

THE EFFECT OF LEAN TOOLS ON THE SAFETY LEVEL IN MANUFACTURING ORGANISATIONS

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Abstract: Lean Management is currently one of the best-known and is the most widely used management concepts in production enterprises. Lean creates such a culture of work in an organization that makes all participants in the organization interested in raising the level of quality, reducing costs and delivery time. However, there is no information about the influence of lean tools on the level of safety in production organizations. The paper presents the influence of five lean tools on the safety level by the example of metal manufacturing organization. The number of potentially dangerous situations and the number of accidents were taken as the measure of safety level. The obtained results indicates that the most important for the safety level is 5S, TPM while Kaizen, Poka-Yoka and VSM are smaller. The paper aims to broaden the knowledge about the dependence of the use of lean tools on the level of occupational safety.

Keywords: VSM, 5S, TPM, Poka-Yoke, Kaizen, Safety, Lean

1. INTRODUCTION

Managing a production enterprise is a big challenge, which is why it is worth trying to improve it using methods that are easy to implement. Thanks to practical solutions such as Lean Management, enterprises can improve production results (Mazur, 2016). This can be achieved with the help of easy and tailored tools (Kleszcz, 2018). As indicated by numerous works - enterprises achieve profitability improvement by implementing 5S practices (Anttila and Jussila, 2018) (Łyp-Wrońska and Tyczyński, 2018), Total Productive Maintenance (TPM), Value Stream Mapping (VSM) (Hines and Rich, 1997), Kazien and simple methods in the field of error proofing, e.g. Poka-Yoke (Garza-Reyes et al., 2018), (Shou et al., 2017) (Helmi et al., 2017). One of the important elements of business management in addition to profitability are issues related to occupational health and safety. Obligations that rest upon the employer are determined by normative acts and standards, which is why in company management they cannot be omitted. Including safety aspects in the business management process is very important from the point of view of efficiency, e.g. production, because

inadequate working conditions may result in potentially accidental events that will result in material and non-material losses (Górny, 2018). Implementation of individual management elements (e.g. human resources management): planning, organizing, motivating and controlling cannot take place without paying attention to elements of occupational safety and health (OSH) (Woźny et al., 2018). The literature lacks information on the impact of lean tools on the level of safety in manufacturing enterprises (Zasadzien and Midor, 2015). The matter is even more complicated if we take into account the problems related to the implementation of solutions concerning Industry 4.0 (Nitkiewicz and Ayen, 2018) and a significant increase in productivity and product individualization (Kovács and Kot, 2017).

2. LEAN MANUFACTURING EFFECT ON SAFETY LEVEL

Incorrect organization of the production environment in the enterprise is the cause of many disruptions during the implementation of production processes (Onyusheva, 2017), (Ingaldi et al., 2018). The scale of disturbances is the greater, the more people employ the enterprise. Often, employees organize their work, guided by their own needs or habits acquired during their professional activity (Gembalska-Kwiecień et al., 2018). In addition to the disturbances typical of production sites, there are also disturbances in auxiliary processes (Pietraszek and Skrzypczak-Pietraszek, 2014). Observing the course of even the best designed and implemented production processes, it can be noticed that they do not run under ideal conditions, i.e. they are not disturbed by any factors. Two types of interference affect each process: random and special (Pietraszek et al., 2016). Random factors usually occur in a large number, each of them having a relatively small meaning, leading to variability that must necessarily be identified. Random factors generate disturbances, which should always be counted, their source is not always known and they affect the parameters of the manufacturing process in a continuous manner with random intensity. They cannot be fully eliminated, but usually their impact is small and results in a slight statistical differentiation of the value of the products' features. The improvement of the process quality can be achieved through organizational changes so as to limit the number of random factors affecting the process or change the process to another (Maszke et al., 2018). By reducing the random factors affecting the process, we also reduce the probability of potentially dangerous situations, which affects the safety level in the production company. Much more disadvantageous due to the quality of the manufacturing process as well as the level of safety are special interferences (Kotus et al., 2018). Special interferences can be detected and identified as causing changes in the process level. These are interferences most often from the outside, occurring suddenly or their impact is systematic and intensifying (Shrimali et al., 2018). They affect significantly the parameters of the manufacturing process as well as the level of safety. The use of lean tools, for example 5S practices, directly affects the reduction of potentially dangerous events (Gálová et al., 2018). On the other hand, JIT practices can cause internal transport problems by increasing the frequency of deliveries and increasing the possibility of occurrence of a potentially dangerous event (Cusumano, 1994). Using a suction system based on Kanban cards, we can achieve a significant variety of products thanks to a faster exchange system (Ulewicz et al., 2016). This is positive from the point of view of marketing, because the diversity of the product and its personalization (the objective of Industry 4.0) generates greater demand for products (Stasiak-Betlejewska et al., 2018). Based on the literature data,

it can be assumed that the know-how and skills acquired during the use of lean tools are beneficial for improving work safety through better understanding of processes as well as potentially dangerous events (Blaskova et al., 2017). VSM can also help to identify the impact of selected factors on the level of safety in an enterprise. Total Productive Maintenance through a comprehensive program of continuous development of employees and organizations and changes in the culture of the production plant in order to maximize the efficiency of machinery and equipment, through constant monitoring and supervision of technical infrastructure provide employees with an attractive and safe work environment while achieving maximum efficiency and productivity.

3. RESEARCH METHODOLOGY

The research was carried out in metal industry production companies. Initial research aimed at the selection of the research sample consisted of 200 business entities in the segment of small and medium-sized enterprises. As a result of the conducted surveys aimed at determining: knowledge of lean tools, their actual use and determining whether given entity has implemented OHSAS/ PN-N-18001 or ISO 45001 safety management system only 20 entities qualified for final tests qualified meeting the assumed conditions. The classification criteria for the research group were: lack of a work safety management system, minimum 3-year period of using lean tools in the enterprise, 5 years of production activity and consent to provide documentation or information on potentially dangerous events and accidents, if any. There were established the scope of applied lean tools based on the surveys which were extended by direct interview. In the surveys, there was used a direct and auditory questionnaire using the Likert scale. The qualifying element was the answer regarding the use of individual lean tools in the enterprise. The entities were qualified with the assessment:

- 4 – I rather agree that the tool (e.g. visual control) is used by the enterprise and
- 5 – I strongly agree that the tool (e.g. pull system) is used by the enterprise.

Table 1 presents the identified lean tools used in the qualified research group of 20 manufacturing enterprises from metal sector of the SME's.

Table 1
Identified lean tools used in research group entities

Lean manufacturing methods and tools		
Pull system	TPM	VSM
Takt time	OEE	Current state map
Leveled production	SMED	Future state map
Visual control	5S	Flow diagrams
Kanban	Error proofing/Poka-Yoke	Safety cross

In the research, a comparative group of companies from the metal sector of the SME sector was used for which the following selection criteria were established:

- the lack of formalized lean tools and practices,
- no safety management system PN-N-18001/ OHSAS 18001 or ISO 45001,
- minimum 5 years of production activity,
- consent to share information on potentially dangerous incidents and accidents, insofar as they have occurred.

3. RESULTS

The research results are based on 20 production companies with five years of production experience and a minimum 3-year period of application of lean tools. At the beginning, there was determined the correlation dependence between the period of use of lean tools and the number of potentially dangerous incidents reported (Table 2 and Fig. 1).

Table 1

List of the number of potentially dangerous incidents during the period of using lean tools

No.	Years of using lean tools	Number of potentially dangerous events during the period of using lean tools	Average number of potentially dangerous events per year
1.	3	5.0	15
2.	5	2.8	14
3.	6	3.5	21
...
20.	5	2.2	11

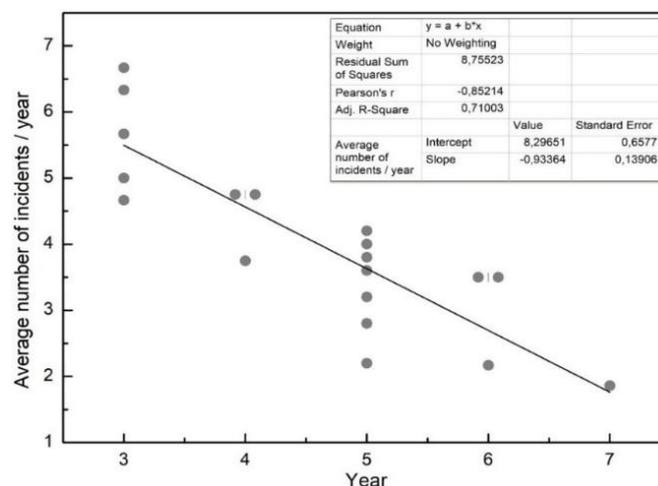


Fig. 1. Correlation chart of scatter of points - dependence of the number of critical incidents on the period of using lean tools

The obtained results indicate that between the analysed features: the number of critical incidents and the number of years of using lean tools there is a strong negative dependency. With the passage of time and gaining experience in the use of lean tools, the number of potentially dangerous events decreases. Analysing the coefficient of determination for the presented data, we can state that 72.6% of the variability of critical incidents is explained by the time of using the lean tools. Referring the results to enterprises that do not use lean tools, we observe a significant reduction in critical incidents in the time period under consideration, and the reduction of potentially dangerous incidents amounted to nearly 40%.

In order to determine the weight of individual lean tools on the level of safety in the research group, employees (20 employees from each of 20 objects) were asked to indicate the weight of each of the five lean tools by placing it in the appropriate position in the hierarchy of validity. Then, the W Severity Rating was calculated (Ulewicz and Nowicka-Skowron, 2017) (Fig. 2). The limitation to the five tools is due to the fact that they are used in all analysed 20 entities.

$$W = \frac{\sum_{i=1}^k n_i w_i}{k \sum_{i=1}^k n_i} \quad (1)$$

where:

W - Severity Rating,

i - indication of tools place,

k - the maximum weight (indication of the order of the tools meant assigning weights in reverse order),

n_i - number of indications of given tools on i -number place,

w_i - weight corresponding to the place of i tools.

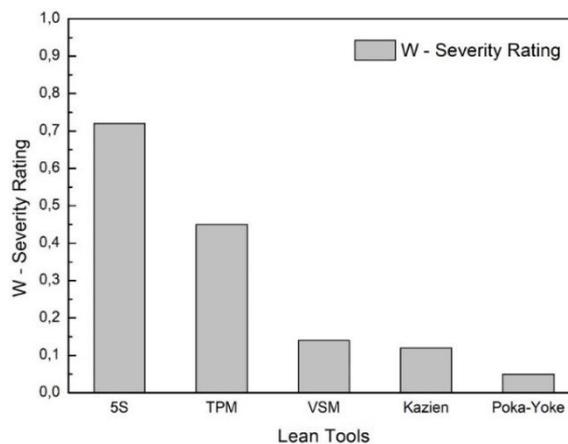


Fig. 2. The impact of selected lean tools on the level of safety in metallurgical industry of manufacturing enterprises

3. CONCLUSION

The article presents the results of the research on the relationship and impact of the selected (basic) lean tools (5S, TPM, VSM, Kaizen, Poka-Yoke) on the level of occupational safety in small and medium-sized metal manufacturing enterprises. As a measure of safety, the number of potentially dangerous incidents recorded on the premises of the company was taken. In the examinations were used extended surveys. A correlation was determined between the number of potential critical events and the period of use of lean tools. Based on the rank indicator, there was determined the importance of the applied lean tools on the level of safety in the employees' assessment. The results obtained will fill the information gap regarding the influence of lean tools on the level of work safety. The research confirms the positive effect of lean tools on the level of safety as a function of time as well as the strength of the effect of selected tools in the aspect of employee's evaluation. The presented research results are a prelude to extended research aimed at supplementing the knowledge of the impact of individual tools not only on the level of efficiency, quality

but also safety in the aspect of the challenges posed by modern production systems as well as the inevitable technical revolution 4.0. Similar methodology appears to be useful in a design of hydraulic for heavy duty machines (Domagała et al., 2018a; Domagała et al., 2018b) or estimation of a life-time of parts (Osocha, 2018) even including special methods of materials science e.g. a fuzzy uncertainty estimation (Pietraszek, 2012; Pietraszek et al., 2017), the image analysis (Gadek-Moszczak et al., 2015; Gadek-Moszczak and Korzekwa, 2017). It may be also fruitful in machining e.g. a surface improvement (Zorawski et al., 2008; Radek et al., 2017; Radek et al., 2018a; Pliszka et al., 2018; Radek et al. 2018b) or a special sintering (Tiziani et al., 1990). It can be also useful in such seemingly distant industries as biotechnology (Skrzypczak-Pietraszek et al., 2018a; Skrzypczak-Pietraszek et al., 2018b) or high energy physics infrastructure (Singh et al., 2016).

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