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Predictive Maintenance Information Systems:
The Underlying Conditions and Technological Aspects

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ABSTRACT

Predictive maintenance has the potential to improve the reliability of production and service provisioning. However, there is little knowledge about the proper implementation of predictive maintenance in research and practice. Therefore, we conducted a multi-case study and investigated underlying conditions and technological aspects for implementing a predictive maintenance system and where it leads to. We found that predictive maintenance initiatives are triggered by severe impacts of failures on revenue and profit. Furthermore, successful predictive maintenance initiatives require that pre-conditions are fulfilled: Data must be available and accessible. Very important is also the support by the management. We identified four factors important for the implementation of predictive maintenance. The integration of data is highly facilitated by Cloud-based mechanisms. The detection of events is enabled by advanced analytics. The execution of predictive maintenance operations is supported by data-driven process automation and visualization.

KEYWORDS

Analytics, Cloud Computing, Enterprise Systems, Implementation Projects, Predictive Maintenance

1. INTRODUCTION

The best running enterprises are running enterprises. The manufacturing of goods and the provisioning of services without interruptions is important to create revenue and increase (Stenström et al., 2016). Therefore, enterprises use maintenance to minimize or avoid downtime (Stenström et al., 2016).

The impact of maintenance strategies on firm performance has already been analyzed by Swanson (Swanson, 2001). Two basic strategies can be differentiated. Reactive and proactive strategies (Bateman, 1995; Stenström et al., 2016). Reactive or also run-to-failure approaches try to optimize the reaction to failures of plants according to Mobley (2002). This reactive (or corrective)

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maintenance is composed of post-hoc activities, executed after a warning or error occurred (Tsang et al., 2006; Nadj et al., 2016). A reactive approach to maintenance implies that an enterprise must keep personnel available and maintain a spare parts inventory for reacting to failures. Even if the parts inventory can be reduced by cooperating with equipment vendors that provide immediate delivery, the vendors demand premiums for quick reaction times. As many failures require deep skills for handling, a significant training effort is necessary. Furthermore, the staff available must be able to cope even with multiple concurrent failures. Additionally, the failures may happen at unfavourable times thus create high overtime labour cost. Mobley (2002) and Stenström et al. (2016) estimate that reactive maintenance operations are approximately three times more expensive than scheduled ones. Also, Swanson (2001) found that reactive strategies have a negative impact on firm performance. Even after a quick repair the manufacturing of products and the delivery of services are interrupted resulting in lost revenue and profit. Furthermore, contractual penalties may also become due because production and availability targets are not met.

On the other hand, Swanson (2001) and Stenström et al. (2016) showed that proactive strategies in maintenance have a significant positive impact on performance. They can be differentiated into preventive and predictive strategies (Bateman, 1995). Preventive approaches have a breadth first approach. They apply maintenance actions to all parts. On the contrary, predictive strategies follow a depth-first approach. They try to identify those parts most likely to fail and fix them before failure.

The first predictive maintenance management approaches were time-driven (Mobley, 2002). They use models such as bathtub curves and statistical trend data to determine the schedule maintenance tasks. Furthermore, the observations of employees were used to detect indicators of a future failure, e.g. vibrations of machinery (Mobley, 2002). The new potential created by digital technologies was already identified by different authors (Kusiak et al., 2009; Ding and Kamaruddin, 2015). Newer predictive maintenance approaches schedule maintenance activities on as-needed basis by obtaining and analysing the actual operating conditions (Kusiak et al., 2009). For this purpose, a new type of information system, so-called predictive maintenance systems were designed (Canito et al., 2017; Chiu et al., 2017; Fernandes et al., 2018). They use the actual operation condition of plant equipment to optimize total plant operation.

To implement predictive maintenance information systems, enterprises must first identify the alternatives and evaluate them. This is very challenging because a maintenance system can be developed and conducted in different ways. However, there is only sparse research and rare empirical insights on the development and implementation of predictive maintenance systems, as shown by our literature review. We conducted a literature review in leading databases such as AiSel, SpringerLink, IEEExplore and Sciencedirect, etc., regarding the recommendations suggested in literature (Webster and Watson, 2002). We did not find appropriate insights about a proper implementation of a predictive information maintenance system. Nevertheless, without a well-founded investigation the understanding of the current implementation, the identification of challenges and main aspects as well as the evaluation of used approaches and technologies cannot be ensured. Further, it is not possible to develop and advance this subject as well as integrate them within the enterprise resource planning world of the organization. This is unfavourable for research and practice as well. Although obviously implementation projects in this topic are important for research (e.g. Mobley, 2002; Tsang et al., 2006; Hashemian and Bean, 2011) and practice (e.g. Columbus, 2016) as well.

We contribute to close this gap in research by investigating predictive maintenance and its current importance. Therefore, our research paper focuses on the following research question: “What are the underlying conditions and technological aspects for implementing a predictive maintenance information system and where does it lead to?”

For answering our research question, we apply a case study research methodology regarding the guidelines of the related scientific literature (Eisenhardt and Graebner, 2007; Yin, 2017). Our paper is structured as follows: The foundations of predictive maintenance and the related aspects are defined in the following background section. Section three describes the used case study research

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