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Benefit oriented production data acquisition for the production planning and control

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Abstract

In order to stay competitive, many manufacturing companies, especially small and medium sized enterprises (SME), face the challenge to transform their production and the corresponding production planning and control (PPC) processes for the upcoming Internet of Things (IoT) Era. Since their time and cost budget is a constraint, SME need to focus particularly on relevant data types, data acquisition points and technologies that will be beneficial for their manufacturing processes. State of the art approaches are lacking in supporting SME sustainably, systematically and company-specific on their way to IoT from a PPC-perspective. Therefore, in this paper a systematic approach is described, which is providing a sustainable, benefit-oriented, and gradual guideline for companies which aim to build an IoT-supported production data acquisition for PPC processes, in order to enable sustainable manufacturing. The developed method is taking into account company-specific production structures through quantitative key performance indicators and qualitative morphological checklists. With the help of the approach proposed in this paper, SMEs are supported systematically on their transformation path of the production data acquisition for the PPC into the IoT Era in order to enable a sustainable production.

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1. Introduction

Sustainable manufacturing in high-wage countries can only be achieved through an efficient production planning and control (PPC). In order to enable a well working PPC, a reasonable data base with company-, product- and production related data is needed. Especially many small and medium sized enterprises (SME) are lacking the knowledge concerning relevant data types, data acquisition points and technologies that will be beneficial for their PPC in the context of their manufacturing surrounding. Even with big data analysis, companies can not plan and control efficiently if they are lacking relevant input data. Since current approaches do not cover the defined issue, in this paper a systematic approach is described, which is providing a sustainable, benefit-oriented, and gradual guideline for companies which aim to build an IoT-supported production data acquisition (PDA) for the PPC, in order to enable sustainable manufacturing.

2. Data needs of PPC and ICT for data acquisition

Due to volatile market demands and a wide variety of variants, the planning and controlling processes are a very important and complex task for ensuring a high adherence to promised delivery dates. One widespread framework for the PPC is the Aachen production and control model. It is highly orientated on the logistic objectives, as it aims to increase flexibility, adherence to delivery dates, capital utilization and to decrease throughput times and work in process [1]. It distinguishes between network, core and cross-sectional tasks, whereby in-plant PPC is one part of the core tasks [2]. This core task itself consists in turn of three tasks which are mainly responsible for the detailed controlling process and is described in the following. The order release determines the point in time when an order is processed to the production and triggers the provision of required materials. Sequencing defines for each workstation which order should be processed

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next. The job of capacity control is to determines the actual capacities usage and decides about extra hours and staff distribution. [3]

Since the mentioned tasks are strongly connected to the shop floor, a high traceability and resolution of production processes is of high importance to enable efficient PPC processes. Depending on specific controlling methods, each task requires different information that should be collected on the shop floor. For that purpose, many information and communication technologies (ICT) are available on the market. Typical solutions to acquire feedback from the shop floor automatically are barcode and radio-frequency identification (RFID) technology which pertain to the group of auto-ID solutions. Other comparatively cheap technologies for PDA are e.g. OCR, terminals, beacons or cameras. PPC related production data such as the starting or the end time of setting up a machine, can be collected through workers scanning barcodes on production orders or through RFID sensors recognizing a transponder within their reading area. Whereas barcodes are already commonly used, RFID solutions gain increasing popularity, especially because of easy handling and higher data storage. The big disadvantage of the RFID technology is its perturbation in metallic surroundings. An even higher information resolution than with RFID can be gained through real time localization systems (RTLS) that are mostly based on Wi-Fi and enable a continuous traceability of objects through the entire production. The drawback of RTLS technology is, that compared to barcode or RFID technology it is quite expensive and bulky.

The transformation process of the production and the corresponding PPC for the upcoming IoT era should take both -the specific data needs of different PPC methods and various ICT collecting consistent data from different sources - into account.

3. Existing approaches

In this chapter, existing approaches which deal with the implementation of a PDA-system are reviewed. The approaches can be classified in four different categories: (1) generic implementation approaches, (2) approaches to implement IoT, (3) concepts to implement specific ICT, (4) approaches to improve the PPC. The approaches are assessed whether they have a guideline characteristic and take PPC of SME into account. Furthermore, it is checked whether a wide range of ICT is considered and whether data acquisition points and the specific data to be collected is defined.

(1) Generic implementation approaches
Within this category, general project management concepts such as Kuster [4] and DIN 69901 [5] were analyzed. Both approaches, but especially the project management standard, are powerful tools to structure and organize the implementation process and help to set a timescale for the whole project.

(2) Approaches to implement IoT
There are many different existing approaches, which deal with the implementation process of IoT. The approaches of Rauen et al. [6] and Chabanne et al. [7] were analyzed and assessed. All authors give a generic view on the topic by considering a large variety of different ICT such as embedded systems, Human-Machine-Interfaces or software systems. Moreover, all authors deal with the topic on a very abstract level and do not discuss the issue of the implantation process itself.

(3) Concepts to implement specific ICT
Fuhrer & Guinard [8], Vasishta [9], Poirier et al. [10], Jones and Chung [11] and Fruth [12] focus their research on the implementation process of specific ICT. In many cases, this is the RFID technology. Whereas the majority of the analyzed approaches address the topics of production and logistics, e.g. Fuhrer & Guinard as well as Vasishta deal with topics from outside the subject area. Although the mentioned approaches do not consider the large variety of different ICT, they give useful hints how to deal with the implantation process itself.

(4) Approaches to improve the PPC
Within the last category, the approaches of Ostgathe [13], Stuermann [14], Zhang et al. [15], Engelhardt [16] and Schuh et al. [17] were assessed. All authors create a strong reference to the PPC and aim to improve the planning and controlling in enterprises through different strategies. In order to deal with the high complexity of the PPC-process, almost all approaches highlight the importance of real-time PDA. On the one hand, approaches within this category are highly relevant due their strong relation to PPC. On the other hand, authors neglect the implementation process itself as they do not show necessary steps depending on specific enterprise characteristics.

Conclusion
In total, the assessment shows that none of the reviewed approaches offers a holistic solution for the benefit oriented implementation of ICT to enhance real-time PDA. Either the approaches are too abstract and only on a generic level or they are too specific by focusing only on single ICT. Furthermore, the majority does not consider the influence of different characteristics of the shop floor and its surrounding and the impact on the level of data resolution that is needed. Last but not least there are no guidelines concerning the positioning of data collecting points.

4. Approach to build a benefit oriented PDA-system

4.1. Overview

The approach to implement a benefit oriented PDA-system for the PPC is shown in figure 1 and consists of four main phases: preparation, current state analysis, target state definition and assessment. Each phase consists of several sub-phases, that are explained in detail in the following paragraphs.

The selection and implementation of a PDA-system is a complex process, which poses a great challenge for SME. In order to cope with the implementation successfully, it is advisable to merge the process into a project. This is followed by the modularization of the shop floor, which is an important