Technologies GmbH, Salach, Germany, since 2001; salesde@priamus.com

Acknowledgments

The author would like to express his gratitude to Klaus Kamm, Manager Design Engineering, and Jörg Schöniger, Team Leader Process Development, both of KE Elektronik GmbH, Kressberg-Marktlustenau, Germany.

Service

References & Digital Version

- You can find the list of references and a PDF file of the article at *www.kunststoffe-international.com/3485469*

German Version

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

Switzerland (Headquarters)
PRIAMUS SYSTEM TECHNOLOGIES AG
Rheinweg 4
CH-8200 Schaffhausen

Tel. +41 52 632 2626
Fax +41 52 632 2627
info@priamus.com
www.priamus.com

Germany
PRIAMUS SYSTEM TECHNOLOGIES GmbH
Postweg 13
DE-73084 Salach

Tel. +49 7162 930 60 480
Fax +49 7162 930 60 481
salesde@priamus.com
www.priamus.com

USA
Priamus System Technologies, LLC
3061 Nationwide Parkway
Brunswick, OH 44212

Tel. + 1 877 774 2687
Fax + 1 877 678 5062
salesus@priamus.com
www.priamus.com