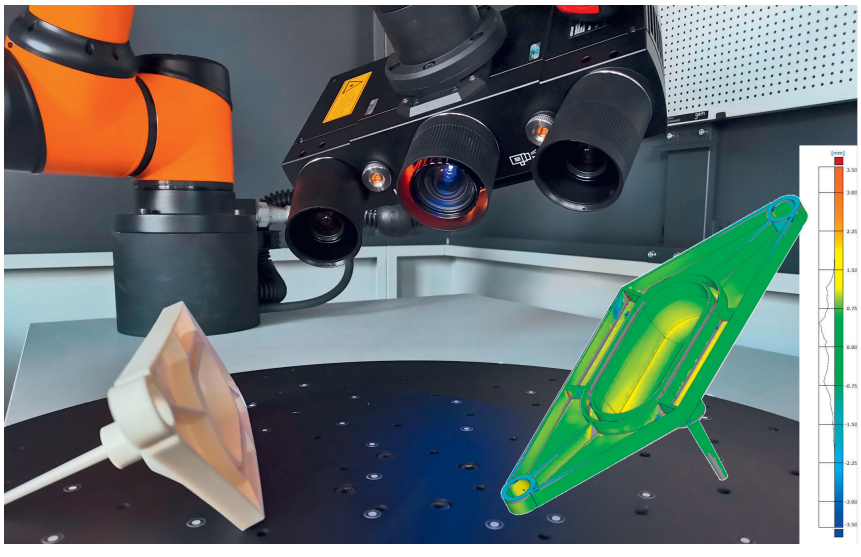
Part 10 and Conclusion: The Digitalization of Plastics Processing Gets a Home

Everything under One Roof

With the completion of the Plastics Innovation Center 4.0, the research infrastructure of the IKV in Aachen, Germany, has been significantly expanded. In conjunction with the expansion of the digital network architecture, researchers can increasingly focus on pragmatic solutions and industry-related projects for digitalization in the following years. The last article in this series takes a look at the technical possibilities for industry-oriented research with project partners.

The newly built Plastics Innovation Center 4.0 (PIC 4.0), which can be used for research purposes, covers 4150 m^2. The seminar room, which is centrally located in PIC 4.0 and has a total area of about 300 m^2, opens up a direct view to the technology center so that trial processes can be demonstrated and observed in a practical manner at project meetings and project-related committees. The tool shop is located one floor below, so that training courses on injection molding simulation, mold making and process setup as well as their digital networking with practical content can be offered in the modern equipped training room next to the practical areas.

The measurement laboratory contains numerous devices for the tactile and optical measurement of component geometries and surfaces as well as electrotechnical equipment for creative work on new sensor and measurement technologies. These include, for example, the O-Inspect 442 from Carl Zeiss AG for tactile measurement of component dimensions (measuring space: 400 x 400 x 200 mm^3; measuring accuracy: 1.6 µm) or the MicroGlider from Fries Research & Technology GmbH for optical measurement of component surfaces (sensor resolution: 10 nm locally in the z-direction and 1 to 2 µm in the xy-direction).



Optical measurement and CAD export of the real component geometry allow deviations from the original and simulation geometry to be compared node by node. © IKV

In addition, a GOM Scan Cobot with Atos Q sensor from Carl Zeiss GOM Metrology GmbH enables the rapid optical measurement of components. Using two 12 megapixel CMOS cameras, a CAD export of the measured components can be carried out automatically in a few minutes in order to compare the real geometry directly with a filling simulation (**Title figure**). Smaller laboratory instruments such as the Halogen Moisture Analyzer HX204 from Mettler Toledo GmbH complete the equipment of the measurement laboratory. The latter enables the determination of the residual moisture content of a granulate sample to a repeatability of 0.01 % and provides drying curves in real time to be able to react quickly to residual moisture fluctuations in trial runs in the PIC 4.0 technology center.

Big Technology Center for Complex Research Processes

The 1100 m^2 processing-area provides space for the numerous testbeds for digitized plastics processing. In addition

Cooperation with Industrial Partners

The new research infrastructure offers numerous opportunities to test potential systems and technologies for digitalization at the IKV and to evaluate their added value for the company's own production and process-related issues in advance. After being contacted by a company, the employees at PIC 4.0 identify the respective problem for data acquisition, analysis or user-friendly applications. Profitable solutions are then developed in joint projects or in a consortium. The research infrastructure of the PIC 4.0 can provide support up to the proof-of-concept stage at the IKV, so that the subsequent industrial implementation is a success.

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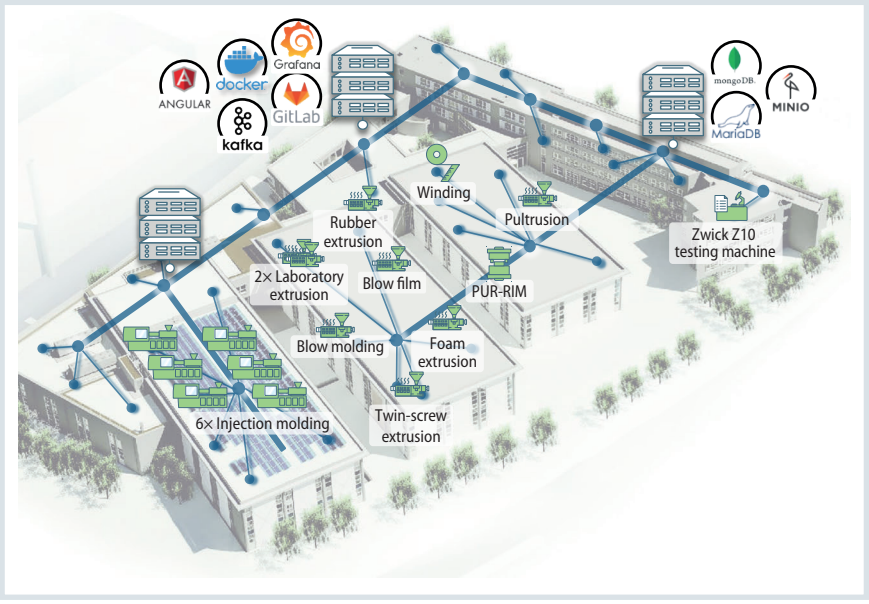

Fig. 1. Connectivity to machines and plants at the IKV has also been expanded beyond the PIC 4.0 technology center; numerous machines enable data-based insights into the process. © IKV

to central material storage and drying, there are testbeds for process setup using artificial intelligence and for processing recycled material [1, 2]. Continuous data acquisition in the PIC 4.0 supports all manufacturing processes [3, 4]. The majority of machines and systems communicate directly via OPC UA or the corresponding Euromap specifications for this purpose. A few still have to be integrated into the digital infrastructure via older interfaces such as Euromap 63 or individual retrofits and separate data acquisition systems (for example, real-time measurement systems to analog signals).

The research focus in the technology center is on injection molding processes with currently ten injection molding machines from different manufacturers in the clamping force range between 350 and 2400 kN. Six of these machines communicate via OPC UA or Euromap 77, two via the older Euromap 63. The necessary peripherals in the form of handling robots and temperature control units are either integrated directly into the data network via the machine or also already follow the Ethernet-based OPC UA interface. Decentralized material conveying systems for a transparent and controlled material flow complete the infrastructure. A host-computer-system provides continuous insights into ongoing trials and highlights disturbance variables that can be directly incorporated into process control. As a result, solutions for connecting machines and devices can be investigated, developed and provided in the PIC 4.0, both on the hardware and software side.

Transferring Research Results to Practical Use

The collection of machine data forms the central core of the service-oriented information and software architecture. Individual software-interfaces (so-called connectors) are developed for all devices and system components, unless the manufacturers provide such interfaces in the form of standardized interfaces. In addition to the data acquisition from injection molding machines in the PIC 4.0 technology center, equipment in the fiber composite and extrusion technology center is also connected to the network (**Fig. 1**). For example, a twin-screw extruder by Coperion GmbH was retrofitted with an OPC-UA-interface, as was the BM-206 blow molding machine from Beckum Maschinenfabrik Traismauer GesmbH. As a result, data on melt temperature »

and pressure as well as die temperature, traversing speed, blowing pressure and time can be continuously measured and recorded, even in a large number of extrusion processes, in order to implement real-time process control and regulation on this basis.

Among others, the data acquisition is fed by laboratory extruders of Brabender GmbH & Co KG on the one hand and Collin Lab & Pilot Solutions GmbH on the other hand, as well as a rubber extruder of TSM GmbH. In foam extrusion, melt pressures and temperatures, extruder speeds, engine performance, and extrudate dimensions and temperatures are also recorded and fed into the databases via the PIC 4.0 data acquisition system. For this purpose, the tridem-setup consists of a melting extruder from Windmöller & Hölscher KG, a multiple rotation system from Gneuss Kunststofftechnik GmbH and an ejection and cooling extruder from Oerlikon Textile GmbH & Co. KG.

Although data availability is an ongoing area of development, especially during the initial integration of new systems, this is no longer a technical challenge with modern machines. Instead, the development of application-specific and modular services from current and future research projects is intended to demonstrate the direct added value of the available data.

Platform for Various Optimization-Modules

For this purpose, a service platform was developed at the IKV, which enables access to individual optimization modules for further research and practical application. Via the combination of

- a web-based frontend, developed in the Typescript framework Angular,
- a Node.js gateway to the Apache Kafka message broker, which is also used for data acquisition, and
- various backend programs for targeted data analysis, for example in Python, Matlab or Labview

a scalable and constantly growing range of applications is provided [5]. This allows the added value of the collected data to be visualized at a control station in the PIC 4.0 technology center to evaluate any digitalization effort for industrial processes in advance and to demonstrate the benefits.

The first service modules already implemented concern automated test planning and analysis as well as a software routine for distortion compensation through simulation-based geometry adjustment of the initial part geometry. Another service currently under development will implement a simple interface for training a neural network with subsequent AI-supported recommendations for process adjustments. Although the optimization and analysis modules implemented on the service platform cannot be equated with solutions suitable for industrial use, they represent a starting point for further developments and demonstration projects.

Closing the Gap between Simulation and Reality

With the completion and commissioning of the PIC 4.0, methods of digitalization in plastics processing will be in focus and support the investigation of further processes through complete transparency of process and quality data. In particular from the Cluster of Excellence "Internet of Production" at RWTH Aachen University, research on data-based set-up procedures can be continued and demonstrated close to the industry, as well as those on "Plug & Produce" applications through the Industry 4.0 administration shell or simulated cooling sections in extrusion.

The measuring-nozzles designed and retrofitted to many injection molding machines in the PIC 4.0 technology center for measuring screw antechamber pressure and melt temperature also allow the machine-specific process-behavior to be characterized in the form of a digital shadow. Correlation with existing research approaches to process optimization thus reveals new dependencies and the added value of retrofitting the digital signals. Coupling these measured values, which are recorded at the interface between the real and virtual process, with the filling simulation thus makes it possible to close the gap between simulation and reality for reliable quality predictions.

Outlook

The extension of the digitalization methods from PIC 4.0 to other IKV technology centers makes it possible to analyze interactions along the material flow of the value chain. In particular, research questions on the circular economy from compounding to the injection molded product and back can be addressed in a targeted manner with the help of the developed infrastructure.

For example, the research project under the acronym KIOptiPack, which started in August 2022 and is funded by the BMBF with a project volume of EUR 23 million, also benefits from the infrastructure of PIC 4.0. Together with more than 40 project partners, application-oriented AI methods are to be developed and validated along the value chain in the packaging sector for improved recycling of plastics. ■

Info

Text

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Series End

This tenth part marks the end of the series on the PIC 4.0 – the nine previous parts were published between July 2020 and August 2022 and can be easily found in our Online Archive by naming the two authors.

References & Digital Version

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