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Development of a digital continuous improvement system for production

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Abstract

The philosophy of the continuous improvement (CI) process aims at improving process stability and performance whilst increasing employees' competencies at the same time. The difference to single improvement projects lies in the way the workforce is included in kaizen activities on an everyday basis. In a target-oriented CI approach the employees are also actively coached and guided by a leader (e.g. group or team leader) to act as a basis of the learning organization. The success and documentation of the improvement steps are therefore highly dependent on the skills of executives. Because of that, CI is currently being carried out in many companies either in a completely unstructured or in a traditional way with paper-based documentation. At that point digitalization concepts can support the effectiveness and efficiency of a CI system. The target of this paper lies in defining the core elements of a successful CI system and rating them against digitalization approaches which have been used in other parts of manufacturing. The compatibility of CI elements and digitalization approaches are rated with the help of the Delphi method. Following that, the concept of a digital CI is presented, which facilitates communication between managers and actual process improvers, documentation and employee learning during the improvement process. It is then compared to a traditional target-oriented CI process to show the major advantages and next steps in the introduction of such a system.

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Keywords: continuous improvement process; smart manufacturing; delphi method

1. Introduction

The fast and continuous ability to alter products and processes is a key aspect for companies' success in a changing market environment [1]. It is also proven that even more than technical advancements, the organizational improvements and the development of employees' competencies help business to be successful [2]. The concept of continuous improvement (CI) offers a framework for improving processes and employees' competencies in parallel [3]. It is part of the lean production philosophy of the Japanese car manufacturing industry and has become a vital part of modern management and quality systems [4]. Depending on the aim of the planned improvement, the CI process can have different characteristics: Target-orientation, employee participation, incremental or sudden improvement, duration of the process, reactive or proactive improvement or the general way how targets are used within the process [5]. Different authors have developed maturity level models or categorization models in order to systemize the used CI approaches within the industry [6,7]. However, independent from the type of a CI system, there are several problems in the industrial application of CI which the following paper addresses by the development of a digital approach.

Furthermore, the digitalization of industrial production holds great potentials for the further development of products and processes [8]. In a study which was conducted in 2015 more than 70% of the participating companies stated that they are either analysing, planning or already implementing systems and tools to connect machinery, workers and products through the internet or among themselves to create a non-disruptive information transport [9]. Products, which they are manufacturing, are itself cyber-physical systems consisting of sensors, actuators and the ability for inter-connection; they will be able to alter physical processes in the production environment, even though they are digitally controlled [8].

However, it is undisputable that even in a future production workers will be necessary to some point even though their work tasks and necessary level of competency may alter [10]:

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Therefore these workers may face issues like the alienation with their own products [10] or the dwindling ability to solve problems in a digital environment.

Therefore, in the following the core elements of a possible newly developed CI system are named and compared with digitalization elements; additionally the main challenges of traditional CI systems are described because they should be addressed and solved in a future approach. By involving experts a Delphi study is conducted to select the CI and digitalization elements which have a great potential of being useful in a digital CI concept. The concept is then developed and compared to an analogue counterpart (see figure 1).

2. Challenges of traditional CI approaches in the industrial application

Depending on the used CI system, different challenges occur in the practical application. In a comprehensive literature research, two problem categories can be distinguished:

a) Challenges in the area of the improvement routine, namely the daily-basis improvement and
b) the underlying organization and infrastructure which supports the CI system.

Concerning a) especially missing competencies of people participating in CI are an issue. The dimensions do rank from the mere lack of knowledge about an existence of a CI system and therefore the non-participating in any improvement activities at all [7] to the missing of concrete problem-solving competencies and the knowledge about tools and methods which might solve found problems [11]. Tools unfit for the support of CI personnel does increase the frustration about the actual underlying CI system [12]; the negative impact of other aspects like impossibility to share information among different hierarchies or within the same hierarchies but different working locations [12] or too many, too complex tools are distinct.

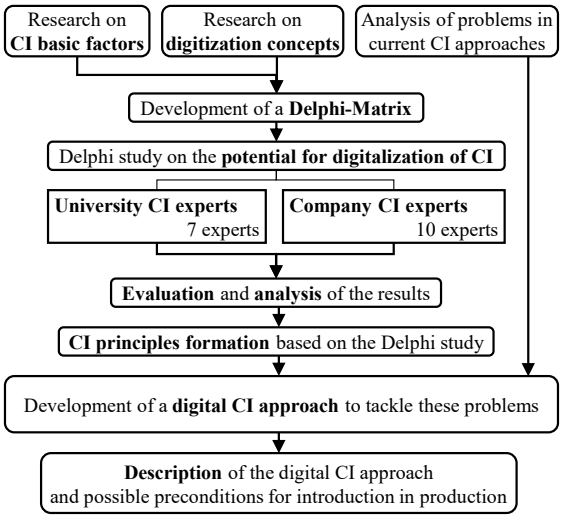

Fig. 1. Development of a digital CI process.

Towards b) companies have issues in implementing and standardizing an enterprise-wide CI system [7]; by implication b) worsens problems already mentioned in a). In the contrary, existing CI-systems are often time-consuming to manage [7] and companies tend to deploy too little resources for managing a CI system or supporting the CI participating with trainings and tools [13]. Missing improvement targets and therefore uncertainties about the content and goal of the improvement are also problematic [14]; that especially applies when targets are set but not used or communicated for CI [14]. Based on the found issues in modern CI systems, a digital CI approach needs to address these issues in a comprehensive manner.

3. Literature research of digitalization approaches potentially suitable for digital CI

In order to be able to evaluate the possibilities for digitalization of the CI process, the possible basic elements of the CI process are first elaborated. Subsequently, digitalization concepts, which could be used in the CI, are explained.

3.1. Basic CI elements for a digital CI approach

The basic CI elements are derived from the target-oriented CI system described by Cachay and Rother [5,15] and marked accordingly in figure 2. Before work can be started in the CI process, an overarching target is formulated. This target consists of a **company strategy, vision and a mission statement (1)** [15]. All targets are oriented towards this goal state which can be assured by tools like “policy deployment” [16]. By introducing **key figures (2)** company targets can be made quantifiable. The objective in CI is partly based on key figures and key figure systems on the one hand and qualitative descriptions of the current and futures process on the other hand. The instrument in which this information is formulated is called a **target state (3a)** [15]; the **current state (3b)** is the counterpart and covers the relevant information of the situation in the present which should be improved. The designated instrument for improvement is the **PDCA cycle (4)**. The PDCA cycle is a problem-solving heuristic which helps to overcome obstacles on the way to the next target state [17]. The sequence of the four steps *plan*, *do*, *check* and *act* is repeated multiple times. The improvement proceeds in small steps with the help of **1-factor experiments (5)**. After a successful cycle, the conditions are adapted to the new findings [15].

CI can focus the whole **value stream (6)** or single process steps. The coordination of the individual improvement measures within a single value stream element is carried out through the objectives of the value streams’ CI [18].

The first target which has to be achieved by the CI are **stable processes and standards (7)** [15]. A standard is the current best implementation for an activity [19]. Standardized processes are the starting point and the prerequisite for CI. Standards must be defined, visualized and communicated to people. Only by means of a standard the current state can be compared with the desired state and an improvement measure can be assessed [18,19].