Implementation of lean manufacturing in the cake mix production line and its effects on *Overall Equipment Effectiveness*

https://doi.org/10.56238/sevened2024.004-023

Samira Abreu Jamal[1] and Rodrigo Zunta Raia[2]

ABSTRACT

The present work aimed to apply the Lean Manufacturing methodology in the cake dough production line of a food industry located in the Northwest of the state of Paraná. The Study of Methods and Times, Poka-Yoke and Kaizen methodologies were applied to obtain information about the process and verify changes through the construction of an action plan for improvements in the mixture filling machine. All tools were supported by brainstorming, carried out at the beginning of the study, to collect previous data and possible improvements, as well as during the application of Lean Manufacturing, aiming for continuous improvement. The results, expressed in packaging losses, demonstrated that, after applying the methodologies that supported the action plan, the percentages of packaging losses were reduced and remained constant in productions with and without setup for product exchange on the production line . Such results were evidenced with the significant increase in OEE, rising from 27% to 62% after the application of Lean Manufacturing in the production line. It is worth noting that some information was removed from the text due to the company's commitment to reliability.

Keywords: Continuous improvement, General Equipment Efficiency, Quality tools, Waste reduction, Toyota Production System.

[1] State University of Maringá/Department of Technology – Umuarama/PR
E-mail: samirabreuj@gmail.com
[2] State University of Maringá/Department of Technology – Umuarama/PR
E-mail: rodrigoraia@gmail.com

INTRODUCTION

After the Second World War, in the mid-1950s, engineers Taiichi Ohno and Eiji Toyoda adopted, at the Toyota factory, located in Japan, a more current approach to the production line, with the aim of eliminating waste. Taiichi Ohno is considered the creator of the Toyota Production System (*Just in Time*), and responsible for developing the Kanban System, which is based on the following principles: leveled production, reduction of preparation time, machine layout, work standardization, improvement of activities and automation (Black, 1991; Monden, 1984)

The concepts developed by Taichii Ohno were based on two conceptions: the first, the perception of Henry Ford, founder of the Ford Motor Company, the first to integrate the entire production process, starting mass assembly in automobile manufacturing, and the second, by own observation of the dynamics in North American supermarkets, on a visit in 1956. In a book published by Ohno, entitled "The Toyota Production System: Beyond Large-Scale Production", the author brings his experiences in the industrial scenario, in addition of the changes that led to the application of his methodology on a global scale. We call this context of applying changes to production processes *Lean Manufacturing* or Lean Manufacturing (ME) (Womack; Jones, 1998).

At the beginning of the 21st century, with the expansion of markets and technological needs, companies that began to deal with a new customer, demanding high-level products and services, began to look for an innovative management style, redefining their notions about quality. This imposed the search for continuous improvements and improvement of products, seeking the almost total elimination of waste (Brito; Dacol, 2008). Thus, to meet the demand for more flexible and lean production systems, the different industrial sectors continue to evolve with the application of practices proposed by Ohno, that is, Lean Manufacturing. Even though it was developed with an industrial focus, lean manufacturing can be defined as a "business system for organizing and managing product development, operations, suppliers and customer relationships", being capable of application in any sector, including the of services, as it allows achieving high levels of quality, low costs and adequate delivery times (Womack; Jones; Roos, 1992).

For the creator of lean manufacturing, the elimination of waste and unnecessary elements, in order to reduce costs, consists of the basic idea that only what is necessary should be produced, at the time necessary and in the quantity required, as production occurs according to the demand of market, but this does not limit losses (Ohno, 1997). Lean manufacturing is the result of eliminating seven types of waste, also called losses, existing within a company, such as :

1. Loss due to overproduction, which is production beyond the scheduled or anticipated volume;
2. Loss due to waiting time, which consists of the time in which no processing, transportation or inspection is carried out;

3. Transport loss, which is the loss caused by unnecessary movements or temporary stocks;
4. Processing loss, in which machines or equipment are used inappropriately in terms of their ability to perform an operation;
5. Loss due to movement in operations, in which there is unnecessary agitation carried out by operators when carrying out an operation;
6. Loss due to defective products or rework, when products do not meet the requirements for use, requiring disposal or reprocessing;
7. Inventory loss, which consists of loss in the form of raw material inventory, work-in-process and finished product.

The Lean Manufacturing methodology has certain tools to be applied according to the needs of the industry to be analyzed. It is worth remembering that the analyzed scenario demands a set of observations until data is obtained so that action plans can then be carried out within the limits established by the company, as it is worth highlighting that the methodology is moldable to the reality in which it is being worked on. . The main tools used in the application of Lean Manufacturing are:

METHOD AND TIME STUDIES

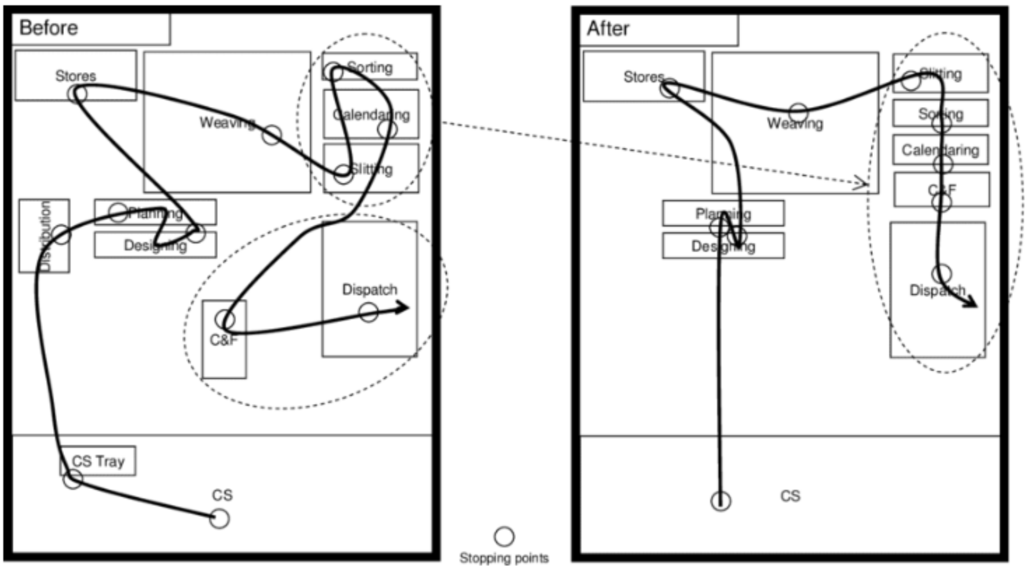
The application of Method and Time Studies is essential for using the tools, in order to observe the current manufacturing environment and note what modifications will be necessary. Along with observation, counting time is essential to assess how much is being spent unnecessarily influencing the process. Both are related to the company's costs, which may be negatively influenced by bottlenecks. This visualization is extremely important, as it influences the entire modification process and any detail must be analyzed individually in order to characterize the damage that has been caused to the company and how to reverse this scenario.

SMED *(SINGLE MINUTE EXCHANGE OF DIE)*

The SMED (*Single Minute Exchange of Die*) or Quick Tool Change methodology is applied when there is a need to diversify products in low production volumes, increasing the number of equipment involved in so-called *setups* . For the authors Sharma (2001), Agustin and Santiago (1996), Severson (1988), Moxham and Greatbanks (2001), Shingo's methodology is about reducing *setup* . This reduction is based on converting, as much as possible, internal *setup* , when carried out with the machine stopped, into external *setup* , carried out with the machine running, that is, activities in a factory environment, during rapid product change, present better results. results when the machine is not stopped for possible modifications, or when it is impossible not to have stops, this time is minimized (Shingo, 1988, 1989) . Monden (1994) proposed the presentation of a set of techniques to achieve *setup reduction* using SMED, such as: knowing the real conditions of *setup activities* , filming to better understand time and movement restrictions and documenting the standard operations routine. With the SMED implementation, the Spaghetti Diagram appears as a tool to visually assist with changes in the process and in the layout of the environment, allowing to reduce the movement of employees and, consequently, bottlenecks, as previously mentioned.

Coutinho (2020), defines that the spaghetti diagram consists of displaying the routes, times and flows of movement on the factory floor. It is done using as a basis the local layout where the movements of each employee, the product and the time it takes to move are drawn. This diagram is of great importance for reducing time and standardizing movement. Figure 01 shows a Spaghetti Diagram before and after applying Lean Manufacturing.

Figure 01 - Spaghetti Diagram before and after applying the Lean Manufacturing methodology (Coutinho, 2020)



5'S

The 5'S methodology brings the idea of “senses” and basically consists of people's commitment to organizing the workplace by maintaining only what is necessary, cleaning the environment, standardization and discipline in carrying out work, with a minimum of supervision possible. The 5'S are the initials of five Japanese words, *Seiton, Seiri, Seiso, Seiketsu* and *Shitsuke* , translated as organization, use, cleaning, hygiene and discipline respectively. According to Egoshi (2006), this methodology was the basis of total quality in Japanese companies, and should also be considered as one of the basic philosophies to support Lean Manufacturing.

KANBAN

The Kanban system is another branch of the Toyota production system, which proposes, in an agile way, the formation of a *Post-it flowchart* aiming to make visible the way in which one is working and the way in which one should work, in addition to what the work will look like after the modifications are completed. For Ohno (1997), the Kanban system is based on the standardization of the layout of equipment and workspaces, avoiding unnecessary movements of employees and wasted time, in other words, another methodology that can be evaluated using the Spaghetti Diagram.

FLOW MAPPING

To map the process, it is necessary to follow the production flow, observing its particularities, the aggregates or not that each operation contributes, as well as the time that the product remains in each of them (RIVERA; CHEN, 2007). In this sense, Lean Manufacturing seeks balance between production time and *Takt* , which is the available production time divided by the customer demand index.

Production time can be defined as the maximum time allowed at each workstation to complete tasks, before moving work to the next station. Along with production time, there is cycle time, a variable that establishes the production speed of a line (STEVENSON, 2001), determined according to the needs of the operation, such as checking the machine configuration, respecting its limits , prior to the start of production, correctly directed labor, as well as the availability of equipment. Thus, the application of process mapping is aimed at the proper functioning of the process, as the greater the demand, the more care must be taken with the flow time, so that the production line functions efficiently.

POKE-YOKE

Shimbun (1998) defines the term *Poka-Yoke* as a method that initially aimed to prevent human error at work, considered the main cause of defects, but which always aimed to obtain zero defects in the production line and eliminate inspections of quality. The implementation of *Poka-Yoke* is linked to the implementation of the kaizen philosophy, which has continuous improvement as its principle.

All the tools mentioned above have similar bases and aim, at continuous improvement, to reduce costs, correct bottlenecks and organize the process, undergoing changes only in the way and situations in which they are applied. The results of applying these tools can be expressed through the OEE (*Overall Equipment Effectiveness*) index, a measure of the effectiveness of equipment in the industry. For Garza et. al (2008), the OEE index, also known as General Equipment Efficiency, has been increasingly used in industry not only to control and monitor the productivity of equipment in the production line, but also as an indicator and engine for process improvement. and performance. Thus, the OEE is able to measure performance, identify development opportunities and direct the focus of improvement efforts in areas with specific demands. Therefore, associating the Lean

Manufacturing methodology with the OEE index results in noticeable changes on the "factory floor", generally expressed in graphic form or percentages of production/productivity (GARZA et al., 2010).

However, for Jeong and Phillips (2001), there is a limitation on the types of losses that the system considers, and the assessment using the OEE index may cause distortions, such as attributing responsibility to production for losses that are not controlled by it. Losses resulting from supplier packaging problems or due to restarting the process after a power outage are examples of failures that have as their root cause problems external to a production process, but which can be commonly associated with production areas. Ljungberg (1998) defends the thesis that the losses considered by OEE must be associated with production or maintenance areas and not external areas.

To apply the tools of the Lean Manufacturing methodology, the cake mix production line with added fat in its composition was used as a source of study. According to ABIMAPI (2021), in a study carried out by Ital (Institute of Food Technology), cakes tend to be central foods for celebrations and domestic hospitality, associating the pleasure provided by the great diversity of recipes, with their nutritional value formed by composition that, in addition to flour, fats and sugar, usually includes eggs, milk, cocoa, fruits, nuts, seeds, among other very nutritious foods. Due to the wide variety of recipes, cakes can have very different amounts of calories and nutrients.

In Brazil, according to Nielsen/ABIMAPI data, in 2020, the total consumption of industrialized cakes was 0.042 million tons, with per capita consumption estimated at 0.196 kg. According to Resolution RDC nº 383, from Anvisa, of August 5, 2005 , establishes the "Technical regulation that approves the use of food additives, establishing their functions and maximum limits for food category 7 - bakery products and biscuits". Specifically, in item 7.3.2 - "Cakes, pies, sweets and confectionery dough, with chemical yeast, with or without filling, with or without topping, ready for consumption or semi-ready" of the table attached to the Resolution, are placed the limits for additives and adjuvants used for this group of products. In addition to RDC nº 383, of August 5, 1999, there is only RDC nº 285, of May 21, 2019, which prohibits the use of food additives containing aluminum in several food categories (ABIMAPI, 2021).

In recent years, trends in the consumer market have led to the launch of new products with ingredients that are better known to consumers and with fewer additives. However, the reformulation of traditional products, which are considered safe by Anvisa and the Ministry of Agriculture, Livestock and Supply (MAPA), is often not an easy task from technological and economic aspects (ABIMAPI, 2021).

Therefore, the present work presents an analysis of the implementation of Lean Manufacturing in the cake mix production line in a food industry located in the Northwest of Paraná, aiming at continuous improvement, reducing waste and increasing the OEE of the machine used to fill this product. mixture.

METHODOLOGY

On-site research , enabling interviews with different sectors involved in the cake mix production line (Selltiz et al., 1967).

The research took place with two main focuses: the first was a general observation throughout the production sector, especially the cake mix production line, seeking to identify and analyze losses during the process and the second aimed to evaluate the data and manuals from the company. The information was collected through operational data and the system used in the tactical management area with leaders, supervisors and collaborators in the sector. Subsequently, the results were evaluated and measured in the form of graphs, which were segregated according to each bottleneck present in the machine in question. The analyzes were carried out during the month of September 2023.

The study began with the choice of the company, which adopts the Lean Manufacturing methodology in its production process system. After the interview with the sector leader, she guided the data collection points, intended for the case study. The formulation was the first step towards better understanding the process. The formulation consists of three processes: weighing the components present in the cake mix, stipulated by the company's quality control, inserting the raw materials into the mixer, where fat is added and, finally, sieving. Figure 02 shows all the previously mentioned steps in the filling machine for the production of cake mix.

Figure 02 – Weighing, mixing and sieving steps in the filling machine of the cake mix production process.

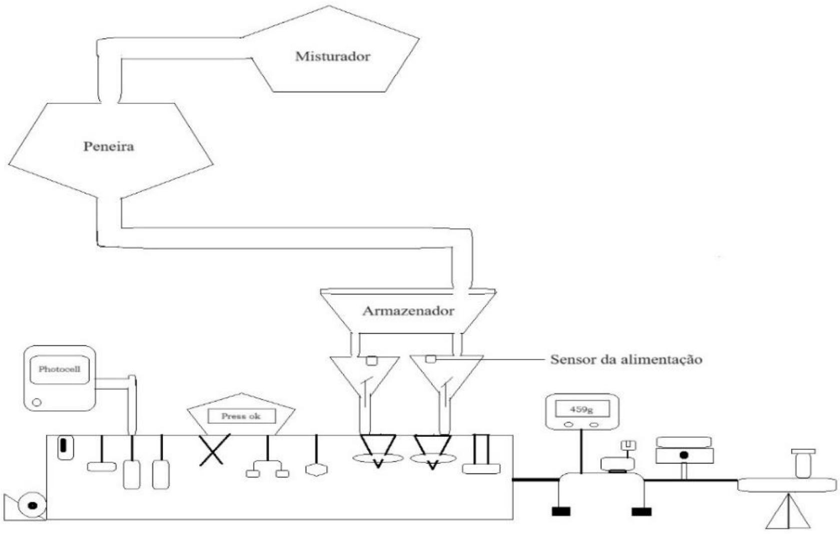
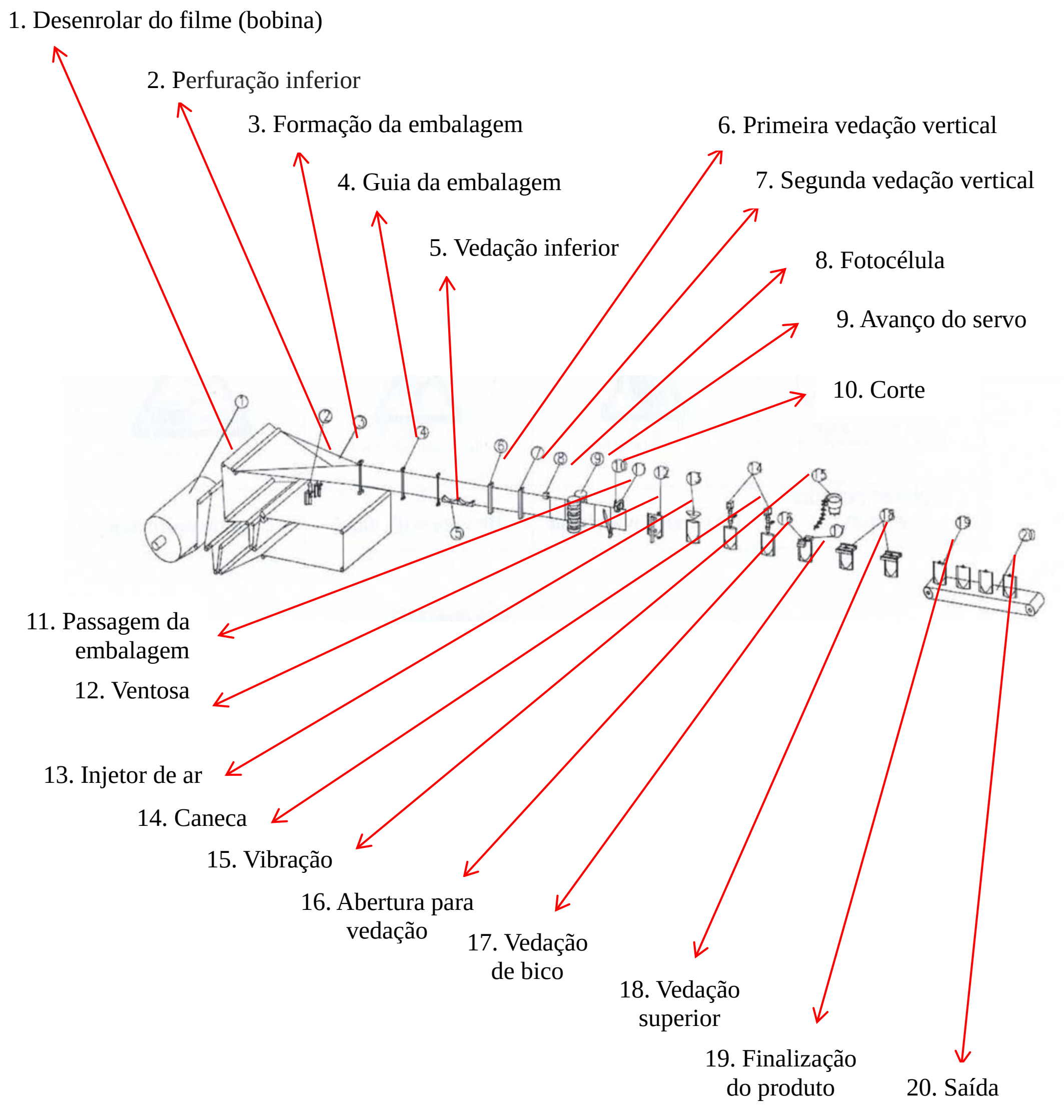


Figure 03 shows the flowchart of the internal part of the filling machine. Empty packages are formed at points 1 to 13, where the coil unwinds following the pattern configured on the machine panel. The mug (14) is responsible for filling the product into the package, which undergoes vibration (15) to accommodate the mixture, as from points 16 to 20, adjustments take place at the top of the package. This vibration is important so that the product is not retained when sealed, as if it is poorly sealed, reprocessing and loss of packaging will occur. The packages containing 500 g of cake mix are sent to the secondary package, cardboard boxes, where 12 packages are manually stored by line employees.

Figure 03 – Flowchart of the internal part of the filling machine.



Colauto and Beuren (2004) express that the interview is a technique for obtaining information in which the researcher personally presents himself to the sample of the selected population and formulates questions, with the objective of obtaining data necessary to answer the question studied. Therefore, any understanding of the process was essential for the course of the study, both observation and dialogue.

When observing the machine, demonstrated by Figures 02 and 03, information was sought through interviews with employees on the production line to better understand the problems, attracting the team's attention to correct errors. Through dialogue, questions were raised regarding the work instructions applied and the machine's installation history, raising key points for understanding the process. During the course of the research, methods and questions were created that led to challenges in the company's mechanical sector, where it was noted that the parameters were different from the manual studied to carry out the case study. Through discussions, based on experience and the methodology applied, new measures were identified to be taken during the process.

The *brainstorming* carried out led to the search for data prior to the beginning of the application of the methodology, such as graphs, the global efficiency index, justifications for machine stops, behavior of the entire manufacturing environment in the face of the problem encountered, spreadsheets of values involving the entire process, in addition to the machine manual, for a better mechanical understanding of the machine. The objective of analyzing spreadsheets, efficiency indices and graphs prior to the application of lean manufacturing is to compare values after the action plans adopted, proving or not the effectiveness of the study.

In the case study, the following tools of the Lean Manufacturing methodology were applied: Study of Methods and Times, *Poka-Yoke* and Kaizen.

RESULTS AND DISCUSSION

Using Lean Manufacturing tools, such as Study of Methods and Times, *Poka-Yoke* and Kaizen, action plans began, aiming to correct the process, using the methodology, generating tables and using measuring devices for collection of the data. Table 01 shows the results generated after applying the tools mentioned above.

Table 01 – Results of applying the Lean Manufacturing methodology tools

APPLICATION OF THE LEAN MANUFACTURING METHODOLOGY			
WASTE	**ACTION PLAN**	**DESCRIPTION**	**RESULT**
Machine interfering with the top of the packaging during the filling process	The researcher and machine operator began correcting the packaging nozzles within their reach.	Using a pointed tool and applying a circular motion, the packages were opened manually.	Significant reduction in packaging loss and reprocessing.
Expulsion of good packages for passing alongside non-conforming packaging on the scale	Analyze the weight at the end of the filling process or collect the non-conforming package.	At the end of the filling process, it must be weighed using a table scale whether the package that was expelled next to the empty one is actually compliant or the empty package must be collected before the machine's scales reach it, taking it to the packing table.	Significant reduction in packaging loss and reprocessing.
Product interfering with the identification of the machine's power system (sensor)	Constant cleaning of the sensor.	Check if there is any product dirt on the sensor and, by tapping the machine with a tool, remove the residue.	Significant reduction in packaging loss and reprocessing.
Excess weight caused by defects in the dosers	Constant correction on the machine panel.	The cake mix is stored in mugs, not filled into packaging due to machine failures, so correction becomes constant through observations.	Significant reduction in packaging loss and reprocessing.
Top of the machine without wind seal cover	Change in wind flow at the top of the machine.	The sector's ventilation system was positioned differently, so that the air did not go towards the top of the machine.	Significant reduction in packaging loss and reprocessing.
Dater failure	Constant observation of the date device and changes to the configuration panel.	When the panel points out the lack of standardization of the date, the operator promptly makes adjustments.	*The time stipulated for the research was not enough to present relevant results
Scissors fail when cutting packaging	Measuring packaging thickness	Using the thickness measuring device found in quality control, the research began with ten packages each production, having a visualization of the standards.	*The time stipulated for the research was not enough to present relevant results
Product Feature	Analysis of the moisture content of the product to be packaged.	Using the moisture measuring device found in quality control, one package per production is taken to the counter that expresses the humidity every one minute, totaling ten. The last value expressed is the quantified one and must therefore be inserted into a spreadsheet to create a standard and compare it to the theoretical values of methodologies.	*The time stipulated for the research was not enough to present relevant results, but significant values were found.
Machine traction out of parameters	Panel adjustment.	Using a ruler, the beginning of the package is measured to the white stripe, where the pattern is coded by the photocell and estimated. With the value found, adjustments were made to the panel. Another action plan adopted was the translation of the manual for better understanding.	Significant reduction in packaging loss and reprocessing.
Sensor light identifying fault	Constant observation of the light sensor.	Research still to be developed.	*The time stipulated for the research was not enough to present relevant results

With the information in Table 01, it was possible to create tables and graphs that showed the reality of the process, making it possible to identify, more easily, the problems associated with it. Table 02 had the purpose of collecting data regarding process errors and waste classification.

Table 02 - Descriptive table of observed waste and causes.

WASTE IN THE PACKAGING PROCESS						
DESCRIPTIVE	**CAUSE**					
	PACKAGING	**ADDITION**	**WAIT**	**MOVEMENT**	**MACHINE DEFECTS**	**PRODUCT LOSS**
Machine interfering with the top of the packaging during the filling process	X				X	X
Expulsion of good packages for passing alongside non-conforming packaging on the scale					X	
Product interfering with the identification of the machine's power system (sensor)	X	X			X	X
Excess weight caused by defects in the dosers	X	X			X	
Loss of cake mix due to excess product in the dispensers					X	X
Top of the machine without wind seal cover	X					X
Scissors fail when cutting packaging	X				X	X
Product Feature	X	X				X
Machine traction out of parameters	X				X	X

Table 02 presents a description of the waste in the cake mix packaging process. The table was filled in with “x” in the causes of waste corresponding to each of the descriptions in the table. It appears that the selected causes are: loss of packaging (PACKAGING), the addition of product during packaging (ADD), waiting for the procedure carried out to take place, such as the formulation of the raw material, mixing time, arrival of the product to the production line, the starting of the machine, the organization of the process, among others (WAIT), how much is necessary for the activity carried out and whether there is dispersion of employees during that moment (MOVATION), the defects presented by the machine during processing (DEFECTS) and reprocessing and/or rejects during process failure (PRODUCT LOSS). Therefore, through the analyzes of Table 02, the problems to be analyzed were formulated, possible changes were constructed, the tool to be used was identified, the variations in the process that were presented daily were observed, and significant strategies were drawn up. to obtain data that leads to the result.

According to the results presented in Table 02, it is evident that packaging loss is the biggest problem in the cake mix production line. The data was promptly processed and possible bottlenecks were identified. Packaging is used to package products for transportation and storage in order to protect and maintain product quality. According to Arnold (2015), they can be divided into two parts: primary packaging and secondary packaging. Primary packaging is directly linked to the product, secondary packaging groups and stores product units. During the analysis it was noted that the loss started from the primary packaging, which occurred through machine failures, incorrect adjustment by operators and even characteristics of the packaged product. Losses in general are the major problems in production processes, which are embedded in complexity, mainly in controlling losses and reducing process costs, often being a point of difficulty for the manager (COSTA, 2012).

Using the description in Table 02, we can individually address each of the problems involved in the loss of packaging in the production process. Regarding problem 1, machine interfering with the top part of the packaging during the filling process, when questioning the operator, he mentioned that it was a suction cup problem (Item 1- Figure 02), which did not open the top part of the packaging to insert the product . By viewing the process, it was observed that the bottleneck in question was the air injector of the packaging, which mistakenly rested on the opening of the packaging, causing folding, and thus generating reprocessing through the mugs (Item 14 - Figure 02). This observation stage was essential for obtaining the first results, as after observation, the openings were made manually, between the air injector and the mugs, finally resulting in the product being packaged, carrying out the first action plan to contain losses. .

For problem 02, “Expulsion of good packages due to passing alongside non-conforming packaging on the scale”, indicated that packages filled correctly, suffered interference, through the total mass, when passing through the scale next to packages filled outside of standards. In several situations, non-standard packaging, which was generally empty packaging, levitated, due to the sector's ventilation, and fell close to correctly packaged packages, indicating a non-standard mass on the scale. Upon observing this situation, the comparison between machine scales and table scales began. The solution was obtained by confirming, using a table scale, that the package was compliant. When this happened, it went to packing; if it didn't happen, it was destined for reprocessing.

Problem 3, “Sensor interfering between the machine's power supply communication and the storage box”, occurred when the cake mix itself caused dirt to accumulate on the filling machine's sensor. The purpose of the feed sensor (Figure 02) is to identify whether there is product in the package feed or not. From observation, it was noted that the storage box (Figure 02) did not communicate with the feeder, reducing the filling of the product through the mug (Item 14 - Figure 03). This perception was also evident when noticing that the light point, attached to the sensor, was unregulated, because, according to the correct functioning of the machine, the red light expressed that the power supply was full and the same light was off, which was necessary. complete the machine with the product.

During observation, it was observed that the light remained on (red) while the feed was empty, initiating a failure process in the machine, called “sieve return”, in which even though the filling request was made by the machine, this was not done. corresponded because the sensor continued to identify that there was product in the supply. When the red light turned off, the product went down from the storage box to the feeder, returning to the correct filling process. Until communication was established, packets were lost. To minimize this problem, manually tap the sensor or quickly configure the machine.

Interconnected with problem 3, there are problems 4 and 5, “Excess weight caused by defects in the dosers” and “Loss of cake mix due to excess product in the dosers”, respectively, in which when regularizing the feed of the machine, due to the problem with the red or off light, the commands were obeyed quickly, filling the packages with an additional amount of product, filling more than necessary. The action plan was to translate the machine manual for operators and employees, providing reading as a better understanding of the process.

Problem 6, “Top part of the machine without a wind seal cover”, occurred externally to the machine, due to the ventilation of the sector which, as it was located above the machine, caused the packages to bend in the nozzle, interfering with the standard weight. The direction of ventilation was then changed to resolve this problem.

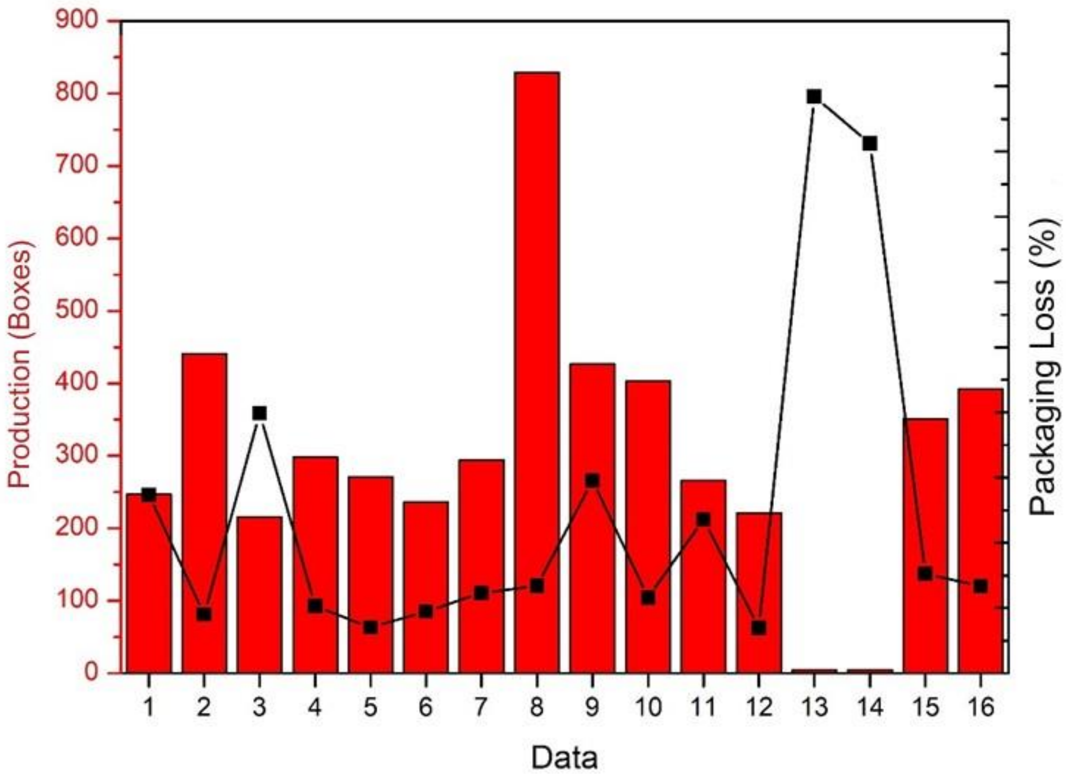
Problem 7, “Scissors failed when cutting packaging”, was verified when the packaging that, when going through the cut (Item 10 – Figure 03), suffered damage. The corrective action began with measuring the thickness of the packages, a method used for quality control in continuous processes. At each processing, a sample of 10 empty and completely clean packaging was collected, so that the thickness could be measured using a thickness gauge. This data collection was used by quality control, which did not yet contain adequate standardization of the coil.

Another approach was problem 8, “ Product characteristic”, a point that clearly demonstrates that the variables of a process shape the application of the Lean Manufacturing methodology, given that this case study has a food product as its commodity, which suffers physicochemical changes. In this case, the consistency of the product in relation to ambient temperature was taken into account, which significantly changed the process. The product contains fat in its composition, which, due to the heat in the sector, modified the characteristics of the product. The action plan began with the moisture analyzer, a device that prints out the moisture content of the food for ten minutes. Another approach was to identify the supplier and standardize the raw material in question, applying flow mapping. It was noted that it would be necessary to use internal ventilation in the machine, which would not interfere with other problems. The company's maintenance sector performed in accordance with what was analyzed.

Finally, problem 9, “Machine traction outside of parameters”, tried to analyze the machine display, noting that the settings were in another language, leading to a translation of the manual for better understanding by the operators. Another action plan was the observation of numerical values, bringing standardization. When contacting the maintenance sector, they inquired about the existence of a mathematical method or method of measuring this traction that interfered with the length of the packages (Item 03 Figure 03). The packaging obtains an appropriate length for packaging, therefore, through measurements taken with a 30 cm ruler, these parameters were established according to the coil of the respective flavor to be packaged, as each one had its own characteristics of thickness and stripe that they were identified by the photocell (Item – 08 Figure 03).

All descriptions highlight the loss of packaging and product as the biggest marker of error during the process, caused by machine defects. Soon, the action plans detailed in Table 01 began, segregating the tables to obtain specific values and providing visual graphics that demonstrate the results. Figure 04 shows the loss of packaging in relation to the daily production of boxes, with 12 packages each.

Figure 04 – Loss of packaging in relation to the production of cake mix boxes.



To better understand Figure 04, some points must be addressed, such as: identifying the date with numerical values from 1 to 16, as during the research period there was a *setup application on the same day* , which consists of the period in which the Production is interrupted so that equipment can be adjusted to change the product. Table 03 expresses the production values, in boxes, for the dates indicated by 1 to 16 in Figure 04.

Table 03 - Production referring to the day for *setup analysis* .

PRODUCT	DATE	DAY	PRODUCTION (boxes)
Ready party cake mix	1	09/05/2023	247
Ready-made anthill cake mix	two	09/06/2023	441
Ready-made corn and cheese flavored cake mix	3	09/11/2023	216
Ready cassava flavor cake mix	4	09/11/2023	298
Ready-made lemon flavor cake mix	5	09/12/2023	271
Ready-made cornmeal flavored cake mix	6	09/12/2023	236
Chocolate flavored cake mix	7	09/12/2023	294
Chocolate flavored cake mix	8	09/13/2023	829
Carrot flavored cake mix	9	09/18/2023	427
Vanilla flavored cake mix	10	09/19/2023	403
Coconut flavored cake mix	11	09/19/2023	266
Pineapple flavored cake mix	12	09/20/2023	221
Ready-made cassava flavor cake mix (export)	13	09/20/2023	5
Ready-made cornmeal cake mix (export)	14	09/20/2023	5
Ready-made anthill cake mix	15	09/20/2023	351
Ready chocolate cake mix	16	09/22/2023	392

Another approach is that the percentages obtained are real values, but will not be demonstrated in the relevant work due to an ethics agreement with the company. Therefore, through visualization it is clear to see the proportion of waste caused in relation to each day of production. From Figure 04 and Table 03 , it can be seen that there was no standardization between production and packaging losses, as waste was greater in expressly small processes. It was then associated with the adjustment of the machine, which can be linked to a considerable percentage when examined individually in relation to the total loss of the process. On dates 13 and 14, which refer to September 20, 2023, the production of just 5 boxes for export represented the biggest packaging loss in the entire month. The percentage calculation of packaging loss occurs through the production carried out, quantity per box, packaging weight and waste, then obtaining the necessary values.

Table 04 shows the dates and days on which the machine was set up, that is, when the machine was adjusted to produce a new flavor cake mix.

Table 04 - Date of data collection with segregation of losses during the process.

PRODUCT	DATE	DAY
Ready-made corn and cheese flavored cake mix	1	09/11/2023
Ready cassava flavor cake mix	two	09/11/2023
Ready-made cornmeal flavored cake mix	3	09/12/2023
Chocolate flavored cake mix	4	09/12/2023
Carrot flavored cake mix	5	09/18/2023
Pineapple flavored cake mix	6	09/20/2023
Ready-made cornmeal flavored cake mix	7	09/20/2023
Ready-made anthill flavored cake mix	8	09/20/2023

From Table 04, it is possible to see that in four days production had to be stopped to adjust the machine to produce another flavor of cake mix, which could lead to packaging and product losses due to the new adjustment. Aiming to demonstrate the segregation of these losses, Figure 05 shows the values of packaging losses segregated into three different causes, namely the adjustment of the machine, the production process itself and defects found in the machine during the processing of cake dough packaging.

Figure 05 - Loss of packaging due to machine adjustment, process and defects.

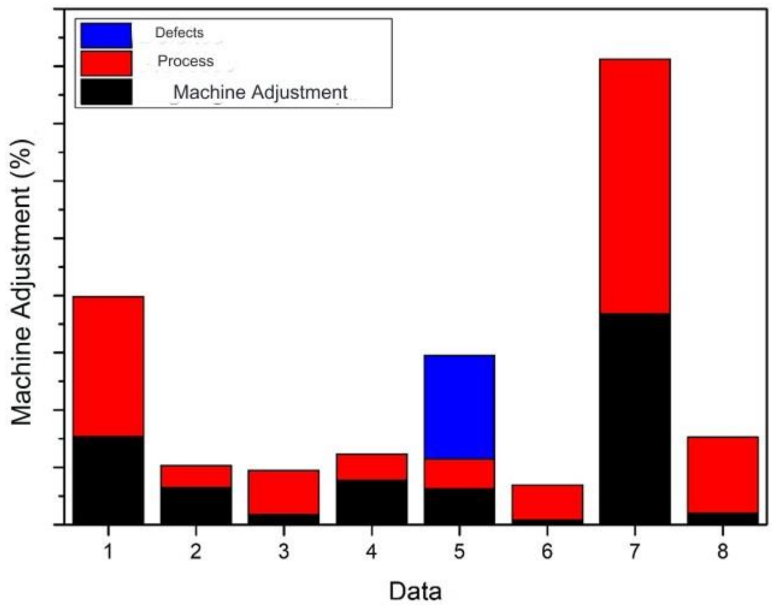


Figure 05 shows that, on most days, the main causes of packaging loss are due to machine adjustment and the process, involving the internal part of the machine (Figure 03), power supply (Figure 02) and physical characteristics. product chemicals. Only on date 5, referring to September

18, 2023, the defects could be seen as a cause of packaging loss, being determined by the lack of standardization of the machine system, which had not been correctly installed since its purchase by the sector. The lack of support from the supplier led to all errors in standardization and understanding of the machine, as no training was applied to line, operator and maintenance employees. It is also worth highlighting that there is a difference in the analysis of the two main reasons for waste, because while the loss during the process can be considered high in comparison with the adjustment of the machine, it is worth remembering that the process time is much longer than the machine adjustment time, that is, losses due to machine adjustment have a much greater impact on the total, highlighting the points mentioned above regarding the lack of correct parameters. Waste due to adjustment occurs in a few minutes, while losses in the process occur over seven hours of production. Again, it is worth highlighting that the percentage values were removed from the graph due to the ethics contract with the company.

Thus, using the data in Figures 04 and 05 and Tables 03 and 04, it is possible to verify that the application of the Lean Manufacturing methodology took place efficiently in the period from September 11 to 13 (dates 4 to 8 – Figure 03) because, after a high value of packaging loss, there was a considerable drop and maintenance of these values in a range below that practiced by the company. In Table 01, it is possible to verify that an action plan was to correct the packaging nozzles within the reach of the operator and the researcher and that the description of this action plan was that, using a pointed tool and applying circular movement, The packages were opened manually, generating less lost packaging and reprocessing. The values for the drop and maintenance of packaging loss are a reflection of this action plan, applied both to the process day without and to the process day with setup, as demonstrated by Table 04 and Figure 05 because, exactly dates 2, 3 and 4, which present the lowest values of combined losses, are the dates on which the action plan, described previously, was applied to the process. However, it is worth highlighting that the process is dynamic and problems become evident during it, interfering with loss control, which can be demonstrated by the increase, shortly afterwards, in the percentage of packaging loss in the cake mix production process. .

To analyze the reasons caused during the process, the loss by scale was prepared, demonstrated by Table 05, in which the percentage values were expressed on a scale from 1, which means a negligible loss of packaging, to 5, whose loss was considered criticism

Table 05 - Packaging loss by scale.

PACKAGE LOSS							
PRODUCT	**DATE/DAY**	**LOSS SCALE**					**REASONS RELATED TO PRODUCTION**
		1	**two**	**3**	**4**	**5**	
Party flavored cake mix	(1) 5/sep			x			Opening of the top packaging with deformation Photocell failure
Tingling flavor ready mix	(2) 6/sep	x					Identification error in the power sensor
Ready-made corn and cheese flavored cake mix	(3) 11/Sep					x	Feed doser reaching edge of packaging Dater failure
Ready cassava flavor cake mix	(4) 11/Sep	x					Machine interference when opening packaging for filling Inadequate packaging for filling
Lemon flavored cake mix	(5) 12/Sep	x					No apparent cause
Ready-made cornmeal flavored cake mix	(6) 12/Sep	x					Identification error in the power sensor Loss due to regulation Machine interference when opening packaging for filling
Chocolate flavored cake mix	(7) 12/Sep	x					The sieve return does not match the sensor Drop in the machine's light panel
Chocolate flavored cake mix	(8) 13/Sep	x					The sieve return does not match the sensor Machine deconfiguration
Carrot flavored cake mix	(9) 18/Sep				x		Cut without parameter Machine defect Photocell failure
Vanilla flavored cake mix	(10) 19/Sep	x					Physicochemical characteristic of the product interfering in the process Misaligned pull length Photocell failure
Coconut flavored cake mix	(11) 19/Sep			x			Non-standard date Misaligned pull length Physicochemical characteristic of the product interfering in the process
Pineapple flavored cake mix	(12) 20/Sep	x					Proper process.
Ready-made anthill flavored cake mix	(15) 20/Sep		x				Machine interference when opening packaging for filling
Chocolate flavored cake mix	(16) 22/Sep	x					Identification error in the power sensor Machine interference when opening packaging for filling

The range of 5 classifications was carried out from the highest value collected during the study to the lowest, clearly bringing the results obtained, since, after applying the methodology, the vast majority remained on scale 1 of losses, demonstrating that the observation and application within the scope of the research had effects.

An addendum to the case study carried out, quality control research was developed, such as controlling the humidity of the food using the moisture analyzer device and measuring the thickness of the packaging, using the Specimeter Micrometer Thickness Gauge, to control the physical-chemical characteristics of the product and for cutting analysis, respectively. In addition to translating the machine manual, for better understanding of the parameters.

The OEE projection showed that after the improvements implemented there was a significant increase from the percentage of 27% to 62% contained in the system and demonstrated in a meeting with the sector, however all data projections will not be expressed graphically as they are internal control of the company, in addition to maintaining the ethics contract with the company that provided conditions for the research to be carried out.

CONCLUSION

Based on the analysis of the case study, the *Lean Manufacturing methodology* is a satisfactory concept for implementation in the processing of the food industry, resulting in an increase in the global efficiency index (OEE) from 27% to 62%, in addition to reducing waste. , which were demonstrated in internal factory graphics for employees. The action plans based on the tools used, including Study of Methods and Times, *Poka-Yoke* and Kaizen, were possible from *brainstorming* and observation. The application is adaptable to the scenario found, protecting the limits of the company, in which all sectors are involved, such as maintenance, leaders and employees, as each administration presents its own way of managing beyond Lean Manufacturing.

REFERENCES

1. ABIMAP, Associação Brasileira das Indústrias de Biscoitos, Massas Alimentícias e Pães & Bolos Industrializados. (2010). Disponível em: http://www.abimapi.com.br/. Acesso em: 18 de setembro, 2023.

2. AGUSTIN, R.; SANTIAGO F. (2006). Single-Minute Exchange of Die. In: IEEE/SEMI ADVANCED SEMICONDUCTOR MANUFACTURING CONFERENCE, 1996. Proceedings.. Piscataway, NJ: IEEE Conference. p. 214-217.

3. ARNOLD, J. R. T.; RIMOLI, C.; ESTEVES L. R. (2015). Administração de Materiais: uma introdução. 1° Edição, Editora Atlas, São Paulo.

4. BLACK, J. T. (1991). The design of the factory with a future. Nova Iorque.

5. BRITO, F. O.; DACOL, S. (2008). A manufatura enxuta e a metodologia Seis Sigma em uma indústria de alimentos. Rio de Janeiro.

6. COLAUTO, R. D.; BEUREN, I. M. (2004). Coleta, Análise e Interpretação dos Dados. Como elaborar trabalhos monográficos em contabilidade: teoria e prática. 2 ed. São Paulo.

7. CONNOR, G. (2006). Poka-yoke: Human-Proof your Process. Journal of Industrial Maintenance e Plant Operations, p.12-14.

8. COSTA, J. E. L. (2007). Gestão em processo produtivo. Ibpex. Curitiba.

9. COSTA, J.E.L. (2012). Gestão em processos produtivos. 1°Edição, Editora Inter Saberes. Curitiba.

10. COTRIM, S. L. et al. (2019). Implantação do programa 5S em uma fábrica de vassouras de garrafa PET a partir do Diagrama Espaguete. v. 16, n. 3.

11. COUTINHO, T. (2006). O diagrama de espaguete atua como grande aliado nos projetos de otimização de layout. Disponível em: https://www.voitto.com.br/blog/artigo/diagrama-de-espaguete. Acesso em: 15 de setembro, 2023.

12. EGOSHI, K. (2006). Os 5'S da administração japonesa. Artigo disponível em http://www.infobibos.com/Artigos/2006_2/5S/Index.htm.

13. FURLANI, K. (2022). Estudos de Tempos e Métodos. Disponível em: https://furlani.eng.br/2022/10/23/estudo-de-tempos-e-metodos/. Acesso em: 19 de setembro, 2023.

14. GHINATO, P. (1996). Sistema Toyota de Produção: mais do que simplesmente Just-in-time. EDUCS. Caxias do Sul.

15. GIL, A. C. (2002). Como elaborar projetos de pesquisa. 4. ed. São Paulo.

16. IMAI, M. (1990). Kaizen a Estratégia para o Sucesso Competitivo. IMAM São Paulo.

17. JEONG, K. Y.; PHILLIPS, D. T. (2001). Operational efficiency and effectiveness measurement. International Journal of Operations and Production Management, v. 21, n. 11, p. 1404-1416.

18. LIAN, Y.; LANDEGHEM, H.V. (2002). An application of simulation and value stream mapping in Lean Manufacturing. Department of Industrial Management, Ghent University, Technologiepark, 903, B-9052, Belgium.

19. LIKER, J. K.; MEIER, D. (2007). O modelo Toyota: Manual de Aplicação. Porto Alegre: Bookman.

20. LIMA, S. (2005). A Ferramenta 5S e suas Implicações na Gestão da Qualidade Total. Academia: Accelerating the world's research.

21. LJUNGBERG, O. (1998). Measurement of overall equipment effectiveness as a basis for TPM activities. International Journal of Operations and Production Management, v. 18, n. 5, p. 495-507.

22. MONDEN, Y. (1984). Sistema Toyota de produção. São Paulo: IMAM.

23. MONDEN, Y. (1994). Toyota Production System: An integrated approach to just-in-time. London: Chapman e Hall.

24. MOXHAM, C.; GREATBANKS, R. (2001). Prerequisites for the implementation of the SMED methodology. International Journal of Quality e Reliability Management, v. 18, n. 4, p. 404-414.

25. OHNO, T. (1997). O Sistema Toyota de Produção: Além da Produção em Larga Escala. Porto Alegre: Bookman.

26. REYS, G. (2010). Uma abordagem sistemática para diagnosticar o status atual dos sistemas de gestão da qualidade e processos de negócios. Business Process Management Journal , Vol. 16 Nº 1.

27. RIVERA, L.; CHEN, F. F. (2007). Measuring the impact of Lean tools on the cost–time investment of a product using cost–time profiles. Robotics and Computer-Integrated Manufacturing, v.23, n.6, p.684-689.

28. ROTHER, M. & SHOOK, J. (1999). Aprendendo a enxergar. Lean Institute Brasil. São Paulo.

29. SELTZ, et al. (1967). Métodos de pesquisa nas relações sociais. São Paulo.

30. SEVERSON, D. (1988). The SMED system for reducing changeover times: an exciting catalyst for companywide improvement and profits. P&IM Review with APICS News, v. 8, n. 10, p. 10, 15-16.

31. SHARMA, V. (2001). SMED for high-mix assembly. Circuits Assembly, v. 12, n. 1, p. 62, 64-68.

32. SHIMBUN, N. K. (1988). Poka-yoke: improving product quality by preventing defects. Portland.

33. STEVENSON, W. J. (2001). Administração das operações de produção. Rio de Janeiro: LTC.

34. WOMACK, J. P.; JONES, D.T.; ROOS, D. (1992). A mentalidade enxuta nas empresas: elimine o desperdício e crie riqueza. Rio de Janeiro: Campus.