APPLICATION OF LEAN PRINCIPLES IN A COMPANY OF THE WINE SECTOR

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ABSTRACT

Nowadays, the COVID-19 pandemic continues to leave its mark on the various national and international sectors. The pressure involved by the inevitable economic crisis, which most companies face, is a major obstacle to their subsistence. Through the implementation of continuous improvement methodologies, these organizations are involved in the search for ways to increase the value of their products and services, and lower production costs, to generate greater profits. An optimized process is important to recover from this tragedy as quickly as possible and, in some cases, to survive and be successful once again.

This study, developed at Adega Cooperativa de Ponte de Lima, aimed for the optimization of a wine bottling line, through the application of certain methodologies of Lean philosophy. The 5S and SMED tools were used to achieve the outlined goals.

With the 5S program it was possible to develop a workplace with a greater organization, storage, and cleaning system, displaying the various advantages that its application offers in reducing waste.

The implementation of the SMED tool, on some equipment, was not completed. At theoretical level, the new organization of tasks allows the reduction of the time spent on the most common setups by approximately 60%, proving to be a valuable strategy that can be adapted on different changeovers and applied in other steps of the process.

Keywords: continuous improvement, *Lean*, 5S, SMED, wine sector

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LITERATURE REVIEW

Wine Sector

Wine is an alcoholic beverage that is obtained by fermentation of the juice of fresh grapes (must). It is the second most consumed alcoholic beverage in the world, but it is possibly the drink with the greatest cultural and social importance in the History of Humanity.

The wide range of wines from all over the world makes the wine market one of the most competitive. Portugal currently occupies the 11th place in the global ranking, both in terms of production and consumption, and 1st place in consumption per capita. The country is on the 9th place in volume of exports, with 3.0 million hL, and 803 million euros in monetary value, according to OIV (International Organisation of Vine and Wine). Giving the latest estimates for 2019, Portugal with 6.7 million hL, was the only country in the EU with an increase in production compared to the previous year (10% more than 2018). Since world production decreased by an average of 10% compared to 2018, this turned out to be a positive aspect for national producers [1]. But it's not all good news. Despite being popular, Portuguese wine has a bad market, causing most producers to be underpaid when observing the international panorama and the influence that this sector has on national exports. In this moment of crisis, betting on new marketing strategies is a challenge for the various institutions responsible for exporting Portuguese wine.

Like all goods that are sold, the one who defines the value of a wine is the customer. Customers know the product they want, when and where they want it, as well as the price they are willing to pay and always demanding exceptional quality. Given the competition, companies in this sector are faced with the need to continuously improve to maintain production, generate profits and meet consumer demands. It is through stable and improved processes, using different methodologies, such as Six Sigma or Lean, that organizations can sustain the value of their products.

Lean

Lean was originated at Toyota, at the end of World War II, with the implementation of the Toyota Production System (TPS).
It is supported by three foundations: *kaizen*, *jidoka* and Just-in-time (JIT). By creating a standard process, companies can continually improve and if small improvements are constantly being made to the process (kaizen), the financial effort when a more radical change is needed can be reduced. Jidoka is the Japanese word to explain a form of automation in which the machine automatically inspects each item after production, stopping and notifying the operators if a defect is detected. Toyota expanded the meaning of jidoka to include the responsibility of all its employees to work in a similar way, that is, to verify everything that is produced and to stop production if a deficiency is identified, until the cause of the defect is uncovered and corrected. JIT's philosophy is based on "making only what is needed, when it is needed" [2]. That means a system capable of producing the right quantity, without excess, quickly and delivering the product in the right place, at the exact time [3].
The objective of Lean thinking is the continuous search to eliminate all kinds of waste, aiming for the continuous improvement of the organization. The 3Ms of Lean, derived from three Japanese words (*mura*, *muri*, *muda*), describe undesirable properties or waste in the process. *Mura* is related to all inconsistencies throughout production and, in turn, *muri* refers to the overload of operators and equipment. *Muda*, derived from the previous two, describes any activity that does not add any value. Seven areas where waste activities can be identified are:

- Overproduction
- Transport
- Overprocessing
- Movement
- Waiting
- Inventory
- Defects

It is through the reduction and elimination of waste that Lean achieves a cut in the cost of production, enabling an organization to obtain greater profits.

There are five important principles in Lean thinking:

1. Define Value
2. Map the Value Stream
3. Continuous Flow
4. Establish a Pull System
5. Pursue Perfection

These principles make it possible to reduce or even eliminate the seven fundamental wastes [4]. To accomplish this goal, Lean uses a wide range of tools, such as TPM, 5S or SMED.
TPM (Total Productive Maintenance) is an approach to equipment maintenance that aims to achieve a perfect production process, increasing productivity, efficiency, and safety. The three objectives of the TPM are zero unplanned failures, zero product defects and zero accidents. It consists of eight sections, known as pillars. Each pillar has its fields of responsibility, but there are topics where they might overlap. This approach relies on the involvement of the entire organization in the quest to maximize productivity and maintain a safe work environment [5]. One of the main goals of TPM is to reduce the six types of losses:

- Breakdowns
- Setup and adjustment losses
- Minor stops
- Reduced speed
- Defects and rework
- Start-up losses

Overall equipment effectiveness (OEE) can be determined from data available on these six losses, giving an overall portrait of the efficiency of an equipment or process [3].
5S program is a globally recognized tool, being described as an element of visual control to help develop a better work environment, both physically and mentally. The term 5S comes from the Japanese words *seiri* (sort), *seiton* (set in order), *seiso* (shine), *seiketsu* (standardize) and *shitsuke* (sustain). It appears to be simple and relatively easy to implement, but it is the most important in Lean, occupying the first place in the JIT diagram [6].
SMED (Single Minute Exchange Dies) is a method that seeks the reduction on the time spent on changeovers between production series. "Single minute" is a reference to the big goal of reducing it to less than 10 minutes, that is, reaching the single digit in minutes spent on a setup [7]. To apply this tool, it is important to

know the difference between internal and external tasks. Internal steps are activities that occur during the transition period and can only be performed when the process is stopped. External steps are tasks that can be performed when the process is still functioning. The SMED methodology can be divided into the following stages:

- Preliminary Phase: Balance of all steps in the initial changeover situation
- Phase 1: Identification and separation in internal setup and external setup
- Phase 2: Conversion of internal steps into external steps
- Phase 3: Optimization of the internal setup and the external setup times

ADEGA COOPERATIVA DE PONTE DE LIMA

This study was carried out at Adega Cooperativa de Ponte de Lima, CRL (ACPL), a wine production and commercialization company. This is one of the most competitive market areas in the world, with great interest within companies in this sector in cutting production costs and increasing the value of their products and customer satisfaction.

ACPL, founded in 1959, is based in the village of Ponte de Lima - the oldest village in Portugal. Being the institutional expression of about two thousand producers, their families, and workers, it is undoubtedly a relevant structure, constituting the largest company in the municipality of Ponte de Lima. Its wines are the result of the vinification of regional grape varieties, exclusively from the vineyards of its associates, thus ensuring the authenticity of its products.

In 1998, ACPL obtained the Certification of Quality from NP EN ISO 9001 Standard, attributed by APCER - Portuguese Certification Association, thus becoming the first winery in the nation to have this certification. In 2018, it was certified by the IFS Food Standard to boost its internationalization to more demanding markets.

METHODOLOGY

The first stage of this project was an initial assessment of the bottle filling line (line 4), examining all types of activities that took place in the workspace. The initial evaluation was carried out through direct observation and dialogue with the various workers, for data collection and analysis of the tasks associated with the process of line 4. The operations of each workstation were observed, including at the level of production, problem solving, transitions between different filling orders, cleaning, and organization.

With this analysis, suggestions for improvement were made for the problems identified and other strategies that could be of interest to the company. These proposals included the application of several techniques from Lean and continuous improvement. After the final decision of the methods to be used with more detail, the rest of this project was concentrated on its application and assembly of results.

To achieve waste reduction, it is important to consider the main steps behind the process of line 4 (Figure 1). There may be some variations in some steps, and/or steps that are not carried out, according to specifications for each product.

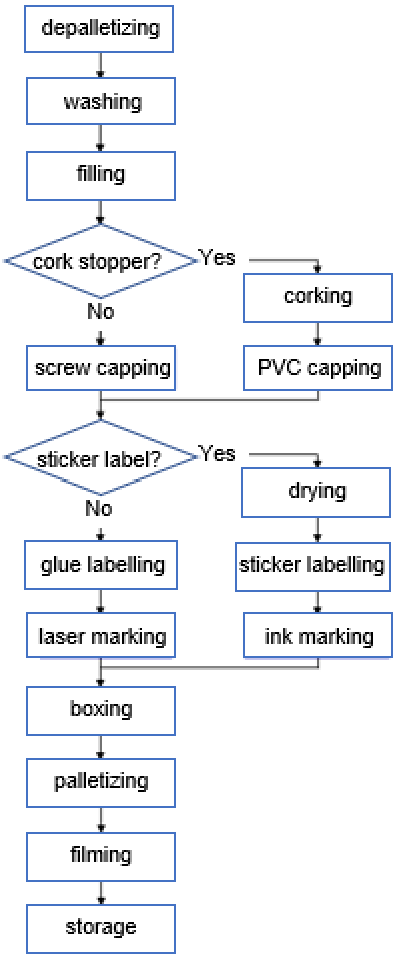

Figure 1 - Flowchart with the main steps of line 4

RESULTS AND DISCUSSION

Initial Situation

The initial assessment allowed to have a perspective of some existing bottlenecks and types of waste in line 4. This wine bottling line was in an adaptation process with several changes and events occurring simultaneously, namely, the integration of two lines into one, the replacement of the boxing machine, the integration of a screw cap tightening machine and the installation of a drying tunnel. It is also planned to install a new screw cap dispenser and the replacement of the sticker labelling machine. Therefore, there are some variations in the workplace resulting from these occurrences.

Examples of bottlenecks identified include:

- Line location on the top floor
- Lack of automatic systems for registration of defective product for statistical control
- Lack of tools in some workstations
- Operator allocated in a workstation in some orders that may not be necessary
- Some cases of *mura* and *muri* on the workload distribution between operators

Once certain bottlenecks were identified, it became relevant to analyze them and find the respective causes, to be able to act and determine useful solutions. In this sense, some quality tools were applied, such as the Pareto diagram and the 5 Whys method. In general, this stage of the project was important to demonstrate methodologies that the company can use to unravel certain bottlenecks.

After brainstorming with operators and supervisors and within the set of exposed proposals, it was agreed to proceed with the strategies covering the application of 5S and SMED tools.

Application of 5S tool

The workplace was divided in 3 zones to facilitate data collection, analysis, and further planning.

- Zone 1: it includes the initial fraction of line 4 (depalletizing and washing machines) and a freight elevator, which serves as input for raw material, mostly for new bottles.
- Zone 2: area which covers from bottle filling until boxing and palletizing
- Zone 3: fraction of the warehouse, which includes a freight elevator, an area for maintenance and another for storage.

After identifying elements in the working area, where it would be possible to improve, it was agreed on the locations and the measures to implement. Unfortunately, during this project, it was not possible to apply the 5S program entirely, having prioritized the first three steps: separation (*seiri*), set in order (*seiton*) and shine (*seiso*).

The technique of marking the floor with tape allows the operator to consider the existence of designated spaces to move, to work, to store, etc. By marking the floor, in Zone 1, it was intended to communicate to the operators that the space in front of the emergency exit and the distribution board is prohibited to place materials, for safety reasons. The battery charge station for the electric pallet truck was also limited, contributing to a reduction in transport waste due to unnecessary dislocation of loaded pallets. Due to the complication that existed in recognizing the exact place where to place the pallet with raw material, near the depalletizing machine, there was time waste to achieve its correct location. Marking the floor for an accurate position, allows a lowering in this type of loss (Figure 2). The implemented techniques, in Zone 1, proved to be important for the fourth step of the 5S methodology, of standardization (*seiketsu*). In the short time after implementation, improvements were observed in terms of organization and tidiness. The local operator respected the marks and was satisfied with the suggestions that were executed.

In Zone 2, the identification and placement of supports on the wall for machine molds reduces the time to recognize and select the appropriate mold at the time of changing in the boxing machine (Figure 3). On some of the shelves, there was a removal of unnecessary materials and a reorganization of the content to be placed in each space. It is important to avoid the accumulation of items that are not necessary for the process or placement, in the same place, or storage of unrelated materials.

The application of a set of techniques from the 5S program, in Zone 3, substantially improved the organization, tidying and cleaning of the maintenance area. The changes made were intended to facilitate orientation within the space and the reduction of movement and waiting wastes, in hopes that it leads to less time spent searching for a specific item. After the initial change in the positioning of the grids (surrounding the maintenance area), the first method employed allowed the removal of meaningless elements from the space. In addition, some tools, which the exact location was unknown, were found, demonstrating the effectiveness of the method. In the second stage, the layout of the various items was improved, to find them more easily, and avoid the acquisition of new material that sometimes cannot be found. The use of new packages to store and the cleaning of this space were also considered, to prevent the accumulation of dirt or rust that wears out, or even damages, the various elements. The identification based on labels and a scheme (available inside the maintenance area) built for the content arrangement on the shelves, improved the levels of *seiton* and *seiketsu* of the storage area. Marking the floor with the tape around the distribution boards, it was intended to draw the attention of operators to not place materials in these places, such as at the entrance to the maintenance area in Zone 3.

The importance of the third S in the program was not overlooked in any of the three areas. The replacement of cleaning sets was important to improve in the efficiency of removing the most varied types of dirt and residues. These kits must be kept in good condition, for reasons related to safety at work and quality in the food industry.

The Lean philosophy requires a commitment and a sense of responsibility from all people. To work, everyone must be responsible in keeping their workstation in good conditions and be willing to take advantage of the appropriate training to perform different types of tasks. Line 4 is undergoing series of profound changes. It is essential not to lose interest in activities dedicated to the organization and cleaning of the workspace, which the team of operators faces daily. The implementation of the 5S tool helps on keeping the focus on these aspects. However, there was a few resilience of certain operators in learning, which would be expected considering that they have been working in the company for quite some time and had work habits that were difficult to change.

Figure 2 - Floor marking for pallet placement

Figure 3 - Placement of brackets on the wall for machine molds

Table 1 - Some examples of workspaces before and after 5S implementation.

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<tr><th><u>BEFORE 5S</u></th><th><u>AFTER 5S</u></th></tr>
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Reduction of Setup Times

SMED tool was applied in a system of three consecutive equipment of line 4 (filling, capping, and glue labelling machines), under the supervision of a single operator (operator A). On average, 2 to 3 changeovers were performed per day in these machines.

The Preliminary Phase consisted of data collecting from the initial setup procedure and the use of various techniques, such as observation of the movements of operator A, dialogue with the operator, timing and filming the different changeover activities. Being the only person with total ease to operate the three equipment, operator A is free to choose the order in which he performs each operation, often switching between pieces of equipment during the transition, not following any standard operating procedure. This first assessment allowed the recognition of 15 activities related to the filling machine, 12 operations associated to the capping machine and 21 tasks around the glue labelling equipment, in a grand total of 48 changeover activities.

In Phase 1, the activities were separated into internal and external. Considering all data, only 7 out of 48 activities in the overall frame were classified as external. These elements were allocated at the beginning of the setup, with no need to change the instant at which they were being performed. Although it was spread over the three equipment, the activities are considered internal since the stop of the last machine, after conclusion of the last item of the old production order, until reaching the desired output in the same equipment, after the transition to the new order.

In Phase 2, the conversion of activities from internal setup to external setup was evaluated. For the filling machine, 3 tasks are easily made external. They require at least one movement to the raw material warehouse, which takes a couple of minutes, and it can be performed by operator A or another operator before starting the exchange. The same thinking was applied for 3 activities related to the capping machine. For the glue labelling machine, 4 tasks were detected previously in the internal setup, which, if properly organized, can be done beforehand. Going to the office was rethought so that the operator can do this task externally. In order to be done as proposed, the filling orders must be properly forwarded some time before starting the changeover, so that when the operator goes to the office or warehouse, he performs all externalized activities, without disturbances.

Phase 3 focused on the optimization of the setup time, with several techniques for this purpose. The improvement of time spent on external operations is usually around storage and transport of materials and tools, such as the optimization of movements, the classification and labeling of parts and tools or the identification of storage locations. This is one of the reasons why actions to improve visual management should be implemented, with the 5S program, for example. In this way, the external setup was reconsidered to save extra movements of operator A. Using a small cart, available in the warehouse, operator A can simultaneously bring bags of cork stoppers and boxes with PVC capsules. There is also potential for improvement in the organization and storage of materials found on different shelves, parts and tools cart (near the filling machine), or inside the warehouse. Improvements in external activities do not directly contribute to equipment downtime, however they set free operators to perform other tasks or so that the operators do not leave their workstation for too long.

The implementation of operations carried out in parallel (assigning operations to more than one operator) is a way to reduce the internal setup time. This approach also makes it possible to reduce the types of *mura* and *muri*, due to the uneven load distribution between the operators and an excessive dependence on operator A. Thus, the operations were organized and distributed by two operators (A and B) to reduce the time lost in a setup and equipment downtime. The new organization of tasks allows the rational distribution of activities during a setup by two operators. The external setup was reconsidered in a way that one is not overloaded or too deprived of time at his position, in relation to the other. With two operators, while one starts the internal setup on the filling machine, the second operator finishes on the capping and glue labelling equipment the last articles of the previous order. Until the last item of the labelling machine exits, and the machine stops, all tasks performed before this point are considered external.

The new planning allows some flexibility. If there is a delay in the execution of his colleague's work, the first operator to finish performing his tasks can help the other one finishing the setup as soon as possible.

In the last days of observation, a second operator was placed to help operator A and there was a demonstration of the potential of working in parallel to reduce setup times. The second operator sometimes needed assistance from operator A when having some kind of hesitation, which is normal at an initial period of accommodation to the workstation.

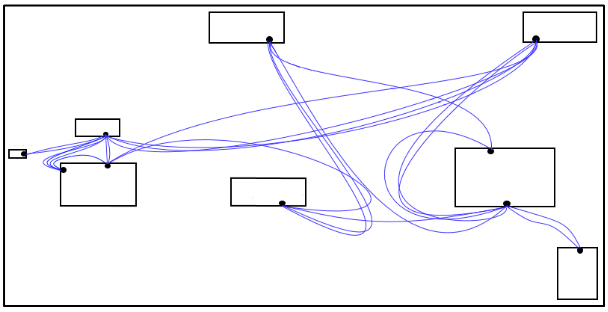

Figure 4 - Preliminary Phase: Spaghetti Chart with the movement of operator A during a changeover

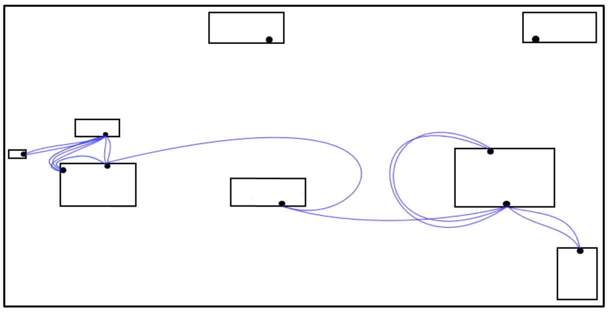

Figure 5 - Phase 2: Spaghetti Chart with the movement of operator A during an internal setup

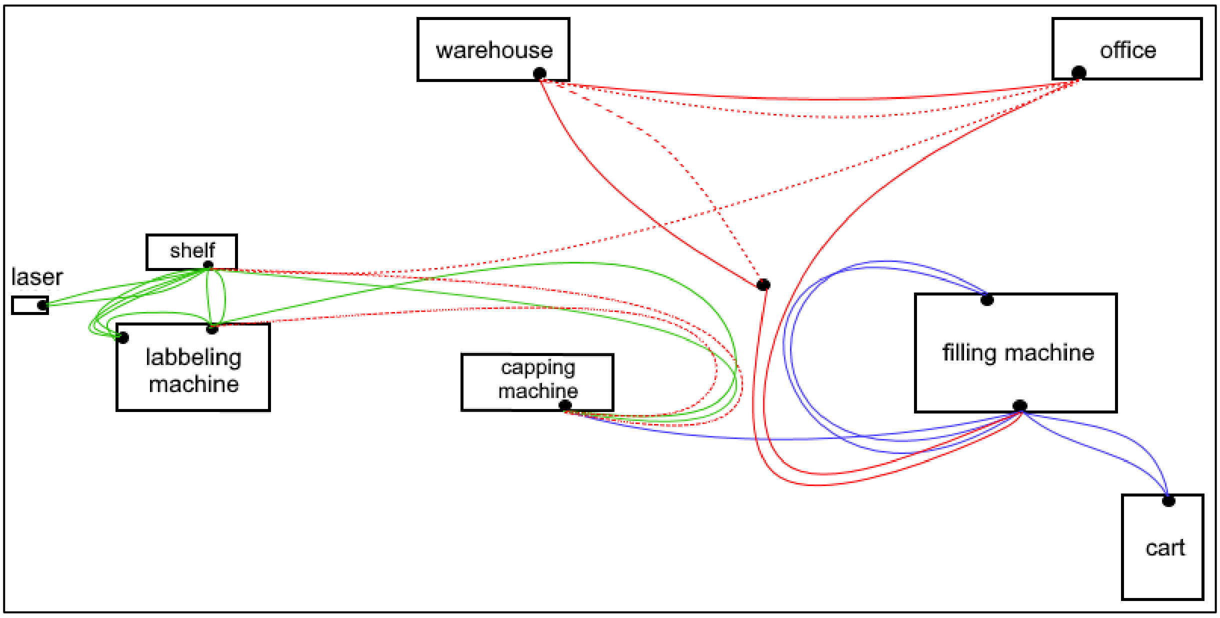

Figure 6 - Phase 3: Spaghetti Chart with the movement of 2 operators (A and B): red for the external setup, blue (A) and green (B) for the internal setup

Using the various footage and observation records, Spaghetti Charts of movement were elaborated. Looking at Figure 5, and comparing with the diagram shown in Figure 4, the movement of operator A during the internal setup is significantly reduced if the activities are externalized (Phase 2). The operator saves a minimum of 160 meters of walk in the internal setup, equivalent to approximately 100 seconds of time wasted in two trips to the warehouse and one to the office. However, on average, this value turned out to be higher because the operator was not always able to bring everything he needed in single motions. Figure 6 shows a prediction of the movement pattern for a changeover, distributed by two operators. It is important to notice a reduction in displacement by operator A, comparing to Figure 4.

Table 2 – Summary of results in the different stages of the SMED application

	Phase 1	Phase 2	Phase 3
Total changeover time	00:28:17	00:28:17	00:19:40
External setup time	00:03:24	00:09:34	00:09:08
Internal setup time	00:24:53	00:18:43	00:10:32
Improvement (internal)	-	25%	44%

This SMED application proved an inefficient procedure for changeover, demonstrating the possibility of reducing the time spent on the largest fraction of transitions in line 4. In Phase 1, after recognition of activities carried out externally, the next stage (Phase 2) proceeded with the identification of additional tasks that could be externalized. This step was very important and showed a possibility of reducing the internal setup time by 25% (see Table 2). The last stage of the program showed that a second person, working in parallel with operator A, can bring benefits in the long run. With the proposed changes to the external setup, a decrease in time of 5% is expected, after the externalization of activities in Phase 2. Initially the lead time may not be reduced, however, as operator B identifies with the various complexities of the equipment, the perspective is for a decrease of 44% (see Table 2), compared to the value presented in Phase 2. The estimate is higher (58%), if compared to the time value obtained in Phase 1, of the initial situation. On average, at the end of the implementation and adaptation to the new procedure, the internal setup would drop from time values around 25 minutes to 10.5 minutes.

A study in greater detail, together with adequate training of operators, can help to achieve the goal of the SMED program, of reducing the minutes of setup to the single digit.

CONCLUSIONS AND FUTURE WORK

In the ultimate goal of waste elimination, a good environment in the workplace is essential to avoid losing time unnecessarily. The lack of good practices on organization, tidying and cleaning, naturally makes the process less efficient.

Although it is difficult to measure its effect, the 5S program is a set of techniques efficient anywhere in an organization. The application of this tool, in general, was successful. In the short time available for control, it was possible to deduce that its action facilitates the work of the line 4 team of operators, demonstrating some of the qualities of this program.

Even though several unnecessary items have been removed, there is potential to remove more. Not only from the space dedicated to line 4, but also in other locations within the ACPL facilities. The floor marking with tape should be checked to determine if it is suitable, and permanent painting can be carried out, if so. A color code can be established for different types of areas. The identification tags must also be updated if there is any change in the organization and arrangement of the materials. Regular cleaning and preventive maintenance schedules should be established. There is also a lack of work standards to carry out certain operations on equipment, such as assemblies, changeovers or cleaning activities.

In theory, despite the relative smooth use, the 5S tool is not easy to fulfill. Often, the problem is in the lack of good practices and self-discipline among the various workers. The most difficult is to create new attitudes and new habits within the company.

Following a growing trend in the variety of articles and volume of bottles sold, decreasing the changeover periods boosts the planned operating time. This can increase the productive flexibility in line 4. It can also translate into a decrease of work-in-process (WIP), often the result of an attempt to dilute a long changeover, and an increase in the volume of finished product. Additionally, this gain in time can be used for other tasks, such as preventive maintenance activities, general cleaning at the stations and equipment, support in other lines, and in the reduction of work overload (*muri*), especially at the moment for operator A.

This application of the SMED program did not focus specifically on tasks related to adjustments. Due to the variability of articles, complexity of some equipment and reduced time for monitoring the operator, it was impossible to distinguish between the various adjustments. It is advised to conduct a more detailed monitoring of certain activities and constant dialogue with operator A to better understand these adjustments.

In a perspective of reducing waste and seeking perfection, it would be advantageous to continue to develop Lean projects and other methodologies, such as Six sigma. Listen to operators who deal with the various tasks on a day-to-day basis and who better know the associated problems. Good communication between supervisors and operators, through brainstorming meetings, is important to take advantage of all situations and to be able to implement the best possible strategies.

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