Part 3 of the Series: Digitalization in Compounding

Every Unit Counts

In the second part of the series the digitalization applied in injection molding was presented with examples. The quality of the granulates used, produced in the upstream compounding process, is an important influencing factor via the viscosity. Can consistent granulate quality be achieved through the use of digitalization in compounding? Does comprehensive data recording bring with it further use cases, and what special attention must be paid to a continuous process? The Eastern Switzerland University of Applied Sciences presents the first results of internal projects.

Alex Ramsauer (left) and Prof. Daniel Schwendemann from IWK take a critical look at the data analysis. © OST

The collection of data along the entire value chain including different processes (here compounding and injection molding) can help to establish correlations between component properties and the data information from both production processes. This information can also be used to reduce fluctuations in compounding, thereby improving the injection molding process. Monitoring this data allows anomalies in the process to be detected in an early stage, such as varying melt temperatures or torque pickups. If these anomalies can be reduced, cost- and time-intensive quality checks at incoming goods can be partially dispensed.

A fundamental requirement is to consider and analyze the compounding process. In line with the use case framework from part 1 and the process concept for digitalization presented in part 2 of this series, the first step is to define six possible use cases with high potential for data acquisition during compounding.

For the consideration of coupled processes, the use case "Direct improvement of product quality/process stability" is of relevance. For this reason, it is first considered which process information can be supplied and which are necessary for the use case.

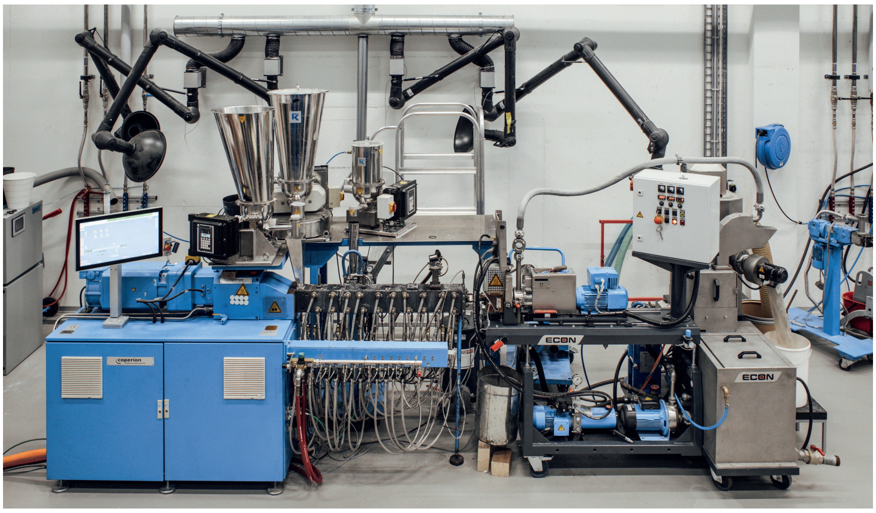

Fig. 1. The compounding plant at the IWK in Rapperswil, Switzerland, was the basis for the internal research project on digitalization. © OST

The Challenge of Data Acquisition during Compounding

In contrast to the discontinuous injection molding, compounding is a continuous process. The data can therefore not be directly assigned to a single part via a cycle but must be continuously recorded and then assigned to different material batches. The challenge here is to assign the recorded process data to the granules produced in such a way that they can be referred to during further processing. Among other things, this interferes with the modeling between the parameters of the compounding process and the quality data of the produced granules. However, it is very possible to constantly monitor the process and thus detect anomalies (process fluctuations) at an early stage.

A compounding line can basically be divided into four subassemblies, storage and finished granules are also considered, as in **Figures 1 and 2**.

Depending on the process control and the number of liquid and solid additives added, the process varies in complexity. Here, each component provides important process information for the process, which is shown in **Figure 3**. The data information is color-coded according to the following groups: temperatures (red), pressures (blue), speeds (orange) and torques (green).

The aim now is to record and evaluate this information from the compounder and its peripheral devices as well as additional sensors. However, standardized interfaces such as Euromap and OPC UA are rarely used for compounding plants, which makes data recording more laborious. As shown in **Figure 3**, a compounding plant consists of many peripheral units from different companies, which are often only combined with main functions (on, off and enable) centered in one control system. Because the manufacturers usually use their own controls and interfaces, data recording is made much more difficult. According to this, often no data for energy consumption and the exact operating data of the peripheral units can be tapped. In practice, this leads to isolated solutions that do not allow overall recording, evaluation, and optimization.

A central data acquisition system will be set up at the Institute of Materials Technology and Plastics Processing (IWK), which will acquire the data from **Figure 3**, combine them and store them using a common time stamp. The choice of the sampling frequency of the individual signals is crucial here. In contrast »

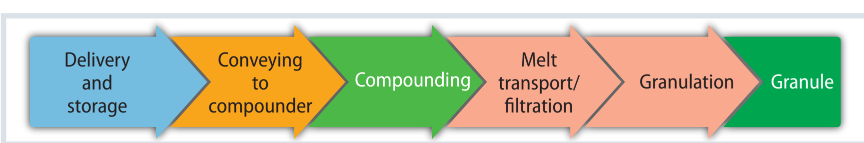

Fig. 2. Main process steps during compounding. Source: OST; graphic: © Hanser

Info

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The Series

This series of articles consists of three parts. Part 1 "Implementation of Industry 4.0 in Injection Molding and Compounding" appeared in Kunststoffe international 7/2021, part 2 "On the Way to the Smart Injection Molding Factory" in issue 9/2021.

Digital Version

A PDF file of the article can be found at ***www.kunststoffe-international.com/archive***

German Version

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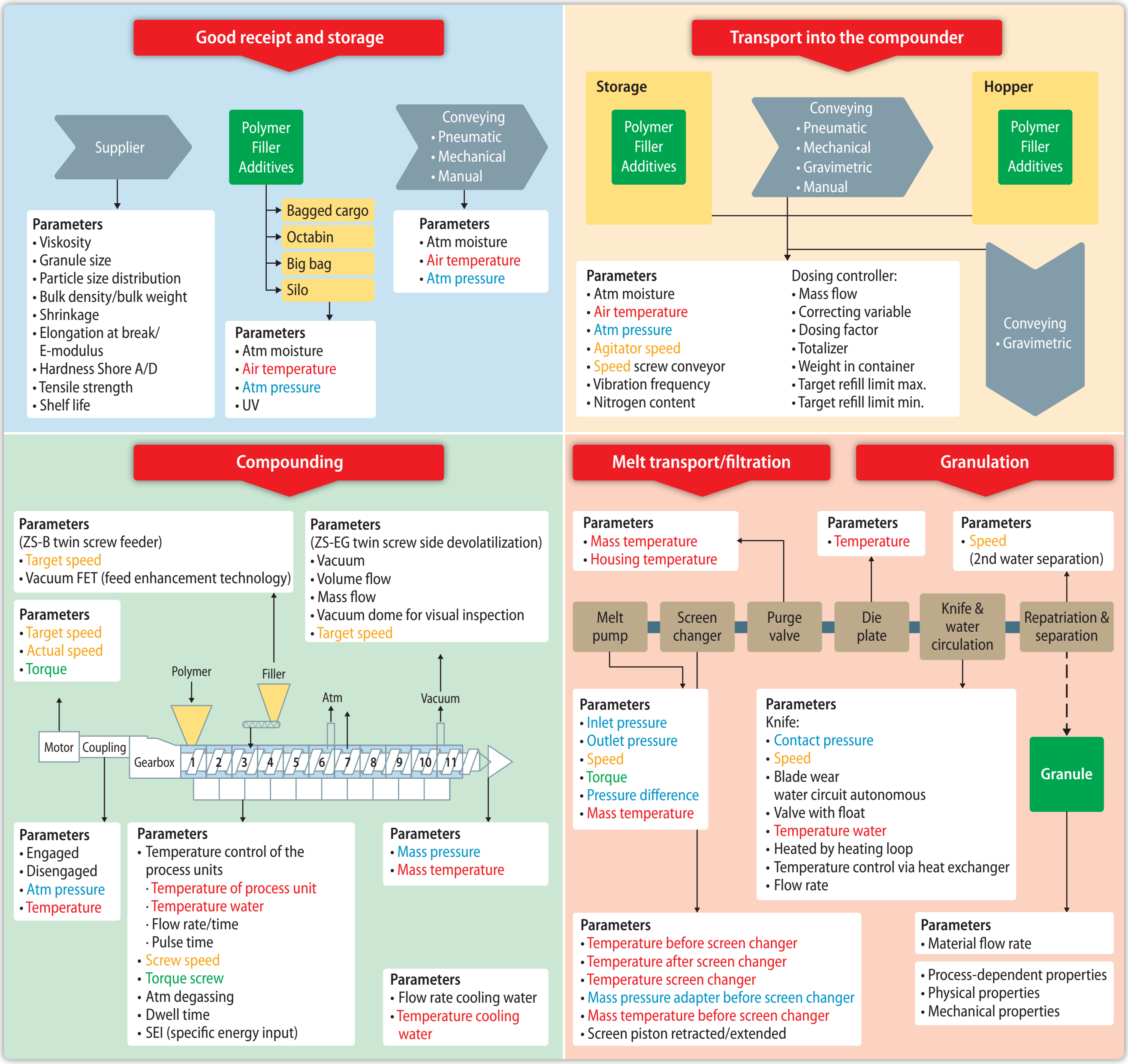

Fig. 3. Overview of the main influencing variables of the compounding process – simplified and divided into process steps. Source: OST; graphic: © Hanser

to injection molding, this usually does not have to be high frequency in compounding, since the processes are often run-in and do not change at short notice. Nevertheless, it must be possible to detect short-term process fluctuations and form suitable characteristic values with a minimal loss of information. The storage space required for the data also plays a decisive role here.

Experimental Setup and First Use of the Data Acquisition

The ZSK-26 compounder at the IWK is equipped with a Siemens S7 controller, which can be well integrated into the data recording. Individual peripheral units have new types of controls and standard interfaces; these can often be integrated directly into the data recording system without major additional expense. For other units, without common interfaces, individual solutions must be worked out in each case. Additional sensors, installed in the compounder or in various peripheral units, can be integrated directly into the data recording. For this purpose, an I/O system is used in which analog and digital current interfaces can be connected and recorded via specific terminals.

It must also be possible to assign further data from upstream and downstream processes that are not recorded in real time to the data recorded in the process. The upstream processes include for example material drying and the downstream processes include granule properties, such as viscosity measurement in the laboratory. For the upstream processes, this is not a simple issue, which is why the concrete implementation is still a target to reach. For the downstream processes, the information can be added batch by batch to the previously stored data.

The data acquisition system that has been set up is already being used for research projects at the IWK. A central major topic for the future is to optimize the energy efficiency of the compounding plant, however, this can only be reached, when the networking of the entire plant is considered.

Further topics are the improvement of process understanding when adding water-based liquid-dosed fillers and the monitoring of process stability. In one project, important findings were obtained by combining the signals from built-in sensors and parameters of the compounder and peripherals. In addition, a deeper understanding of the project made it possible to identify the critical point when adding liquid fillers.

The knowledge gained in compounding can also be used for extrusion. Correlation with the end product is easier here. Because in extrusion the recorded data can be assigned to the extrudate, for example, via the linear meters of the profile. ■

Use Case	Description
Direct improvement of product quality/process stability	With real-time access to the data and information during the process, material characteristics can be kept constant. Based on the historical data, disturbance patterns can be detected by machine learning.
Indirect improvement of product quality	An increase in product quality can also be achieved after the process. Different qualities/material properties are produced, to mix the different batches in a further step in such a way that, for example, the desired viscosity is achieved.
Remote access	The operator can access the most important process parameters of the complete plant online and in real time. In addition to that, the most important information and specifically desired data are provided, for example on monitors at the desired locations.
Predictive maintenance	Through the targeted installation of sensors and the recording in a central database, the wear of the plant can be monitored and optimized. This also enables access by external experts and thus early and more efficient maintenance measures and possibly simplified maintenance.
Logistics	The complete storage information of the materials used is recorded and entered into the data structure as an upstream process. This enables traceability in case of process variations and monitoring and optimization of storage.
Optimization of energy efficiency	Centrally recorded data for the entire plant, including all peripheral units, provide an overview of current and past energy consumption for various processes and configurations. This data is the basis for optimizing energy efficiency.

Table 1. Possible use cases for the compounding process. Source: OST