RESEARCH IN LOGISTICS & PRODUCTION

APPLICATION OF LEAN TOOLS TO MEASURE AND IMPROVE WORK IN ASSEMBLY CELL: A CASE STUDY

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Abstract: The article describes a research project conducted by the authors in 2015 in one of the manufacturing companies of the automotive industry in Poland. Described manufacturing company engaged in the production of body frame of truck cargo space. The aim of the project was to improve the part of production process involving assembling walls in one production area. The article describes the project realization, starting from defining the problem, identifying measures to improve the organization of production process, then selecting analytical tools of the current situation and in brief selecting improvement tools that were implemented in manufacturing company. As a result of the research work identified measures have been improved as explained in the article.

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1. INTRODUCTION

Lean Manufacturing is currently one of the fastest growing disciplines of production and operations management (Moyano-Fuentes & Sacristan-Diaz, 2012). A magnitude of publications appearing in the last decade demonstrates the huge interest of studying Toyota Production System (TPS) in the scientific research as an origin of Lean Manufacturing (Holweg, 2007). This concept strongly demonstrates its practical purpose and orientation of research on issues important from the point of view of industrial problems. It is one of the few research trends, which is strongly associated with theory and practice. Therefore enrolling to such direction of academic activities is consistent with the current conviction for the integration of these two environments (Guide & Van Wassenhove, 2007).

Based on the confidence that industrial research is a right way we have begun a cooperation with one of automotive industry companies from Lublin Voivodeship. Description of the company and the main problems that we came to be measured will be described later in this article. In contrast, at the outset it is worth noting that the goal of our work was to improve a limited scope of production process. This emerged as a need to conduct research related to the implementation of Lean tools on a micro scale (only within selected assembly cell) and further spread our efforts for the whole production system based on research results confirmed by company managers (Marodin & Saurin, 2013).

The selection of assembly cell was provided by company managers. They were heavily involved in the research project. When conducting our research we had strong support from them. The proposed research program, the selection of Lean tools, implementation of selected Lean tools and their dissemination to the whole production system was with the full approval of management.

The research problem was initially outlined by management. It has become the basis to focus our efforts on the implementation of Lean tools. We defined research objectives which refers to the evolution of the TPS in accordance with the perception of its main creators: Taiichi Ohno (Ohno, 1989). The main objective of our research was the elimination of waste resulting in reduced production efficiency in the selected assembly cell.

Considering above statements, the structure of the article is as follows. In the second chapter we briefly introduced Lean Production reported in the literature. We characterized the manufacturing company as well as justified research program and adopted measures for verifying research results. The third chapter delineates research investigation and shows results achieved before Lean tools implementation. In the fourth chapter we described solutions proposed to improved current state and yields the results of Lean tools implementation. In the last chapter we formulate conclusions and directions for further work.

2. BACKGROUND

2.1. Outline of the literature related to lean tools

Generally, lean production was formalized as an integrated socio-technical system, whose main objective is to reduce production costs and lead time by eliminating wasteful reveals the internal variability of the production system and an external uncertainties on both suppliers and customers of the production system (Shah & Ward, 2007). For this purpose a number of lean tools has been developed to achieve the above objective. Literature suggests the use of such lean tools in the proper configuration with regard to the speed of total improvement apparent in short time (Golińska, 2014).

According to the aforementioned definition of lean production three areas of waste exploration are clearly highlighted, namely, external supply chain, process execution inside the manufacturing system and fulfilment of customers' requirements. Due to the fact that often the causes of emerging waste can be seen in the system management, the process control should also be considered as an additional area to be revised due to the goal achievement. The main tool for the overall evaluation of the company's activities in the context of seeking sources of waste has become a value stream mapping (Rother & Shook, 1999). The process of value stream mapping is divided into two stages: depicting the current situation of the company and establishing the roadmap from future state of the company. The second stage of value stream mapping is particularly important since it is the basis to determine the extent of the improvements required to achieve a higher level of leanness. The future state map becomes the basis for the selection of improvement tools that require immediate implementation to the production system (Dal Forno, Pereira, Forcellini & Kipper, 2014, Rohac & Januska, 2015).

The use of specific lean tools in their original form is published in a variety of ways. In one current of literature the impact of improvement tools on production system or in general on organization is confirmed using simulation (Abdulmalek & Rajgopal, 2007, Hao & Shen, 2008, Schmidtke, Heiser & Hinrichsen, 2014). Another type of publication are case studies proving actual participation of standard lean tools to reduce production costs or delivery times. It seems to be the most explored mode in research of lean production. For example, Rewers, Mandziuk & Trojanowska, (2015), point out the contribution of TWI tool to improve general working conditions in the machining system. Chomątowska & Żarczyńska-Dobiesz, (2014), showed the impact of kaizen workshops to improve quality and increase productivity in the two cases of automotive manufacturers. Hadaś & Karaskiewicz, 2014, appeared to improve production capacity of manufacturing plant that deals with the production of steel halls after the implementation of continuous flow.

Another group of publications are the original overtures for the use of authors' own improvement tools or standard lean tools (developed by Japanese Great Inventors such as Sakichi Toyoda, Kiichiro Toyoda, Taiichi Ohno, Shigeo Shingo, Seiichi Nakajima), although substantially altered or improved for the specific purpose of implementation. For example, Slomp, Bokhorst & Germs, 2009, propose a hybrid method of MTO production control system called CONWIP/FIFO/takt time, which was implemented in high-variety and low-volume production conditions. Further, Thürer, Stevenson & Protzman, 2015, developed a new method of production control called COBACABANA as an alternative method to the traditional kanban-based pull system that has been also invented for the production system characterized by high diversity of manufactured products.

2.2. Company and assembly process background

The company deals with manufacturing of body frame of truck cargo space. The final product includes building set consisting of main components such as roof, front wall, side walls, intermediate frame and portal (one of three portal type: door-type, flap-type or blind-type). Each main component consists of major parts, which include: a body panel made by suppliers in different technologies (e.g. FerroFoam, GFK-Foam-GFK, Aluwood, etc.), aluminium profiles as a frame around a panel and interior decorative elements (e.g. washboard, fixing rails, plywood, etc.). Major parts are combined using glued technology or by connecting parts, which include rivets, screws, bolts and other items.

The production system is divided into three departments. The first department deals with processing of major parts. It includes four production areas, namely, processing of aluminium profiles, steel profiles, sheets and welding. A paint shop is the second department. Finally, the last department deals with assembling parts. The assembly process is divided into four assembly areas: roof, portal, walls and dispatching areas. Each of three departments is managed separately by planners assigned to them. Each area employs a group of operators managed by foremen.

A characteristic feature of the production process in the analysed production system is a huge variety of product mix. Practically, every job is different. What is more, jobs are usually released on single pieces of final product. Differences in range of job specifications related to the product length, width, height, panel type or even colour used, may also contain the difficult modifications such as the type of portal used, the need for installation of side door, the type of rails used and the number of rail rows, the type and colour of plywood installed on internal side of walls, finishing openwork etc. Such large variety of parts that can compose the product represent the type of small-batch or even unit production. In this case there is a problem of organizational management, in which the lack of proper procedures results in reduced efficiency of available production resources, including operators, machines and equipment. The result is often an unrealized production plan, frequent shipment delays of finished products and the need to start overtime. Such situation appears in analysed production system.

2.3. Problem definition and research justification

Due to unit type of production the analysed company adopted monthly number of working-hours as a measure of production capacity. With respect to such measure the company developed required labour consumption to perform each job. The analysis of company data in terms of solely direct production employment appears that the production system has 7500 of working-hours monthly. In turn, the monthly reports generated after jobs execution reveal that the average production capacity does not exceed 5000 of working-hours monthly indicating efficiency is oscillating towards 75%. In addition, the expected value of labour consumption is calculated based on timekeeping measurement. The duration of each processing step was being measured several times. The average value of time was approved for every processing step. It implies that the company assumed the possibility of waste occurrence during job execution and the effectiveness of production process can be relatively declined to 50%.

Such formulated problem gives the foundation to claim that certain dose of waste occurs during jobs execution. Thus, the root reasons of waste occurrence should be investigated through the process observation. Due to limited time and the clear position of the management of the company our research has been limited to investigate only walls assembly area. Based on the statement of the company management this area generate the most interruptions of production process in whole production system. It confines our research work related to the point improvement of production process which strongly limits the scope of the improvement project and also enables us in-depth understanding of the root causes and consequences of waste in selected area of the production system.

The main objective of the research work is to investigate the root causes of waste hidden in the wall assembly area, further to identify the possibilities (improvement tools) allowing the reduction of observed waste as much as possible and to implement these improvement tools in such way that they can be copied to other areas of the production system in the future. Such formulated research work has got a scientific nature. Its foundation is a PDCA (Plan-Do-Check-Act) cycle developed by Deming (Deming, 1986). The description of the adopted method of waste investigation and its reduction by selected improvement tools (as an elements of our research work) is presented in the next section.

3. RESEARCH AGENDA AND PRELIMINARY RESULTS

We adopted the following research plan that is adjusted to the company environment. The research plan is depicted in Figure 1 in the form of several stages. The research plan was developed in order to identify and reduce waste occurring in the walls assembly area.

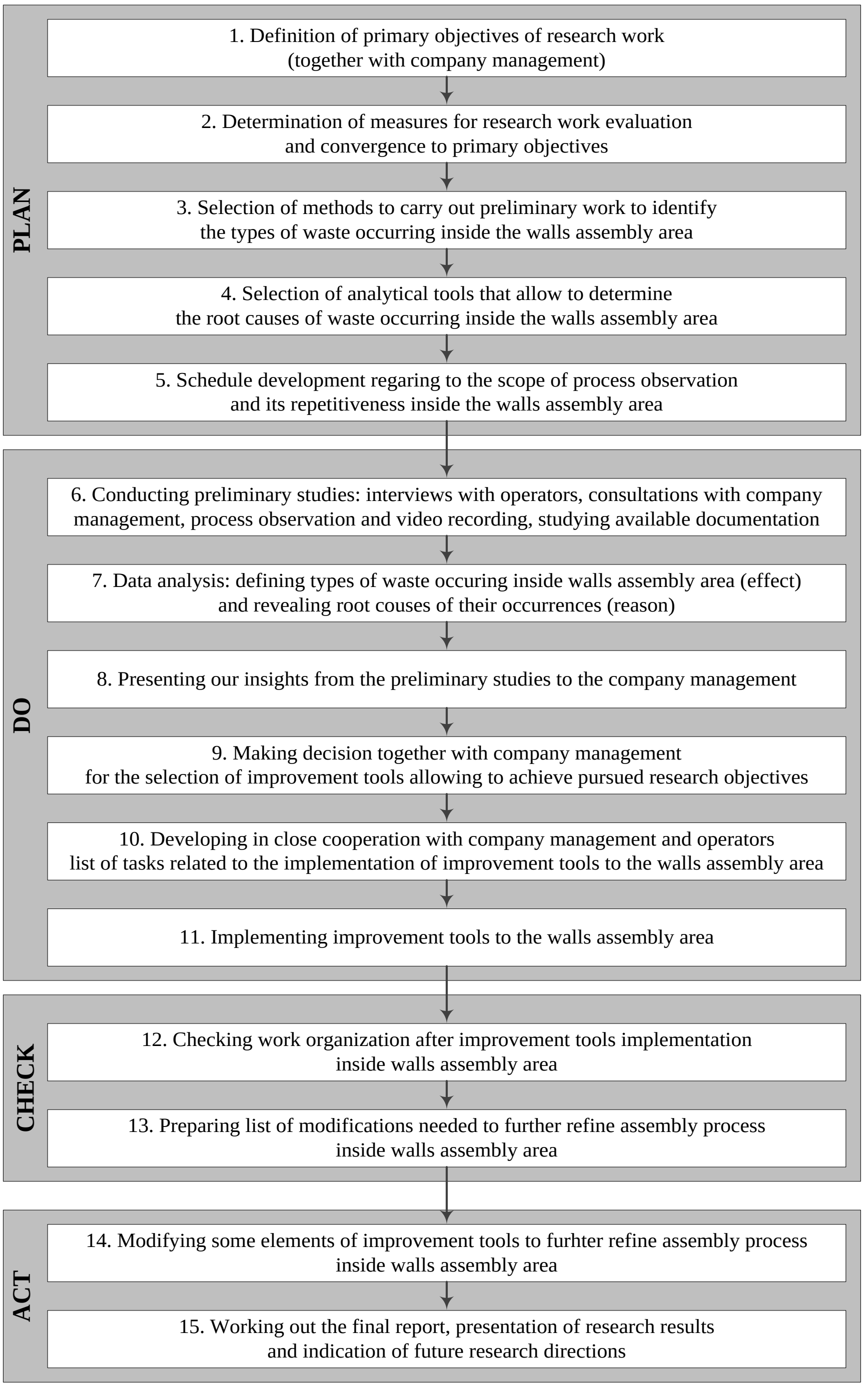

Fig. 1. The research plan developed to identify and reduce waste in analysed company

The adopted research plan reflects full PDCA cycle developed and maintained by E. Deming in industrial practice. A key element of the plan is a "Plan" research stage which, together with the company management, was targeted to identify waste in the walls assembly area. Identification of waste was made in two steps. The first step identified basic types of waste occurring in the walls assembly area. The division into basic types of waste is compatible with the original TPS approach (Ohno, 1989). Identification of waste was made using snapshot observation of walls assembly process. Snapshot observation was aimed at identifying disruptions occurred during walls assembly. We did not take into consideration proper run of sequential execution of subsequent assembly operations. Snapshot observation revealed a distribution of basic types of waste. Basic types of waste are shown in Figure 2.

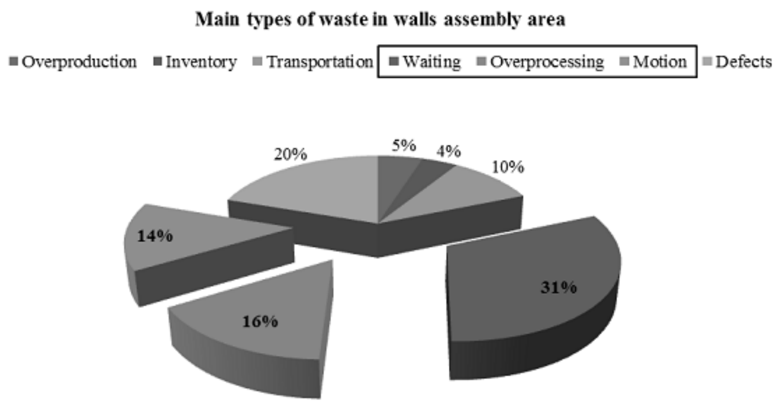

Fig. 2. Distribution of basic types of waste in walls assembly area

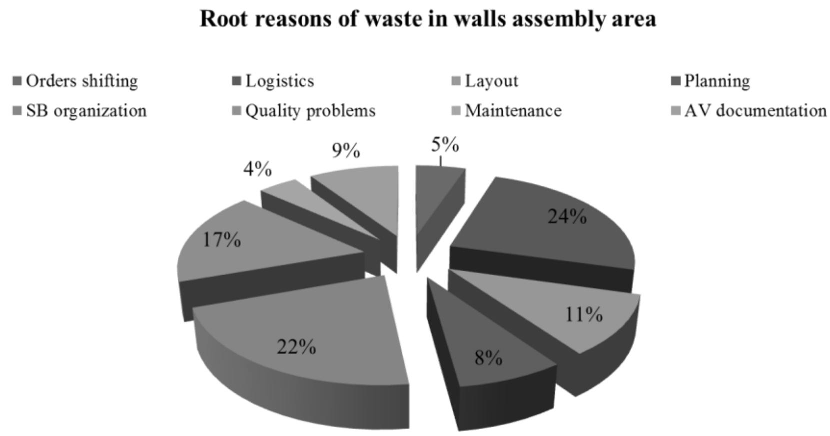

Fig. 3. 5Why analysis to provide root reasons of waste in walls assembly area

Generally, snapshot observation revealed that almost 24% of time was wasted in total observed time. In addition, as shown in Fig. 2, more than 60% of wasted time are the 3 types of waste, i.e. waiting, over processing and motion.

The division into basic types of waste allows a deeper analysis of the reasons for its occurrence. Basic types of waste are only results of malfunctions occurred in the production system as a whole. Hence our work was focused on investigating the root causes of waste to further take steps to improve the organization of the production system. For this purpose, a key tool to identify root causes was selected. It is the 5Why analysis. Fig. 3 shows the result of the 5Why analysis.

The 5Why analysis showed as many as 55 different root causes of waste. Because of such a long list of root causes we have decided to group them together. Figure 3 shows the result of grouping process. Figure 3 revealed that the greatest influence on waste appearance during walls assembly execution has logistics (the contribution of 24%) and work organization inside the area (described in Fig. 3 as SB organization, the contribution of 22%). The main cause of waste in logistics is the lack of availability of connecting parts, and the main cause of waste resulting in poor organization of the area is the lack of access to tools when they are required for use. These two groups of root causes were the basis for the selection and implementation of improvement tools.

4. IMPLEMENTATION OF IMPROVEMENT TOOLS AND RESULTS

As stated in the chapter describing the definition of the research problem a low level of production capacity that accounts for 5000 of working hours per month is a basis for improvement activities. Knowing the distribution of the main types of waste and their root causes we decided to implement some improvement tools aimed at reducing waste occurring and thereby improve capacity utilization. Choosing improvement tools was consulted with the company management. It was decided to implement the following improvement tools:

- The first three elements of the 5S tool, namely, "Sort", "Straighten" and "Shine" including operators' responsibilities of the walls assembly area,
- Kanban racks for connecting parts as a part of pull system with by logistics exploitation,
- The fourth element of the 5S tool that is "Standardize" including foremen responsibilities for supervising general order in tools and materials used in the walls assembly area.

Implementation part of the research work was carried out according to PDCA plan contained in Figure 1. The work included designing shadow tables, kanban racks, places and intermediate storage areas for tools and materials used in the walls assembly area. Each designed element has been consulted with employees of the company and improved (sometimes several times) according to the suggestions and wishes of the people involved in the project.

As a result of the implementation work, a new way of organizing work in the walls assembly area has been conducted. A half a year after research accomplishment we provided the external audit to see whether the company has achieved improvement goals. After an audit we found that waste was reduced by approx. 25% in the walls assembly area which, in turn, resulted in an overall improvement in capacity utilization by approx. 5%. Thus, the company is now able to account for the use of 250 working hours more per month.

5. CONCLUSION

The presented research project justifies the need for integration of science and industry. Integration is particularly important in the field of production engineering as a key area of activity of manufacturing enterprises and application of possible solutions developed by science to practice environment in an appropriate manner can contribute higher level of companies competitiveness. Our research project proved the reasonableness of actions taken to improve production processes using some lean tools. A key element of our work has become, however, a scientific approach based on the full PDCA cycle that has been verified over several decades. Moreover, without the planning phase that justified in-depth analysis of the root causes of emerging interruptions our implementation work could include organizational elements that are irrelevant when taking into account improvement of production process directed on defined goal of capacity utilization.

The research work contributed to the improvement of the organizational aspect of the company only in one production area. Improvement tools used to obtain such situation are so versatile and easy to implement the company management decided to implement them in other parts of the production system. Moreover, the terms of cooperation between science and industry were held on sound principles and mutual respect, which in turn led to the awarding of the next project including value stream mapping in the whole production system.

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BIOGRAPHICAL NOTES

Paweł Wojakowski is an Assistant Professor at Cracow Univeristy of Technology. He teaches subjects involved production management. His research interests are focused on lean production systems and scheduling under uncertainty. His work is affected real-world problems in cooperation with many polish manufacturing plants such as Grupa Kęty, AluTeam, Schneider Polska, TQMsoft etc.

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