A3 methodology: going beyond process improvement

Geraldo Maciel Santos Filho
Logística, Universidade do Vale do Itajai, Bauneário Camboriú, Brazil, and
Luiz Eduardo Simão
Escola de Negócios, Universidade do Vale do Itajai, Bauneário Camboriú, Brazil

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Abstract

Purpose – This technological article deals with a case study to implement an improvement to reduce the machine setup of an industrial process, in addition to the development of people using the A3 methodology for problem-solving.

Design/methodology/approach – As a research method, action research was used in a single-case study applied to a motorcycle production company, using the concept of the A3 report for problem-solving as the theoretical basis.

Findings – The implementation of the improvement in the process resulted in a reduction of 70.4% of the preparation time (setup) of the machines, thus eliminating the need to add a third production shift.

Research limitations/implications – It has been applied to only one company, so it lacks a feasibility check to be implemented in other companies.

Practical implications – Regarding its practical contribution, the authors first consider that the proposed method can also be applied in small and medium-sized companies (SMEs), since the investment in this problem-solving approach is low without necessarily implementing the lean production system that, it is usually complex, time-consuming and requires the allocation of a substantial amount of resources by companies. The second practical contribution of this work is that the proposed A3 problem-solving methodology can serve as a guide for managers to implement or improve different industrial and service processes.

Originality/value – It has been applied to only one company, so it lacks a feasibility check to be implemented in other companies.

Keywords Tool A3, Continuous improvement, Setup, Production, Performance

Paper type Research paper

1. Introduction

The increasing level of market competition for industries has made the implementation of lean thinking a robust approach to be adopted (Herzog & Tonchia, 2014). By definition, lean thinking is widely understood as a concept that leads to excellent performance and competitive advantage (Womack & Jones, 1996). In this sense, Thangarajoo and Smith (2015) define lean thinking as an approach to a production system that is carried out to effectively and efficiently create value, with a focus on consumers and the company's competencies.

The high number of implementations of lean thinking, especially in industries, is due to the many benefits obtained from its application (Rini, 2021). Some of these advantages are greater process understanding, reduced inventory, less waste, reduced lead-time, less rework and financial savings (Girardi & Tortorella, 2015).

In order to achieve these goals, companies heavily invest on the implementation of quality systems that bring problem-solving methodologies and continuous improvement, such as

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plan–do–check–act (PDCA), define, measure, analyze, improve and control (DMAIC) and A3 Report (Bassuk & Washington, 2013). These systems are based on reducing errors, waste, redundancies and streamlining processes (Yorukoglu, Ozer, Alptekin & Ocal, 2017). In this sense, Bassuk and Washington (2013) state that problem-solving and continuous improvement methodologies come in various shapes and sizes, giving managers the option to choose the one that best suits their company.

Major problems are usually solved through activities that are detected and controlled by management. The way this company is able to increase performance is through leverage and focus. The lean production system (LPS) imposes basic problem-solving on all employees. In this way, each employee can become a problem-solver, making it possible for the company to effectively leverage its personnel resources. For more complex problems that require a high degree of problem-solving skills, management members are trained through Kaizen events. According to the LPS philosophy, the information needed to describe a problem is: a description of the current situation and historical trends, the goal, including the difference between the goal and current status, and the detailed description of the problem (Liker, 2004).

Among the various methodologies created by quality systems to solve problems and implement continuous improvement, we highlight A3 report. It is a method that emerged at Toyota and became popular among Japanese companies (Rodrigues, 2014). A3 is an improvement process that applies lean thinking to problem-solving (Flinchbaugh, 2012). It is an approach to present a comprehensive yet organized report on a single page. This tool is considered useful in the early stages of preparing to implement lean thinking onto problem-solving.

> This methodology allows showing the key and essential information about a given problem or set of problems, which must be perceptible in a short period of time and outlined on an A3 sheet, presenting different structures in the scientific literature, but all of them are based on in the PDCA cycle (plan, do, verify, act). (Pereira, Silva, Bastos, Ferreira & Matias, 2019, p. 746)

A3 building blocks can be categorized into (1) history, (2) current condition, (3) objectives/goals, (4) analysis, (5) proposed countermeasures, (6) implementation plan and (7) follow-up. However, A3 is more of a way of thinking than a standard document format (Rini, 2021). Thus, the basic elements in the A3 report can be adjusted according to the needs and conditions of each company.

This methodology is described by Priori and Saurin (2020, p. 64) as "...a systematic problem-solving guide, through consensus between the affected parties, which documents the main problems of a process and proposals for improvements". Generally speaking, the A3 report is used to structure, summarize and document a thought process (Sobek & Jimmerson, 2016).

The A3 process emerged at Toyota as part of the Toyota Production System (TPS) in the 1960s to summarize the activities of the improvement circle or Kaizen (Dennis, 2007).

The A3 method is primarily used for collaborative problem-solving, status reporting and proposal submission (Dennis, 2007). It is currently widely applied as part of the implementation of the LPS in different sectors, perhaps because of the good results achieved by its application, combined with the simplicity of the methodology (Bassuk & Washington, 2013). This approach was applied in research center improvements (Bassuk & Washington, 2013), showed excellent results when implemented in a pathology laboratory (Yorukoglu *et al.*, 2017), was implemented in a hospital emergency (Priori & Saurin, 2020), had a successful implementation in the flexography sector of a plastics company (Pradella, Grando, Ely & Turatti, 2015) and generated excellent results in an automobile industry (Grilo, Oliveira & Junior, 2016).

As seen earlier, the A3 thought process is generally based on the Shewhart cycle (1931) PDCA for problem-solving and continuous improvement. According to Rosa, Silva, and Ferreira (2017), the PDCA is a tool or technique of the LPS and is used as a support to identify opportunities to reduce waste and increase efficiency. For Jiang, Sun, Ji, Kabene and Keir (2021), the PDCA, also known as the quality cycle, checks the result of a process, summarizes and analyzes the cause of failures, and starts a new PDCA cycle to improve the process. This creates a flow that the authors call an "endless cycle of scientific quality management and control". Song and Fischer (2020) understand that PDCA is a control structure for the execution of a series of improvement activities that emerged in the industry. The fact is that the PDCA tool became popular and has shown such good results that it left the industry scope and is now applied to a wide range of processes.

During the A3 development process, several tools that are part of lean thinking are used. In the analysis phase of the problem root cause (4.4), the methodology called "5 whys" is used. The "5 whys" method is a scientific approach used in the Toyota Production System to get to the real root cause of the problem, which is usually hidden by obvious symptoms. The "5 whys" analysis is a tool for solving problems. The "5 whys" help to identify the root of a problem or the cause of a discrepancy in the production process, in order to find preventive actions to minimize the ineffectiveness of the production process. It consists of asking the question "Why" five times to understand what happened (the root cause). According to Weiss (2012), for the analysis of the "5 whys", although it is called that way, less "whys" can be used (three, for example), or more "whys", according to the need to find the root cause. It uses a specific set of steps, with associated tools, to find the root cause of the problem, so it ispossible to (1) determine what happened; (2) determine why this has happened and (3) figure out what to do to reduce the probability of it happening again.

In the phase called "propose countermeasures", the 5W2H tool is used. This tool was created by professionals from the Japanese automobile industry to be used as an auxiliary tool in the use of the PDCA (Silva, 2013). Polacinski, Raquel SassaroVeiga, Tauchen, and Pires (2013) describe that the 5W2H tool consists of an action plan for pre-established activities that need to be developed as clearly as possible, and maps them through the central objective of 5W2H tool, which is to answer seven basic questions and organize them, namely what; where; why; when; who; and the 2H are how and how much.

(1) What: What action (countermeasure) will be taken?

(2) Where: Where will the action (countermeasure) be taken?

(3) Why: Why will the action (countermeasure) be taken?

(4) When: When will the action (countermeasure) be taken?

(5) Who: Who is responsible for this action (countermeasure)?

(6) How: How will the action (countermeasure) be carried out?

(7) How much: How much will it cost to carry out the action (countermeasure)?

In this paper, a case study of the implementation of A3 methodology is presented in an industry of the motorcycle-producing in the two-wheel sector. The focus of the study was to understand how to use A3's problem-solving methodology to make improvements and develop people's mindsets.

This technological paper is composed of the following parts: context and investigated reality, in which the environment where the case study took place will be contextualized; diagnosis of the problem situation, that will clarify the problem the company is facing, the improvement cycle and the tool that will be used to solve the problem; analysis of the problem-situation and improvement proposal, which will explain the methodology that will be used and its use; conclusions and technological contribution – at this stage the conclusions will be described, as well as the contribution of this work and its limitations.

2. Context and the investigated reality

This technological paper aims to present an improvement project using the A3 methodology implemented in the machining sector, in an industry within the two-wheel sector (production of bicycles and motorcycles) at the Manaus Industrial Pole (MIP).

The industry under study has Japanese origin, has 1,600 employees, produces 88 models of motorcycles, and sells to the domestic and export markets.

The 2wheels company's production process is quite vertical and comprises the following production processes: casting, machining, stamping, aluminum painting, metal painting, plastic painting, welding, engine assembly and chassis assembly. The focus of this paper was on the machining process.

3. Diagnosis of the problem situation

Due to the expected increase in sales in 2020, the company under study identified in its sales and operation planning (S&OP) process that several production processes would lack the production capacity to meet the new forecast. For some processes, the solution to the problem was easy, as it was about increasing the number of people. However, for other processes, the solution was more complicated as it would be necessary to add shifts or buy machines, which would increase costs and the need for investments.

The worst situation was the machining process, as it already worked in two shifts, and the addition of the third shift would make the company incur several additional costs such as cafeteria operation, transport, emergency medical service, labor engineer, payment of night hours, among others. It would be the only area of the company that would work in three shifts.

An additional factor was that, when working in three shifts, there would be no alternative for production recovery in case of any problem that would generate a production plan delay.

During a preliminary study carried out by industrial engineering, it became clear that it would be possible to meet the new demand by keeping the two shifts if the machining process could reduce the machine setup time. This would increase the productive capacity.

Thus, to solve this problem, the methodology chosen was the A3 report for problem-solving, as it is an approach that the company intended to use to foster a culture of problem-solving and operational improvements, in addition to promote the development of exceptional people and teams who could follow the approach based on the LPS principles.

4. Analysis of the problem situation and proposal for improvement

To analyze the problem and propose a solution for it, the method applied was action research in the form of a case study. According to Melo, Filho, and Chaces (2016, p. 154) "action research is widely used by researchers in the human and social sciences... the research modality has a cyclical character, which means that there is a joint action between researcher and subjects from the admission of the initial question to the effects resulting from the study to action research". A case study, on the other hand, "is a research strategy that absorbs specific interpretations of data collection and analysis, helping senior management in decision making" (Yin, 2010, p. 15).

Aiming at a multi-disciplinary approach in solving the problem for this project, a team was formed under the coordination of one of this study authors, in the role of an internal consultant. Thus, all areas of the company that were somehow related to the analyzed value stream were called. With this, a multi-functional group was created, made up of people from the machining process, from the tooling area and from the maintenance area.

The methodology followed for solving problems encompassed 8 steps, according to the following steps. These steps were defined internally by the company with the participation of the authors of this paper.

(1) 1: Define the problem;

(2) 2: Understand the problem;

(3) 3: SMART targets;

(4) 4: Root cause analysis;

(5) 5: Countermeasures;

(6) 6: Measurement result;

(7) 7: Standardization;

(8) 8: Reflections.

As a general criterion used in this case study, before deciding to open an A3 problem-solving report and starting to work on each of the steps of the proposed methodology, it is necessary to check whether the A3 approach is the best methodology to solve the analyzed problem. In order to use the A3 methodology in the 2wheels company, four questions were defined: (1) Is the problem repetitive? (2) Do they have historical data on the problem? (3) Are the actions necessary to solve the problem within the company's autonomy? (4) Do the solutions positively impact the organization?

If the answer is "yes" to all four questions, continue with A3; if not, it is necessary to use another problem-solving or project approach outside the scope of this paper.

Each step of the A3 methodology adopted is described below:

4.1 Define the problem

The first step of the A3 methodology for problem-solving was to correctly define the problem. It seems simple, but it is one of the most important steps, as the problem is not always clear to everyone. One of the main mistakes is to confuse the effects of the problem with the problem itself (Vanzolini, 2017).

To solve this, some steps were taken so that the team could have a clear view of the problem:

(1) First, it was necessary to understand the context of the problem: What is the purpose for the client? What are the environmental conditions? What are the company's purposes?

(2) Next, it was necessary to visit the factory floor (gemba). One cannot improve unless one understands the real situation, which means going to the source, observing and analyzing in-depth what is happening (genchi genbutsu);

(3) What is the type of problem that must be solved? There are four types: (1) containment; (2) deviation from the standard; (3) target condition and (4) innovation. The first two categories of the four-type structure involve higher degrees of critical analytic thinking and look for root causes. They tend to act reactively to problems that have occurred. The last two types are proactively created, in other words, one chooses to take something to a higher standard. This often involves higher degrees of lateral or divergent creative thinking methods, and one looks for better solutions even when there is no problem at all. The problem in this study is classified as a (2) deviation from the standard, that is, something was supposed to work one way and is working another way. If a process does not have a defined standard, it cannot be improved. Standardized tasks are the basis for continuous improvement and employee training.

(4) Can the problem be explained concisely and measurably? The shape of an A3 usually reflects improvement steps. They are written in a succinct, bulleted and visual style that tells a story with data. In short, there is no need to write a lot, the problem must be shown through numbers.

In the case presented in this paper, a carcass machining line was selected to apply the A3 methodology, and the result of this learning would be later replicated to the other lines.

The chosen line was the carcass 2 machining, which is made up of four machining machines. The problem identified by the team after the data survey was that the setup – that is, the preparation of the line to change the model – was taking 152 min, and this time had to be reduced to 81 min. So, the team had the challenge of reducing 71 min of the total machine preparation time, as shown in Figure 1.

The total setup time was divided into three types, according to the definition by Womack and Jones (1996):

(1) Value (adds value): Processes that transform raw materials and information into parts, products and services. Time is being spent effectively adding value to the product. In the case, 12 min.

(2) Semi value (type 2): It does not add value but it cannot be avoided within a certain scenario. It is possible to be reduced or minimized, but it is not possible to be eliminated. In this case, 69 min

(3) No value (type 1): It does not add value and there is the possibility of eliminating it immediately. In this case, 71 min.

4.2 Understand the problem

The second step of the proposed methodology is to understand the problem. A large part of solving a problem depends on understanding it. In this step, it is important to use quality tools such as check sheet, trend chart, scatter chart, histogram, Pareto chart, control chart, flowchart and spaghetti chart. Basically, at this stage, the objective was to seek answers to the following questions: What is the problem? Where does it take place (what is the process)?

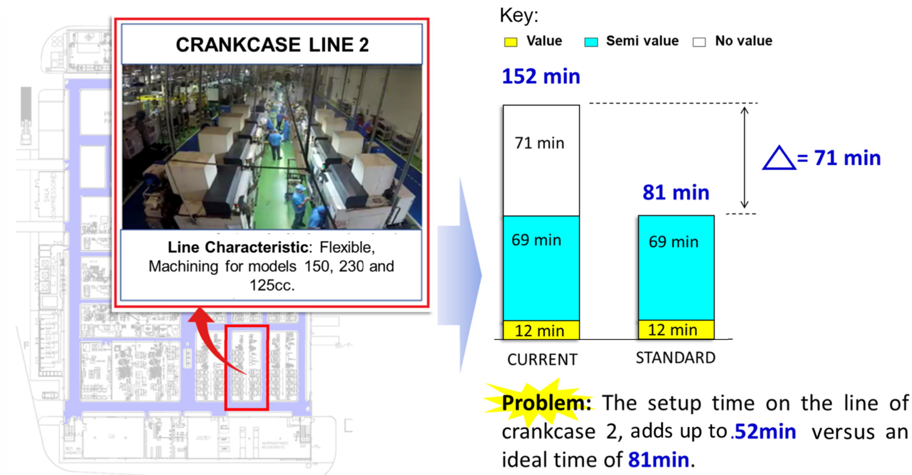

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Figure 1.
Problem definition (concise and measurable)

Who is affected? When has it happened? Why do you need to solve the problem? How can the problem be measured? What is the financial impact (Vanzolini, 2017)?

In the case under study, after a clear understanding of the problem, it was decided to work to reduce the “no value” time of the setup process (71 min). Thus, in step 2, the decomposition of the “no value” time was performed, and the following activities were identified: transport of the machining device to the carcass line (27 min), cleaning of the machining device (19 min), waiting time until the machining device was changed from all four machines on the carcass line 2 (17 min), removal of the device from the machine (3 min), pick up of the new device (2 min), positioning of the new device (1 min), placement of machine fork on the device (1 min) and removal of the chips (aluminum chips removed during machining) from the machine (1 min).

After decomposing the “no value” time, the team responsible for A3 decided to work to reduce the 3 biggest times (transport, cleaning and waiting). The summary of this step is in Figure 2.

4.3 Define SMART objective

The third step of the method consisted of defining the objective or goal that was intended to be achieved by solving the problem. The critical point at this stage is to be able to translate the objective into numbers, that is, the objective should preferably be expressed quantitatively (Grilo *et al.*, 2016). In the company 2wheels, the concept of SMART objective was used:

(1) Specific: Define in detail what you want to achieve;

(2) Measurable: Define how the result will be measured;

(3) Achievable: The objective must be within reach of the power that the group holds;

(4) Realistic: The goal must be something that can be accomplished;

(5) Temporal: Define when the objective will be reached.

In the presented case, the objective was to reduce the setup (preparation) time of carcass line 2 from 152 min to 89 min until October 31, 2019 (Figure 3). This means that out of the 71 min of “no value” time, the team must cut 63 min.

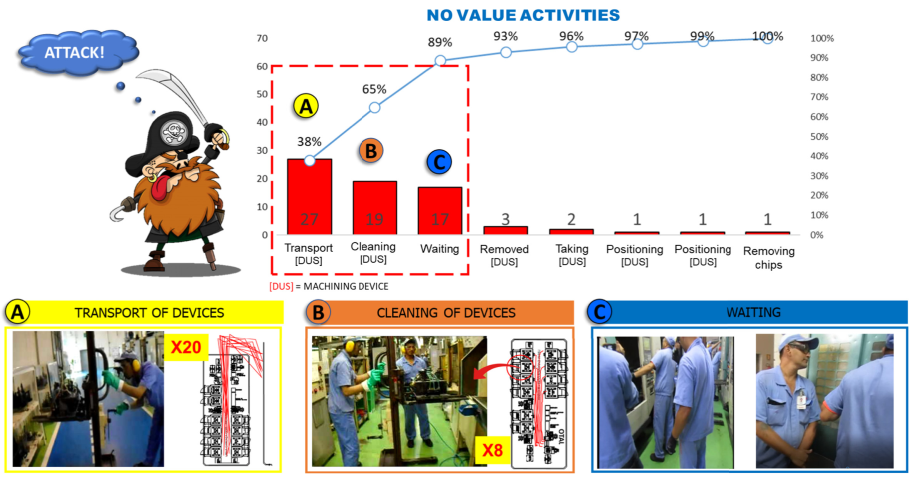

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Figure 2. Understanding the problem – setting priorities

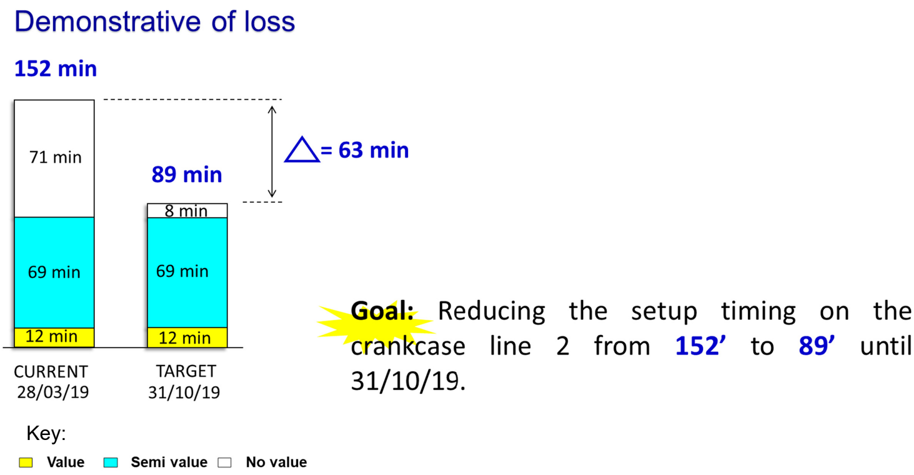

Figure 3. Objective setting – SMART

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4.4 Analyze causes

In this phase of A3 method, it is time to gather information about the causes of the problem and generate ideas to solve it (Yorukoglu *et al.*, 2017). The focus is to find the problem's root cause, that is, to find the primary cause of the problem, the event that triggers the problem, the element or situation that, when eliminated, restores the default condition (Vanzolini, 2017).

In the cause analysis, we can use quality tools such as 5 whys – in which it is enough to ask five times in a row "why?" regarding a problem; cause and effect diagram, in which we list potential causes taking into account six factors – (1) machine, (2) material, (3) method, (4) measurement (5) environment, and (6) labor and brainstorming, which consists of listening to the participants in a free and uncensored way, so that they expose problems and solutions (Buchele, Tereza, Souza & Dandolini, 2017).

In the case under study, the technique of the 5 whys was initially applied, as shown in Figure 4.

Thus, it was found that the root cause for the very long transport time problem (27 min) was that the devices that are placed on the machining machines could only be transported one at a time, due to the limitation on transport carts.

Also using the 5 whys technique, for the very long cleaning time problem (19 min), it was identified by the improvement team that the root cause there was only one point of device cleaning, and the operator, in addition to traveling to that point, often waited while another operator was already using that location. Another root cause identified in this process was that it did not have a defined standard for how the operator should carry out the device cleaning.

As for the problem of very long waiting time (17 min), after applying the 5 whys technique, it was identified that the root cause of the problem was the absence of a standard to perform the setup of the carcass line 2. Each operator did it their way and, as the casing line 2 has four machines, the change of devices only took place when all the machines had completed the previous product.

It is also possible to see in Figure 4 that, after determining the root cause of each problem, a confirmation of this cause was performed by going to the factory floor, and it was confirmed with data and facts that the diagnosis was correct.

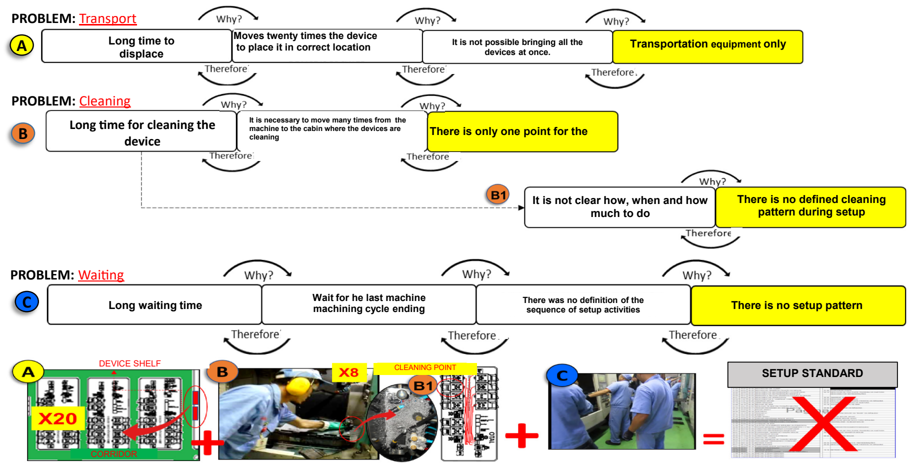

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Figure 4.
Cause analysis

4.5 Propose countermeasures

In the fifth step of the proposed method, it is necessary to define the countermeasures or action plan to determine what will be done to solve the problem. At this stage, one should list what will be done to reach a future state. In other words, the countermeasure is nothing more than the actions that will be taken to eliminate the root cause of the problem and return the process to its original pattern or improve it (Vanzolini, 2017).

In the case under study, a technique adapted from the 5W2H was used in 2wheels company, as shown in Table 1. The countermeasures listed in Table 1 are related to each of the root causes listed in Figure 4 (cause analysis).

As described in Table 1, to solve the problem of transport time (27 min), whose root cause was the possibility of transporting only one device at a time, three countermeasures were established: (1) insert rotation in the cabinets where the devices are allocated, (2) optimizing the transport of the device with the aid of a trolley and (3) bringing the plug pressing devices closer to the carcass line 2. These three actions would solve the transport time problem.

CAUSE	COUNTERMEASURE	WHO	WHEN PLANNED	IMPLEMENTED	WHEN ACHIEVED
A	Insert casters in the cabinets, in order to enable displacement of all the devices at a time.	Luiz (USI)	12/02/2019	100%	08/08/2019
	Optimized transport of the device by assistance of car for moving, was being transported in manual way.	Luiz (USI)	08/04/2019	100%	20/08/2019
	Move devices near the line for pressing the conical plug	Everardo (USI)	15/05/2019	100%	16/05/2019
B	Installing points of compressed air next to machines, devices will be cleaned in the machine.	Wilson (PGI)	15/05/2019	100%	09/08/2019
B1	Develope device cleaning patterns	Wilson (PGI)	12/08/2019	100%	14/08/2019
C	Making time to internal and external setup and standardize activities by means of pattern operation.	Ramon (TVP)	08/04/2019	100%	15/05/2019

Source(s): Authors

Table 1.
Defined countermeasures – actions to remedy root causes

To solve the problem of cleaning time (19 min), whose root causes were the existence of only one place with an air point and the lack of a standard for cleaning, two actions were established: (1) air points were installed in the same machines, so the devices could be washed at the workplace, and (2) a standard operation for cleaning the devices was created.

To solve the waiting time problem (17 min), a countermeasure was proposed and implemented: creating a group with external (engineering) and internal (operators) people with defined standard operation to perform the simultaneous setup of the line, that is, each machine that finished the previous product would be setup, without the need to wait for all of them to finish.

4.6 Result of countermeasures

In this step of the A3 methodology, it was demonstrated whether the objective established in step 3 (objective) was achieved. The unit used to measure the result must be the same as that used to define the objective. In step 3, it was defined that the objective was to reduce the setup (preparation) time of carcass line 2 from 152 min to 89 min until October 31, 2019 (Figure 5).

All countermeasures were implemented until 8/20/2019 (Table 1), and the result achieved is shown in Figure 5. As it can be seen, the target was not only achieved, but it was surpassed. Thus, the setup time that we had as a goal to reduce to 89 min went down to 45 min, that is, the goal was surpassed by 44 min.

This result was achieved because, in addition to reducing the “no value” time from 71 to 8 min, the “semi value” time was also reduced from 69 min to 33 min.

4.7 Standardize

Step 7 refers to standardization. At this stage, it is time to incorporate the learning and stabilize and standardize the changed process. At this point, the solution can also be deployed to other areas of the company that have the same characteristics, once the solution was successful.

At 2wheels company, seven standardization activities were carried out:

(1) *Activity 1*: Elaborate standard operation to all the operators that take part of internal and external setup;

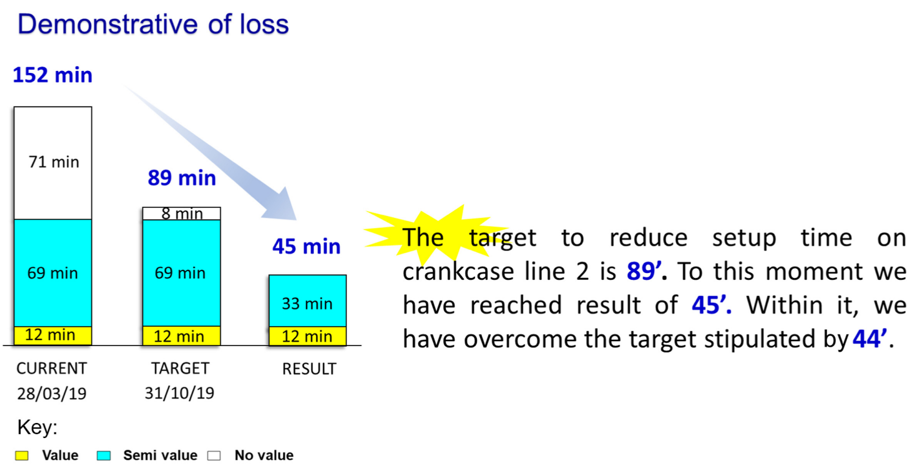

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Figure 5.
Result measurement

(2) *Activity 2*: Develop vests for visualization of team and their responsibilities at the moment of internal and external setup;
(3) *Activity 3*: Install sound sign and visual indication of which line is in setup;
(4) *Activity 4*: Develop logbook to the devices;
(5) *Activity 5*: Identify devices that are removed from the line and sent to shelves;
(6) *Activity 6*: Acquire easels to isolate line when setup starts.

The first activity comprises items (1) and (2): elaboration of a standard operation for the setup considering internal and external teams; (3) a yellow vest was developed for teams to wear during setup in order to differentiate them from other collaborators; (4) visual and audible signs were installed on the line to indicate the setup process; (5) a logbook was created where operators could write down all anomalies and suggestions for improvement in the setup process; (6) identifications were created for the devices that are removed from the machines, informing whether they are ready for new use or not (green card indicates ok and red card, not ok); (7) easels were purchased to isolate the area at setup time.

4.8 Reflect

In the last step of the proposed method, it was time to reflect on learning. At this stage of the A3 methodology, we sought to identify what worked well during the tool application process, what did not work as it should, what was learned by the team during the process, what could be improved, and which other areas of the company could use what was learned and the implemented improvements, as described below:

(1) *What worked*: Objectively of the stages that simplify comprehension about the diversion, simplifying visualization of the point of cause;
(2) *What did not work*: Divergence ideas in step 4;
(3) *What did we learn*: Tool helps us to do range of activities in a standardized way providing a more accurate vision of the actions to be adopted throughout the analysis;
(4) *What can we improve (in the A3 process)*: Improvement of technique with use of A3 tool. Necessity of being open to utilize new tools. Not being content with the good and always exploit the best. Importance of interacting with adjacent sectors;
(5) *Departments that will receive copies of this A3*: Engineering, Tool Room, Machining, Quality Assurance (GQ);
(6) *Recognition (Others involved in this A3)*: We thank the departments which have contributed for the development of the work (EIC, Ferry, GQ Machining).

In fact, this A3 step is very important as it allows reflection to enhance the next improvement cycle using A3 method. An important point in this phase is to celebrate the result with everyone involved in the project.

5. Conclusions and technological contribution

As demonstrated in the analyzed case, the A3 approach to problem-solving is critical for any industry, regardless the company size, as it allows improving internal communication between levels of the organizational structure, in addition to being the basis for implementing a culture of continuous improvement of company's processes through the development of people. Moreover, this A3 methodology made it possible to use the PDCA cycle to improve processes in order to define the problem, present clear goals and objectives, as well as allowing an alignment between the analysis of the causes of the problem, the action plan and the monitoring of project indicators.

Different authors (Herzog & Tonchia, 2014; Girardi & Tortorella, 2015; Priori & Saurin, 2020) claim that the implementation of lean production tools in a company can reduce waiting times, costs, defects and improve material flow. All these goals are very important for companies to survive in an environment as competitive as the current one. However, despite these benefits, studies published on the topic focus only on the issue of improving the efficiency and cost reduction of processes (Pradella *et al.*, 2015; Grilo *et al.*, 2016; Yorukoglu *et al.*, 2017).

The main theoretical contribution of this technological paper is to empirically demonstrate the two most important guiding principles of LPS: (1) waste elimination and (2) people development (Liker & Franz, 2013). Regarding the principle of eliminating waste, which is the focus of great part of the studies published on the subject, it is related to the elimination and reduction of activities that do not add value – only costs – in order to improve efficiency and reduce the processes costs. This was demonstrated by the 2wheels company project, which initially had the purpose of creating the third shift and the various costs and expenses associated with it. For this, the improvement team, after defining the problem, chose as its objective the reduction of the setup time of the machines in machining line 2. The reduction obtained was 45 min, and this improvement was then implemented in all the machines in this process (total of 140 machines).

The second theoretical contribution of this technological paper was to make clear the need to develop people through the PDCA. The objective of the improvement cycle is not just process improvement (waste elimination), since PDCA is much more than a way to obtain results with process improvement, it is a way to develop people (Liker & Franz, 2013). This is important because the "just do it" mentality destroys the PDCA cycle. The mindset should be to use PDCA as a way of thinking and learning, as great people and great processes go side by side to achieve operational excellence.

A third theoretical contribution of the paper is related to the presentation of a new A3 methodology for application in improvement cycles, consisting of 8 steps, instead of 6, as in the models used in other studies (Sobek & Jimmerson, 2016), without the need to use lean philosophy practices (Rother & Shook, 2012). The traditional A3 report template consists of 6 steps described on two pages. The first page represents the left side of the A3 template, describes the current state, consisting of: (1) theme and context, (2) current condition and (3) root cause analysis. The second page represents the right side of the A3 model, describing the future state with the planned improvements, consisting of (4) target condition; (5) implementation plan and (6) indicators. The difference is that in the proposed method there are (8 steps.

At the last stage of the A3 methodology, we sought to identify what worked well during the tool application process, what did not work as it should, what was learned by the team during the process, what could be improved, and which other areas of the company could use what was learned and the improvements implemented. This is a basic principle of LPS that considers that if a person is not challenged and is not learning, he or she is not being respected. So, one needs to standardize what works, share learning and identify more issues for PDCA.

Regarding its practical contribution, we consider, first, that the proposed method can also be applied to small and medium-sized companies (SMEs), since the investment in this problem-solving approach is low, without necessarily implementing LPS, which is generally complex, time-consuming and requires the allocation of a substantial amount of resources by companies (Herzog & Tonchia, 2014).

The second practical contribution of this work is that the proposed A3 problem-solving methodology can serve as a guide for managers to implement or improve different industrial and service processes, whether in SMEs and at the same time it may be used for the development of people using PDCA methodology.

In summary, the proposed A3 problem-solving report is a very useful tool for the organization. It simultaneously documents the key results of problem-solving efforts in a concise manner and incorporates a complete problem-solving methodology that starts with a deep understanding of how the job actually gets done. When properly implemented, this approach allows the organization to move toward a systemic view rather than point optimization, as the problem-solving team seeks information and, ultimately, consensus from all parties affected by the proposed change.

However, the improvement cycle using A3 problem-solving methodology was implemented in a single company, so its result can be considered a limiting factor for this study. Therefore, as a suggestion for further work, it is recommended to apply the procedures adopted here (A3 model with its eight phases) to different SMEs, specifically, the A3 model with its eight phases, based on contingencies and most relevant business objectives for improving the performance of processes, in order to carry out a comparative study with this paper.

We hope, however, that this technological paper may help to fill some of the gaps that exist in the literature on this topic, and that it may be useful to managers who face similar problems.

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Corresponding author
Geraldo Maciel Santos Filho can be contacted at: geraldo.maciel.santos@gmail.com