The International Journal of
TRANSPORT &*LOGISTICS*
Medzinárodný časopis
DOPRAVA A LOGISTIKA

ISSN 1451-107X

VALUE STREAM MAPPING (VSM) METHOD IN SMALL AND MEDIUM ENTERPRISES SME

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Abstract: *Most of modern companies implement a principles known as "lean" to the management. One of the methods proposed by logistic production is a VSM – Value Stream Mapping. There are known applications of this method for large production systems. VSM can be used to improve the continuity of the flow of materials and information, and to eliminate the losess. The article presents the basic principles are used in the VSM, as well as the possibility of its use in small and medium enterprises (SME). Possible to obtain the results shown in the specific example.*

Key words: *lean management, logistics production, mapping*

1 INTRODUCTION

However, the development of the concept of the delivery chain has brought about a slightly different, broader perspective on logistics. Currently, the key to understanding the function of a company is to be aware that it operates as a part of a greater whole [1]. The systemic view of an organisation gives an opportunity to see it from the inside, and its relationships that extend beyond the company itself. Development of the SCM concept forces companies into a transformation from functionally-oriented organisations into process-oriented organisations. It is important that this turn towards processes applies not only to individual companies, but also to all of the links in a delivery chain. Material flows constitute a shared element that combines different approaches to logistics. They must be understood and managed with expertise. This means that flow control methods may serve as a tool used to achieve this goal. Hence, new concepts and production logistics tasks emerge. Referring to delivery chains, Nyhuis and Wiendhal [2] write plainly that:
The fundamental goal of production logistics can thus be formulated as the pursuance of greater delivery capability and reliability with the lowest possible logistic and production cost [2]. Coyle observes this as well, finding that integration of production planning with logistics is currently becoming more and more common in many companies [3].

In a more market-related perspective proposed by Nyhuis and Wiendhal [2], production as the basic function used to complete orders for specific products is more and

more often employed to improve efficiency of company operation in the market. Besides high standards relating to quality and prices of products, the logistical factors: *delivery dates, completion capacity, and reliability* are able to gradually assume the potential that may distinguish a company in the marketplace. Therefore, the following elements determine market success (over the longer term): production costs, reliability, and delivery completion capacity. Relations between these indicators are shown in Figure 1.

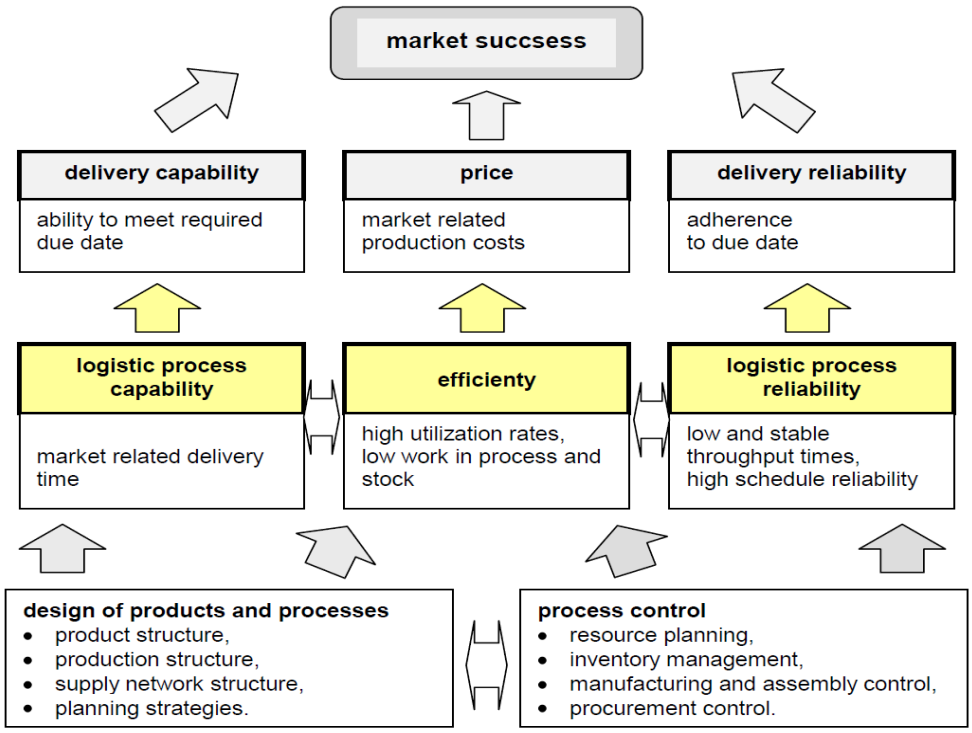

Fig.1 *Key Logistical Performance Indicators (KPI) for production firms [2]*

Gudehus and Kotzab [4] discuss the complexity of the issues related to interconnections between logistics and production in a slightly different way. They treat production system as a network of interconnected processing stations linked by a transport and storage system. *Production systems* are special performance systems which transform input material into physical goods. As logistics networks supply the input and distribute the output of production systems, production and logistics are closely interrelated. Production planning without taking into account logistics is incomplete as logistics without considering production. Production systems are multi stage networks of elementary production stations, which are directly linked by transport systems or indirectly connected via intermediate buffers and storage systems. Tasks of production logistics include organisation, planning and scheduling of product manufacturing processes, but it is not an objective of logistics to develop new technologies or to improve manufacturing processes. The latter tasks are the roles of production technology and process engineering. In other words, production planning and organisation are in the realm of production logistics, while technologies and improvement of technological processes are the tasks of production engineering.

Long-term planning is essential from the point of view of the production system life-span. According to Gudehus [4], it should be carried out at least once a year, or more frequently if management process requires it. The following procedures must be conducted and approved:

1. Optimisation of the existing production network, respectively design of new production network.

2. Documentation of network structure, specification of limit performances of available production stations and transport connections and determination of capacities of the necessary buffers and storages.
3. Segmentation of the final and intermediate products into kanban-storekeeping of an order of items and parts.
4. Definition of standard production chains and tress: selection and design of cost optimal production chains or trees for the different product groups.
5. Specification and documentation of the involved production, performance and storage stations.
6. Organization of production scheduling: definition of the tasks of production scheduling.

In logistics the emphasis has been on relatively small consumable components and not on the system as a whole [5]. More recently, the field of logistics has been expanding to greater proportions through the development of supply chains (SCs) and implementation of the principles and concepts of supply chain management (SCM), with logistics being a major component thereof. An objective and challenge for the future is to address logistics in a much broader context, reflecting a total system's approach [6].

2 VALUE STREAMS

In recent years, Womack and Jones [7] have proposed a completely innovative approach to looking at companies. Although certain solutions that they propose are controversial and not always possible to use, they are still worth intellectual exploration. *Lean thinking*, a concept that they propose, is an excellent method for production companies with diversified product ranges and frequent retooling in production lines. Their concept of the lean ‘company’ is based on five fundamental principles:
1. Defining value for each product,
2. Determination of product value stream,
3. Obtaining an undisturbed value flow,
4. Making it possible for the client to get value from the manufacturer,
5. Ceaseless striving for perfection.

Therefore, the lean company is an organisation that allows for the conduct of ongoing consultations by all units participating in the value-generating process. Their objective is to create a flow channel for the complete value stream, allowing all sorts of wastage to be eliminated completely. In lean approach it is necessary to go beyond company, in order to examine complete set of operations making up the process of preparation and production of a certain product. It is necessary to take into consideration all operations performed, starting from working out a concept, through detailed design, until the moment of product occurrence in the market. On the other hand, it is necessary to specify all operations from order acceptance and production planning until order completion. Moreover, it is needed to describe operations from the moment of acquiring raw materials until product delivery straight to the client. Therefore, the process of establishing a lean company requires a completely new look at the relationships between individual enterprises, establishing simple rules to regulate mutual behaviours of companies, and clarity of successive steps taken in regard to the value stream. This allows each chain participant to determine if the other companies are complying with the established rules.

From this perspective of perceiving the company, it is absolutely necessary and indispensable to use the SCs concept of the delivery chain (suppliers and consumers) [8]. In the elimination of waste *lean thinking* is very useful , as it allows feedback of information concerning the effects of efforts made in order to convert *muda* into value.

Thus, production processes are accompanied by the value stream. The value stream is a set of all operations required to manufacture a specific product (goods, service) in a process consisting of three tasks that are critical from management point of view:

1. Product design (from the concept, through detailed design, to implementation in production);
2. Information flow (from acceptance of orders, through production planning, to delivery of finished products);
3. Physical execution of product manufacture (processes that involve processing of raw materials into a finished product delivered to the client).

This is also why it is necessary to identify the complete value stream for each manufactured product (or group of products). Typically, the value stream analysis leads to the following conclusions:

- many operations performed contribute to creating value,
- many other operations do contribute to creating value, however they cannot be avoided considering technologies used by company, and production facilities (*muda* of the first type; e.g. quality control),
- there are additional operations that do not contribute to establishing a value, and that can be eliminated immediately (*muda* of the second type).

Small and medium companies account for as much as 90% of all businesses in Poland. Unfortunately, in terms of the production processes of these entities, the tools, methods and techniques described by *Lean Management* are not used on a very frequent basis, or they remain simply unknown to many companies. Trainings and implementations of *lean* systems offered by professional companies are too costly, or they are regarded as unprofitable and inapplicable for such reasons as certain behaviour (mentality) of the employees. Nevertheless, in many cases, the introduction of selected (not necessarily all) methods may crucially boost the efficiency of the production process or business productivity rates. There are a great number of methods and techniques that may be used in production activity. Therefore, selection of the appropriate ones for a given company and the specific processes may in some cases be challenging.

In literature, these methods are indicated to a growing extent as *The Lean Toolbox*, and they include, among others:

- Value Stream Mapping (VSM) method,
- Total Productive Maintenance (TPM) method,
- 5 Pillars of the Visual Workplace (5S) method,
- Single Minute Exchange of Die (SMED) method,
- Just in Time (JiT) system,
- Kanban system – card-based organisation and controls,
- Six Sigma (6S) method – appropriate product quality,
- 5W1H (5 Why and 1 How) method – recognition of the reason of the problem,
- 7M (7 Muda, 7 Wastes) method – elimination of loss and wastage in processes,
- Pareto principle – influence of reasons on results,
- 3M (Muri, Mura, Muda) – elimination of three basic losses in industry,
- Heijunka (Sequencer) technique – production levelling,
- Jidoka (Autonomation) technique – possibility of line or process stop,
- Kaizen process – evolving process of constant improvement,
- Kaikaku process – innovation, a sudden change for the better.

In this place, two distinctive statements by J.P. Womack [9] and J. Burton [10] are worth citing for managers of small and medium enterprises:

J. P. Womack: The departure point of *lean* is to go and see how things are done, and only thereafter: create.
J. Burton: A manager must get up from his or her desk and see what is really happening in the plant.

A very extensive publication of various tools, techniques and methods supporting the *lean* concept have been presented by J. Bicheno and M. Holweg in their book entitled: *The Lean Toolbox: The Essential Guide to Lean Transformation* [11]. The specific chapters deal with, among others, Value and Waste, Transformation Frameworks, Mapping, Layout and Cell Design, the Supply Chain and Accounting and Measurement.

As one of the basic methods and techniques permitting one to see *how it is done*, the mapping process of all business processes is provided. The follow-up of the value stream and the preparation of a current status map makes a perfect basis for the purpose of wastage elimination and change proposals, which J.P. Wormack referred to as '*create!'*. Value stream mapping is a method employed to analyse a production system. It entails illustrating a value stream, which means identifying all operations (both those that add value, and those that do not) within the scope of product manufacturing process, starting from raw material to finished product. Visualisation of value stream allows to observe all types of waste in it, and to direct further "slimming" actions in a company in order to eliminate waste from the area of its value-adding operations. The feature that distinguishes mapping from other methods used to analyse production systems is that it includes both material and information flows. The Value Stream Mapping method is a process consisting of three stages [12]:
Stage 1. Diagnosis of the existing situation – Value Stream Analysis (VSA) – analysis of the current condition of the value stream [13].
Stage 2. Creation of a vision of the future situation– Value Stream Designing (VSD) – construction of the target condition of the value stream [14].
Stage 3. Improvement plan – Value Stream Work Plan (VSP) – improvement and implementation plan for solutions employed [15].
The following set of values shall be prepared while creating first maps:
- cycle time (C/T),
- time for retooling (C/O),
- availability (availability of station for commencement of work),
- EPE indicator (production batch volume expressed in time units),
- number of operators,
- number of product types,
- available work time,
- reject rate.

The scope of data that should be identified and shown on the map primarily consists of:
- the level of client's monthly orders,
- delivery completion form,
- manufacturing processes carried out,
- characteristics of these processes taking cycle times into account,
- time required for retooling, availability of machines, number of operators, etc.
- raw material surpluses, surplusesfor production in progress, and surpluses of finished products physically identified for individual streams in a production system,
- system allowing for the information of individual processes about the sequence of ordered production,
- information exchange system with client and supplier,
- material flow form (e.g. "push" type), etc.

In order to draw a clear and comprehensible map it is necessary to use specified graphic symbols. A complete map of the current situation shows two features that are characteristic for all value stream maps. Product flow is illustrated in the lower part of the map and runs from left to right, while information flow occupies the upper section of the map and goes from right to left.

The timeline is an important map component. On the basis of observation data it is possible to determine condition of the current value stream. The timeline (in form of a meander) is used to calculate the total time of the product passing through the value stream, that is time required for a single product to go through the complete production process, starting from the delivery of raw materials to the moment of shipping the product to the client. Elapsed time (e.g. in days) is calculated as a ratio of the volume of surplus (given in intems) to daily demand for products as reported by the client. Mapping of the future situation (the second stage of the process) is aimed at working out an implementation plan, which would determine the desired target condition of the manufacturing system in the next months and indicate the set of actions necessary to achieve the vision developed. The principal objective of these operations is to adjust the production rate to the pace of orders placed by client, and to reduce surpluses in all component areas of the company's production system.

The process of developing a desired production system is systematised and proceeds in several stages. The map showing the future condition is worked out on the basis of the current condition map and knowledge of *lean manufacturing* methods and techniques. The following algorithm has been proved effective by the author:

1. Selection of a process subject to analysis.
2. Preparation of a detailed diagram of the production process.
3. Collection of process data, e.g. orders, supplies, inventory, etc.
4. Determination of the basic parameters and quantities describing the process, performance of the necessary time study of operations.
5. Preparation and description of icons used in mapping.
6. Description of losses and wastes in the process.
7. Preparation of a current status map (legible, suitable format, e.g. A2).
8. Agreement and collection of information on possible suggestions of changes in the existing system.
9. Entering of proposed changes on the value stream map.
10. Arrangements and settlement of dates of possible changes.
11. Introduction of changes.
12. Analysis of effects after the introduction of changes.
13. Strict observance of Kaizen!

3 VALUE STREAM MAPPING IN SMALL COMPANIES - EXAMPLE

The research covered the manufacturing process of multiple step aluminium ladders. The product range includes ladders with 2, 4, 6 and 8 steps. The plant possesses relatively modern equipment (specialised automatic assembly unit, semi-automatic units, manual devices).

Production: on average 15000 ladders/months, with a strongly varying product range.
Customers: mainly Polish and foreign supermarket chains.
Material suppliers: mainly foreign, according to client's specification.
The following problems have been identified:

- irregular orders,
- problems with forecasting of materials and sales,
- lack of strategic plans,

– very weak information flow (virtually no system),
– long refitting times of a few devices,
– chaos and mess in the production hall,
– lack of staff integration,
– lack of knowledge about basic tools from a widely understood *lean* toolbox, among both operators and management.

Possible improvement:
– casual, almost sudden,
– long-term - planned construction of a production line in a new hall.

Proposal (management greatly interested in changes):
– analysis of the current status,
– description of wastes and losses, immediate change proposals,
– preparation of a current status map with the indicated possible improvements,
– preparation of a change introduction schedule,
– short training on *lean* rules for all employees.

Figure 2 presents a diagram of the aluminium ladder production process.

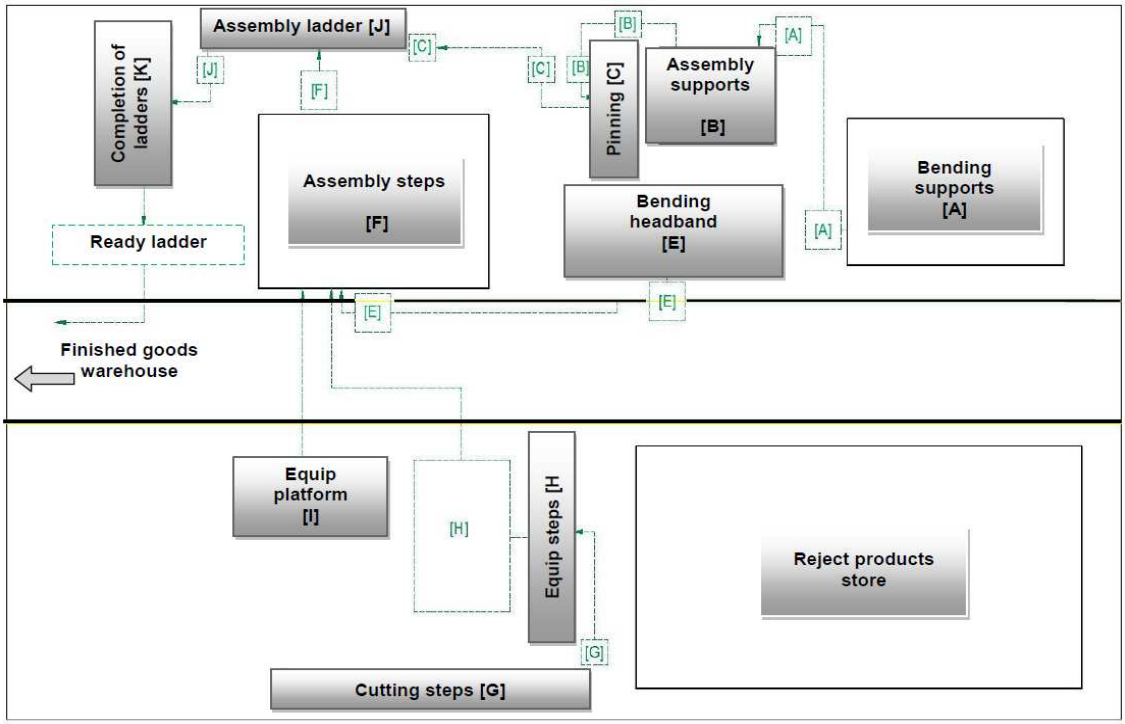

***Fig. 2** Diagram of ladder manufacturing process*

Preparation of a detailed map requires the analysis of all component processes of ladder manufacturing. According to the diagram (Fig. 2), this includes 11 processes from A to K:
A – bending of supports,
B – installation of supports,
C – fastening,
D – bar reinforcement,
E – cutting of openings and arch bending,
F – installation of steps,
G – cutting of steps,
H – reinforcement of steps,
I – reinforcement of platform,

J – installation of ladders,
K – ladder completion.
Example of analysis: Arch bending and assembly openings cutting station [E]
The bending operation [E] takes place at a specialised station. Thanks to the appropriate displacement of devices and the buffer for bent arches, the process itself is very efficient. Due to the specifics of the equipment, a refitting from short (1-5 steps) to long ladders (5-6 steps) takes approx. 30 minutes. The arch is the basis for the construction of all other parts, and it is also the largest construction element of a one-sided aluminium ladder. Due to this, its easy movement is a critical point of the production process. Figure 3 presents a manufacturing process at station E.

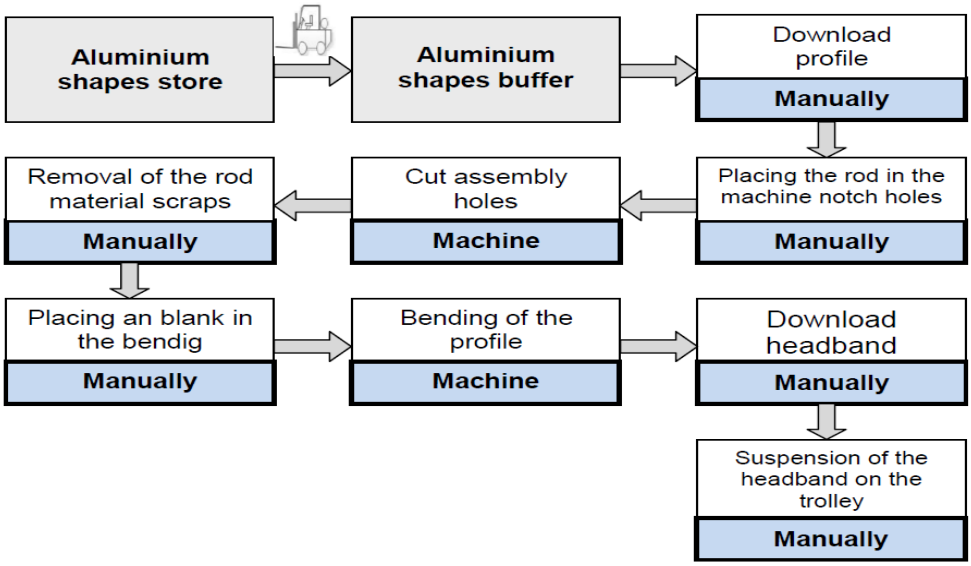

Fig. 3 *Process of cutting holes and bending the headband*

The transport of arches to the steps assembly station [F] is performed with specialist trolleys also acting as semi-product buffers.

Fig. 4 *Pallet jacks used for arch transport [E]*

Unfortunately, in the case of carrying the longest arches for seven and eight step ladders, pallet jacks cannot be used, as they are too low. The elements attached to the jack reach the

ground and therefore cannot be efficiently transported. The transport problems of the longest arches without impeding the carrying of shorter elements can be solved by installing a height adjustment feature within the jack handle. Figure 4 presents the currently used jacks, while the proposed solution is in Figure 5.

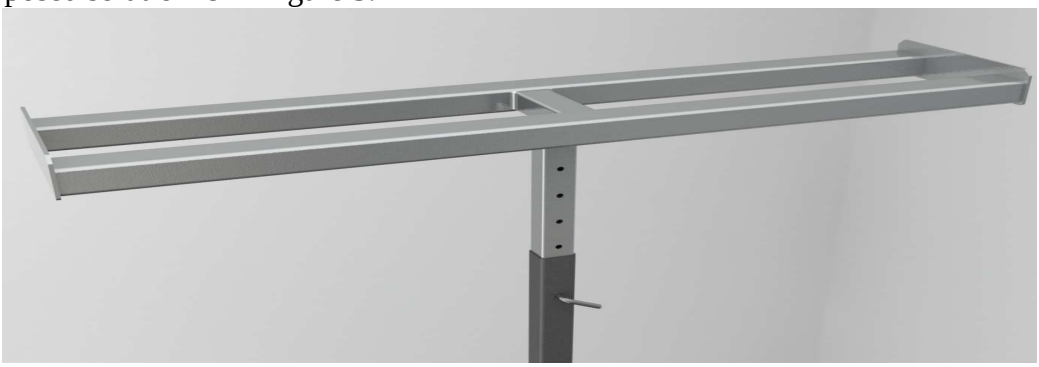

Fig. 5 *Proposed modification of the arch jack*

Similar analyses were performed with regard to other processes. Changes applicable at very short notice can be proposed for almost all processes. As a final stage of the analysis, a map of the current status with numerous change proposals indicated on its specific sections was prepared. Due to its size (A1), only a fragment thereof is presented in Figure 6.

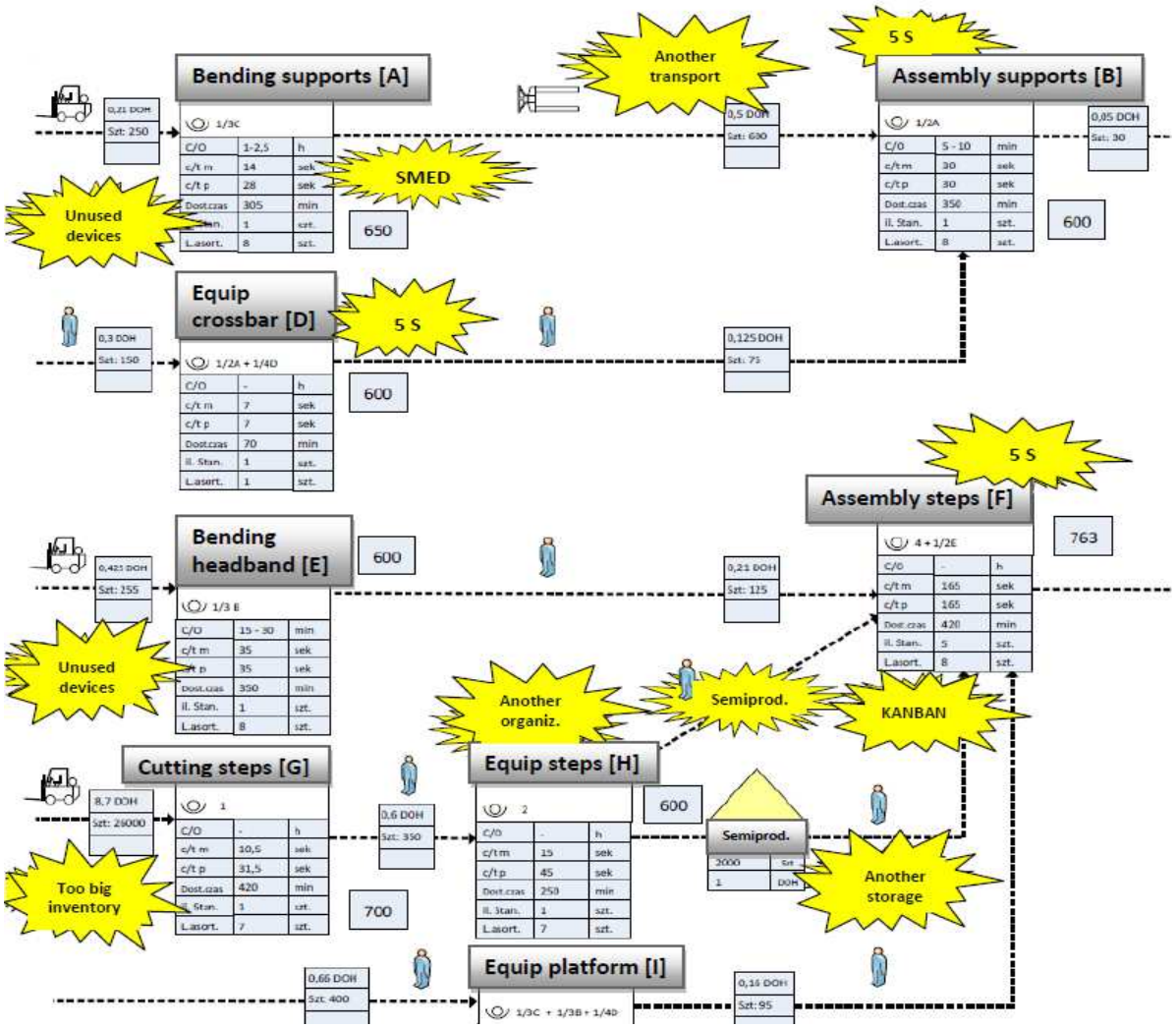

Fig. 6 *Value Stream Mapping - part of the current status map*

According to the analysis, a production increase (which is somewhat likely) will necessitate a study of a TPM implementation. This pertains mainly to two stations with limited equipment availability. Its value is greatly increased, first of all, by breakdowns and a very lengthy machine refitting process.

6 CONCLUSIONS

The implementation of single *Lean Manufacturing* items cannot be regard as *lean*, but merely as the beginning of the road. The viewing of the overall process stands as the real challenge. Logistics specialists try to cope with this by introducing ever more sophisticated computer software [16]. As claimed by J.P. Womack, this is not yet the true road to success. A proper solution does not rely on the multiplying of management tools, but on the creation of such a management system which is effect-oriented and which restricts wastes - as suggested by lean management.

In the case of small and medium enterprises, perception of the overall process may seem too difficult. Thus, the other possible choice is introducing single items. However, in order to produce an effect of synergy, it is worth constructing a system designed for a longer period of time and to set specific stages for such a period. In the beginning, actions relating to the internal stream will be sufficient, i.e. dealing solely with the internal flow of the enterprise. Quick results may be gained e.g. by the elimination of wastes (7 M, 3 M) and introduction of organisation pursuant to the 5S principles.

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Recenzia/Review: *Dr.h.c. prof. Ing. Dušan Malindžák, CSc.*