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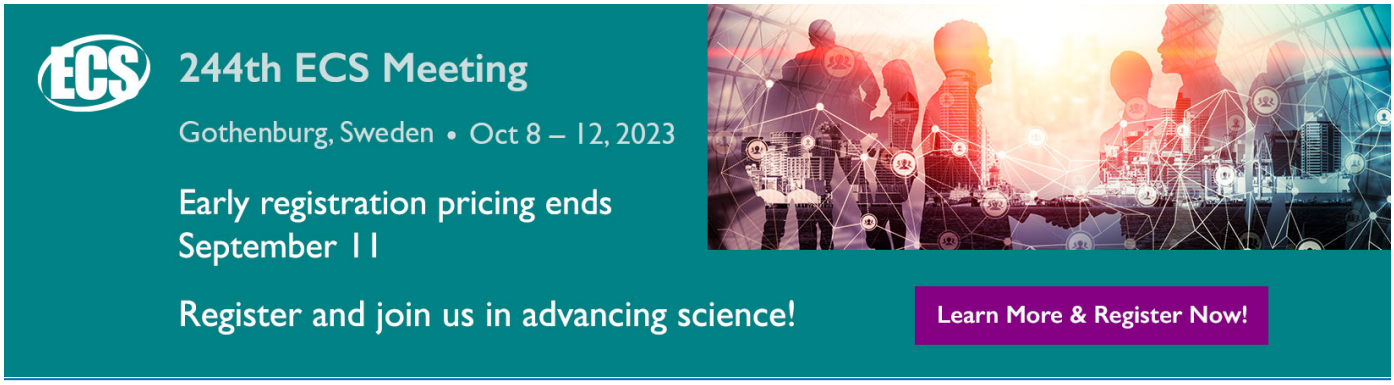

Lean Safety - assessment of the impact of 5S and Visual Management on safety

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Abstract: This study was developed in a furniture company and aimed to implement some Lean tools, such as 5S and Visual Management to reduce waste, by improving the production process. To carry out this analysis an observation plan was used, having the Spaghetti diagram as a reference as well as the value-added analysis of the operations. The implementation of 5S's allowed the improvement of the visual management and the organization through a reorganization of the layout, as well as normalization of the production process. With this, a reduction of 40% was achieved in terms of waste related to activities that did not add value to the product, such as unnecessary movements, waiting times and even movement of materials, having achieved a level of productivity of 74% and 87% in the finishing and joinery sections, respectively. In addition to improvements in the production process, the impact of the measures at the safety level (lean safety) was assessed. For this purpose, a questionnaire was prepared to assess the opinion of the employees, in which 40% considered that the implementation of the tools provided a greater motivation to develop their work activities safely.

Keywords: Lean Tools; Lean Safety; Lean Implementation, Visual Management, 5S.

1. Introduction

Over the years, the concept of quality has evolved, but it was during the industrial revolution that the first big leap took place. The concern about the need to reduce waste in organizations began to be stated, with low margins of error being implemented, in parallel with the need to normalize production processes [1]. Thus, the search for increased productivity became essential, associated with the optimization of production processes, which aimed to achieve an improvement in the use of existing resources producing with higher quality, at a lower cost and with a better service. The Toyota Production System (TPS) has been implemented in several organizations over the years, which has enabled organizations to increase their productivity, eliminating waste and meeting customer needs by taking advantage of employees' capabilities and involvement [2]. The origin of TPS remits to 1950, when Eiji Toyoda and Taiichi Ohno visited one of Ford's manufacturing units in Detroit, in the United States of America. After returning to Japan, they analysed the mass production system and its feasibility in Japan and proposed a new production system that would come to be known as TPS - "Toyota Production

System". Taiichi Ohno realized that the Japanese were wasting an opportunity and considered that for Toyota Motors Company to survive it would be necessary to guarantee a diversity of products, maintaining a high level of quality, at a low cost. In the 90s, TPS took a new approach called lean philosophy that featured more defined management principles that apply to all sectors of activity, through the improvement of operations, processes and associated logistics. The lean philosophy aims to eliminate waste in all its dimensions [3]. Currently, several studies and publications have appeared, focusing on the impact of lean practices on safety, which has come to be called "lean safety". Studies have shown that the adoption of lean philosophy by organizations has had a positive impact on improving workers' working conditions [4].

2. Literature Review

According to Gnoni et al. [5], lean safety consists of creating a safe work environment, which requires the motivation and commitment of all workers. Implementing the Lean philosophy, the same authors used 6S - an extension of 5S (Sort, Set in order, Sweep, Standardize, Sustain + Safety) - as the basis for all improvement programs: waste reduction, a cleaner and safer work environment, reduction of non-value-added time, effective work and the visual perception of the workplace. The creation of a lean work environment requires the motivation of workers as well as the commitment of top management [6]. All hierarchical levels in an organization need to focus on continuous daily improvement and on working together to achieve a better performance, by reducing waste [7]. In the words of Bevilacqua et al. [8], another way in which lean changes the safety environment is how it helps to make safety more apparent and visual through visual management. The creation of visual instructions and diagrams, with indications on how workers should perform their tasks correctly and safely, will influence workers in carrying out their activities. Visual management allows workers to have the ability to assess whether they are carrying out their activities correctly or not and whether they are safe or unsafe. This important awareness on the part of workers allows them to identify whether an action is being carried out in an unsafe manner and helps them to correct it before it becomes an injury to the worker.

On the other hand, according to Brown & O'rourke [9], while the intensification of work can increase companies' productivity it can also mean higher numbers of ergonomic problems and adverse health effects related to higher stress levels on the workers. According to Mehri [10], the impact of lean on safety must be considered when implementing improvements in operational processes and methods, if they are not yet fully assimilated by the workers. Also, the productivity gains expected in the short term by management may be at the root of increased pressure from management (stress management) and work for employees [11]. Other literature sources report that when implementing the lean philosophy, some organizations obtained financial benefits, however, some presented negative results concerning the difficult working conditions, highlighting the effects of pressure and intensification of work. If, on the one hand, positive impacts on organizations in terms of quality and productivity are identified, there are other cases that identify negative impacts in terms of the social climate considering tensions, labour conflicts and increased stress.

2.1. 5S in Safety

According to Cirjaliu & Draghici [12], 5S have enormous benefits in terms of safety as they allow the workplace to be always clean and organized. According to Kilpatrick [13], the primary objective of 5S + Safety is to maximize the level of health and safety in the work environment, thus also promoting increased productivity. According to Filip & Marascu-Klein [14], 5S + S make it possible to clean the entire work area and equipment, so that the workplace has the best possible conditions in terms of hygiene and safety. Cleaning and storage are associated with preventing accidents at work: obstacles are removed, passages are cleared, and 5S help to identify and eliminate waste in the workplace. They also help to establish and maintain a quality and productive environment, forcing organizations to look at issues that are often overlooked [15]. By associating an occupational safety specialist on-site, the risks associated with the jobs can also be identified and addressed, for example, by providing facilities for tools and dangerous products, during the implementation of 5S. For Seddik [16], 5S is one of the most

helpful lean tools for companies to improve their work environment. In table 1, a short list of the main papers related to 5S topic can be observed, as well as a summary of the content of each paper.

Table 1. Analysis of a few case studies of the Benefits of Implementing 5S**.**

Author/Year	Analysis
[17]	Waste reduction | Increase of 31% to 91.7% in the quality of the work environment | Reduction in the occurrence of accident risks | Improved stock management
[18]	Reduction of Non-Value-Added Activities | 86% reduction in the occurrence of accident risks
[19]	5% reduction in stock costs | 84.38% reduction in the occurrence of accident risks | Improved efficiency
[20]	Waste reduction | 64% reduction in the occurrence of accident risks | Improvement in the work environment
[21]	45% reduction in the occurrence of accident risks | 11% improvement in product quality | Reduction in stock costs

2.2. Visual Management in Safety

Visual management allows, from the use of visual perception information, to guide, normalize and organize production, with the objective of guaranteeing production safety and improving productivity, making the visual management system intuitive, simple, promoting general self-awareness and initiative to observe discipline, obtaining autonomous management and self-control for all [22]. The content of visual management includes rules, regulations and work standards, production tasks and completion figuration that are combined with management to perform the visual display of standardized information [23]. This technique consists of using fast and intuitive means of communication. There are several visual management systems, such as information boards, space boundaries, andons (transmission of information and notices, usually in the form of electronic panels or traffic lights) and work instructions, their aim is to train workers so that they can interact autonomously in their workplace, reducing errors and other forms of waste [24]. Visual systems are also used to support safety management - for example, construction facilities generally have safety advisory councils, and in many countries, safety regulations require mandatory safety devices (such as safety bars or fireproof devices for elevator doors) - proposing an innovative role for visual controls as a set of visual devices, such as physical barriers, color codes and sirens [25]. In table 2, a short list of the main papers related to Visual Management topic can be observed, as well as a summary of the content of each paper.

Table 2. Analysis of a few case studies of the Benefits of Implementing Visual Management.

Author/Year	Analysis
[26]	Better organization in the manufacturing area | It was found that 83.4% of workers agree that the work environment has been improved regarding safety, thereby reducing the risk of accidents.
[27]	It was noted that the study helped top management to measure, analyse and improve the overall safety plan to protect workers' lives and health.
[28]	Positive effects on workers' mental health at work, reducing their stress during working days.
[29]	It improved the understanding of the organization's processes and increased awareness of performance and associated problems, it also increased transparency, discipline, information sharing, team involvement and the quality of the work environment.
[30]	Improvement in operators' well-being.

3. Methodology

This research aimed to assess whether companies can achieve improvements in terms of safety through the implementation of lean tools, such as 5S and Visual Management. For this effect, a set of improvements were implemented on the factory floor of a carpentry business, in the various productive sections, having been evaluated the perception of workers in this matter through a questionnaire. This

survey consisted of 12 questions and was distributed to employees working in the Finishing, Pre-Assembly, Assembly and Packaging sections, also including Logistics and Quality since these were the sections where the project was already implemented as a whole.

4. Results and Discussion

The project was implemented to reduce Lead Time, thus creating a culture of continuous improvement in the organization. For this, the project started with the Pre-Assembly, Assembly and Packaging section, as it is the place where it's possible to easily understand the effectiveness of the delivery plan to the customer. In the first phase, an initial diagnose was carried out to detect the existence of waste in the activities of this section, and then determine which were the most appropriate lean tools to reduce waste.

As a result of the work developed in the final phase of the production process, the need arose to intervene in the Carpentry and Finishing section, using the same methodology. Data collection was carried out through the monitoring of each process, seeking to obtain the necessary information for the correct application of the tools. In an initial phase, a survey of the company's main processes was carried out to map the current situation and identify opportunities for improvement. However, throughout the project, the involvement of the employees was sought to maintain the organization of the space.

4.1. Improvements implemented in the Pre-Assembly, Assembly and Packaging section

The layout of the Assembly section was improved to eliminate activities that add no value, allowing bigger space for placing workbenches, implementing and identifying IN and Out Zones for planned parts to be assembled and parts already completed and to improve the organization of the workbenches to be able to implement 5S in drawers to lower the time spent searching for tools.

This improvement was achieved also through the implementation of Kanban systems and a better sharing of information among employees, the reading of the Production Notes, the creation of alert systems in the NP - shaded fields with various recommendations and alerts on technical and quality issues - and the creation of technical drawing consultation posts.

To provide employees with increased autonomy in the execution of the assembly, the assemblers were integrated into the preparation of the technical drawings, not only allowing them to feel more integrated into the design of the pieces but also to be able to share their points of view in this regard.

Different locations were identified for the placement of the pieces, and also the signalling and demarcation of corridors for the placement and transportation of pieces and the movement of people. With the implementation of signage, it was possible to create a work pattern, thus facilitating the activities of assemblers and contributing to increased productivity. The areas with the biggest need for attention in matters of safety were also highlighted to inform the places with the greatest risk of accidents at work.

4.2. Improvements implemented in the Finishing Section

It was possible to concentrate operators on value-added activities thus reducing their movement. A worker was allocated to provide support in the preparation of paints for the lacquering booth, as the existing operator, single-handled, needed a lot of time for this job. Visual Management was used for the delimitation of areas such as the central aisle that was marked only for circulation of parts, people and forklifts, the creation of out zones next to the workstations, as well as the identification of parts that needed work through the implementation of production monitoring boards.

Regarding the organization of the painting booths, separators and signs were also implemented in the cabinets of materials and tools complemented with visual management, to facilitate the operator in identifying the placement of each one.

4.3. Improvements implemented in the Joinery Section

In the joinery section, a new built-in ergonomic layout was developed (that is, an in-line supply) that consists of a new approach for the distribution of machines and tools with planned supply methods for replacing materials at the points where they are most needed, being always triggered based on the need

of each joiner to reduce the delay time and remove activities without added value, working as follows: Technical department together with the personnel of the machinery area, ensures that the joiner has on their stalls all the materials needed to carry out their activities as well as the production kit with all the specifications of the parts to be produced by each of the carpenters thus preventing them from leaving their workstations. The creation of a new technical dossier, (since the existing one containing the layout, manufacturing range and work instructions was out of date) reduces the absolute dependence on the know-how of operators, errors, mistakes and doubts, constant rework, reduction of Lead Time and the reduction of dependence on carpenter's skills. With the online supply, the use of decentralized supermarkets was used, that is, a material preparation area and a rack with components that works like a supermarket for a quick and efficient response to the refill of the line edge. This implementation of the supermarket made it possible to reduce stock levels at the end of the line, eliminating the need for travel by carpenters, as it allows having all the necessary materials at the edge of their jobs.

4.4. Assessing the impact of Lean Tools on Safety through a questionnaire

The questionnaire aimed to assess the perceptions of workers throughout their work environment, asking them about their views regarding the impact of implementing lean tools in the workplace, considering factors such as work environment, health and safety, organization and cleanliness and interpersonal relationships. In a population of 40 employees, 30 responses were obtained. Table 3 shows the sum of the most positive results obtained through the questionnaires. It was chosen a Likert's scale from 1 to 5, being 1 the most critical and 5 the most favourable. Only the results "4" and "5" have been counted to the sum presented in table 3.

Table 3. Results of the workers' perception regarding the work environment.

Question	Value
1. The workplace is cleaner and tidier.	83,3%
2. The work environment improved.	83,3%
3. The border of areas or zones contributed to the reduction of accidents at work.	83,3%
4. It reduced stress at the end of the workday.	40,0%
5. Improved communication and information sharing across the company.	66,7%
6. Reduced the time spent searching for needed items.	76,6%
7. Decreased physical effort in the workplace.	46,7%
8. Increased the productivity and efficiency.	53,3%
9. Suggestions for improving working methods are more quickly dealt with.	73,6%
10. It has become easier to manipulate components and materials.	63,5%
11. There is a greater motivation to develop work safely.	60,0%
12. It made it easier to make suggestions.	40,0%

In general, the results of the questionnaire demonstrate that the adoption of lean tools has brought improvements in terms of safety and health.

From the point of view of the employees, aspects such as a cleaner workplace, reduction of accidents at work through the demarcation of zones, improvement in workplace safety and reduction of time wasted searching for materials as well as improvement in the communication/information sharing were the ones that had the most positive impacts thus showing great potential for improving the quality of the work environment. However, a relevant aspect is the opinions about physical effort and stress at the end of the working day, which have shown the highest values in terms of disagreement, corresponding to 40% and 30% respectively.

It is important to highlight that these values demonstrate that, although the implementation of lean presents several benefits in terms of production, there were significant improvements on the part of the employees, overcoming some factors linked to cultural and historical aspects of the company covered by a general context of the organization, and it was not possible to improve them with the

implementation of lean.

In conclusion, this study supports the theory that organizations can achieve productivity increases, as well as benefits in ergonomics, safety and job satisfaction on the part of employees when lean practices are implemented through an integrated approach. This approach is based on the proposed relationship between employee satisfaction, ergonomics and safety and productivity. The maximum benefits can be seen in all areas if the leadership acts appropriately and engagingly with the workers. In general, the project has helped to stimulate communication and employee involvement.

5. Conclusions and future studies

This research made it possible to assess whether lean tools have an impact on safety in organizations. By evaluating the obtained results of the questionnaires, it was possible to conclude that the workers recognized that the adoption of lean tools made their work activities easier because the materials and parts started to be available more easily in the expected places. It also made it possible to improve the work environment, making it cleaner and more pleasant whilst also improving information sharing, which made it possible to increase safety in the work environment. Through this work project, it was possible to conclude that the lean tools allow obtaining improvements beyond what is expected in terms of the production process, reducing waste and costs, but also allowing for an improvement in the quality of the work environment and workers' safety. This result is supported in the values shown in table 3. Indeed, workers have clearly shown that work environment has been deeply improved, increasing their safety and creating a more pleasant workplace. The work environment is a very important factor for the satisfaction of employees and, consequently, for the increase of the company's productivity. To continue the work planned and some of the already carried out, the philosophy of continuous improvement already ingrained in the company must be maintained.

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