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Value Stream Mapping as Lean Production tool to improve the production process organization – case study in packaging manufacturing

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Abstract

In the paper, the method of the production process improvement with the use of lean production tools has been presented. The Value Stream Mapping (VSM) for the cardboard packaging production process has been presented. On the basis of the current state map (CSM), areas for improvement have been designated – 5 organizational changes of the process were marked out. To minimize the three basic losses excessive storage, unnecessary movement and delays, the changes were introduced in the method of inter-operative transport, supervision of the storage condition (input and output of the process), control at the processing operation and the use of a production loop. As a result of the changes, it is possible to shorten the process time, shorten the total time of operations adding value and reduce the number of non-compliant products.

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1. Introduction

The production processes are characterized by the vector of inputs and outputs that constitute restrictions on the movement of the up and down stream, and are necessary to make the objectives of the process possible to achieve. Input data (which should be considered as the activation elements of the process), the actual course of the process and the required resources as well as the result are the basic parameters for defining the process. On the other hand, the processes are defined as timely, and in terms of content – complete sequence of operations (WAGNER K., PATZAK G. 2007, KUHN A. 2008).

Modern enterprises must be characterized by innovation, flexibility and efficiency. At the same time, attention is paid to the need for efficient management of the implementation processes of improvement and innovation (KUHLANG P., ET AL. 2013; MORLOCK F., MEIER H. 2015). One of the more well-known concepts of managing the production sphere is the Lean Production concept, which is based on improvements in lean management with the active use of the PDCA cycle (JAGUSIAK-KOCIK M. 2017).

Process improvement as a continuous operation is the goal of quality management systems, and the result can be reduction and cost optimization, improving the quality of work, productivity gains, the search for ways and tools for continuous improvement. Continuous improvement and optimization of costs are necessary for any company that wants to stay on the market. As it is known, constant development and improvement are weapons in market competition and foreign trade. The purpose of this work is to present the possibilities of improving the production process using the tools of lean production that will make it possible to visualize the places in the process that need to be reorganized.

2. Experimental

In industrial practice most Lean methods are targeted at being used in manufacturing industry, which results in a finished product. Lean principles are as follows: value, value stream, flow, pull and excellence (RESTA B., ET AL. 2015). Consequently, Lean concepts and methods require working out a model for production to ensure its application. This model consists of five stages (ANDRÉS-LÓPEZ E., GONZÁLEZ-REQUENA I., SANZ-LOBERA A. 2015):

1. Establishing and clarifying the Lean principles.
2. Determining the co-workers' role in the Lean Service.
3. Identification of wastage (*muda*) during the process.
4. Implementation: evaluation of Lean methodology.
5. Lean production model verification: performance monitoring and continuous improvement.

Value Stream Mapping (VSM) is a simple but effective method used for the illustration and redesign of value streams, i.e., a process flow. The method originates in the Toyota Production System (and consists of two main phases: value stream analysis, in which the current value stream is visualized by current state map (CSM), and value stream by future state map (FSM) (HAEFNER B. 2014). The method targets at a lean, dynamic value stream with short lead time, optimal time to add values and reduced inventories (ROTHER M. 2003, NASH M. A., ET AL. 2011). It is widely used in industrial practice.

In this work the analysis of the production process for one of the largest producers of cardboard food packaging in Poland has been carried out. Demand for carton packaging produced by the company depends to a large extent on the economic situation in other industries, in particular, in the food industry. Along with the consumption of food products, an unexpected increase in the interest of company's products was observed. In the face of increased production in the enterprise, the implementation of the lean management rule and improvement of the process organization was planned.

The company treated its clients as a starting and ending point, which means simplifying the optimization on the part of the client's needs, not from the internal capabilities associated with the company. Implementation of improvements in

the Company in accordance with the concept of Lean Manufacturing, required the use of all available tools, methods or ideas offered by the science of managing a lean enterprise.

3. Results and discussion

In order to strengthen the effectiveness of the conducted process, the attempts to identify the existing types of waste have been activated. In accordance to the 3M rule, three types of waste (*muri*, *mura*, *muda*) were selected. *Muri* is an excessive burden for employees, machines and processes that can lead to frequent mistakes, increase in the failure of a machine park, or employee absence. To counteract the presence of *muri*, first of all, it is to focus on the safety of all processes occurring in the enterprise and the implementation of work standardization. *Mura*, this is incompatibility and irregularity of tasks. If there is a *mura* in the company, then there is also a high probability of an overload of workers or machinery (*muri*). In contrast, *muda* refers to excessive storage, large amount of qualitative non-compliance, unused human potential, unnecessary movements and time-wasting. Actions that will help to prevent the creation of *mura* and *muda* are: proper supply management, implementation of changes to the process or product, creation of work standards for all employees. All three elements of the presented 3M model are in close synergy, so the most effective action will prevent these three phenomena.

Fig. 1 presents the current state map, where the upper part of the map shows the flow of information that begins with the individual customer (from the right side), then goes to information exchange in the plant, up to two raw material suppliers (on the left).

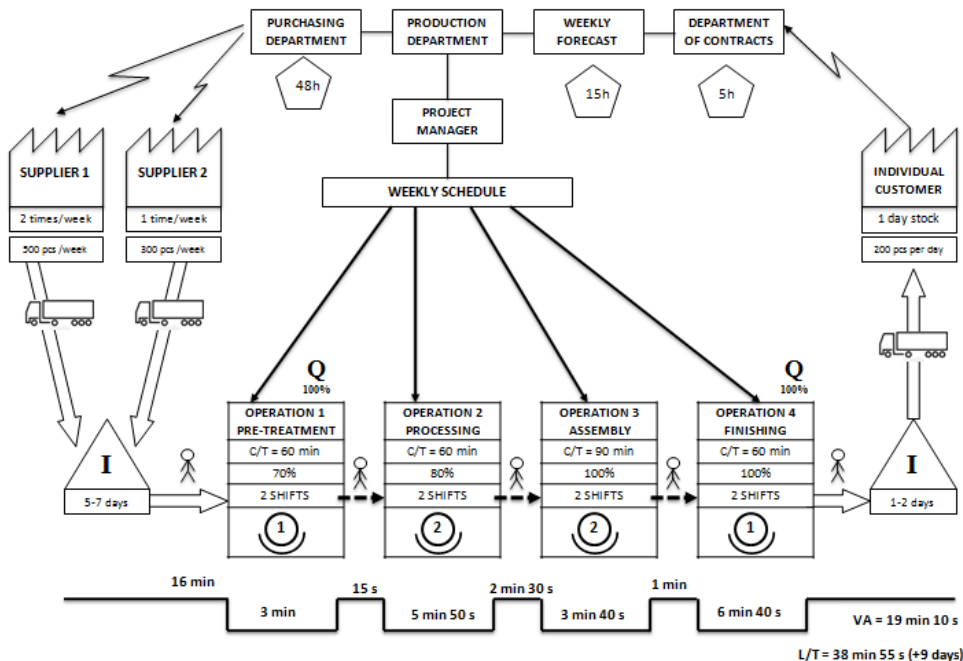


Fig. 1. The current state map (CSM) for the analyzed production process

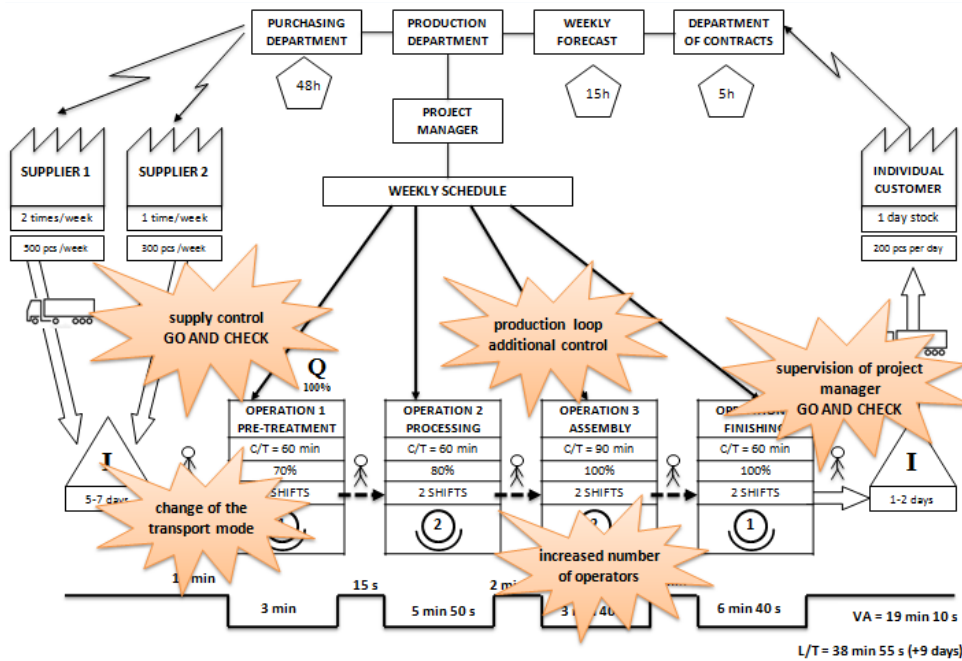


Fig. 2. The current state map (CSM) with proposals to improve the organization of the analyzed production process

The map also shows the flow of materials, starting from the supplier through the warehouse, from where the prefabricates are manually transported by the worker to the hall to operation 1 with the slotter (pre-treatment) - after the pre-treatment process, the product inspection is carried out. Subsequently, after the pre-treatment and control, the cardboard form moves by a flexographic printer and a slot cutter, where the proper processing starts, i.e. the format of the box with the print. The flap box, after its appropriate cutout, is transported under the gluing machine, where assembly processing begins. After gluing, the flap cardboard is transported for packaging on a pallet - finishing with final control (operation 4) and is transported to the finished product warehouse and stored for 1 to a maximum of 2 days. From the warehouse, flap cartons are collected by the employee and sold to the customers. It should be noted that the times of operations adding values in the production cycle have been presented for one piece, while the processing times on the machines (operations 1-4) for the batch of material that is necessary to start production. During the collection of data for the preparation of the map, it has been observed that during the production process the significant number of non-compliant products is generated. Most of the quality wastes appeared on the assembly operation - it is designated as bottleneck for the process. The significant number of non-conformities caused a strong reduction in the process's efficiency. The total material flow time in the production cycle is 38 minutes and 55 seconds (plus a maximum of 9 days of storage - with the FIFO system in stock), while the sum of the adding values operation times is only 19 minutes and 10 seconds (+9 days, with the FIFO system in stock).

Based on the visualization of the process, it has been found that many aspects of the company's business generate unnecessary costs without contributing to the increase in the value of the final product. The most dangerous ones were: excessive storage, unnecessary movement, and delays.

In Fig. 2 the current state map with indicated areas that firstly require improvement is presented. The improvement proposals in Fig. 2 are relate to three types of waste:

1. Storage: materials that are not currently used generate costs such as paying storage space. Of course, a certain level of inventory is needed to avoid unnecessary interruptions in production, however, there is the possibility of reduction through the use of the Just-in-time method based on perfect synchronization with suppliers.
2. Unnecessary movement: unnecessary movement of employees may result from poor organization of the process and the failure to use the available technical tools (manual transport replaced by forklift).
3. Downtime and delays: all the moments in which workers are idle, constitute a loss for the company. The inability to continue the operation was caused by the lack of tools or materials at the workplace.

Figure 3 shows the value stream flow map of the analyzed production process, taking into account the introduction of the proposed changes. The changes relate not only to the flow of streams, but also to the implementation of the order (order acceptance, planning, scheduling and quality management). A significant emphasis has been applied to the quality, because the consideration of complaints and stoppages associated with costs increase.

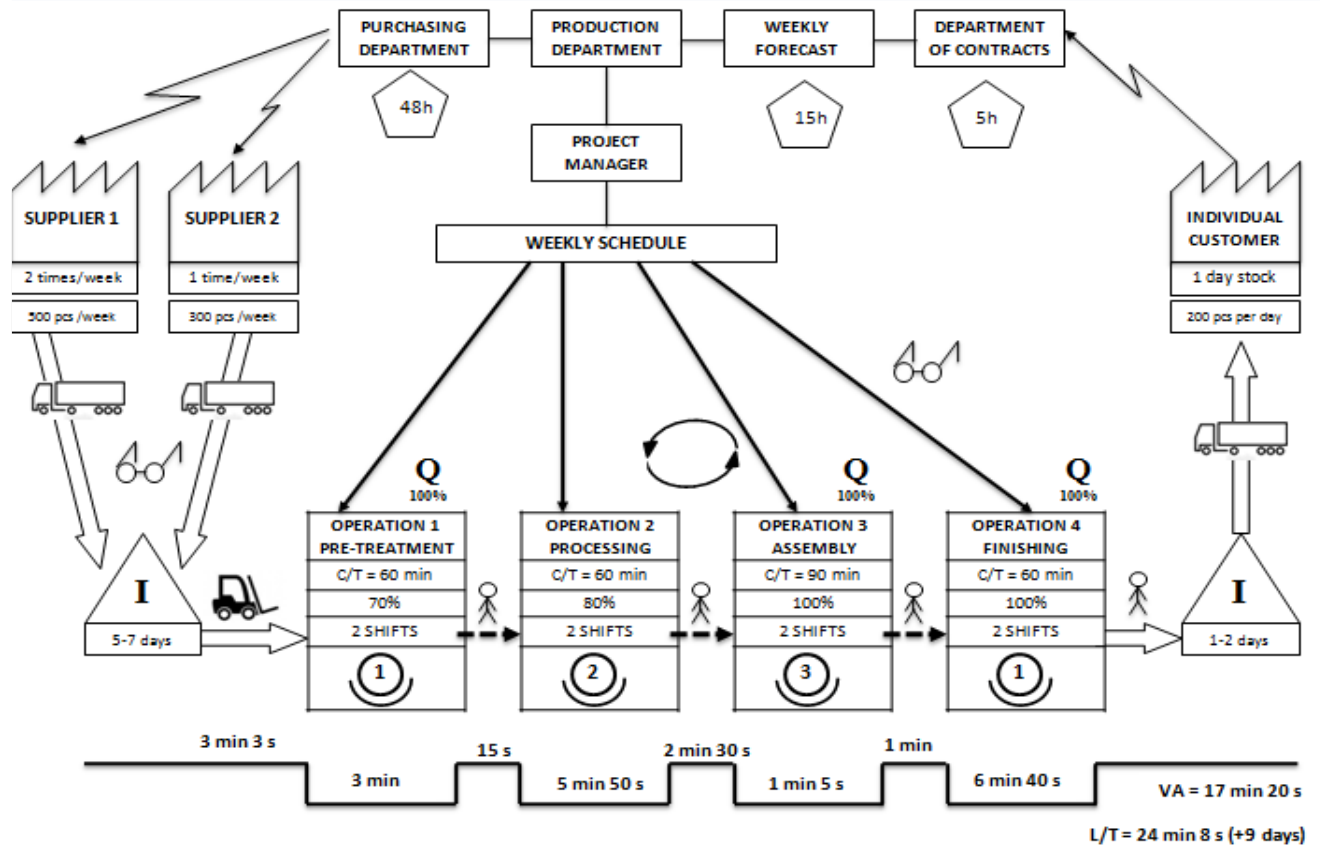


Fig. 3. The future state map (FSM) with introduced improvement in the organization of the analyzed production process

The method of material transport from the warehouse has been changed. During the observation it was noticed that the company is equipped with a transport trolley, however, due to the lack of competence of employees, it was not used in inter-operational transport. Such a change is able to significantly reduce the material flow time, it is only necessary to direct the employees of the warehouse to the training entitling them to operate the device. In two areas of the process, it was proposed that the project manager should check the inventory status (at the process input) and after the process (at the process output). Supervision at the input of the process would streamline the process of the necessary materials purchasing, while the supervision of the process output allows to obtain information about the inconsistencies in the process. Operation 3 has been modified in terms of the number of operators at the station, which would enable the introduction of 100% control of products and/or create conditions to introduction of a production loop, which would eventually eliminate the bottle neck of the process. Additional product control would prevent later problems that may occur, such as denting, bad gluing. An additional employee would help in the packaging of finished products on a pallet, which will significantly reduce the processing time combined with the control. Owing to the introduced changes, it would be possible to significantly reduce the time of material flow in the whole process. As can be observed in Fig. 3, the time after changes is 24 minutes and 8 seconds (plus a maximum of 9

days of storage – with the FIFO system in stock). Due to the introduced changes it is also possible to reduce the time of the value adding operations (although according to the principles of lean management it was not the main goal). The total time of operations that add values is only 17 minutes and 20 seconds (+9 days, with the FIFO system in stock). One of the significant consequences of process improvement is also minimizing the share of non-compliant products (operation 3), thus minimizing the wastage of material (directly) and time (indirectly)

4. Summary and conclusion

In order to improve the process, it is possible to use different approaches, based on the detection of causes and indicating which events, changes in settings, raw material properties, etc. affect the product quality and process efficiency. Improvement of the process is based on predicting the result of the introduced changes - prediction of the consequences of changes in the process, which allows to select:

- process variables,
- undesirable values,
- the best technical means,
- the best organization of the process.
- the best organization of the workplace.
- the best process parameters.

As it can be concluded from the presented research results (the current state map CSM and the future state map FSM), the production process can be reorganized by introduction of the small changes. The appropriate use of the potential of the technical portfolio and increasing the competencies of employees in relation to Toyota's management principles is a very good starting point for further changes. In the case of the discussed process, the production time shortening also requires the introduction of two additional controls and the involvement of an additional employee.

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价值流图作为精益生产工具来改善生产过程的组织 - 包装制造业的案例研究

關鍵詞

VSM
精益生产
填料

摘要

本文介绍了利用精益生产工具进行生产过程改进的方法。已经提出了用于纸板包装生产过程的价值流图（VSM）。在目前的状态图（CSM）的基础上，指定了改进的地方 - 过程的 5 个组织变化被标记出来。为最大限度地减少存储过多，不必要的运动和延误这三个基本的损失，在运输方式，存储条件（工艺输入输出），加工操作控制和使用生产循环。由于这些变化可以缩短处理时间，缩短运行总时间，增加价值，减少不合规产品的数量。
