VALUE STREAM MAPPING AS A TOOL IN OPTIMISING PRODUCTION LOGISTICS. CASE: HE TELETECHNICS

Hurt, U.; Tomba, A. & Koppel, O.

Abstract: Contemporary production logistics might involve newest IT-solutions, wireless communication and technological supplies for running the automation, but it still needs surveillance of process speed and productivity. Value stream mapping (VSM) among other LEAN methods becomes even more necessary, but also more productive as a tool in Industry 4.0. conditions. The current paper explains the usage of VSM in production logistics optimisation. Based on an example case, the paper also analyses the strengths and weaknesses of the method. Finally, it suggests methods of better time cycle and performance analysis for production logistics.

Key words: automation, Industry 4.0., optimisation, production logistics, value chain, value stream mapping.

1. INTRODUCTION

The paper focuses on the specifics and perks of using value stream mapping (VSM) in production logistics optimisation. Since Toyota first introduced methods of LEAN in production management, the aim of the sustainable production is to diminish the waste of resources through better planning and timing of production as well as reducing the amount of stock (both material, semi-finished and finished products) [1].

All tools of applying sustainable production such as 5S, just-in-time, VSM derive from the principles of sustainability and the company's interest of minimising the waste of resources.

It has been a recent trend and a practice at the department of Logistics and Transport at Tallinn University of Technology to provide the companies of the sector a service of optimisation calculations often using value stream mapping as a method. HE Teletechnics Ltd [2] requested such an analysis of their production logistics and material flow. The problem of the current Estonian production sector is that LEAN and other optimisation methods (incl. VSM) are relatively new tools in development processes. Miina [3] states that even though LEAN ideas have been known and studied extensively, there is still yet much to be studied for development of better implementation methods.

The systematic methods of optimisation such as VSM are applicable and even more effective in Industry 4.0. conditions as the data is available online in real time.

2. VALUE STREAM MAPPING (VSM)

2.1. VSM and LEAN

Optimisation is a concept in need of tools and methods in order to be prepared and implemented. LEAN thinking is a wider structure that has supported new emerging methods and tools for analysing and suggesting improvement actions/changes in production process in order to gain savings or higher rate of meeting deadlines.

LEAN thinking has been the driver of systematic elimination of waste in the supply chain. It has first been introduced in
Toyota's production system and discussed and studied by many researchers. LEAN as well as its methods (incl. VSM) aim at elimination of waste and non-value-adding activities [4]. But Bicheno [5] stresses on the process of avoiding rather than eliminating non-value-adding activities and waste. The target of the implementation of better lean tools is the reduction problems of lead time in every stage of production. According to Womack et al [6] it leads to lower costs and higher quality as well as improvement of safety and morale. According to Ohno [7] the wastes can be structured into eight groups and explained as following.

- Overproduction: excess production to storage leads to excess inventory as well as waste of resources in production process.
- Waiting: all time the production process meets waiting is considered waste.
- Excess transport: transport of raw materials, components or final products in between the process cycles or territory.
- Ineffective production methods or technologies: tools or product design specialties leading to excess movements or actions during the production process.
- Unnecessary or excess inventory: raw materials, components, products in production, completed products in storage.
- Unnecessary movements: all excess movements that the employees have to make to reach material, tools or their materials.
- Fault management: system of defining and managing faulty products.
- Low use of knowledge and experience of employees: system allowing improvements suggested by members of the process.

2.2. VSM in production logistics

Originating from Toyota's production management optimisation, VSM is a tool that allows visualisation of transport, material and information flow throughout all processes in the supply chain or a part of it. Mapping the current situation, the total time of production and total value adding time can be assessed [1] as well as attention to hidden problems or waste of time/resources can be discovered. Following the mapping of current value stream and defining of the bottlenecks, the suggestions for avoiding waste can be suggested. Eliminating the sources of waste is a process following the defining of the structure and details on selected types of wastes [8].

3. METHODS OF IMPLEMENTATION

The methods of implementing VSM as an optimisation tool involve modeling the movement/flow of activities, information and material [8]. Among the mapping, assessment of processes involves measuring time use of the activities as well as stating whether the process is a value adding or non-value-adding process [8]; the first involving material unpacking or delivery of materials and the latter involving mainly assembling, folding, painting [10]. The results are in addition to calculations, presented it visually. The method involves mapping the current value stream and suggesting a future value stream. The map of the future value stream can be compiled through consultations with all stakeholders, such as production participants, operations managers and company's management [1]. Goals to be achieved with the future map are [1, 9-10]:

- information on the cycle time and rhythm of the production;
- information on planning and management of production;
• one process decided to be the pace-maker (speed setter);
• if possible, constant flow of material must be achieved, if not possible, the pulling principle must be implemented;
• the productivity of the production flow must increase and all methods of diminishing time-waste must be counted in;
• data on information flow for the production management.

Indicating the wastes and suggesting ways of eliminating or minimizing the causes of wastes is the main goal to be achieved within the method. The mapping has visual tools and key icons for the visualised map are shown in Fig.1.

4. RESEARCH RESULTS

4.1. The current value stream.
On-site measurements and production information system data analysis combined led to mapping the current value stream and observations, calculations, interviews and consultations led to mapping the future value stream. During the research, four different high-runner products were thoroughly analysed.

The flow was analysed separately on all the products aiming at the effectiveness one-piece flow analysis [12].

The future value stream was composed based on the research performed. A simulation as also suggested by McDonald et al [13] of the lead time was calculated and alternatives suggested.

The map stated bottlenecks and wastes in the processes for four different products. The current value stream as an example of one product is visualised on Fig. 2.

The material for the selected products are delivered in two patches - one to the storage of raw materials in the beginning of the process flow, the other to the buffer storage before final assembling. Unpredictability extends the amount of time materials "wait" in the buffer. Even though "safety stock" is a concept often used to explain the over-production of components [14], in current case, the level of safety stock was not unified for similar products as well as safety stock level was not set.

In addition, the production in some cases tends to over-produce some details "just in case" as the setting times of machines for detail-cutting are relatively long. There are no shortages in details, rather than raw material as it has been produced
into details waiting in storage for products that are not yet ordered by customers. The main task was to define the pace-maker of the material flow and production logistics for the selected products and its components throughout the production process. Painting was defined as the most inflexible process as well as concluded to be the pace-maker.

4.2. Defined wastes
The following wastes were indicated and prioritized for actions of minimization (see also in Table 1).

Fig. 2. Current value stream

<table>
<thead>
<tr>
<th>Factor</th>
<th>Importance/impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>overproduction</td>
<td>***</td>
</tr>
<tr>
<td>waiting time</td>
<td>***</td>
</tr>
<tr>
<td>transport</td>
<td>*</td>
</tr>
<tr>
<td>work arrangement</td>
<td>*</td>
</tr>
<tr>
<td>inventory</td>
<td>***</td>
</tr>
<tr>
<td>unnecessary movements</td>
<td>*</td>
</tr>
<tr>
<td>defects</td>
<td>*</td>
</tr>
<tr>
<td>employee knowledge</td>
<td>*</td>
</tr>
</tbody>
</table>

Table 1. Wastes and their importance

- Overproduction: during the analysis period, it could be stated that the focus of the stamping work-station is to use one sheet of metal fully, not according to the needs.
- Excess waiting time derives from overproduction of semi-finished products in the first workstations bringing the waiting time of products even up to 60-100 minutes in the process.
- Excess transport does exist between the workstations, but as they are overly close and structured in a following layout, the factor is not maximum-critical.
- As for unnecessary/unsuitable arrangement of work the factors' impact was not significant on the material flow analysis.

- Excess inventory is in of the key indicators in the case researched as due to overproduction, excess inventory is gathered before every process/workstation.
- Unnecessary movements, could be considered low in amount separate from the excess movements made due to overproduction.
- Defects are well handled and stopped before reaching the next workstation.
- Use of human capital is at a good level in the case researched and well communicated.

4.3. The future value stream
The future value stream was composed and accompanied with calculation methods. The future value stream is visualised on Fig. 3.
The future value stream shows eliminating buffers and overproduction of semi-finished products. Mainly, the focus is on lowering excess
inventory in every stage of production and eliminating the current overproduction leading to components waiting between processes.

Three main suggestions and changes were underlined for HE Teletechnics in optimising their production process using tools of VSM. First, together with the setting time, the "pulling" principle needs to be implemented to avoid excess waiting time. For that, the "pulling" principle best discussed by Jonsson et al. [15] was suggested.

Second, the material usage structure was suggested to be rearranged to avoid overproducing details not needed in production yet.

Thirdly, deriving from lower amount of details overproduced the number of buffers and amount of semi-finished products in buffers and buffer storage is lowered. The minimising of the inventory was suggested to be fully observed and re-calculated with the help of the production information system.

5. CONCLUSION

The methods of VSM find extensive use as a tool of optimisation in production process. It still needs discussion as the university has also contributed in promoting the method. In Estonia and in the case of HE Teletechnics, both LEAN and VSM have become useful tools that have proven its applicability.

Based on the research, the company acknowledged the real pace-maker in the production process and re-arranged (at least got suggestions of doing so) the production flow based on the tact time of the painting unit. Today, as not all the companies are up to date, the visualisation as well as data gathering and comparison, unfortunately is still time-consuming.

In progress of more and more automation as well as computerized and network-managed Industry 4.0. production systems, the optimisation methods such as VSM can be used in a perfected way as precise data availability is higher.

Finally, the methods are components of teaching methodologies in the Tallinn University of Technology Department of Logistics and Transport as well as a hands-on learning case at the Laboratory of

Fig. 3. Future value stream
Logistics and Supply Chain Engineering in the TUT Mektory Centre.

6. REFERENCES


7. ADDITIONAL DATA ABOUT AUTHORS

1) Ulrika Hurt (MA), corresponding author, PhD researcher at Tallinn University of Technology, ulrika.hurt@ttu.ee, phone +372 52 14251, Department of Logistics and Transport, Tallinn University of Technology, Akadeemia tee 15A, 12616 Tallinn, Estonia;
2) Andrei Tomba (MSc), supply chain engineering professional in private sector;
3) Ott Koppel (PhD), visiting professor at Tallinn University of Technology.