USE OF LEAN TOOLBOX FOR IDENTIFICATION OF WASTE

Bożena Zwolińska*, Katarzyna Smolińska** and Edward Michlowicz***

*AGH University of Science and Technology, Kraków, Polska, Email: bzwol@agh.edu.pl
**AGH University of Science and Technology, Kraków, Polska, Email: ksmol@agh.edu.pl
***AGH University of Science and Technology, Kraków, Polska,
Email: michlowi@agh.edu.pl

Abstract Business management according to the Lean Management concept is a constant and comprehensive process of implementing changes in process and organizational structure. Some of the key elements in production management according to the Lean concept include: correcting mistakes (e.g. TQM), eliminating the existing muda (e.g. Kaizen, 5S) increasing effectiveness of value adding processes (e.g. TPM) and reducing duration of activities that are essential, but do not generate added value (e.g. SMED). The article involves examples of using tools of the Lean toolbox (i.e. VSM, Spaghetti plot) at the stage of identifying losses in a chosen production process.

Paper type: Research Paper

Published online: 16 July 2016
Vol. 6, No. 3, pp. 207-216
DOI: 10.21008/j.2083-4950.2016.6.3.2

ISSN 2083-4942 (Print)
ISSN 2083-4950 (Online)

Keywords: *materials flow, Lean production methods*

1. INTRODUCTION

In English language, the word "Lean" describes a skinny silhouette, whereas "management" most often refers to running a business. There is no Polish language expression for that phrase, which results in the original version being used. Lean management consists in substantial limiting of resources required for production: space, investments, time and people while maximizing the use of the resources and adapting the company to the conditions prevailing on the market at the given point in time. The Lean management concept is based on using tools of the Lean toolbox so as to effectively manage the flow of "one item", according to what the recipients do. The primary and basic production principle, according to the Lean code is to start up production at the moment when primary demand occurs (Byrne, 2013). Pull system consists in implementing the waterfall demand model, which means the components needed for production are picked from the previous level only when necessary and only in the necessary amount. In such model production is carried out in small batches and is responsive to the customer's rapidly changing needs. An efficient, immediate reaction is key to maintain competitiveness on the market (Czerska, 2009).

2. GENERAL CHARACTERISTICS OF THE PLANT'S STRUCTURE

Improving the continuity of production processes using tools of the Lean toolbox stimulates process innovation in production systems. In order to obtain tangible results of the implemented Lean solutions, it is necessary to plan the implementing adequately. The main principle is to individually adapt the Lean tools to the already existing production system, taking into account technical and technological solutions and constraints of the production system environment, from a tactical and strategic perspective. Production system operationalization begins with assessment of the present condition and determining the existing Muda, Mura and Muri (the so-called 3M). The first stage of implementing the Lean solutions consists in analyzing the priorities and taking into account the company's economic and personnel possibilities. The given example analyses a process of manufacturing steel elements of air-conditioning hoses. The discussed company is one of the leading multinational corporations, but the discussed case is one of its three plants located in Poland. The examined plant produces, among other things, hoses for the power steering system, cooling and air conditioning systems, braking system, suspension and fueling system. The product range reaches more than 200 different types of hoses. The main recipients include: Volvo, Volkswagen, Fiat, Renault, Scania, DAF, Valeo and others. Figure 1 presents model sub-assemblies manufactured in the examined plant.

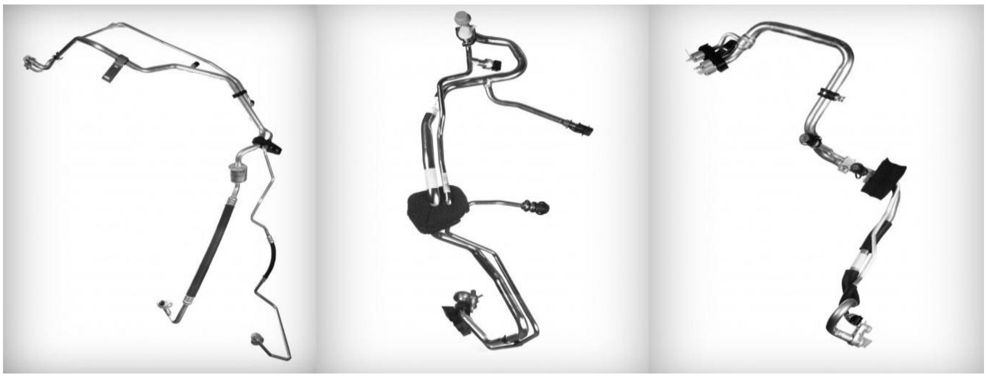

Fig. 1 Sample air conditioning hoses

Given the broad diversity of the product range, the analysis concerns one of the air conditioning system elements: a steel bracket (Fig. 2). The production process of various air conditioning steel brackets is similar. The choice of this product results from the planned thorough reorganization of the hall. At the moment, an upwards trend in such elements made of aluminum can be observed on the market. The automotive sector observes a slow withdrawal of products from the market, therefore the companies that produce sub-assemblies are obliged to continue their production while introducing new solutions at the same time. Such situation influences the EPEI index significantly.

Fig. 2 Sample hose brackets

The company operates in three-shifts system with the effective working time of 7 hrs 40 mins. Use of the Lean solutions started with assessing the possibility to implement tools of the Lean Toolbox, based on a 10-point scale. That assessment allowed to determine the sequence of changes implemented and compare their effectiveness in order to plan the related costs. Table 1 presents a compilation of results.

Table 1 Analysis of priorities for implementing the lean toolbox solutions

Lean tool	Priority	Expense	Probability of success	Cost reduction	Total points
VSM	9	4	1.0	5	19.0
Spaghetti diagram	8	7	1.0	3	19.0
SMED	6	2	0.7	7	15.7
KAIZEN	7	3	0.2	5	15.2
TPM	8	2	0.5	4	14.5

3. PRODUCTION SYSTEM CONDITION ANALYSIS

The first stage of improving operational efficiency consists in analyzing the condition of the company. At this stage, in case of serial production enterprises, Value Stream Mapping – VSM is the most often used method. The VSM methodology is a basic tool that allows to identify and divide actions (times) into value added time and non-value added time (Michlowicz & Smolińska, 2015). Moreover, a VSM map is a graphic presentation of introducing a lean production system, setting out the objective that should be pursued. A value stream is defined by all the actions and occurrences that a product passes through, starting from supplier to customer (Pierścionek, 2011). In the production process it involves transport, set-up times, waiting for processing, the actual processing, quality checking, packing and losses resulting from defects (Rother, 2008). Figure 3, given its comprehensibility, presents a simplified VSM map for A, B and C product families, whereas the cycle duration parameters are included in table 2 and the level of inter-operational stocks – in the table 3.

Table 2 Cycle duration parameters

Process number	Process level	Tact time C/T [s]	Locking time B/T [s]	Quality Q [%]	Load [%]
1	10	4.80	4.80	100	83
2	15	11.37	11.37	100	79
3	30	34.60	34.60	99	78
4a	30	43.34	43.34	73	63
4b	30	62.22	62.22	82	54
4c	40	46.66	46.66	74	96
5	60	1.54	1650	100	76
6	70	8.04	8.04	99	87
7	120	12.46	4800	99	99
8	150	21.96	21.96	98	86
9	290	19.80	19.8	100	7

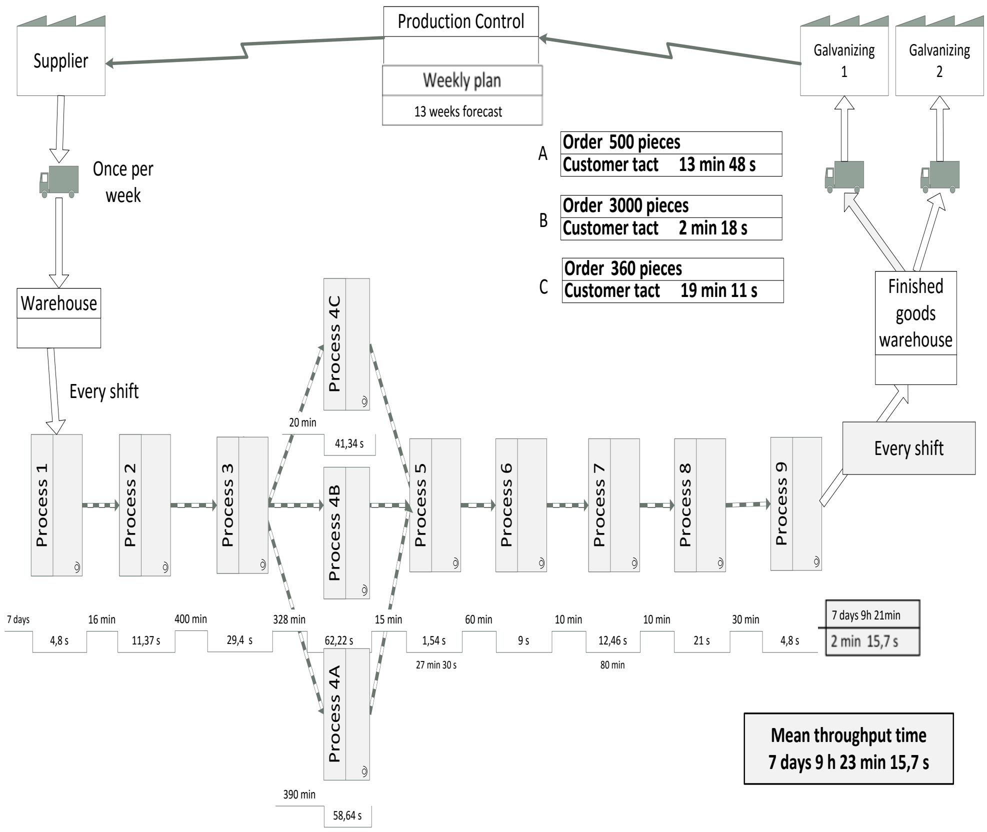

Fig. 3 Simplified VSM map of analysed flow

Table 3 Level of inter-operational stocks

Level number	**10/ 15***	**15/ 30***	**30/ 40***	**40/ 60***	**60/ 70***	**70/ 120***	**120/ 150***	**150/ 290***
Family **A**	100	161	115 15 15	137	137	164	164	162
Family **B**	230		430 35 35	340	365	365	365	270
Family **C**	0	50	95	81	123	122	165	158

*10/15 means, respectively, buffer value in units between the level of 10 and 15, that is, between processes 1 and 2.

In the analyzed example, the production plan is drawn up 13 weeks ahead of time, based on the schedule of orders and a short-term forecast. The components required for production are stored outside the plant, in a cooperating company responsible for keeping the required level of stocks and verifying supplies regarding the quality and quantity of input materials. Moreover, the very cooperating company is responsible for the following processes: storage of finished goods and transport between the producing plant and the storehouse. Supplies into the (cooperating) input storehouse are carried out once a week and are organized by an external freight forwarding company. The components are delivered to the production hall, at the "cross-docking" zone once per shift and using the so-called "two-ways" routes, the finished goods are also received in shifts. There is no Internal Logistics Department at the production site, which obliges the operators to pick the components from buffers on their own, instead of in standard lots. Lack of operators' work standardization influences duration of the cycle. For instance, during block grouting on a tube, some operators picked several tubes and blocks at a time, consequently increasing the process efficiency. Other operators processed the very action one by one. In such situation it is difficult to compare the OEE index of the same process at different shifts.

The created VSM map presents the logic of the flows without reference to arrangement of the production equipment and machinery. The essence of mapping consists in designating the places where the flow of materials is stopped and where stocks are piled. Downtime occurring means production problems such as: too long refitting, extended duration of task completing, incorrectly balanced cycle times and too long distances between particular operations. All of these wastages occurring result in irrational use of the owned resources. Flows between the operations are completed according to the "push" principle. Distances between individual posts are between 3 and 40 meters. Distances so long walked by the operators inclined to make Spaghetti plots of material flow for the examined product families. Production based on the "push" structure makes each of the processes included in the value stream work according to its own "storehouse" time, irrespective of the actual requirements of the processes which are recipients of its products. Such situation is a result of the greatest waste of all, which is overproduction. Overproduction contributes to generating the other muda: needless use of materials and resources, machinery and staff, needless transport, increased level of stocks that must be stored. Muda in the form of overproduction appears also in the analyzed example. There are several accidental places of piling semi-finished products manufactured in too large amounts at the production hall in the steel products zone, between operational posts. The buffers also include products of each production stage, both from the steel and the aluminum product line, in the number of several to several dozen items. The oldest product has been lying for more than two years (827 days). Two fields marked with asterisk (*) on the drawing present the arrangement of storehouses for overproduced products.

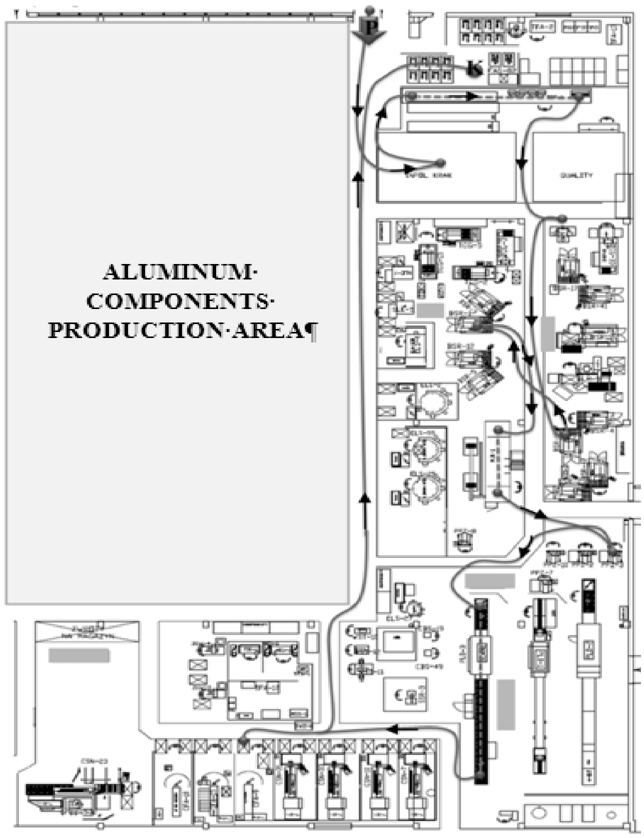

Fig. 4 Spaghetti diagram for the flow of a selected product family

The diagram (Fig. 4) presents a long and roundabout way covered by the product. In some cases, a reverse flow direction is needed so a material can "transfer" to another post. The wrong arrangement of the machinery generates needless transport and a substantial decrease of process efficiency. There is one operator assigned to one machine in the analyzed example. In case an employee is responsible for operating a machine and supplying his/her work post with components located at a significant distance simultaneously, then the productive capacity of the process decreases significantly. Fig. 5 presents work load for operator of one of the co-shared processes between the aluminum and steel product lines, responsible for picking components from twelve different places.

In case of completing processes at a co-shared work post between two product lines (steel and aluminum) there is no component picking schedule. Lack of task queuing makes an operator pick elements randomly – most often the ones located at the nearest available storage place. There is also no possibility to mention to the washing station operator that the container with components on a given post is full.

Moreover, not all of the component picking posts are visible from the perspective of the washing station operator's post, which results in many empty runs (needless movements) occurring or, very often, waiting for the container to be emptied. The overfilled inter-operational buffers increase the WIP, thereby extending the process lead time. The longer the WIP and the transfer time, the lower the level of use of the post and the less elastic the production line is (Womack & Jones 2009).

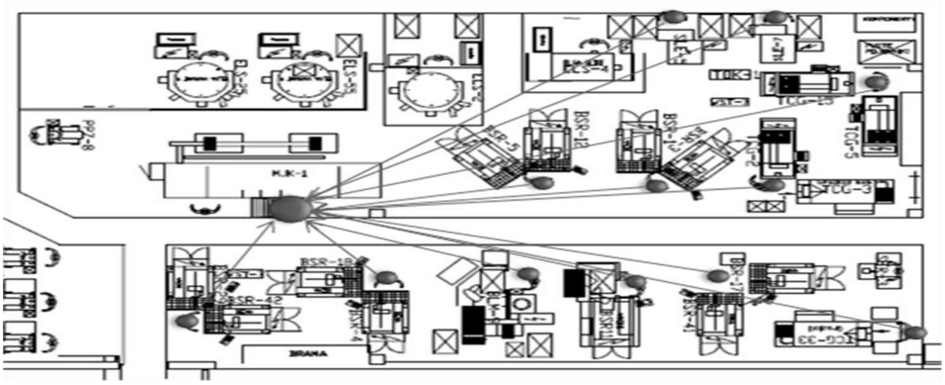

Fig. 5 Washing station operator's work load

The situation in which the flow is controlled in an arbitrary way by operational employees results in blocking the "chosen" processes and imbalance in machines' loading. Figure 6 presents use of two forming machines during five various working days.

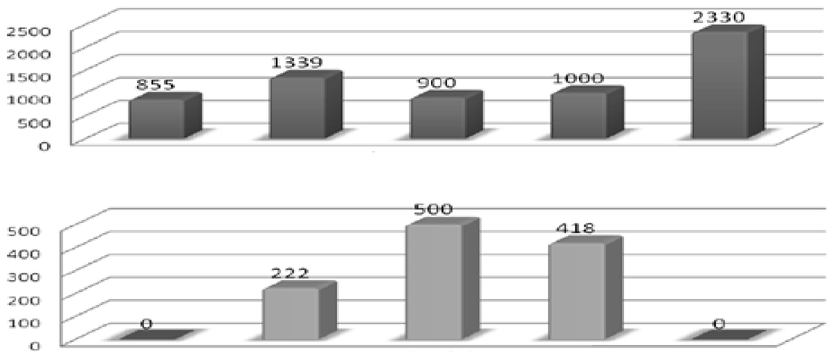

Fig. 6 Sample weekly forming machines loading

The chart presents a very high volatility of machines' loading. Lack of balancing generates downtime, plus, the enclosed chart shows that one of the machines was not working for the entire period of five days. At the same time, on the fifth day, a machine with the same parameters performed a "schedule" with a nearly double production increase compared to four previous days.

4. CONCLUSION

The examined model presents the methods of identifying the existing wastages in the process of producing steel brackets for air-conditioning hoses. Most of the losses result in lack of standardization, not only in the operations made, but also in the processes of arranging the machines after refitting. Two different machine parameters settings were observed for the same process during the measurement, which resulted in shortages on one of the posts.

The analyzed example presents an incorrect arrangement of machines order in the process. Arranging the machines according to the operation sequence shall, firstly, reduce the inter-operational stocks, decrease the distances between the operations (shorter transport routes) and shorten production lead time. Presently, in case of the analyzed product family, the average transfer time is 7 days 9 hours and 23 minutes, while the processing time for each of the products is no longer than 3 minutes. The produced brackets require around 80 minutes of ageing after the soldering process, so the disproportions of value added time to non-value added time are too large. Imbalance in the use of machines (e.g. in the forming process), as well as their wrong arrangement, lack of operators' work standardization and the large series production makes the entire production process unstable and unrepeatable. Lack of correct balancing of the works decreases the entire system's efficiency.

The works that improve the bracket production process should firstly – after a finished stage of identifying the wastage – cover an improvement of production levelling, taking into account introduction of J-I-T system. In addition to daily production planning, it is also necessary to introduce an arrangement of work cells dedicated to separate product families.

ACKNOWLEDGEMENTS

This work was supported funded by research project AGH University of Science and Technology 15.11.130.965.

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BIOGRAPHICAL NOTES

Bożena Zwolińska is a graduate of Faculty of Mechanical Engineering and Robotics at AGH University of Science and Technology in Krakow. She received her Ph.D. degree in Industrial Engineering from AGH in 2009. Her professional interests concern the area of production and revers logistics.

Katarzyna Smolińska is a graduate of faculty of mechanical engineering and robotics at agh university of science and technology in krakow. She received MSC degree in manufacturing mechatronics (2013) and is a phd student at AGH University. Her professional interests concern the area of production logistics.

Edward Michlowicz is a Professor at AGH University of Science and Technology in Krakow. He works at the Faculty of Mechanical Engineering and Robotics at the Department of Manufacturing Systems. The research deals with the industrial logistics, transport systems, as well as the application of operations research in logistics systems. For many years, prefers the use a systemic approach in terms of general systems theory.