Implementation of Industry 4.0 in Injection Molding and Compounding

Part 1 of the Series: Use Cases Based on Strategic Priorities in Plastics Processing

The challenge in digitalization is to maintain an overview of possible technologies and to identify their benefits for use cases in the own company. Small and medium-sized companies in particular find this difficult. Based on interviews in industry, this article describes a common understanding of the most important use cases. The results capture the current direction in the plastics industry.

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Industry 4.0 covers a wide range of possible technologies and applications. This increasing digitalization is opening up new opportunities for production companies. Within the framework of a three-part series of articles, the challenges of implementing Industry 4.0 in the area of injection molding and compounding production technologies will be highlighted. In this first article, the focus lies on the use cases of Industry 4.0. The question is how to identify the use cases that are relevant for a company. A focused and targeted approach based on specific use cases has proven to be promising. However, the challenge usually lies in the diversity and complexity of the different use cases. Here, a common understanding of the definition of the relevant use cases is a central point. In most cases, they form the basis for the data acquisition requirements, including the development of the necessary IT infrastructure. This view of the use cases essentially shows which signals have to be recorded and in which quality they must be available.

	Procedure steps	Description
1	Set strategic priorities	Importance of costs, quality, delivery time and flexibility
2	Select use cases	Derivation of use cases from the framework
3	Adapt use cases to specific context	Adaptation of the use cases to the individual circumstances as well as assigning the appropriate technology as a switch
4	Evaluate impact on strategic goals	Continuous assessment of the impact on strategic priorities
5	Allocation of potential and complexity	Evaluation of the use cases with regard to future potential and implementation effort
6	Implementation plan	Future development and implementation

Table 1. Procedure steps for the use case evaluation Source: based on Classen et al., 2018

This basis shows companies how artificial intelligence can be used to learn from the data of the specific case.

More about this topic will follow in the next two articles in this series. In this first article, an approach for the identification of use cases in plastics processing is presented. The results are identified use cases based on the strategic priorities of the manufacturing companies.

On the Way to the Smart Factory

Digital technologies form the core of Industry 4.0 and the basis of the many different use cases that result from it. When networked products and machines grow together in production, this leads to a smart factory [1]. Cloud computing or IoT predictive maintenance are just some of the technologies mentioned in this context [2]. There are also various approaches to implementing Industry 4.0 in the field of plastics processing [3]. The challenge is to maintain an overview of possible technologies and to derive their benefits for individual use cases for one's own company. Closely linked to the effective benefit of a specific use case is the relationship to corporate strategy.

Furthermore, the existing IT infrastructure of the companies will influence the further development and the identification of new use cases. A 2018 survey of Swiss manufacturing companies shows that small and medium-sized enterprises (SMEs) in particular are reluctant to implement digital technologies [4]. The variety of possible technologies overwhelms small and medium-sized enterprises in particular in identifying the use cases that are relevant for them. The study also shows that the focus of smaller companies lies on increasing sales, whereas medium-sized companies are concerned with increasing efficiency. Companies with a size of 500 employees want to increase both sales and efficiency by selecting suitable use cases [5]. This gives first »

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indications, where the focus of possible use cases lies.

Six Steps to the Right Use Cases

The structured approach in the identification of suitable use cases enables companies, based on strategic priorities, to identify technologies for their own production. This article is based on the use case framework for the smart factory [6]. **Table 1** shows the procedure structured in six steps for the evaluation of suitable use cases.

The framework shows small and medium-sized companies in particular how to quickly identify potential use cases. With the help of the generic use cases, a common understanding can be built up and the question of the appropriate implementation of digitalization measures can be discussed. The most targeted use of the required resources is related to the maturity of the infrastructure and the processes of the company.

In order to identify the relevant use cases in the field of injection molding, five companies were surveyed on the generic use cases. The results should be viewed critically as the sample can not be regarded as representative of the basic industry population. The results of this article are mainly suitable for highlighting general trends.

The interviews focused on the current status of already realized implementations and the potential benefits in the future. The participants of the survey is composed of the following companies in the value chain of the plastics industry:

- suppliers of sensors and measuring systems (1),
- machine manufacturer (2), and
- processing industry (2).

By selecting companies along the value chain, the priorities can be shown for the plastics industry. The various people interviewed were each asked to take the point of view of the processing industry, so that agreements can be shown with regard to the prioritized use cases. The following results claim to capture the current direction in plastics processing.

Application of the Method in Practice

With the definition of the strategic priorities and the resulting core processes, the common consensus on the most

The Series Continues

The following two articles highlight the challenges of implementing specific use cases and learning from data using artificial intelligence in the field of the production technologies injection molding and compounding.

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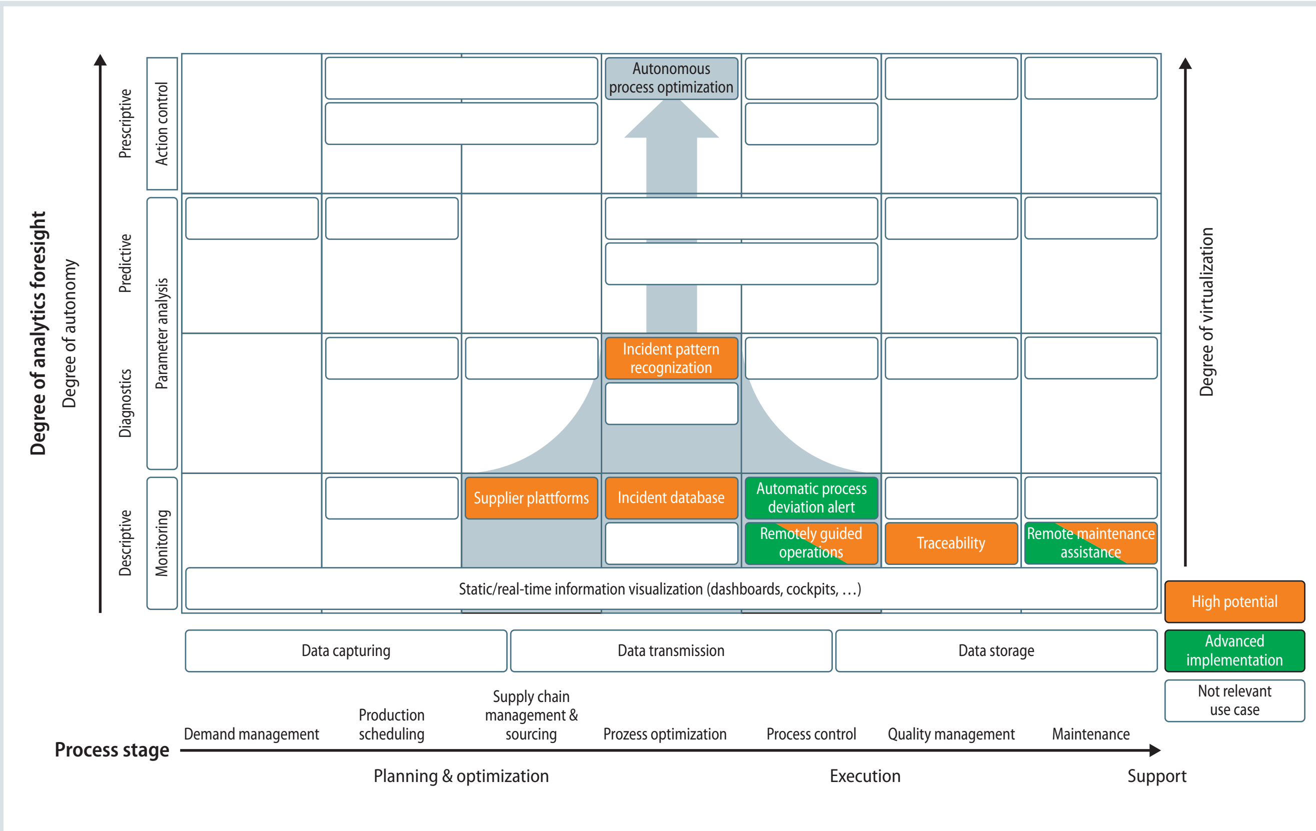

Fig. 1. Framework of generic use cases Source: based on Classen et al., 2018; graphic: © Hanser

Use case	Description
Autonomous process optimization	Real-time access to data and information enables optimization across multiple system levels, making recommendations and automating actions in a closed feedback loop. A self-optimizing process is a self-adjusting, self-learning set of software technologies that work together to anticipate and adapt to future conditions.
Incident database	Centrally recorded and stored (error) data from machines and entire plants are reconciled and processed on a central server. This data forms a knowledge base about past incidents as well as the entire process history.
Incident pattern recognition	Centrally collected and stored (error) data from machines and entire plants, enable the recognition of fault patterns through Big Data analyses such as machine learning on historical data.
Remote maintenance assistance	Because machine maintenance often requires a great deal of expertise, manufacturers often rely on experts and their knowledge. Digital technologies help to decentralize this knowledge, with the expert guiding the worker without actually being on site.
Remotely guided operations	The operator is supported by technologies such as smart glasses, monitors or similar devices and receives all relevant information (e.g. for the next production step or maintenance activity).
Supplier platforms	Online platforms that allow suppliers and customers to connect with each other to offer (or purchase) various manufacturing services and goods.
Traceability	Entire batches or even individual production lots are tracked throughout the entire manufacturing process. Each completed process step is automatically recorded in the system, resulting in greater transparency and traceability.

Table 2. Description of the generic use cases Source: based on Classen et al., 2018

important use cases can be established. **Figure 1** illustrates the common view of the companies surveyed with regard to the potentials and the current status of their implementation. The use case framework for the smart factory can be used to draw conclusions about relevant use cases based on the corporate strategy.

The evaluation revealed a common consensus on seven use cases. All of these show high potential. The exact definition of the use cases is recorded in **Table 2**. The two use cases "Remotely guided operations" and "Remote maintenance assistance" have already been partially implemented and ensure the decentralized exchange of knowledge between machine manufacturers and the manufacturing industry.

The remaining five use cases are being tested for implementation on the basis of preliminary studies or concepts. The survey showed that the trend is toward "autonomous process optimization", with this use case representing the highest level of maturity in the framework. The common effort towards the reduction of downtime leads to the optimization of process efficiency via clearly defined fault conditions. The integrated data flow via a central database provides the basis for implementation. The goal of autonomous process optimization at the machine or plant level requires that both the transmission and the analysis of the parameters are mastered.

The interviews showed that the companies are already working on many use cases. However, the knowledge learned usually remains with the project team involved. As a result, it is difficult for the companies to record progress in terms of implementation.

The presented framework supports the prioritization of use cases as well as the implementation based on the specific context in the companies. The results of the six process steps are developed by a project team. The common understanding leads to an early clarification of what influences the implementation and what advantages are achieved in terms of costs, quality, delivery reliability and flexibility. The multi-stage approach in conjunction with clear strategic goals means that existing knowledge can be built upon through previous projects. The definition of specific use cases is of central importance when talking about the same throughout the company. In general, the identification of use cases should be carried out using a defined method in order to deploy resources in a targeted manner. ■