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Computer aided manufacturing processes using Lean Management and Lean Manufacturing methods

Komputerowe wspomaganie procesów produkcyjnych z zastosowaniem metod *Lean Management* i *Lean Manufacturing*

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In the paper the basic assumptions leading to identification of causes and to the elimination of waste occurring in production processes based on the assumptions of Lean Management and Lean Manufacturing are defined. Presented is the use of example applications for computer-assisted value stream mapping of production streams in industrial practice.
KEYWORDS: computer-aided preparation of production processes

Contemporary production processes implemented in industry require at the stage of their implementation the use of advanced methods of managing the course of the manufacturing process. One of them is the recognized methodology of comprehensive management of manufacturing processes and flows in value chains, known as Lean Management (slimming management). The methodology on the American and then European level was popularized in the late 1980s by James Womack, who researched the productivity of American, European and Japanese factories. He defined the Toyota Production System (TPS) as "slim production".

Nowadays, slimming management is not only an effective strategy for company management, but also a planning strategy for manufacturing processes, called Lean Manufacturing (slimming production), based on the assumption of providing customers with the expected products in the simplest way.

The most important assumptions of these methods are: implementation of management practices from the client's perspective, continuous improvement of production processes leading to wasting of waste (seven forms of wastage were identified) and implementation of management philosophy, whose element is respect for employees involved in the production processes [1, 2].

Management in accordance with Lean Management principles is based on the principles of the organizational process referred to as Lean Thinking.

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Lean Thinking traditionally defines five steps to improve processes, including streamlining production processes:
1. **determination of the value** of individual products from the customer's perspective – the basis of the process is the assumption that only usability perceived by customers is a real determinant of value,
2. **mapping the value creation process** (mapping value stream) – specialized computer applications that facilitate the mapping process are extremely useful at this stage; selected examples of applications are indicated later in the study,
3. **improving the flow** of all resources (raw materials, work in progress, finished products) within the entire value chain of the organization,
4. **implementation of the PULL strategy**, i.e. adopting as a general rule the principle postulated in supply chain management processes, according to which only the need (actual demand) from the client starts the production process – this principle should be reflected in the target maps of processes, which are based on mapped flows at the stage of step two,
5. implementation of the principle of **continuous improvement of processes** towards the elimination of waste, so that every action in the process becomes a contribution to adding value significant for the client.

The diagram of these activities is shown in fig. 1.

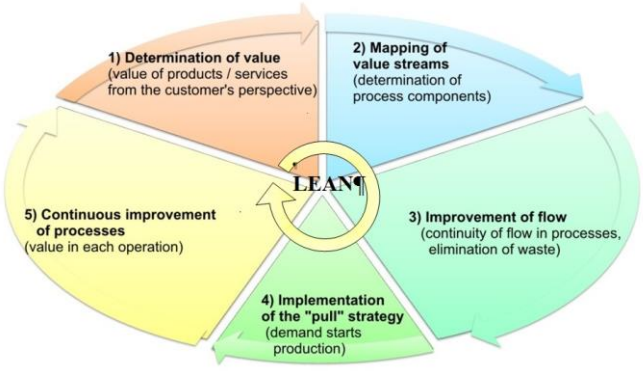

Fig. 1. The most important principles of lean methodology (steps of weight loss loops)

Seven forms of waste in production processes

The Lean Management and Lean Manufacturing methodology, according to the most popular colloquial definition, is based on the elimination of wastage (Japanese *muda*) from value creation processes.

It is true that eliminating wastage in Lean Management is a key element in improving efficiency, however, an in-depth analysis of organizational processes indicates that contrary to popular belief, this is not an element determining the effectiveness of the lean implementation process. The lean principle is first of all slimming down (limiting to the necessary minimum) flows of resources and information. Everything that distorts this flow is a waste.

Seven forms of wastage are commonly referred to in literature [3]. These are:

- **overproduction** is potentially the most frequent type of waste in production processes,
- **excessive waiting** is apparently the least severe type of waste; waiting means the inactivity of employees, materials, parts, substitutes and machines and devices,
- **excessive transport** (transportation) understood as unjustified movement of components, semi-finished products, finished products, technical elements and additional parts,
- **unnecessary processing** (overprocessing) is the implementation of unnecessary steps in the process of machining production components included in the finished product,
- **excessive inventory** that goes beyond the actual needs of stocks at the input, during and at the output of the production process being carried out,
- **unnecessary movement** (motion) associated most often with excessive movements by people and transport devices,
- **errors** (defects), i.e. losses arising as a result of errors in the implementation of tasks (errors in machining, machine settings, storage) or as a result of an infinite flow of information [4, 5].

In the subject literature, there is also the eighth waste area, defined as **untapped creativity of employees** [6].

5S method – a basic tool for improving the quality of the workplace

Fig. 2. Workplaces that meet the requirements of the five steps of the 5S method [8, 9]

An important tool for the practical implementation of lean methodology is the 5S method. Its name comes from five consecutive steps [7]. These are:

1. **sorting** (Japanese *seiri*) – segregation at the workplace,
2. **systematics** (Japanese *seiton*) – consists in organizing and marking all elements of the workplace,
3. **cleaning** (Japanese *seiso*) – the workplace should be not only orderly, but also clean,
4. **standardization** (jap *seiketsu*) – creation of possibly uniform rules that will allow to maintain the effects of implementing the first three steps of the method,
5. **self-discipline** (Japanese *shitsuke*) – understood as making habits and habits necessary to perceive improvement solutions.

Workplaces that meet all the requirements of this method are shown in fig. 2.

Mapping of value streams

A popular tool used during the implementation of lean methodology is building maps of value streams. Enterprises create them to determine at which stage of the production process losses occur, and how to eliminate them.

The assumption of mapping according to the Lean Mapping method (Value Steam Mapping – VSM) is not diminishing the role of improving the implementation of individual technological tasks performed during the process, but emphasizing the role of flow continuity in the whole system. Negligence of organizational aspects leads to the prolongation of production transition times.

Value stream mapping relies on the mapping of both material flow logic (successive production activities) and information flows. As a result, you get an image of all (not just technological) activities (adding value and not adding value) that make up the finished product.

An exemplary map of the value stream of a production company is shown in fig. 3.

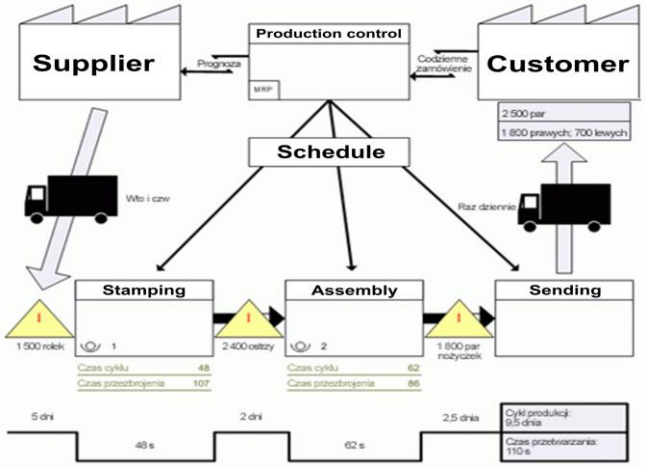

Fig. 3. Map of the lean value stream [10]

The transition time of the entire process, largely determined by the level of inventories, is a determinant of the effectiveness of the production process. At the same time, excessive stocks (one of the manifestations of waste) are often the result of production problems (changeovers, breakdowns, etc.). The reduction of inventories (by eliminating production problems), allowing for shortening the transition times, is the essence of the Lean Manufacturing approach.

Interpreting the map consists in highlighting the places where the flow of resources in the process is inhibited. On the basis of a list of activities that actually add value with the total duration, one can conclude on the level of operational efficiency of the entire system. In this way, the visualization of waste is manifested, which is manifested above all by excessive expectation.

An exemplary map (fig. 3) indicates the total time of the production cycle (9.5 days), and at the same time determines the processing time for 110 s. Such a diagnosis of the current state, made using the application supporting the mapping process (VSM), is an introduction to the lean implementation.

Value stream mapping consists of three stages [11]:
1. diagnosis of the existing state, analysis of the status of the stream of values (Value Stream Analysis),
2. a vision of the future state, construction of the target state of value stream (Value Stream Designing),
3. plan for the improvement and implementation of solutions (Value Stream Work Plan).

The correct implementation of these mapping stages, in relation to the imaging of flows with a higher degree of complexity, requires the use of dedicated tools for computer-aided planning of production processes.

Computer applications supporting mapping of production processes

The popularity of the Lean Manufacturing methodology in the planning and production improvement processes means that there are many applications available on the market that enable comprehensive implementation of the total value stream mapping. VSM practically allows you to view and visualize the details of value creation processes, both in the context of the current state and the development of improved processes. One of the most popular tools is the ConceptDraw PRO software (fig. 4).

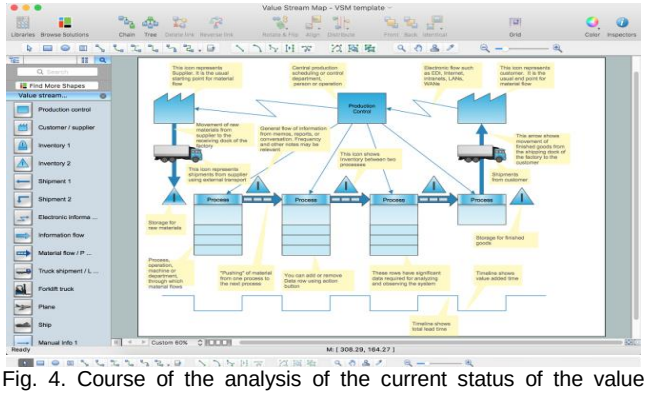

Fig. 4. Course of the analysis of the current status of the value stream in the production enterprise (ConceptDraw PRO) [12]

In fig. 4, there is a template that summarizes the analysis status of the current value stream (VSA). The application offers many pre-designed templates, and additionally prevents the creation of maps that do not comply with the basic rules of value stream visualization, which facilitates the work of inexperienced users.

The map contains information on: the time of a single operation (C/T – Cycle Time), changeover time (C/O – Changeover Time), the method of communication with the customer, the requirements of the recipient, customer demand and its variability, form and time of information flow inside the company, inventory, details of the production process, time of order completion, time needed to obtain cash from the customer (financial liquidity).

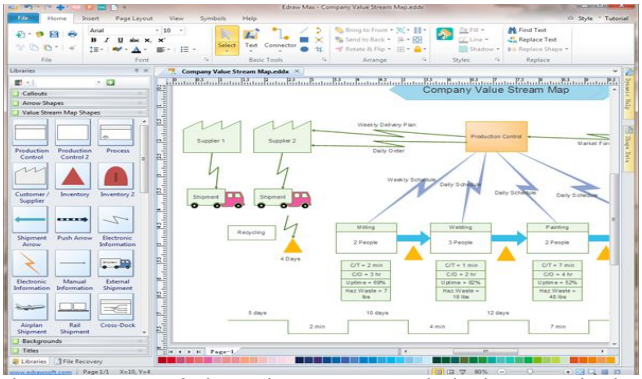

Fig. 5. Course of the value stream analysis in a production enterprise (Edraw Max) [13]

Another application – Edraw Max – offers similar functionalities, and at the same time allows you to work in the cloud and extends the scope of personalization of applications. An important feature of Edraw Max is the complexity of solutions supporting the design and planning of changes in production processes from an external supplier to an external customer in a given facility. The application allows for seamless integration of block diagrams, organization diagrams, network diagrams, mind maps, UML diagrams, workflows, program structures, directional maps, Six Sigma diagrams (and other popular schemes) within a single project. An example of using this application to analyze a specific production process is shown in fig. 5.

In addition to activities aimed at shortening lead time in the computer-aided process mapping for the current state, it is very important to define the bottleneck that occurs during the implementation of a given manufacturing process. Due to the development of the map, it is possible to define more precisely the places of the longest downtime.

Conclusions

An example of the use of computer aided value stream mapping is presented. Additional, beyond the simplification of visualization, measurable benefits from the use of modern computer applications in the manufacturing organization were indicated. Due to them, it becomes possible to imaging more than a single process carried out during production. Moreover, it is possible to quickly and unequivocally notice the waste and its sources as well as to clearly present the effects of decisions regarding flow changes.

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