Chapter 17
A Maturity Model to Organize the Multidimensionality of Digitalization in Smart Factories

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ABSTRACT

Smart Factory concepts describe fully networked, autonomous factories and form an essential part of flexible, but still highly efficient production systems. The requirements for the further development of existing production environments towards a Smart Factory are multidimensional and vastly complex. Many companies therefore fail in the structured realization of a holistic Smart Factory concept. They either focus one dimension of the challenge or merely address the maximum penetration of powerful technologies. This chapter addresses this issue and describes a systematic development path towards a Smart Factory by means of a domain specific maturity model. Based on the analysis of existing maturity models, requirements are derived which must be considered when realizing a Smart Factory. In total, 20 design fields (e.g., degree of intelligence, communication protocols, human-machine-interface and IT security) and respective detail descriptions result from this research. They holistically structure the relevant fields of action to pursue a Smart Factory.

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INTRODUCTION

The industry is in a fundamental shift. With the opening of new markets and increasing international competition, the environment for manufacturing companies is becoming increasingly dynamic as well as unpredictable (Bauer et al., 2014, p. 6). The trend towards product individualization up to lot size one and the overall volatile market conditions require production systems which are able to flexibly adapt to new environmental circumstances (Roth, 2016, p. 5). In order to meet this demand for customer-specific products in developed industrialized countries, solutions are needed which allow a cost-effective, complex and varied production (Baumer, 2014, p. 264). In this context, the fourth industrial revolution, known as "Industry 4.0", is currently heavily discussed. Industry 4.0 represents an approach in which information and communication technology (ICT) enables networked production in an entirely new way (Roth, 2016, p. 5; Bischoff et al., 2015, p. 1). An elementary component of this visionary form of manufacturing is the fully self-controlled, modular and intelligent factory, the so-called "Smart Factory". Powered by the opportunities of IT paradigms and technologies, physical production processes merge with the digital data recorded within smart factories (Russwurm, 2013, p. 21). By applying technologies for information generation, networking and processing, many elements of a production system can be digitalized and thus automated within processes. For example, the traditional planning functions of production systems that base on statistical models and assumptions may be replaced by real-time data driven production control (Bischoff et al., 2015, pp. 3, 8).

Thus, the interconnection of heterogeneous system elements such as sensors, actuators, workpieces, machines, and planning and control systems requires a network of previously decoupled and proprietary information and production systems (Wolff & Schulze, 2013, p. 11; Siepmann, 2016, pp. 726).

The combination of already established, independent technologies and methods from different application areas (such as internet technologies, bio-informatics, etc.) to reach a uniformly effective solution is often described as the essential innovation and most challenging task of Smart Factory initiatives (Siepmann, 2016, p. 37).

For companies, it is a major challenge to see which technologies and methods are needed and how they can be orchestrated to accomplish a Smart Factory. Due to the complexity and the high investment of such projects, many companies are implementing delimited components to gradually approach a Smart Factory according to the principles of Industry 4.0 (Spath et al., 2013, p. 120). Keeping this incremental implementation plan in mind, first a clear identification of the current system state and then a profound development plan become necessary for Smart Factory initiatives.

The relevant literature currently offers only limited support to manage such challenging projects. Individual development areas (e.g. employee competences and processes) as well as single technologies (e.g. sensors) are either viewed in isolation or emanate significantly from the overall goal of a complete penetration of Industry 4.0 technologies. However, a comprehensive and standardized development path is still not available (Bischoff et al., 2015, p. 69). Due to the lack of a holistic consideration of these heterogeneous aspects, strategic conclusions and concrete recommendations for actions cannot be easily identified (BDI 2015, p. 27). In a nutshell, a structured and defined approach including all fields relevant for a Smart Factory is missing. This hinders many implementation projects focusing on the implementation of a Smart Factory (Bischoff et al., 2015).

For companies, initiatives and projects in the context of intelligent factories come with numerous problems. They mainly arise from the complexity of the overall task. So it is necessary to provide a procedure model for the gradual introduction. Such a model should offer paths for technologies and

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