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DIGITAL TWIN READINESS ASSESSMENT: CASE STUDY AT A PRINTING COMPANY

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ABSTRACT

Digital twins provide a way to control various manufacturing processes. To justify their implementation investment, a systematic readiness assessment is conducted at a printing company. The assessment highlights readiness gaps and provides basis for further implementation of digital twin technology. Three implementation scenarios are elaborated and evaluated jointly with the company's representatives. A digital twin solution for optimization of the folding process to improve delivery time estimation is selected for further implementation.

1 INTRODUCTION

A digital twin is a virtual representation of the manufacturing system to monitor, analyze and control its behavior. Simulation is an important component of digital twins (Shao et al. 2019). It is used to perform real-time prediction of system's behavior using the current operational data. The digital twins have attracted a significant attention as a way to control various manufacturing processes (Jeong et al. 2020). At the same time, development of digital twins is complicated and time-consuming, and it is important to identify suitable application areas (Woitsch et al. 2020). The objective of this work is to assess digital twin readiness at a small and medium size (SME) company and to propose digital twin based manufacturing process improvements. A structure readiness assessment methodology is employed and approbated.

2 METHOD

The digital twin readiness assessment is conducted according to the methodology provided by the European project Change2Twin, which supports manufacturing SMEs in their digitalization process by providing digital twin solutions (Woitsch et al. 2020). The aim of the methodology is to evaluate the current digitalization maturity of a company and to identify suitable scenarios for digital twin development. The assessment contains two parts: 1) the overall assessment of the company or digitalization compass; and 2) digital twin readiness evaluation. The assessment focuses on such area as infrastructure, twin building, usage of the digital twin in live operations, business actions controlled by the digital twin, life-cycle support (or cradle to grave) as well as organizational culture as it affects adoption of digital twins. The readiness score is calculated according to a questionnaire filled out by company's representatives.

The methodology was applied at a case company, a small and medium size printing company. The company specializes in printing of high quality books, diaries, advertisements and similar products. The number of books printed was 4.5 mill. in 2020. The company performs an end-to-end printing process on paper sheets. The main activities are: 1) printing sheet layout design; 2) plate preparation; 3) offset printing; 4) cutting; 5) folding; and 6) binding. The binding activity has many variations due to many customized products. The production process is proceeded by inventory management and logistics process. During the study, researchers analyzed the company's strategy and production processes as well as interviewed production managers and information technology specialists. Three implementation recipes (i.e., alternative digitalization scenarios) are elaborated and evaluated jointly with the company's representatives.

3 RESULTS

The identified digitalization scenarios concern: 1) folding process optimization to improve delivery time estimation; 2) process monitoring to track work-in-progress inventory, and 3) process simulation to improve production loss estimation. In the case of the folding process optimization, the digital twin mirrors the folding process using a state-of-the art equipment. The process is selected because it is a current bottleneck and the machinery provides the necessary data for implementing the digital twin.

The overall assessment is shown in Figure 1 (a). According to the questionnaire and analysis of the manufacturing process, it is identified that pre-conditions for successful implementation of the digital twin exist. There are small gaps concerning infrastructure and business action. Additional sensing capabilities will be provided in collaboration with vendors of the manufacturing equipment. Business action-wise, the company wants to preserve involvement of human decision-makers in some of the key activities. The proposed digital twin includes Estimation, Sequencing and Monitoring modules (Figure 1 (b)). It receives information from the Resources planning system and interacts with the folding machine. The digital twin provides the Resources planning system with estimates of production time for quotations being prepared. That includes a Monte-Carlo simulation to evaluate risks of delays. The digital twin represents live data from the folding machine about the work completed and displays production sequencing information to machine operators. The discrete event simulation is used to evaluate efficiency of sequencing decisions.

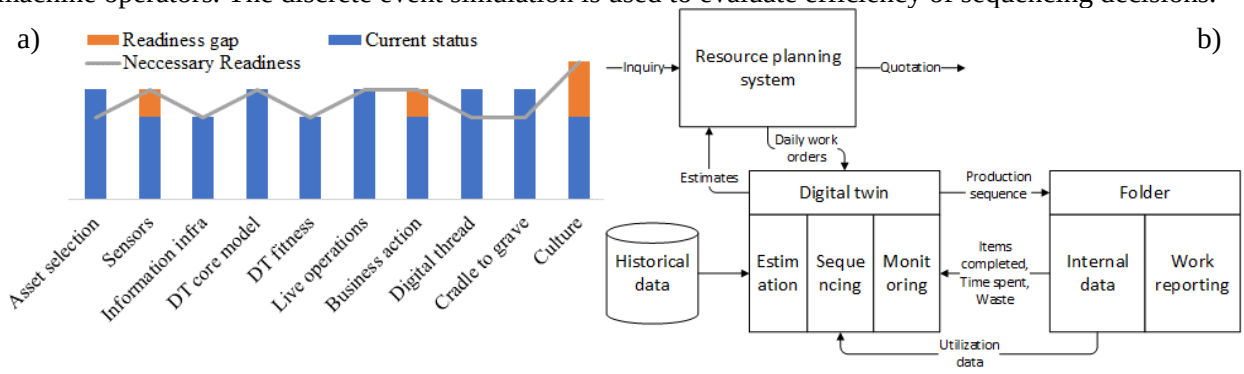

Figure 1: The readiness assessment (a) and the overall digital twin design (b) for the folding process.

4 CONCLUSION

The Change2Twin readiness assessment methodology was shown as a suitable approach to introduce the digital twin technology to small and medium companies. The folding process optimization was chosen for implementation because it has the narrowest readiness gaps. Collaboration between production mangers and information technology consultants proved essential to design an implementation blueprint of the digital twin. Accounting for capabilities and limitation of the available manufacturing equipment is also important for successful introduction of digital twin technologies. The digital twin designs created are used in further manufacturing process improvement activities.

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