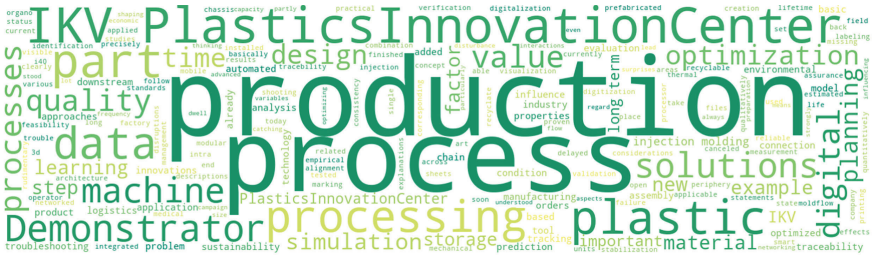
Focus on the User Benefit

Part 5 of the Series: Practical Demonstrators for the Plastics Innovation Center 4.0

In an online survey, representatives of the plastics industry formulated their expectations toward the Plastics Innovation Center 4.0 (PIC 4.0). Beside better possibilities to transfer the research results into industrial practice, the respondents expect progress in the area of quality assurance, process optimization, simulation and the linking of process chains. In order to explore these issues, representative demonstrators are being set up within the new PIC 4.0 pilot plant.



Wordcloud generated from the answers to the open question concerning the most important use cases for PIC 4.0 © IKV

With the Plastics Innovation Center 4.0 project, the Institute for Plastics Processing (IKV) at RWTH Aachen University, Germany, is erecting a technology and demonstration platform for plastics processing companies that offers solutions to urgent and relevant issues in industrial production. To support adapting the research environment to the needs of the plastics industry in the best possible way, 44 industry representatives prioritized the most important application fields in an online survey between October 2020 and January 2021.

As indicated by the response to an open-ended question about their expectations, respondents expect PIC 4.0 to have a strong practical focus and offer solutions that link multiple process steps to improve traceability. Data based process optimization is also a particular focus of interest. In addition, some respondents expect the development and application of Industry 4.0 standards or the investigation of a certain special process.

In the further course of the survey, the participants first qualitatively evaluated 23 application fields (use cases) with regard to their relevance. Finally, they highlighted the five most important application fields by awarding one to five points (**Fig. 1**).

Inline Data Acquisition for Better Process and Part Quality

From the survey, inline quality assurance emerges as the most important application field for the use of digital methods. Quality assurance relates closely to the, also highly rated, application field of *setup refinement and optimization*: an unstable process generally leads to insufficient part quality. It is well known that, particularly in injection molding, controlling only the machine parameters cannot compensate for fluctuations in raw material properties or ambient conditions.

Advanced adaptive control concepts, such as the pvT control developed at the IKV [1], allow a variance reduction compared to the traditional control of only the machine parameters; the part quality can however not be inferred directly. The same applies to commercially available products such as APC plus by KraussMaffei [2] and iQ weight control by Engel [3], which recognize material-related viscosity fluctuations by a change in the injection pressure profile and compensate for them by adjusting the switchover point. Since they do not measure the actual part quality, these control concepts are as good as the previously defined reference curve at most.

Similarly, when using unsupervised machine learning for anomaly detection, a typical process trajectory does not automatically indicate a good process. However, an inspection of all manufactured parts is usually too expensive. When inspecting random samples only, the inspection result usually cannot be linked to the exact manufacturing cycle. This circumstance also complicates establishing AI-based quality prediction models, as their training requires a large amount of process data annotated with the part quality. Therefore, an inspection of all parts is usually necessary at least for a certain period of time [4].

Alleviating the Quality Dilemma

To alleviate the quality dilemma, the PIC 4.0 pilot plant will feature a modular inspection cell for injection molded parts. A defined connection between injection molding machine and part inspection through a handling system simplifies and automates assigning the quality data to the process data and machine parameters. As a result, quality data recorded through different measurement technologies (e.g. imaging test methods, scales) is directly integrated into the cyber-physical production system. Annotated data sets that can be used to train predictive models or develop new control concepts are consequently available from a central database.

Furthermore, as demonstrated by the IKV at the K 2019 [5], such a setup can sig-

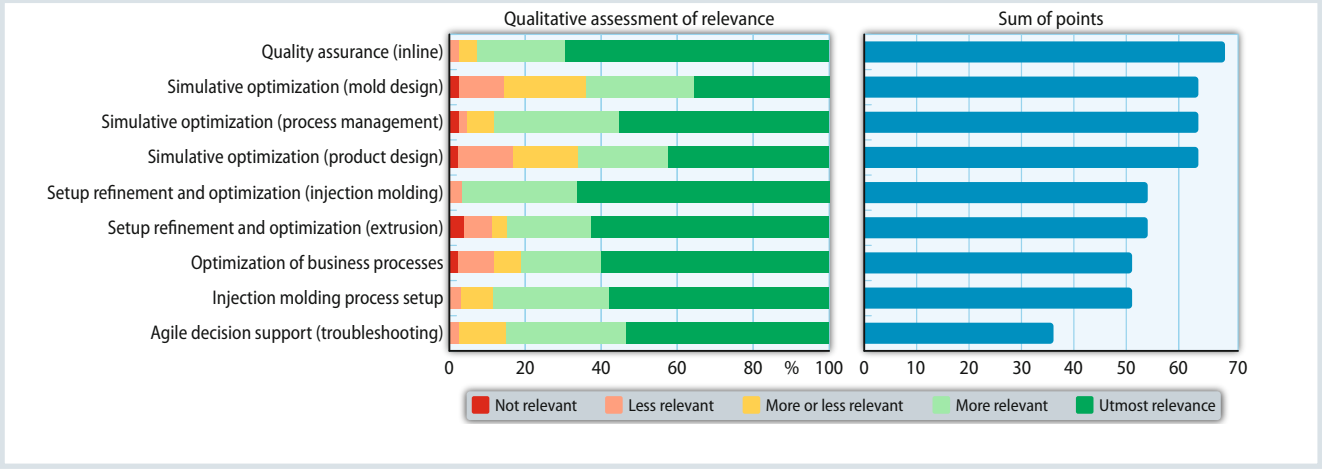


Fig. 1. Survey result (excerpt): how relevant do you consider the listed use cases (left)? Which use cases would you like to highlight as particularly relevant (right)? Source: IKV; graphic: © Hanser

nificantly accelerate the process setup during injection molding, too: combined with simulations, the direct feedback on part weight and warpage made it possible to learn a predictive model for part quality as a function of the setup parameters with reduced efforts. An optimization calculation based on the learned model delivered a functioning working point after only a few tests.

Linking the Process Chain

Many respondents expect an improved linking of data generated along the process chain. This expectation is also reflected in the high rating of the application field *feedback of process data*.

Not only the molding process, but also the composition and molecular weight of the material as well as its moisture content and thermo-mechanic history influence the properties of the molding [6, 7]. Particularly due to the »

increasing importance of circular economy and therefore recyclates, it becomes important to pass on data on material properties and processing history along the value chain and to correlate them with the resulting process and quality data. Provided significant correlations exist, fluctuations in material quality could eventually be compensated along the processing chain, thereby making the use of recyclates possible and economically viable in further fields of application.

The recycling of PET bottles provides a suitable complexity to represent an interlinked process chain on a laboratory scale; it therefore provides the basis for a demonstrator for closed material cycles (**Fig. 2**). Standardized data acquisition via OPC UA, and a central semantic data repository make it possible to link the quality data of the part with the process parameters and measured values from all upstream processing steps. For example, the mechanical energy input and thermal history of the material can be monitored throughout the entire processing chain in order to optimize processing.

Taking into account the susceptibility to damage and processing history of the material, production companies can consequently determine the most economically and technically sensible processing steps as well as an optimal process point for each step. A suitable material and processing model may for instance anticipate whether pre-damaged material, although withstanding the preforming process, will fail during blow molding.

Digitization at Your Fingertips

Many respondents wish to see practical examples of digitization solutions and better possibilities to assess their benefits. To this end, PIC 4.0 implements digital services for shop floor and production planning, which IKV employees, especially the ones not explicitly working on digitization topics in their own research, will use on a day-to-day basis. Specifically, an assistance system for carrying out experiments and a system for booking machines and equipment, which can later also serve as the basis for automated production planning, are being developed.

On one hand, these practical services help digitization researchers at the IKV to explore questions of ergonomics and usability; on the other hand, industrial customers can experience these demo applications in the research lab for themselves. Together with the demonstrators for quality assurance and circular economy described above, the Plastics Innovation Center 4.0 will thus offer a tangible experience of the possibilities of digitized plastics processing. ■

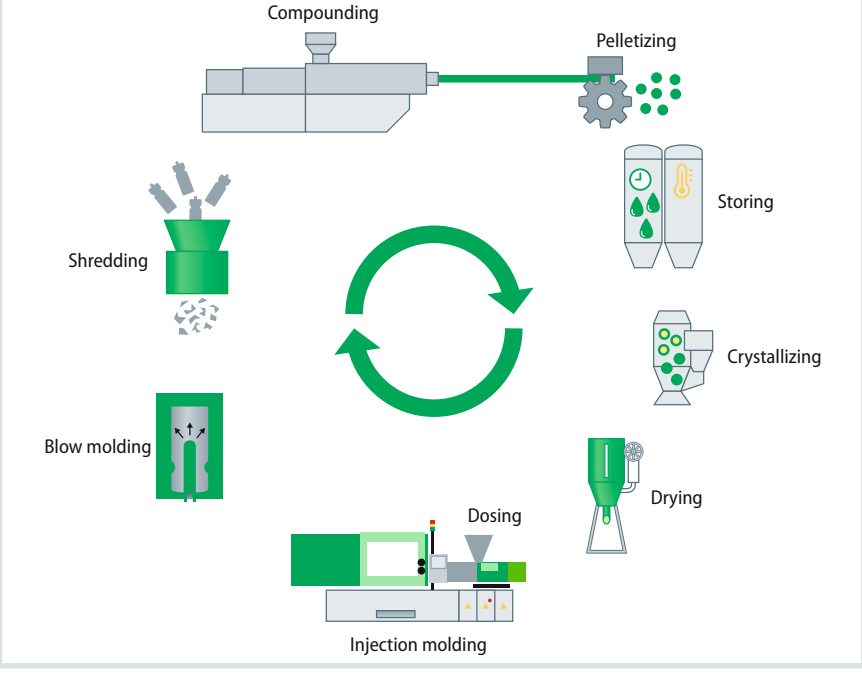


Fig. 2. PET bottle recycling constitutes a suitable use case for a demonstrator for closed material cycles Source: IKV; graphic: © Hanser

The PIC Survey

A detailed presentation of all survey results can be found at

- https://share.ikv.rwth-aachen.de/s/SinCdYGiXBBMdp2

The Authors

Univ.-Prof. Dr.-Ing. Christian Hopmann has held the Chair of Plastics Processing as Head of the Institute for Plastics Processing (IKV) in Industry and Craft at RWTH Aachen University, Germany, since 2011.
Pascal Bibow, M.Sc., is managing director of the Plastics Innovation Center 4.0.
Judith Weber, M.Sc., develops smart production systems at the IKV. Within PIC 4.0, she is responsible for use case development and testbed definition;
judith.weber@ikv.rwth-aachen.de

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The Series Continues

In addition to the physical testbeds in the pilot plant, PIC 4.0 also explores the virtual process chain in digital engineering, which has emerged as the second most important use case from the survey. In one of the next issues, the authors report on the tools of digital engineering to ensure consistent data transfer between production and development. The previous parts have been published in issues 5/2020, 7/2020, 10/2020, and 2/2021.

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References & Digital Version

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