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Value stream mapping 4.0: Holistic examination of value stream and information logistics in production

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ABSTRACT

Value stream mapping is a widely used and proven method that enables the mapping and analysis of process chains and helps to derive potentials for improvement. The digitalisation of production according to Industrie 4.0 promises new opportunities to develop more efficient production lines. Particularly companies which digitally upgrade existing operations need to be introduced to a new approach. This holistic approach extends proven methods of Lean-Production while systematically mapping opportunities for digitalisation to derive measures for improvement. A comprehensive view at information-logistic waste is shown while regarding recording, handling, processing, analysing and optimising (information-) processes.

1. Introduction

Industrie 4.0 (I4.0) promises nothing less than the 4th industrial revolution. Through cyber physical systems (CPS) a new level of organisation, control throughout value chains and complete lifecycle of products is expected to be achieved. Estimated results are dynamic, real time optimised, self-organised production systems and networks that can be set up according to different criteria [1,2].

In contrast to I4.0 lean production (LP) is based on standardised processes, finding abnormalities, problem solving and continuous improvement in order to reduce waste activities and to achieve higher levels of flow [3,4].

Particularly companies with an existing LP-system need orientation how to react to the new challenges raised through I4.0. This article offers an upgraded Value stream mapping (VSM) method to those companies. This allows them to systematically understand opportunities offered by digitalisation and I4.0 to develop their lean production approach to the next level. In a value stream a material flow is always connected with an information flow, e.g. to schedule production or to evaluate performance information. Often different IT-Systems or even paper is used to store information. Naturally, data management throughout the value stream is accompanied by wasteful actions that hinder a truly lean and digitalised production. The worlds of LP, digitalisation and I4.0 are addressed by looking at the basic and digital value creation using the value stream mapping 4.0.

1.1. Lean production, digitalisation and Industrie 4.0

The classic Toyota approach for LP is oriented towards the ideal of a waste-free value stream for all improvement activities: 100% value adding, 0 errors, one piece flow in the sequence of customer demand and the appreciation of the employees. The basic way of LP is to: (1) stabilise production processes (e.g. variant cycle times or frequent machine downtimes) to (2) prepare the condition for production flow and to (3) support this by a continuous improvement of processes (step 1–3, Fig. 1). In LP proven methods – as value stream mapping – address problems in a "learning to see" manner (digital development path (A), Fig. 1) [4].

Optimisation of production can also be supported by digitalisation or digital tools that simplify and enhance information usage and availability. A good example are Augmented Reality work assistance systems to stabilise and level cycle times in employee-intensive areas such as assembly. Furthermore an accelerated flow

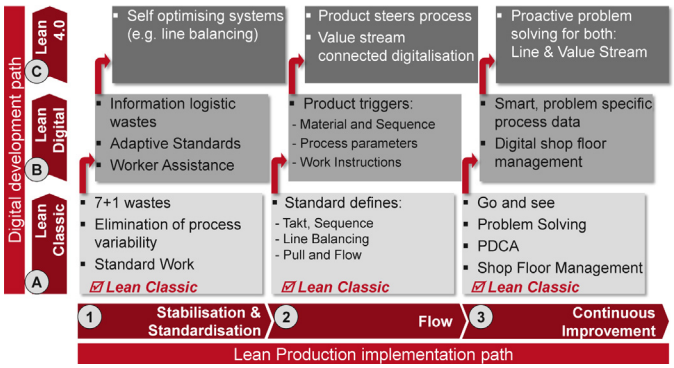

Fig. 1. Incorporation of Industrie 4.0 approaches in lean production.

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of information can contribute a flow of production to reduce processing time, e.g. by use of e-Kanban. A good vertical integration of IT systems in each workspace supports this step (digital development path (B), Fig. 1) [1,2].

The approach of I4.0 sums up these digital solutions. It is based on digitalisation of production with a focus on Internet technologies, automation and a deep integration of customers in an interconnected production web. However, the beneficial reliance of digitalisation requires the availability of necessary production data provided by a horizontal and vertical integration of IT systems as well as data flows throughout a value stream. Thus an efficient layout of value stream processes focusing on data management is necessary for a successful realisation of I4.0 (digital development path (C), Fig. 1) [2].

For companies it is an ideal opportunity to analyse the potentials of improvement offered by LP, digitalisation and I4.0. They aim at optimising a value stream and should be understood as parts of a hierarchical improvement model (see Fig. 1): Existing value streams are optimised using LP methods while taking into account data flows in order to allow a following digitalisation and implementation of I4.0 solutions. In this regard, the question arises, how LP can incorporate I4.0 approaches to get closer to the postulated Toyota ideal. We propose three main approaches: Firstly, it is necessary to examine how the classic Toyota 7 + 1 waste types can be suitably addressed and reduced by LP, digitalisation or I4.0. Secondly, information logistic wastes (see Section 2) must be analysed and eliminated. Thirdly, the options of I4.0 are to be examined in order to support the implementation of a lean value stream audit (Fig. 1). The here shown method allows to find systematically problem based opportunities offered by LP, digitalisation or I4.0 to reach the next improvement level.

1.2. Value stream mapping

Only few methods for optimising production offer a holistic mapping and design approach such as the value stream method proposed by the book "Learning to see" by Rother and Shook [5]. The book title aptly describes the aim of value stream mapping: it should enable the systematic identification of waste in consecutive production processes and detection of improvement potentials. Learning to see is not easy to discuss in view of the subject I4.0. Nevertheless, for the systematic and reasonable application of digital solutions for the optimisation of process, material and information flows, the current state of manufacturing must be captured. Otherwise a non-purposeful optimisation might be forced.

The value stream mapping 4.0 introduced in this article opens up new possibilities. The classic value stream mapping is thereby extended that it helps to grasp and clearly depict Information-logistic-wastes (ILW) (described below) as well as digital improvement opportunities. On the one hand wastes uncovered by classic value stream mapping are examined whether LP or a digital solution leads to possibilities of improvement. On the other hand, wastes are found dealing with data and information. This means for example redundant systems and memory media or media breaks are recognised with the data processing.

2. A new way to identify information logistical wastes

Information logistics (IL) are understood as the planning, management, realisation and control of the totality of information flows as well as the storage and processing of these information. Especially information flows for decision making are taken into account for IL [6].

The "data-information-knowledge model" describes the way how signs are interpreted as data, are compacted into information and then to knowledge in order to finally enable decision making [7]. Correspondingly, there are individual types of waste/-categories that can occur on the process from signs, data and information towards knowledge and actions. In a literature research of eleven journals and books belonging to the definition of ILW was shown that five authors copied the 7 + 1 classic lean types of waste to describe problems within IL. Four authors tried to derive new point of views out of the classic lean wastes and only two authors defined new wastes. A target based approach for analysing IL-processes, based on the purpose of the data-information-knowledge model was developed to get the categories of wastes along the information flow process at itself. This was missed in literature before.

Therefore ILW were classified in three easier understandable groups: data generation and transfer, data processing and storage and data utilisation, which represent the life cycle of information. Each group is divided in multiple sub categories [8]:

Data generation and transfer:

This group includes a continual process from data selection, over data quality and data collection to data transfer. Through this process a basis is set for additional processing and utilisation of data.

Data selection describes the selection adapted to information purposes of data to be collected especially with a view to the utilisation of data itself (customer perspective). Which means to collect as much data as necessary and as little as possible.

Data quality requires an evaluation of data according to their content, meaning, origin, use, granularity, collection frequency, consistency, etc. in each case of a process.

Data collection considers automation degree and whether the data collection is completely automated, semi-automated (i.e. with an input mask) or manual/paper-based. Especially manual activities should be avoided and seen as wasteful actions.

Data transfer includes all media and systems involved in data transport and especially considers data consistency. Media and system discontinuities should be avoided.

Data processing and data storage:

In LP one of the main topics is to enable a continuous material flow for example to reduce lead time. This issue can be supported by a constant information flow. Therefore some LP wastes types can be transmitted in a new context within this group.

Waste in form of **wait periods and inventory** matters particularly with regard to data availability in real time. Latencies in the system as well as unprocessed data lead to delays which can affect manufacturing processes.

Transfer, movement and search include especially manual activities caused by inefficient IL through complex and partially not value-adding transport routes, manual interventions or search processes. Information is not available in real time, especially when it is written on paper.

Data utilisation:

Finally wastes are summed up in this group in conjunction with overarching tasks of decision support.

Within the framework of **data analysis** waste has an important role to play by omitting data analysis. New insights, which enable continuous improvement within manufacturing processes, can only be gained by linking data with further analysis.

Decision-making-support. Only when data and further analyses are suitable for decision making, it is possible to improve processes continuously. Ideally, data will be prepared in a way that

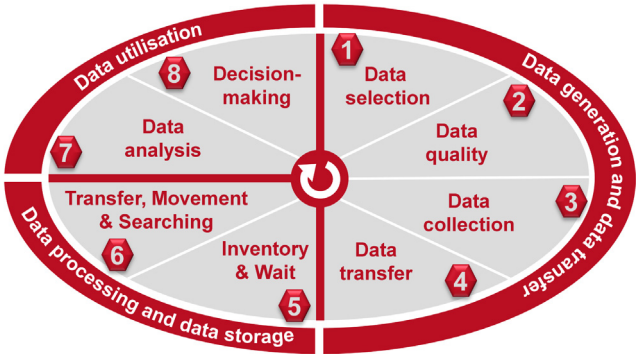

Fig. 2. Cycle of information logistic waste analysis.

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