LPS – LEAN PRODUCTION SYSTEM

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Abstract Both in the Polish and global economy, many companies are looking for solutions and management methods that, with such high competition, will allow them to adapt to the changing conditions and increasingly demanding customers. Many companies, to meet their expectations, began to improve their processes, moving away from the conventional way of thinking for a new approach, and new management methods. The purpose of this article is to analyze the selected methods of the implemented production system, based on Lean Manufacturing principles, which is still evolving. The leitmotiv of this system is the elimination of all loss-making activities, finding the right solution and using the appropriate tools, as well as involvement of employees. The research was carried out on the case study referring to the corporation, which operates in the sanitary technology sector. The paper attempts to assess the scope of implementation of the individual Lean Manufacturing tools and their importance in the process of eliminating of various types of wastage.

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1. INTRODUCTION

Since the 1980s, the notion lean appeared in the textbooks for production management as a synthesis of the results of the research carried out for the American automobile industry by the Massachusetts Institute of Technology (MIT) by comparing of the selected volumes (benchmarking). The notion lean was initially interpreted as a name for a production structure, which was shaped in such a way that the departments related to maintaining traffic and repairs were removed from it – hence the term lean production (Wyrwicka, 2003). Production management has gone as long history as the modern industry. This development is characterized by specific properties. Production management has always been closer to the reality of the production workshop (or classic manufactory) than to theoretical considerations. At the basis of production management, to a greater extent than in the case of other disciplines of management science, there are practical experiences that can be accounted for, among others (Głowacka-Fertsch, 2004):

- production of identical and complex products from identical parts using repetitive technological processes,
- application of scientific methods for the analysis, interpretation and design of production processes,
- mass production of complex products in the production line, in a rhythmical and repeatable way.

The above elements allowed both to meet the demand for means of production from other branches of the industry developing at that time, as well as to meet the needs of final customers. New possibilities of information and communication technologies are now adjusting the environment of lean production (Wagner, Herrmann & Thiede, 2017). Contemporary solutions of the management issues include greater flexibility of a company, integrity of processes and the ability to implement innovative changes. The production area is therefore influenced by the concepts and methods introduced both in the particular subsystems of the organization and the enterprise on the whole.

The purpose of this article is to present the selected elements of the production system in a selected production company. The first chapter describes the enterprise under research together with the tools for lean production and the general philosophy of operation. The second chapter describes an example from the Raw Sorting Department that has been assessed. The same has been done in the third chapter, still it focuses on another tool. The final conclusions are the complement to the article.

This system operates in different versions, corresponding to the specificity of particular plants, it is a coherent global philosophy of lean production. This phenomenon has been assessed on the basis of the analysis of different sources and the author's experience in implementation of the system.

2. LEAN MANUFACTURING AND A SELECTED COMPANY

Although success associated with implementation of lean production requires a broader business perspective (Jones & Womack, 2017), such implementations are often carried out in a fragmented way without a sufficient integrity in functional areas (Marodin & Saurin, 2013).

The plant, in which the observations were carried out, is part of an international group that is a leader in sanitary technology. The company maintains a strong position on most European markets, offering a unique added value in the sanitary and bathroom ceramics sector. Production is carried out in 35 factories, 6 of which are located overseas. The Group generated net sales for 2017 at the level of 2.9 billion Swiss francs, employing 12,000 employees in more than 40 countries. Below is an example of a casting bench in the production plant under study (Fig. 1).

Fig. 1 A view of the production department (own study)

For decades, sustainable development has been one of the company's main principles. This effort turns out with a vengeance: the planet, the public, customers and partners, employees and shareholders. The ideas of sustainable development are expressed, inter alia, in products that reduce water consumption, new logistics solutions, energy-saving production installations and training.

Manufacturing companies take care of the needs of customers, which is a must in order to survive in the market and to effectively fight the competition. The issue of quality and productivity are the fixed elements of modern management trends of organizations. One of the most effective and increasingly popular concepts for improvement of production companies is the concept of Lean, or the concept of Lean Manufacturing related to the manufacturing process. The term describes manufacturing systems with a significant degree of thinning compared to traditional mass production systems (Wisniewski, 2010). Eliminating auxiliary variables to shorten the total time cycle is the main goal of the Lean policy (Chakraborty, Biswas & Sarkar, 2013). The basis of the LPS system is a set of lean production rules, introduced in Japanese Toyota factories, and then, under various names, developed, supplemented and adapted in hundreds of companies around the world.

Among many of its tasks, the most important is the standardization of processes, optimization of the material flow, adjustment of production to the demand, and avoidance of unnecessary actions and wastage. Unnecessary activities prolong pro-duction time and often result into an organizational mess, additionally causing low production quality. Several branches from the automotive industry to the service sector integrate their strategies in accordance with the principles of lean production, aimed at improving productivity and efficiency by reducing costs (Botti, Mora & Regattieri, 2017). In addition, the systems of lean manufacturing may still be susceptible to interference come-binding from the external environment, such a strikes, natural disasters and prosperity (Soliman, Saurin & Anzanello, 2019).

Regardless of the type of production or plant – the system, thanks to its flexibility, can be easily adapted to local conditions. Tools can be different, as well as projects, but the rules are always the same and are applied to all employees. The system, production, materials and factories – all of this sounds very technologically, but that, what gives sense to the LPS operation, are people. It's their knowledge.

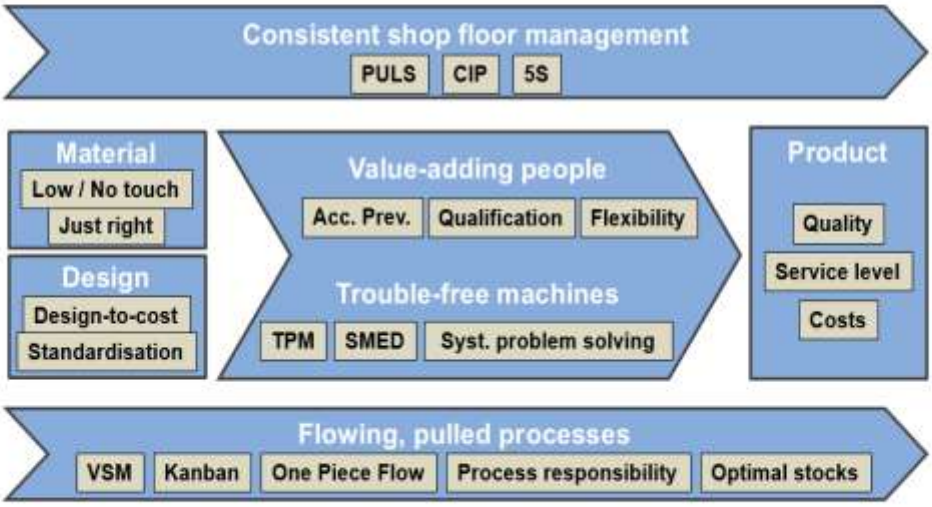

Fig. 2 Scheme of the production system rules in the surveyed company (source provided by the company)

Everyday experiences and observations that allow us to develop and still optimize this global solution. The implementation of LM practices improves the ability to use the workforce by involving employees, integrating work and encouraging continuous improvement (Tortorella, Fettermann, Frank & Marodin, 2018).

Employees learn from each other – both external and internal trainings are systematically carried out, and each newly admitted person becomes familiar with the principles of LPS. The system allows to shorten manufacturing cycles, raising the quality of the products, reducing production costs as well as involvement of the team. Figure 2 presents the general outline, a philosophy based on a set of principles that the concept of Lean Manufacturing involves.

3. CASE STUDY. GLAZING ROBOTS LINES

Over the last decade, work with robots has evolved from the basic research on production technology to the ready- to – use industrial equipment (Uhlmann, Reinkober & Hollerbach, 2016).

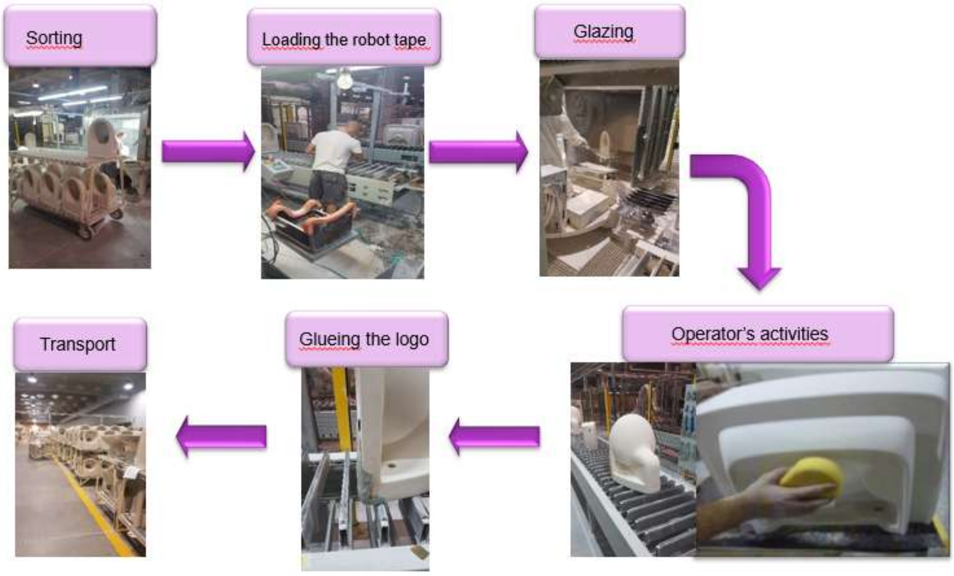

Fig. 3 Scheme of activities performed at the Raw Sorting Department (own study)

The area that has undergone verification is the raw sorting department, along with the glazing robots lines. The flow of the assortment at particular positions in the processing of the semi-finished product, starting from the raw sorting department to firing in the tunnel kiln, will be analyzed. The present state shows that it is realistic to achieve improvement by eliminating activities that do not give an added value in the processing of the intermediate on individual positions. Activities performed in the studied area affect in part the quantity of the controlled semi-finished product on the robots' lines, as well as its efficiency. In addition, glazed products must be subjected to a subtle correction made by an operator of the line.

In Figure 3, we can observe that employees of the raw sorting department blow out the dust and the rest mass from the semi-finished product. Using an abrasive, they even the surface and grind the semi-finished product, and then they set it on the robot's tape. The glazed assortment has a wiped base and a funnel from the enamel layer by the line operator. Next, an operator places the semi-finished product onto transport trolleys and transports it to the Logo stand. A worker, after putting the logo, transports the ready – made trolleys to a buffer for the Settings Department. The initial state – activities performed at particular stages.

Potential reasons for lower performance used at various stages presented in Figure 4. Clearly, we can see the potential failures and their causes in relation to the performance of the glazing robots.

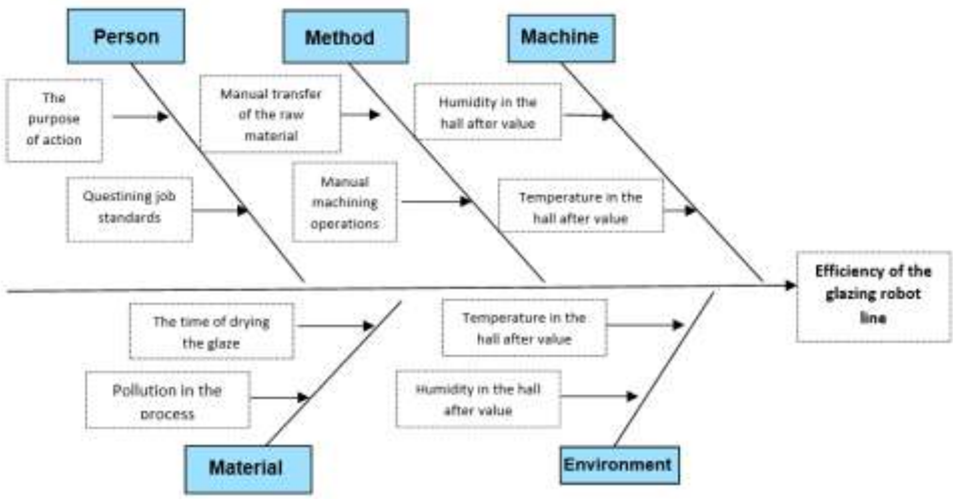

Fig. 4 Ishikawa diagram (own study)

There are the 7 main types of MUDA in the observed area:

- Overproduction – production over the state of pieces for a given project with a specific logo
- Overstocks – keeping the semi-finished pieces in the buffer

- Waiting – an robot line operator is waiting for the glaze to dry before moving the piece to the kiln trolley
- Unnecessary movement
- Transport – transport of trolleys with a semi-finished product in between the stands
- Excessive processing – grinding of unneeded surfaces
- Scraps and defects – damage during transportation.

The analysis included a larger number of pieces on being glazed by the robot through eliminating unnecessary activities in the secondary processes. A precise verification of processing of raw products makes sense particularly on raw commodities. The final state – actions performed at particular stages after changes.

Fig. 5 Actions performed in the Raw Sorting Department after the change (own study)

A lot of manual activities have been observed, where a worker makes surface corrections which are not required. An operator before removing the semi-finished piece from the robot's loading tape, is waiting for the glaze to dry and then to move it having the enamel structure intact. In addition, there has been observed time expectation as a result of the absence of the operator.

The low efficiency of the robot line is caused by processes that are not directly related to the time during which the enamel is glazed by the robot. Some activities performed by an employee do not contribute to the quality improvement, they simply generate time and do not constitute any added value in the processing.

A considerable amount of time and work is being wasted by placing the glazed pieces on trolleys, which are transported only partially to the Sorting WG, and then ultimately to the target department. An extra tape discharge on the output robots' line, enabling direct application, as well as collecting of the glazed semi-finished product by employees, will save a lot of time and space in the production hall. Thus, the position of the robots' line exit will be moved directly to the Sorting WG Department, where it is loaded into the kiln.

Table 1 Table showing the efficiency of the glazing robots (own study)

Working day	**Robot 1**	**Robot 2**	**Working day**	**Robot 1 (after change)**	**Robot 2 (after change)**
1	265	281	**1**	295	301
2	262	275	**2**	262	311
3	267	274	**3**	297	293
4	263	274	**4**	307	309
5	235	271	**5**	284	290
6	261	273	**6**	302	311
7	245	279	**7**	267	317
8	222	261	**8**	309	317
9	262	249	**9**	303	297
10	251	274	**10**	283	274
11	248	254	**11**	294	304
12	238	256	**12**	291	302
13	232	271	**13**	298	298
14	231	248	**14**	289	311
15	266	272	**15**	299	291
16	249	232	**16**	287	294
17	246	226	**17**	288	297
18	248	220	**18**	295	299
19	244	268	**19**	298	299
20	253	273	**20**	289	295
Average of robot	**249.00**	**265.40**	**Average of robot (after change)**	**291.90**	**300.50**
Average of line		**515**	**Average of line (after change)**		**592**

A period of one working month was assumed for the analysis. The line efficiency has been improved by almost 15%. Unnecessary transportation between stations has been reduced. The buffer has been reduced by about 330 trolleys.

3. CASE STUDY – 5S

The 5S tool, which is linked to the ordering of the workplace, belongs to the basic optimization tools (Kucerova, Mlkva, Sablik & Gejgus, 2015). The diagram is visible in Figure 6. The introduction of 5S is not an easy task, because it requires development of the appropriate employee's skills, such as regularity, discipline, standardization and a continuous training. Work on these skills is extremely important, because it affects a better understanding of the process and taking more responsibility for their actions (Golińska, 2012). The workplace is then safer and easier to organize, employees perform their tasks more efficiently in a clean work environment, stocks are smaller, and this allows a faster control (Kocira & Krawczuk, 2016). Each letter "S" in 5S represents a step in the process that improves the functioning of the company (Kasher, Mani, Sharma & Zhand, 2018).

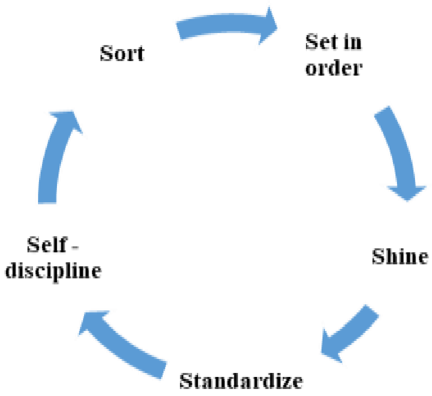

Fig. 6 5S scheme (own study)

Selection consists in getting rid of unnecessary materials, tools, equipment and machines from the workplace.

	Reduction
Number of tool sets	68%
costs	40%
floor space	78%
Search time	90%

Fig. 7 Tool board 5s (own study)

The result of selection in the company under research was the removal 68% of unused tools for the repair work production. Thanks to this, 78% of the space needed to store tools was added. The removal of useless things and a good selection resulted in a desirable saving of almost 90% of time necessary for finding of the right tool needed for production work.

Systematicity consists of clearly marked areas of the production hall (seats, warehouses and roads) using the information boards and organize places of work (shelves, tables shadows etc.).

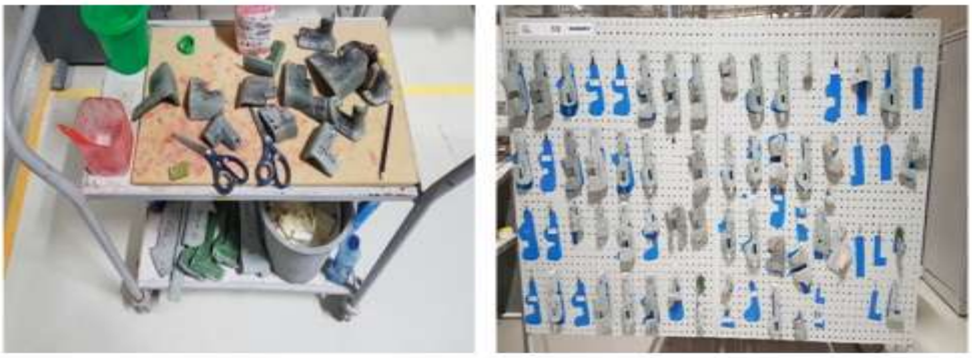

Fig. 8 Production table 5s (own study)

In the company setting in order has been implemented in different areas. In the first stage, unnecessary horizontal lines were deleted, which did not reflect the real organization of work. After the analysis, 25% of the area, which could be used for other activity, was recovered. The tooling equipment in halls was also ordered and their methods of storage were changed. It shortened time for finding the instruments by workers on average of 29%. Figure 7 shows the layout of production templates before and after the systematization.

Effective implementation of tasks requires a clean and organized production environment, where all kinds of waste can be a source of clutter and inefficient work. Getting rid of the main causes of impurities allows for faster detection of failures causing dangers, and regular cleaning eliminates waste.

The standardization of work begins with improvements and develops into a reliable method of operation. Work standardization is also one of the 5S tools and its idea how to ensure repeatability of processes, maintaining and continuous improvement of standards that establish the best ways and order of work, and help achieve maximum efficiency and minimize waste (Golińska, 2017).

Self-discipline is the most difficult step implement. Without this element, even perfectly organized 5S implementation plan, everything will slowly disappeared and returns to the initial state. If the profits from the introduction of the 5S method to be achieved, the employees should be explained to the role of this element in achieving success. Everyone must understand not only the importance of order, cleanliness as well security, but also their willingness to take the necessary steps guarantee good maintenance and motivate themselves to achieve the goals (Kocira & Kravchuk, 2016).

5. CONCLUSION

Currently, there are many concepts and methods of managing the organization. The example of sanitary technology production has assessed the suitability of the most popular concepts related to Lean Manufacturing to this industry. Thanks to the implemented production system there received a better quality of manufactured products. The data indicate the reduction of the number of scraps and financial losses. Health and safety conditions have been improved. However, it should be done carefully, according to the previously developed and previously adopted scenario, focusing on those sectors of the company's activity, in which particular difficulties may occur during its implementation. Based on the above mentioned data it can be confirmed than the implementation of Lean Manufacturing tools in the company under research gives the required effects in relation to efficiency and profitability of production. It should be noted that LPS as a component of the lean production philosophy constitutes the basis for a continuous development. The system definitely helps to control the correctness of everyday work.

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BIOGRAPHICAL NOTES

Artur Włodarczyk is working for production companies for 7 years. He is a mechanical engineer, currently he is studying in the field of management at the Faculty of Management Engineering in Poznan and the Institute of Computer Science of the Polish Academy of Sciences in Warsaw. He has participated in many international projects on launching of new products to the market or improving the existing ones. He has to deal with Lean Manufacturing tools on a daily basis.