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DESIGN / DEVELOP A LEAN IMPLEMENTATION THROUGH A PRATICAL EXAMPLE

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Design/Develop a Lean Implementation Through a Practical Example

Task description:

The aim of this work, is to identify the main factors that can affect the operational performance of the Line 27 (production line number 27), through problem solving tools and suggest possible improvement actions in order to comply with the proposal. Also, the paperwork intends to describe some actions that helps to eliminate waste and increase the operational performance of the L27.

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As an independent consultant of the author of this thesis I hereby declare that the student took part in the planned consultations.

Gödöllő, 09 of May 2023.

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1. INTRODUCTION

1.1 Background of the Study

While many developed regions have gone through an industrial phase as part of their growth trajectory, Africa appears to have bypassed this stage. Industrialization is considered a significant driver of growth, and many development initiatives involving Africa prioritize industrialization. The African Development Bank identifies industrialization as one of its top five priorities for accelerating Africa's economic transformation. The New Partnership for Africa's Development (NEPAD) launched in 2001, identified industrialization as the crucial means for achieving growth and reducing poverty. In 2016, the United Nations General Assembly proclaimed the period between 2016 and 2025 as the Third Development Decade for Africa, emphasizing industrialization as a key focus. Furthermore, industrialization is the ninth objective of the Sustainable Development Goals (Opoku & Yan, 2018).

With the increasingly competitive global market, it is necessary for companies to invest in the continuous improvement of their production processes. The primary objective is to increase productivity, with few resources and in a faster and more efficient way, always prevailing the design of products according to customer requirements, optimizing costs in order to win in the market (Ahuja and Khamba, 2008)

Suzaki (2010) states that the lean concept involves identifying and removing waste while enhancing flow to ensure that all processes within the system contribute value. The author also notes that when we examine the time workers spend in a factory, more than 95% of it does not add value but rather adds costs.

The successful implementation of Lean Manufacturing depends on the unique characteristics of each company and the ability to adapt to its organizational, technological, and environmental context. Although the application of Lean Manufacturing is complex and requires investment, proper implementation can have significant impacts not only on the production process but also on planning and decision-making. While knowledge about the details of implementation may not be widespread, introducing Lean concepts and culture to the manufacturing environment can already yield important results for the organization (SANTOS et al., 2017).

To gain an advantage in the market, many companies have employed the lean philosophy as a strategy for change. The book "The Machine That Changed the World" emphasizes the lean concept, presenting a study on the automotive industry and highlighting the superiority of Japanese industries, particularly Toyota, over others (Souza, 2017). Suzaki (2010) also emphasizes the importance of the lean philosophy.

Companies, currently, are forced to accept the challenges due to globalization, automatically forced to evolve facing country markets, obtaining identical products at low prices in an emerging way. With industrialization growing in Africa, companies on the African continent, especially in Angola, are embracing the idea of constant innovation and continuous improvement of their products and services, afraid of losing space in a market that is proving to be very competitive and that is still being created other companies making it more complex. This work demonstrates the importance of using lean manufacturing in the company, as well as showing the state of operation of the company's production lines, the lean methodologies help us to identify the problems according to the productive complexity with great existing diversity, and the presentation of solutions with an estimate of their impact. Therefore, this work is of great value to the company, because it will contribute with new concepts and mentality about continuous improvement within the company, allowing new and different productive approaches, using continuous improvement and the elimination of waste as the maximum exponent.

1.2 Justification

Currently, the global market has undergone immense changes, the constant changes and demands on the part of suppliers and customers require an improvement in the performance of organizations. To remain competitive, companies must constantly innovate, have the flexibility to adapt and respond to any disruption, seeking to minimize costs, increase productivity and product quality in order to satisfy customers.

Thus, to adapt to changes and ensure sustainability in the market companies implement philosophies that ensure the maximization of their internal resources, making it crucial to eliminate waste, reduce costs and optimize processes to add value.

In this sense, the operational efficiency of any process arises, becoming the metric of this project. This method is based on issues of product quality, productivity and equipment availability during a production process.

1.3 Problem/Hypothesis

Line 27 is equipped with the latest technology from the Krones's company, with a capacity to produce 36,000 boxes or more in two shifts. After the assembly of line 27, 36 to 37 thousand boxes on good production in two shifts, and now it produces only 28 thousand boxes or less in two shifts. There may be some factors that are generating waste on the production line and that can be mitigated by using Quality Control tools to improve the performance of the line 27.

1.4 Research Question:

What could be the factors or problems that affected the performance of the line 27? Also, what could be the possible Quality Control tools to improve the performance of the line 27?

1.5 Objectives

1.5.1. General Objectives

The aim of this work, is to identify the main factors that can affect the operational performance of the Line 27 (production line number 27), through problem solving tools and suggest possible improvement actions in order to comply with the proposal. Also, the paperwork intends to describe some actions that helps to eliminate waste and increase the operational performance of the L27.

1.5.2. Specific Objectives

In order to achieve the goal in compliance with the general objective, below are listened some of the specific objectives through which this work will flow and finally find what has been created in its hypothesis. These and the general objective, define the purpose of my thesis.

- Characterize the production line of a beverage industry;
- Identify mechanical processes that add value to the production line;
- Assess the need for operational improvement of the line and possible suggestions for such issues.

2. LITERATURE REVIEW

In this work, the main concepts and philosophies that will serve as support throughout the dissertation will be addressed, with regard to the concepts of continuous improvement, waste reduction and increased operational efficiency of a beverage bottling production line. The increase in efficiency and continuous improvement of a factory is directly proportional to the implementation of the Lean Production system, bringing with it quick responses and an enormous productive capacity, these two variables meet the demands of orders, safeguarding the minimum possible stock with quality.

Some companies abdicate changes for fear of factors contrary to the implementation of the Lean system, they look for other systems or ideologies, remaining in the old habits of non-innovation.

2.1 Lean and Its Evolution

John Krafcik (1987) coined the term "lean" after examining Toyota's production system. His analysis validated the principles established in Ohno's model at Toyota. Krafcik noted that:

- Less investment was required for a certain production capacity;
- The process of designing and delivering their products required less time and effort, given the production capacity;
- The products being sold had a lower frequency of defects.

Krafcik's (1987) observations revealed that compared to large American companies, the production system at Toyota required half the workforce, half the space, half the investment in equipment, and half the time for new product identification. Additionally, the system required less than half the amount of inventory, resulting in reduced space usage and fewer defective items. The system also allowed for greater production of a wider variety of units, which were less standardized.

The fundamental principle of the lean concept is to optimize consumer value by minimizing waste, thereby enhancing the perceived value of products or services while utilizing minimal resources. The ultimate objective of lean is to deliver an ideal product to the consumer with zero waste. A company that adopts a lean system is dedicated to a pursuit of perfection through an ongoing process of improvement, akin to the body's continual striving for a state of equilibrium (Krafcik, 1987).

According to James C. Paterson (2015), the origins of lean can be traced back to the construction of roads and the production of weapons by the Roman Empire that dates back to the 6th century BC. Despite the literature referring to various origins regarding the initial application of lean principles, it was after World War II at Toyota Motor Company where it developed as a philosophy, characterized by a collection of principles and tools (Jasti and Kodali 2015).

The Lean concept originated in Japan, namely in the Toyota Motor Company, in the 1950s, in a period of reconstruction in Japan after the Second World War. While the United States of America was experiencing economic growth with a production paradigm based on mass production, in the post-war scenario, Japan was completely destroyed, with great losses in terms of resources and market (Meyers & Stewart , 2002; Suzaki, 2010). Faced with this reality, the only way to maintain the sustainability of companies was to find a way to produce in smaller quantities and with a greater variety of certain products or materials, since the level of demand was low. The idea of the mass production system developed by Frederick Taylor and Henry Ford was then abandoned, which consisted of machine-assisted production, without skilled labor, of large standardized batches, whose only advantage was the reduction of unit costs of the products. products for their large-scale production, since the introduction of a new product would bring very high costs (Womack et al., 2007).

With the abandonment of mass production, a new production system developed in the Toyota company called Toyota Production System emerged, where engineers Eiji Toyoda and Taiichi Ohno played a key role in the development and application of this system in the company (Womack et al., 2007).

This production system aimed to create a continuous flow that did not require long production cycles to be efficient, based on the fact that only part of the effort and time spent in manufacturing adds value to the final product (Melton, 2005). In this way, the Toyota Production System was essentially based on eliminating waste throughout the organization and paying attention to customer satisfaction (Womack et al., 2007).

Thus arises Lean Production which uses, compared to mass production, less human effort, less manufacturing space, lower investment costs in tools and less time in designing new products, and promotes the reduction of stocks, the reduction of defects and the increasing variety of products (Womack et al., 2007).

During and after World War II, Toyota experienced financial difficulties due to an increase in unsold car stocks. As a result, the company underwent restructuring, and Kiichiro Toyoda resigned, leaving his cousin Eiji Toyoda as the Managing Director for Production. Eiji also traveled to the US in the 1950s to study production methods and returned with a desire to implement mass production, but the low volumes of the Japanese market and financial difficulties prevented this. To overcome this crisis, Toyota started producing a wide variety of cars in small volumes, which became known as the Toyota Production System (TPS). Taiichi Ohno was the mentor of this system (Jasti and Kodali 2015).

Ohno identified the following weaknesses when examining the production systems used in the West (Jasti and Kodali 2015):

The manufacture of components in large batches resulted in the accumulation of excess inventory, which had negative effects on the company's cash flow and required additional storage space. Furthermore, the production of large batches led to an increase in the number of faulty components;

Producers who focused on large batch production struggled to cater to the diverse needs of their customers.

Em 1948, Ohno iniciou a implementação de seu modelo de produção utilizando lotes de forma abrangente para atingir seu objetivo principal de redução de custos por meio da eliminação de desperdícios, gerado no nascimento do Sistema Toyota de Produção (TPS). O TPS consiste em várias técnicas para desenvolvimento de produtos e processos, gerenciamento da cadeia de suprimentos, alternativas inovadoras para solução de problemas, melhor atendimento ao cliente e novas estratégias para liderança e trabalho em equipe. James C. Paterson (2015) observa que o desenvolvimento do TPS levou 30 anos para ser concluído e foi finalizado em 1975. Uma linha do tempo de eventos inspirou que impactaram a história recente é apresentada na figura abaixo. Houve uma recente presença dessa filosofia em vários setores e campos, conforme observado por (Jasti e Kodali 2015).

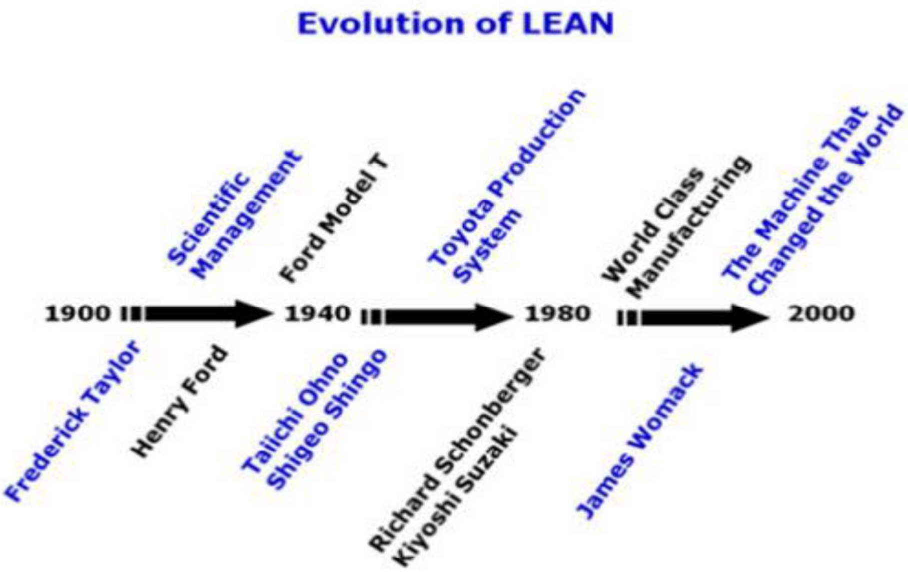

Figure 1- Evolution of lean

(Source: Roberta S. Russell and Bernard W. Taylor, 2011)

2.2 Lean Manufacturing

In today's competitive global market, it is imperative for companies to focus on constantly improving their production processes. The main goal is to enhance productivity, while minimizing resource usage and achieving greater efficiency, all while ensuring that products are designed to meet the needs of customers and optimizing costs in order to gain an advantage in the market (Ahuja and Khamba, 2008).

Lean thinking encompasses two major concepts: removing inefficiencies and generating worth. Scholars such as Womack and Jones (1996), Emiliani (1998), Spear (2004), Murman et al. (2002), and Hopp and Spearman (2004) assert that lean production is sustained by five principles.

- **Frist: Identify Customers and Specify Value.**

  To begin, it's important to acknowledge that a vast majority of an organization's time and resources do not contribute to the end customer's benefit. By precisely defining what the customer perceives as valuable for a particular product or service, it becomes possible to pinpoint and eliminate all non-essential activities or "waste." Value entails determining the purpose that a product serves for a customer and then working backwards to construct the production process. In order to determine what customers perceive as valuable, it is critical to answer questions such as: What do customers desire? When and how do they prefer to receive it? What combination of attributes, capabilities, availability, and cost will be most desirable to them? (Čiarnienė & Vienažindienė, 2012).

- **Second: Identify and Map the Value Stream.**

  To guarantee that each stage in the production process adds value, companies create a value stream map. The value stream is made up of all the processes and activities throughout the organization that collaborate to deliver the product or service, representing the end-to-end process of providing value to the customer. Once you have determined your customers' desires, the next step is to assess how effectively you are meeting those demands. The value stream is not limited by company boundaries, which is why it's important to strive for integration between suppliers, manufacturers, distributors, and even retailers when identifying and analyzing the value stream. Additionally, three primary categories of activities are identified (Čiarnienė & Vienažindienė, 2012):

  - Those thet add value;
  - Those that do not add value but cannot be currently avoided;

- And those that do not add value and shouldtherefore be eliminated.

– **Third: Create Flow by Eliminating Waste.**

Flow involves restructuring processes to enable products to move smoothly through the value-adding stages. Typically, when initially mapping the value stream, it is discovered that only 5% of activities contribute to value creation, though this percentage can rise to 45% in a service setting. Eliminating this waste guarantees that your product or service moves to the customer without interruption, delay, or idle time. In lean manufacturing, waste is not merely discarded material but is instead defined by what the customer is willing and unwilling to pay for, and production planning is based on creating the best product in the shortest amount of time. Any processes that do not contribute to value creation, as defined by the customer, are eliminated (Čiarnienė & Vienažindienė, 2012). Rawabdeh (2005) and Carter (2011) identified at least seven domains (refer to figure 2) in which opportunities exist to minimize waste or surplus of a product.

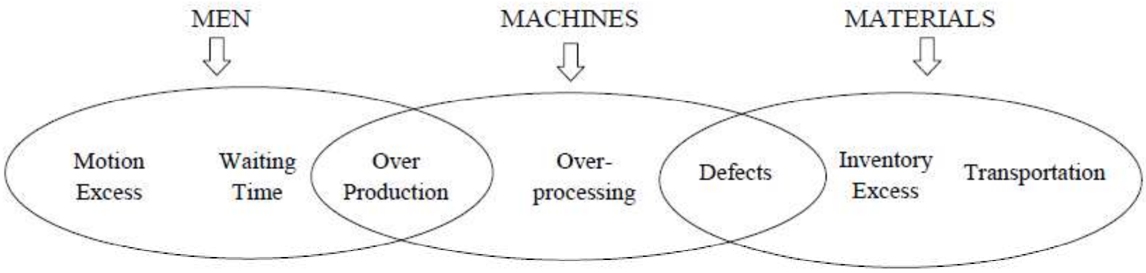

Figure 2- Wastes to be eliminated.
(Source : Čiarnienė & Vienažindienė, 2012)

The overproduction of a product results in waste and potential losses from selling items at a reduced price. Stockpiling or inventory is a wasteful practice that restricts the availability of cash for other purposes. While some movement is necessary in the production process, it may be worthwhile to evaluate whether any movement is unnecessary, as this can save time and money. Reworking parts represents a significant source of overspending, and reorganizing the production process to manufacture parts in a single, specific way can generate lean savings. If the movement of a component places excessive strain on an operator, then reworking or redesigning their motions can reduce the risk of injury and lost time. Incorporating superfluous processes that offer no value to the customer results in higher costs and decreased production efficiency. Operators should not be idle during the machining process since this constitutes a waste of time (Čiarnienė & Vienažindienė, 2012).

- **Fourth: Respond to Customer Pull.**

  The key concept here is to comprehend the customer's demands for a service and subsequently devising a process that can accommodate these requirements. The goal is to produce only what the customer desires, when they need it, instead of forcing companies' products onto the customers. The entire production chain, including suppliers, should be linked together to ensure that materials are not released and activities are not performed until necessary. This approach enables customers to "pull" value (products or services) towards them, rather than companies pushing their products towards the customers. Kanbans are utilized to establish and maintain the discipline of pull, which are physical or electronic devices employed to communicate the need for parts and subassemblies from one point in the process to the preceding one (Čiarnienė & Vienažindienė, 2012).
- **Fiveth: Pursue Perfection.**

  Striving for perfection involves continuously meeting customer needs and improving processes to achieve zero defects. Flow and pull are initiated by reorganizing individual process steps and become more effective as the steps become interconnected. As waste is gradually identified and eliminated, the process moves closer to the goal of perfection, where every asset and action contributes value for the customer. The Lean philosophy requires ongoing improvement efforts and a commitment to maintaining the discipline of improvement (kaizen). By following these five principles, an organization can establish a standard approach to delivering value to customers, and ensure that its processes support its overall strategy. This approach allows the organization to maintain a high level of service and adapt to changing circumstances through sustainable change (Čiarnienė & Vienažindienė, 2012).

The book "The Machine That Changed the World" highlights the lean concept, focusing on the automotive industry study, specifically the comparison of Japanese industries, with a major emphasis on Toyota (Souza, 2017). After the book's publication in 1990, many companies attempted to implement Lean production practices, but struggled as the book did not provide implementation guidance. To address this issue, Womack and Jones published "Lean Thinking Banish Waste and Create Wealth in your Corporation" in 1996, which serves as an informative guide for starting a business Lean (HICKS, 2007). These concepts became fundamental and revolutionized the way businesses operate, specify value;

- Define the value chain in the process;

- Create fluidity in the production line;
- Production “pulled” by customer needs;
- Pursuit of perfection.

According to the principles of Lean philosophy, customer value is the top priority, and it involves identifying the product characteristics that customers are willing to pay for, in order to ensure that the investment in the product provides added value to the customers. After defining customer value, the value chain is determined, encompassing all the processes and activities involved in the production of a product, starting from the raw material procurement to the product delivery to the customers. The purpose of defining the value chain is to detect any wasteful activities, creating a seamless flow between the value-adding processes. This flow is characterized by the efficient movement of materials between different sectors, with no waiting time in between. Every sector should treat the next sector as its customer, increasing the responsibility of each operator and enforcing the obligations of each sector. Allowing customers to pull the product reduces inventory, resulting in a leaner production line. The pursuit of perfection is a central tenet of the Lean philosophy, which is realized through the concept of Kaizen. This involves continuous improvement, with the aim of reducing or eliminating waste. The Lean philosophy promotes a spirit of dissatisfaction among operators to encourage them to continually seek improvement (LIAN and LANDEGHEM, 2002).

It's worth noting that according to the Lean philosophy, there are two types of operations: value-adding and non-value-adding. The non-value-adding operations can be further divided into two categories: "necessary" and "unnecessary", with the latter being eliminated immediately. This leads to an increase in value-adding activities and ensures that only what is required by the customer is produced, preventing unnecessary stockpiling and production line confusion (LEITE, 2008).

To obtain the intended improvements, the application of Lean must be comprehensively understood and implemented, and it should not be applied in isolated cases, as this can lead to failure (STRATEGOS, 2001).

Suzaki (2010) explains that the Lean concept involves the identification and elimination of waste, as well as the improvement of flow, to ensure that all processes in the system contribute value. The author also notes that when we consider the time spent by workers in the factory, over 95% of their time is spent on activities that do not add value and only add costs.

The Lean philosophy originated in the aftermath of World War II (1939-1945), when the Japanese automotive industry was facing challenges, unlike the European and North American industries that had a dominant market position due to their reliance on mass production. To increase its sales volume, Toyota started studying other industries, and its vice president, Taichi Ohno, observed that there was little product variety and inflexible processes in these industries, resulting in losses. The brand's president realized that a new method, completely different from what was prevalent in the industry at the time, needed to be adopted in Japan. Thus, the Toyota Production System (TPS) was developed by Taichi Ohno, an industrialist from Japan, and later continued by Shigeo Shingo. The philosophy of this new system is based on the "complete elimination of all waste," which eventually became a globally recognized system (Holweg, 2007; Dahlgaard and Dahlgaard-Park, 2006).

According to CAKMAKCI (2008), the fundamental system of Lean production, known as TPS, is characterized by flexible production lines that use methods to facilitate tool changes and effective communication, enabling the control of small product batches and allowing the system to adapt to the constant variations in today's markets.

Ohno introduced the Kaizen principle, which involves continually seeking improvement, leading to the enhancement of the operators' performance at workstations, and ultimately improving the overall production line (CAKMAKCI, 2008).

Melton (2005) states that Toyota aimed to provide a wide variety of products while maintaining high quality at low cost and constantly focusing on waste elimination and customer satisfaction. This paradigm shift enabled the Japanese industry to respond effectively to market demands, distinguishing itself for its diverse products, high quality, and low cost. Lean production has been widely adopted as a tool and philosophy to enhance efficiency, eliminate losses, and generate financial gains for organizations since its inception at Toyota and subsequent dissemination. According to Shah and Ward (2007), lean production utilizes fewer resources compared to mass production, requiring less human effort, equipment investment, product development time, and production space. The concept of Muda, or waste in Japanese, serves as the foundation of lean philosophy. Waste in this context refers to any human activity that consumes resources but fails to create value from the customer's perspective, and as such, should be minimized or eliminated (Melton, 2005).

The initial step in eliminating waste is to identify it. This can be categorized into seven groups, as shown in Figure 2.1, and the main aim is to eliminate the sources of waste that arise in various company processes. By doing so, the organization can experience heightened productivity and competitiveness (Tiwari et al., 2016).

2.3 Success Factors in Lean Implementation

The process of implementing Lean philosophy and principles involves a series of steps and procedures that begin with planning, defining success factors, and culminating in implementation and progress measurement. In this study, the authors have summarized the works of Martinez & Perez (2001), Anchanga (2006), Pettersen (2009), Sim & Rogers (2009), and Duque & Cadavid (2007) to present a model for the implementation of Lean (refer to the figure).

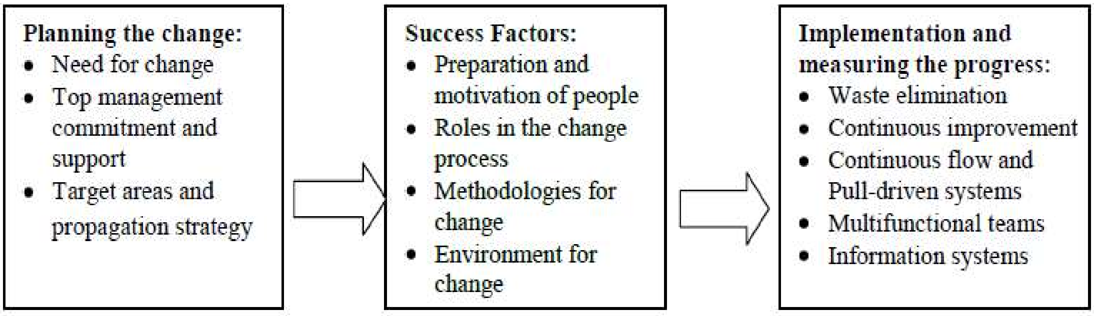

Figure 3- Model of Lean implementation process.

(Source : Čiarnienė & Vienažindienė, 2012)

- **Frist: Planning the change.**

  At the initial stage of implementing the Lean philosophy, the first step is to plan the change. There are three essential elements that must be considered:

  i. The first stage of implementing Lean philosophy is to define the need for change. It is crucial to comprehend and consistently communicate the reason behind the Lean transformation, as it provides direction and transparency for all individuals in the organization (Čiarnienė & Vienažindienė, 2012). The second key element for successful implementation of Lean philosophy is the commitment and support of top management. It is crucial that the employees perceive and trust in the commitment of senior executives for the initiative to be effective. This commitment should not be limited to words but should also be demonstrated through actions, such as the participation of managers in shop floor activities and kaizen events (Čiarnienė & Vienažindienė, 2012)..

  ii. To implement Lean philosophy, it is important to identify target areas and come up with a strategy for its propagation. This involves creating a plan that outlines the processes and production lines that will undergo transformation to Lean, the sequence in which this will occur, and the expected timeframe for implementation (Čiarnienė & Vienažindienė, 2012).

- **Second: Success Factors.**

The implementation of a lean initiative deemed successful when four crucial factors are met:

i. The first factor for success in implementing Lean is preparing and motivating people, which involves effective communication, clarifying expectations, highlighting the necessity of change, and informing employees about what to expect (Čiarnienė & Vienažindienė, 2012).

ii. To achieve a successful lean implementation, certain roles need to be fulfilled, including informed and active leadership, employee involvement, expert coaching, and support from management and other functional areas. These roles are crucial to the success of the project (Čiarnienė & Vienažindienė, 2012).

iii. The methodologies for change refer to the technical tools utilized during a Lean implementation. These tools include model lines, equipment right-sizing, and physical line layout modifications. Additionally, kaizen events are employed as a means of displaying fast and noticeable enhancements, while the focus remains on taking action, flow orientation, and teamwork-oriented problem-solving. Lastly, practical training is emphasized as a crucial component of the change process (Čiarnienė & Vienažindienė, 2012).

iv. The success of a Lean implementation depends on four key factors. Firstly, the preparation and motivation of people is important which involves clear communication, setting expectations, and making people aware of what lies ahead. Secondly, the roles in the change process should be defined, including active leadership, employee involvement, coaching from experts, and support from management and other functional areas. Thirdly, various technical methodologies for change, such as model lines, right sizing of equipment, physical line layout changes, kaizen events, focus on flow, problem-solving in teams, and practical training, should be employed. Lastly, an environment conducive to change, facilitated by upper management, should be created which includes job security, reinforcement of guiding principles, a safe space for experimentation, and a climate of mutual trust between workers and management. All these success factors should be considered during the planning stage of the process before the implementation phase begins (Čiarnienė & Vienažindienė, 2012).

- **Third: Implementation and monitoring the progress of a Lean implementation.** To ensure the effectiveness of the changes made, it is crucial to monitor progress and evaluate the efficiency of the various tools and techniques used. Indicators can be used to measure progress in each area of improvement. These areas include waste reduction, continuous improvement, efficient flow and pull systems, cross-functional teams, and information systems. The extent to which these objectives are met will determine which indicators are used to assess the progress of a team or production line in implementing Lean Manufacturing. Once implemented, these indicators will be used to construct control charts and set improvement targets for specific reporting periods. (Duque & Cadavid, 2007).

2.4 Advantages and Risks of Lean Production

Lean manufacturing aims to enhance customer value and decrease resource consumption and cycle times by eliminating waste. Like any other management philosophy, there are pros and cons that must be weighed for each organization. Some of these benefits and risks are discussed by various authors including Holweg (2007), Sim & Rogers (2009), Kropf (2008), Wood (2012), and Kelly (2012), and are summarized in Table 1.

Table 1 - Advantages and Risks of Lean Production.

Advantages		Risks	
Customer satisfaction	By reducing waste, the final product is delivered to a customer with value. The advantage of this is increased customer satisfaction.	**Customer Dissatisfaction Problems**	Because lean manufacturing processes are so dependent on supplier efficiency, any disruption in the supply chain and therefore, on production can be a problem that adversely affects customers. Delivery delays can cause long-lasting marketing problems.
Productivity	Productivity is increased because of the focused improvements made to processes with the intent of eliminating waste.	**Productivity Costs**	In order to achieve such productivity, there is a significant upfront investment in achieving a level of standardized processing which can be a disadvantage during the implementation process.
Change of Attitude	Implementing lean production often demands a significant change in an organization's attitude, which can be very challenging if an organization is not well slated to deal with the changes.	**Lack of Acceptance by Employees**	Lean manufacturing processes require a complete overhaul of manufacturing systems that may cause stress and rejection by employees. Lean manufacturing requires constant employee input on quality control, which some employees may feel disinclined or unqualified to do. There may also be some difficulty finding managers with sufficient leadership and persuasion skills to overcome this.
Quality	As a result of process improvement initiatives, the overall quality of a company's product is also improved in the process	**High Cost of Implementation**	Implementing lean manufacturing often means completely dismantling previous physical plant setups and systems. The purchase of efficient machinery and training employees can add considerably to companies' payroll expenses.
Delivery times	Another fundamental element of lean production is just in time production, which is the idea that excess inventory will not be maintained in order to fulfil customer orders.	**Supply Problems**	Because only a small amount of inventory is kept on hand, lean manufacturing depends heavily on suppliers. Problems like employee strikes, transportation delays and quality errors on the part of suppliers can create manufacturing holdups that can be fatal. Vendors may be unable or unwilling to supply parts or products on a tighter schedule or in smaller amounts.

(Source: Čiarnienė & Vienažindienė, 2012)

According to Orr (2005), inadequate trust and commitment exhibited by employees in the workplace are major reasons for unsuccessful implementation of Lean manufacturing. The focus has been on deploying new techniques rather than understanding how work is organized and led, and the term "Lean" seems to have overlooked the debate on human motivation. To achieve economical Lean production and a healthy work environment, it is essential to practice Lean behavior that incorporates all the Lean principles, as stated by Emiliani & Stec (2004). However, many companies fail to apply all the Lean principles together, and the right behavior must exist among the employees for the business to fully benefit from Lean (Sanjay & Peter, 2006).

Lean is as much about establishing a "lean corporate culture" as it is about lean manufacturing and production processes. A lean culture seeks to motivate workers to participate and even initiate lean initiatives to improve the corporate bottom line. For this reason, companies need to develop a lean corporate culture along with lean manufacturing initiatives to maximize the effectiveness of lean solutions. Implementation of Lean philosophy and principles is a long journey process and not easy implemented. To fully benefit the company for Lean implementation, both the concept and techniques should be considered (Čiarnienė & Vienažindienė, 2012).

2.5 Lean manufacturing tools and methodologies

From a practical viewpoint, Lean Manufacturing involves the utilization of a range of methods and tools with the objective of decreasing waste throughout the production process. The research conducted employed various techniques and tools such as SMED, Study of Methods and Times, 5´S, Kanban, Value Stream Mapping and Poka-Yoke (SHERRER-RATHJE et al., 2009).

2.5.1 Kanban

The kanban system works based on the use of signals to activate the production and movement of items through the factory. These signals are conventionally made based on kanban cards and kanban holder panels. The cards are made of durable material to withstand the handling resulting from the constant turnover between the customer's stock and the item's supplier (TUBINO, 1999).

Shingo (1996) lists the main characteristics of the kanban system:

- Total and continuous improvement of production systems;
- Regulation of the flow of global items with visual control in order to perform these functions accurately;
- Simplification of administrative work giving autonomy to the shop floor; 4.Information transmitted in an organized and quick manner.

Liker and Meier (2007) state that Kanban is a communication method that can be symbolized by a card, a container box, a container car or even an empty space, with the message I am ready for more, sent from the customer to the supplier.

Shingo (2007) reports that around the year 1960, when he happened to meet Taichi Ohno at the Toyota factory, he had his first contact with the idea of a Kanban system to control the order point in relation to the stock level. So Shingo had experience with operations on railways where signs with previously established holes.

Ohno (1997) stated that Kanban is the Lean Production System's tool to manage the flow of materials in a production process. The term Kanban means record in Japanese, and the record is used in the form of cards. The main characteristic of the Kanban system is to pull parts and components needed for production only when there is a demand, which helps to reduce inventory and improve production flow. There are two types of Kanban cards: production Kanban and transport Kanban. The production Kanban is used at the workstation where the component is produced, while the transport Kanban authorizes the movement of parts between sectors (CORREA and CORREA, 2012).

2.5.2 Muda

According to Melton (2005), the main principle of the lean philosophy is to eliminate *"Muda"*, which is the Japanese word for waste. In this context, waste refers to any human activity that uses resources but does not add value from the customer's perspective. Therefore, it should be minimized or eliminated.

Identifying waste is the first step towards its elimination. Waste can be categorized into seven types, as shown in the figure 4, and the ultimate goal is to eliminate these seven types of waste that occur in various processes within a company. By doing so, organizations can achieve increased productivity and enhanced competitiveness as advantages (Tiwari et al., 2016).

Figure 4 - Identification of the seven waste

(Source: http://www.leanlab.name/the-7-wastes)

2.5.3 Poka - Yoke

Poka-Yoke is a Japanese term that means "mistake-proof". The term "poka" refers to "inadvertent mistakes" and "yoke" means "prevent" or "avoid". Shingeo Shingo developed this approach to improve processes in the early 1960s. The technique has become a valuable asset in identifying and preventing errors, ultimately avoiding their consequences in the production line. Shingo believed that defects could be prevented by detecting errors early. Poka-Yoke aims to do just that, using automated devices to prevent defects or errors, such as human errors due to distractions, production failures due to a lack of knowledge by the operator to perform a certain task, and so on (AL-ARAIDAH, JARADAT and BATAYNEH, 2010).

This tool suggests that warnings may be appropriate for occasional errors, but frequent errors or those with significant negative consequences should be addressed using this method. The purpose of the system is to set limits on the practice of an activity to ensure that the operation is performed correctly. There are various ways to implement this method, including:

- 100% inspection;
- Identify defects as soon as they arise;
- Immediately rectify the defects detected in order to avoid their recurrence;
- Design mechanisms to prevent the production of defects.

Poka-Yoke aims to detect errors before they happen, but if an error is not detected and occurs, the system will interrupt the process to quickly and efficiently eliminate the cause of the defect, so that the production process can be restored promptly (AL-ARAIDAH, JARADAT and BATAYNEH, 2010).

2.6 Quality management and continuous improvement

Suzaki (2013) argues that Lean encourages a very high standard of quality in production processes, and emphasizes the importance of continuous improvement, known as Kaizen, for companies to enhance their performance. Suzaki also notes that there is no such thing as a perfect process, as there is always room for improvement.

To improve quality and drive continuous improvement on a global scale, one approach is the Six Sigma methodology. The primary goal of this methodology is to eliminate defects in all processes, from initial design to final product, resulting in increased efficiency and excellence, while also providing cost savings and higher quality outcomes (Hoon and Anbari, 2006).

The Six Sigma methodology consists of a five-step process as shown in the figure 5:

- **Define –** In order to make improvements, it is essential to have a clear understanding of what is being studied and all the factors involved;
- **Measure** - The problem needs to be defined by gathering and analyzing data, often utilizing tools like flowcharts, Pareto charts, and others;
- **Analyze** - Identify the cause-and-effect relationships between the variables involved:

- **Improve** - Carry out the actions to improve the process and demonstrate the effectiveness of the measurements taken;
- **Check** - Verify if the problem has been resolved and if yes, sustain the continuous improvement to ensure that favorable outcomes persist.

Figure 5 - Six Sigma Methodology
(Source: https://www.sixsigmadaily.com/)

According to this perspective, there are various tools available that aid in measuring and consistently applying the Six Sigma methodology, including Visual Management, Gemba Walk, and Total Productive Maintenance (TPM) (Hoon and Anbari, 2006).

2.6.1 Total Productive Maintenance

In the 1970s, Japan developed the Total Productive Maintenance (TPM) philosophy based on the principles of productive maintenance and its methods. The aim of TPM is to enhance equipment efficiency by eliminating breakdowns and failures, and to improve employee skills so that they can work together and communicate effectively (Ahuja, 2008).

Thus, the machines are set to achieve five primary goals: (1) no breaks; (2) no defects; (3) no failures; (4) improved availability; and (5) profitability. Suzaki (2010) suggests that a viable approach to achieve zero breakdowns is to eradicate potential causes like dust, noise, loose screws, distortions, or wear, as according to the author, breakdowns arise from a combination of these factors. By implementing TPM, manufacturing processes and profitability become simpler, and the main objective is to reduce the occurrence of machine breakdowns that interrupt production, resulting in significant financial losses, which can amount to millions of euros per year (Ahuja, 2008).

2.6.2 The Six Major Equipment Losses

Nakajima (1988) stated that the primary aim of TPM is to enhance equipment efficiency, increase availability, and improve productivity while minimizing defects in the entire production process.

To achieve global efficiency, the table 2 shows us production losses, which are related to the six main equipment losses that inevitably result in efficiency losses (Santos and Santos, 2007):

- Breakdowns - Equipment failures during the production process that result in its unavailability, including unplanned maintenance stops, are considered a major cause of reduced efficiency;
- Change, tuning and other stops - This relates to activities such as changing the product being manufactured, replacing tools, conducting cleaning procedures, and addressing any operator shortages that may arise;
- Small stops - Lima (2014) explains that these losses are connected to brief interruptions caused by the previous or subsequent stages of the production process, which are relatively short and do not require maintenance interventions. These stoppages usually last for 5 to 10 minutes and are often unnoticed or undocumented by operators, resulting in efficiency losses;
- Reduced speed - This refers to a situation where the equipment is running at a lower speed than it is supposed to, resulting in erratic operation and potentially requiring the operator to make adjustments to keep it running. However, this may hide the underlying reason for the speed reduction;
- Defects and rework - The production of non-conforming products that require rework due to poor product quality is known as defect losses. Start-up losses, on the other hand, are associated with rejected products during start-up, non-compliance with specifications, or tuning errors.
- Start-up losses - is directly linked to the product(s) rejected during start-up, due to tuning errors or even non-compliance with specifications.

Table 2 - The Six Big Losses to gain additional actionable insight to the OEE Factors of Availability, Performance, and Quality.

Overall Equipment Effectiveness	Recommended Six Big Losses	Traditional Six Big Losses
Availability Loss	Unplanned Stops	Equipment Failure
	Planned Stops	Setup and Adjustments
Performance Loss	Small Stops	Idling and Minor Stops
	Slow Cycles	Reduced Speed
Quality Loss	Production Rejects	Process Defects
	Startup Rejects	Reduced Yield
OEE	Fully Productive Time	Valuable Operating Time

(Source: https://www.oee.com/oee-six-big-losses/)

According to Santos and Santos (2007), the concept of the six major losses does not include planned stops like breaks for meals, meetings, training, and autonomous maintenance performed by the operator.

2.6.3 Overall Equipment Efficiency

Starting from the TPM and the six major equipment losses, the concept of Overall Equipment Efficiency (OEE) was developed. It is a set of metrics proposed by Seiichi Nakajima in the 1960s to measure improvements in processes, equipment performance, and productivity monitoring. Its purpose is to provide a global reference and reveal hidden costs in a company, although according to Silva (2013), it does not entirely reflect the true costs of stops and losses in production. The OEE is not sufficient to make everyone aware of the actual costs (Nakajima, 1988).

The author explains that the OEE is a metric that encompasses the primary losses present in the manufacturing context and is based on three indices: availability, efficiency, and quality. These indices are calculated by stratifying the six major losses, and the OEE is obtained by multiplying the three indices together, as indicated in the equation (Silva, 2013).

$$\text{OEE} = \text{Availability} \times \text{Quality} \times \text{Efficiency}$$

The index of availability evaluates the duration in which the equipment is ready and functioning. The index of efficiency assesses the equipment's capacity to produce at the highest potential, while the quality index evaluates the equipment's capability to manufacture products that meet specifications and can be sold (Silva, 2013).

According to Muchiri and Pintelon (2008), it should be noted that the OEE is designed to identify losses that consume resources without creating value, and that it only measures the equipment's conditions. This view is similar to the one presented by Nakajima (1988) and provides a better understanding of the concept.

According to Nakajima (1988), the ideal goal for any organization is to achieve an OEE value of 85%, while the average value in companies is around 60%. To obtain this value, the three indices of availability, efficiency and quality must be around or exceed 90%. The correct application of the OEE can bring several benefits, as pointed out by Lesshammar (2006):

- The analysis of problems and its subsequent resolution at the level of production and / or maintenance to act on the root cause of the problem;
- The identification of the machines that should be the main focus of maintenance management.

2.6.4 Theory of times

Currently, companies cannot afford to wait for equipment breakdowns to occur, as even a minor equipment stoppage can incur significant costs for the organization. As a result, there are two concepts related to production downtime that lead to OEE losses: Mean Time Between Failures (MTBF), which measures the average time between equipment failures, and Mean Time to Repair (MTTR), which indicates the average time it takes to repair the equipment. These two indicators have a direct impact on the loss of equipment availability and are commonly used by companies as a reference for making decisions (Song et al., 2004).

Equipment breakdowns decrease equipment availability, resulting in reduced available production time. These indexes aim to monitor, control, and prioritize equipment that needs more attention. Improvements can be observed when the MTBF increases, indicating that the equipment has become more reliable. On the other hand, a decrease in MTTR indicates an improvement in the maintenance team's efficiency in resolving equipment malfunctions (Gill, 2005).

Companies can use the data obtained to identify and eliminate the underlying causes of malfunctions by utilizing quality tools, as suggested by (Song et al. 2004).

Daychoum (2007) states that visual tools play a crucial role in the communication process, leading to enhanced process management and improvement.

2.6.5 Gemba Walk

A critical tool for companies is the Gemba Walk, which is a fundamental aspect of the lean philosophy. The term "Gemba" refers to a place where value is added, and "Walk" refers to physically walking through an area for which someone is responsible, carefully observing the whole process and tasks. The key principles of this approach are observation, questioning why, understanding, and showing respect, which lead to more reliable outcomes. This methodology should be utilized by top management and work teams alike (Suzaki, 2013).

2.7 Quality tools

Organizations have access to a diverse set of tools for identifying and resolving problems. These tools can be classified as either strategic or statistical, with strategic tools being used to generate ideas, establish priorities, and identify the root causes of problems, while statistical tools are used for performance measurement, decision-making, and continuous improvement. Out of the many available tools, this work will focus on the Ishikawa diagram, the GUT matrix (gravity, urgency, trend), and 5W2H (Behr et al., 2008).

2.7.1 Ishikawa Diagram

The fishbone diagram, also known as the Ishikawa diagram in honor of its creator Kaoru Ishikawa, is a tool used to identify and analyze potential causes of problems (Freitas, 2012).

The cause and effect diagram, also known as the fishbone or Ishikawa diagram, is primarily created by identifying the problem to be analyzed. Then, a group brainstorming session is held to generate ideas and identify the possible causes that may be the root of the problem. The key question to be addressed during this process is "why" the problem occurs (Behr et al., 2008).

Freitas (2012) stated that the cause and effect diagram can categorize all problems into four main factors, known as 4M's: (1) labor, (2) method, (3) materials and (4) machine, and the figure 6 shows the other two factors properly. In addition, Suzaki (2013) expanded this concept by including two more factors that he considers relevant to the use of the tool: (1) measurement and (2) environment.

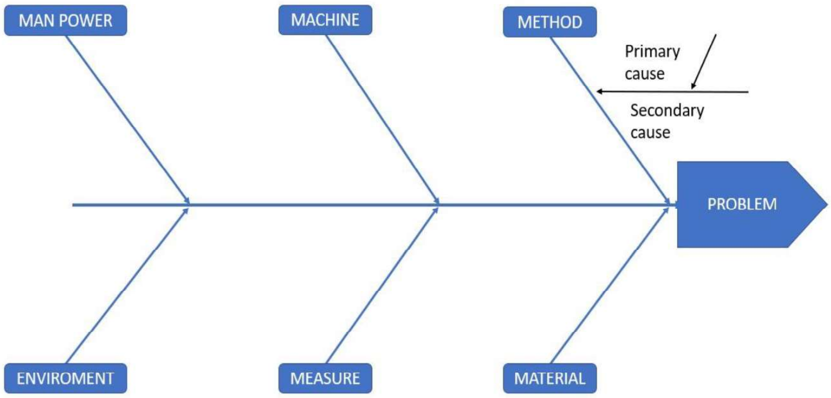

Figure 6 - Ishikawa diagram

(Source: Feliciano, 2023)

2.7.2 GUT Matrix

Sotille (2014) explains that the GUT matrix, also known as Gravity x Urgency x Trend matrix, was created in 1981 by Charles Kepner and Benjamin Tregoe. Its main purpose is to establish a priority scale for problems, allowing organizations to prioritize the most critical issues that require immediate attention and action.

The tool, as indicated by its name, is assessed based on three factors: Severity, Urgency, and Tendency. Severity assesses the level of impact that the problem may have on the operations and people involved if it is not resolved. Urgency is related to the available time to solve the problem. Tendency refers to the likelihood of the cause worsening if no action is taken or remaining the same if there is no immediate action (Behr et al., 2008).

The GUT matrix can be applied individually, but its effectiveness is improved when used by a group of people. The method involves creating a list of problems identified in the Ishikawa matrix and assigning a score to each topic on a scale of 1 to 5 for each of the three aspects: Severity, Urgency, and Tendency. The scores are then multiplied to calculate a total score for each cause, and the ones with the highest value are identified as the top priorities. These high-priority issues are likely to have the greatest impact on the production process and should be addressed as soon as possible (Lima, 2016).

2.7.3 5W2H

This tool originated in Japan and is known for its ability to solve problems arising from cause and effect diagram, GUT matrix, brainstorming and other methods. Its primary objective is to gather all the necessary information to implement actions within an organization, carefully attend to the productive processes and achieve significant improvements for success. Each action must be specified using 5W2H terminology, where 5W refers to five questions that require specific answers (see figure 7): what, when, where, why and who. The 2H aspect involves two additional questions: how and how much (Daychoum, 2007).

- What - To solve the problem, "means what" refers to identifying the specific objective or goal;
- When - This pertains to the timeframe or deadline for resolving the problem;
- Where - This element of the 5W2H tool pertains to the place where the action will take place, or the specific location involved;
- Why - This question asks for the reason behind the problem and aims to provide a clear understanding of why it is happening;
- Who - This component of the 5W2H specifies the person or group who will take responsibility for implementing the action;
- How - This involves specifying the method or approach that will be used to perform each task, or in other words, how each task will be carried out;
- How much – This refers to the financial aspect of addressing the problem, specifically the costs involved.

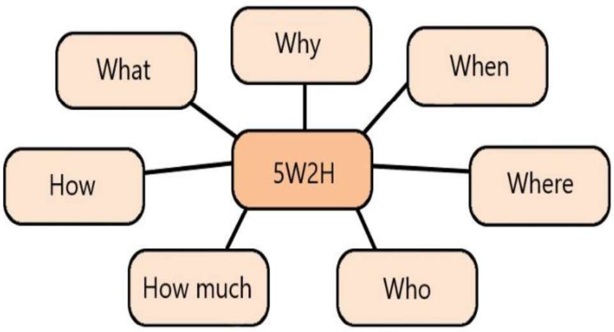

Figure 7 - 5W2H Analysis.

(Source: https://www.thinkleansixsigma.com/article/what-is-5w2h)

The action plan should be kept visible to the entire team after it is prepared, to ensure that the actions are implemented (Lisbôa and Godoy, 2012).

2.7.4 Program 5s

Shigunov and Campos (2004) report that the 5S Program, which has been adopted by many companies, is a straightforward method that yields sustained and long-term outcomes. The present chapter will examine the program's concept, history, and goals.

According to Silva (1994), various aspects such as the new economic scenario, the intellectual development of society, and the consumer protection code, have prompted companies to evaluate their approach. In light of this, several critical factors need to be considered to ensure the survival of the company, including quality, cost, service, and innovation. The Japanese-style Total Quality Management approach incorporates these factors into a systemic view. To adapt to this new reality and make improvements in its processes, the company needs to start somewhere, and the most recommended way, according to Mr. Ichiro Miyauchi (apud Silva, 1994), is through the 5S Program. The implementation of this program can lead to several positive outcomes, such as improved employee motivation, reduced accident rates, improved quality, and increased productivity. Therefore, it is important to understand the concept, origin, and significance of the 5S Program (Silva, 1994).

The Quality program known as 5S, which forms the basis for applying Total Quality concepts and practices, was first developed in Japan during the early 1950s. Although it has been particularly emphasized in Japan, Silva (1994) notes that the program is not limited to this country and can be utilized by all types of organizations.

The Five S's Methodology was used as the first approach to solving problems at Toyota and constituted a fundamental pillar in the implementation of an adequate and favorable work environment for all employees (Ablanedo-Rosas et al., 2010).

The methodology comes from the acronym consisting of five Japanese senses: Seiri (organization), Seiton (arrangement), Seiso (cleanliness), Seiketsu (standardization) and Shitsuke (discipline). The 5S tool aims to provide an increase in productivity by maintaining an optimal working environment, through the systematization of cleaning, tidying and organization activities in each workstation (Prabowo, 2008).

Seiri - Sense of sorting and tidying: this stage consists of analyzing the work areas with the purpose of proceeding with the selection of what is relevant for the execution of activities (Nakagawa, 2012). Thus, at this stage, one should start by identifying and classifying all the objects and documents that are present at the workstation, in order to differentiate those that are used from those that are unnecessary. Next, the materials that need to be kept at the workstation, which must be stored elsewhere or which must be disposed of, are defined (Pillet et al., 2007). This stage begins at the workplace of each employee and extends to all the other facilities of the organizations, with the aim of preventing expendable items, which accumulate, hindering the performance of activities by workers or reducing their efficiency. work (Nakagawa, 2012).

Seiton - Sense of organization and order: after eliminating what is unnecessary, the material identified as necessary should be arranged and organized (Nakagawa, 2012). Materials should be organized in such a way that they can be easily identified and reached when needed (Prabowo, 2008). The implementation of visual systems, such as the identification of cabinets, compartments or equipment, becomes an asset in this sense, since it simplifies the search and storage of materials, by people external or internal to the workplace (Brady, 2012; Oakland, 2014).

.**Seiso -** Sense of cleanliness and inspection: this stage has the main objective of guaranteeing the good functioning and cleanliness of workstations and equipment (Pillet et al., 2007). Cleaning and inspection rules and procedures must be defined, specifying what must be cleaned, the necessary cleaning means and by whom and how often it must be carried out (Dennis, 2008).

Seiketsu - Sense of normalization: consists of the standardization of the previous 3S, that is, it is the adoption of the first three steps as constant and routine practices of the organization (Nakagawa, 2012). To do this, it is necessary to plan and create procedural standards, as well as taking into account the time required for them to be applied (Nakagawa, 2012; Oakland, 2014). In this way, this sense can be designated as the “sense of conservation”, where the definition of standards becomes essential for the preservation of the progress achieved by the company (Pinto, 2008).

Shitsuke - Sense of discipline: in this stage, the previous 4S become a culture of the organization, that is, an integral part of the routine of the company and the employees. At this stage, all employees work automatically and consistently through norms and instructions for organization, tidying and cleaning (Nakagawa, 2012; Pinto, 2008).

The most traditional way to start the implementation of 5S, according to Silva (1994) should be to elaborate a plan that does not conflict with local culture, but that allows change to flow harmoniously. Knowing the current reality and starting from it is fundamental. It is important to note that you should not copy an existing plan, because each company has its own management model. To maintain and improve the program it is necessary to reflect deeply on the style of the current administration. The quality of an organization always reflects in senior management, and in turn manifests itself in the working conditions and behavior of employees.

2.8 Deployment Strategies

Many continuous improvement methods of lean manufacturing were mentioned in the literature review taken from many literatures, for this work the methods like: Ishikawa diagram, GUT matrix, 5s and 5W2H were used. This work will describe the lean implementation in the Refriango’s company. Firstly, the history and its produced products will be described, the beginning and the end of the production process of the respective line of study will be described, the main factors that affect its operational performance will also be presented and the result will be presented.

2.9. Refriango's Company

Refriango is a company specialized in the production and distribution of a variety of beverages, including soft drinks, water, energy drinks and alcoholic beverages (figure 9). It was founded in 2002 and is a joint venture between Portuguese and Angolan capital. The company has the capacity to produce 200 million liters of beverages annually and has more than 3,800 employees, mostly Angolans (95%), the rest being Portuguese and Brazilian.

Figure 8 - Refriango´s company.

(Source: Refriango, 2023)

Refriango has a higher production capacity than the average of other companies in Africa. It is one of the leading companies in Angola and also one of the largest on the African continent (figure 8). They have a portfolio of 15 brands, some of them market leaders in their respective segments. Some of their popular products include Blue soda, Água Pura, Nutry, Tutti, Tigra and Welwitschia tonic water. These products are among the best sellers in their categories.

Figure 9 - The main products.

(Source: Refriango, 2023)

Refriango has one of the biggest and most technologically advanced industrial units for beverage production on the African continent, occupying 42 hectares of land. The unit is divided into two factories, namely factory 1 and factory 2. Refriango is a leading company in the Angolan beverage market, with a production capacity of 1.9 billion liters per year and 24 filling lines that cater to over 150 products in various packaging types. It has expanded its business beyond Angola and is currently operating in 10 different countries. Refriango aims to grow its presence on the international stage and is considered an ambitious player in the industry.

3. TECHNICAL PROBLEM

In this chapter I will show the problems I encountered during my evaluation on the production line (line 27) of the company Refriango.

3.1. Technology of fresh drink

Refriango has two factories (Factory 1 and Factory 2), in Factory 1 they produce products with Pet and cans containers, and in Factory 2 they produce product glass containers. The line under study is line 27 at factory 2, the production process begins at the depalletizer, where the machine operator places the pallets of boxes with empty containers on the depalletizer and this, in turn, depalletizes and they are taken to the degrader by means of a conveyor, the degrader removes the bottles from the boxes, separated on different conveyors, the bottles are transported to the bottle washer and the boxes to the box washers.

After washing, the bottles are transported to the bottle inspector, in order not to allow any contaminated bottle to pass through, then the bottles without contamination and in perfect condition are transported to the filler, then pass through the capping machine and the full bottle inspector. For the durability of the product it has to go through a pasteurization process, that is, after the bottles are filled with the product (full bottles) they are transported to the pasteurizer. After the pasteurizer, the bottles are transported to the labeler machine, where the brand of the filled product is placed, then they are transported to the crater, which in turn places the bottles in the boxes (crate) that are transported to the palletizer (figure 10).

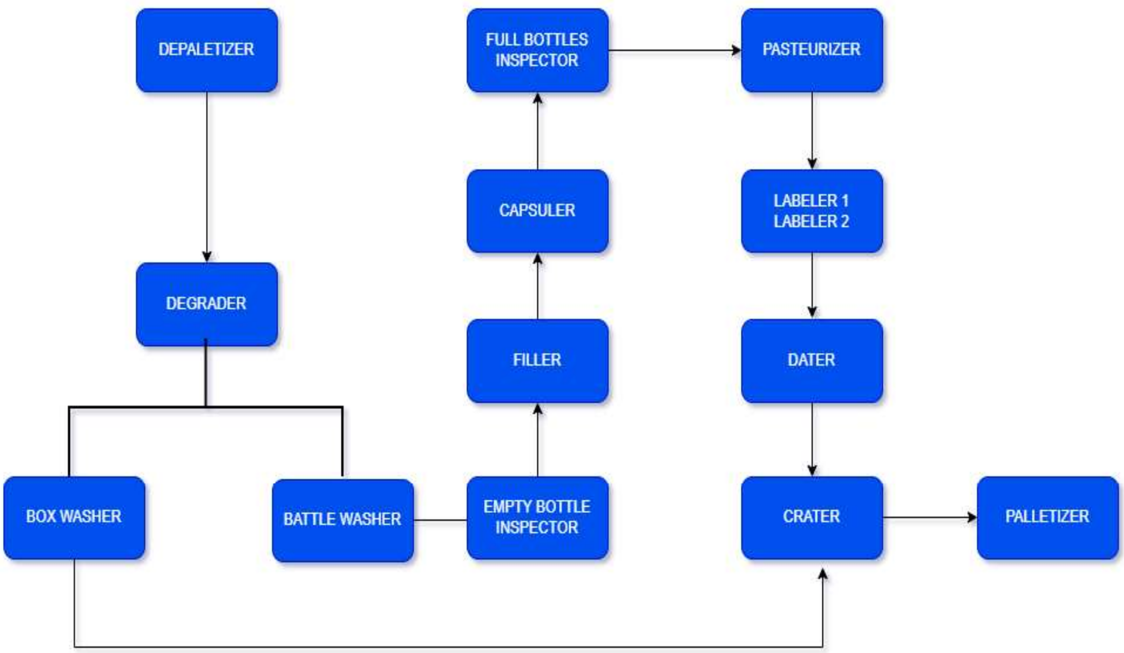

Figure 10 - Schematic representation of the course of the glass bottles.

(Source: Feliciano, 2023)

Refriango's line 27 (Refriango production line number 27) has two labeling machines instead of one which is the normal standard, the company's intention is not to stop production, and the labeling machine is like a clock that always needs adjustments. And these adjustments have stopped production, so the company thought that while one should be adjusted, the other continues production and if both are spinning, increase production.

3.2. Problems Presentation

As a starting point, it was decided that line 27 (Refriango production line number 27) will be the one where my work will focus. Because it is a line that is expected to produce more and the technology of the line is the latest with the capacity to produce 37,000 boxes in two shifts, so there was a need to achieve this goal. Line 27 is equipped with the highest technology from the company Krones, after the assembly of line 27, the line was producing from 36 to 37 thousand boxes in good production in two shifts in the presence of technicians from the company Krones who were there giving support technician, and now produces just 28,000 cases or less in two shifts. There may be some factors that are generating waste in the production line and that can be mitigated with the use of Quality Control tools to improve line performance 27.

A technical assessment was carried out on the line and one of these factors was technical (mechanical) problems, production operators and maintenance technicians at Refriango claim that since the line was set up 17 years ago, preventive maintenance has never been carried out. The survey of problems or factors affecting efficiency was carried out according to the information from the technical assessment that was carried out on line with production and maintenance employees, taking into account the interview and reports, which were imported into excel connected to Power BI, which, in turn, presented in an organized way the information of the technical problems that the line presented and shows in a graph of downtimes that each machine made, through Power BI, (Figure 11), we verified the equipment with more time of failures (Washer of bottles, labeller, crater, degrader and conveyor).

Figure 11 - Stop control and low production efficiency.

(Source: Refriango, 2023)

The bottles came out of the bottle washer with labels as shown in the figure below, and some even with small percentages of soda, which is why the Quality department ordered the production to stop.

Figure 12 - Bottles with labels at the bottle washer outlet.

(Source: Refriango, 2023)

The figure 12 above illustrates the appearance of labels affixed to the bottles, many of them with small percentages of caustic soda, this was due to the case of the showers not working properly, it was found that the showers were clogged and many of them warped and with very damaged wheels. With warped showers and damaged wheels, there was always a jam, making it impossible to use.

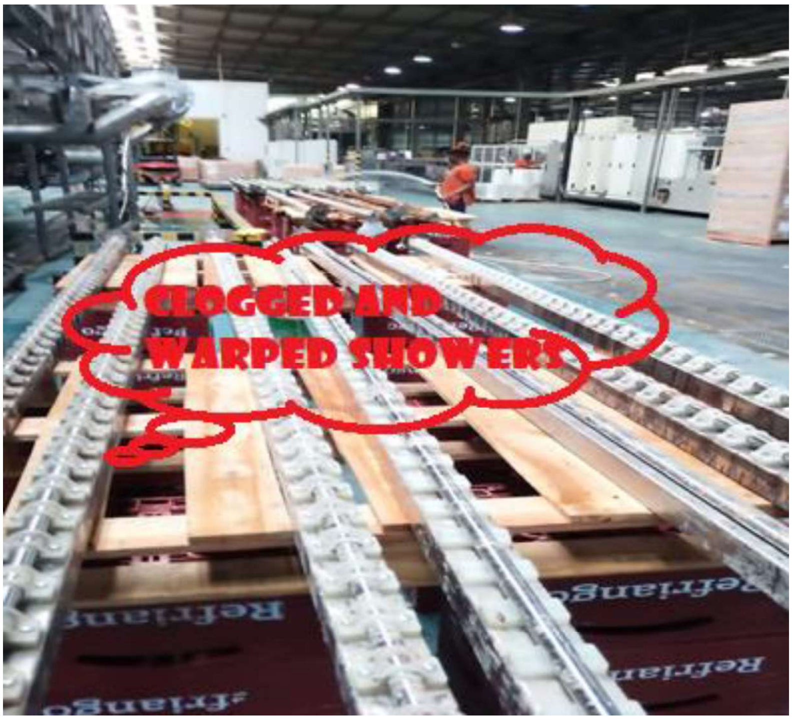

Figure 13 - clogged showers.

(Source: Refriango, 2023)

The showers have the function of injecting water into the bottles, with the purpose of washing or removing all contamination residues. There were many problems with the washer and one of them is the clogging of the showers (figure 13), so it would be impossible for the bottles to come out without contamination.

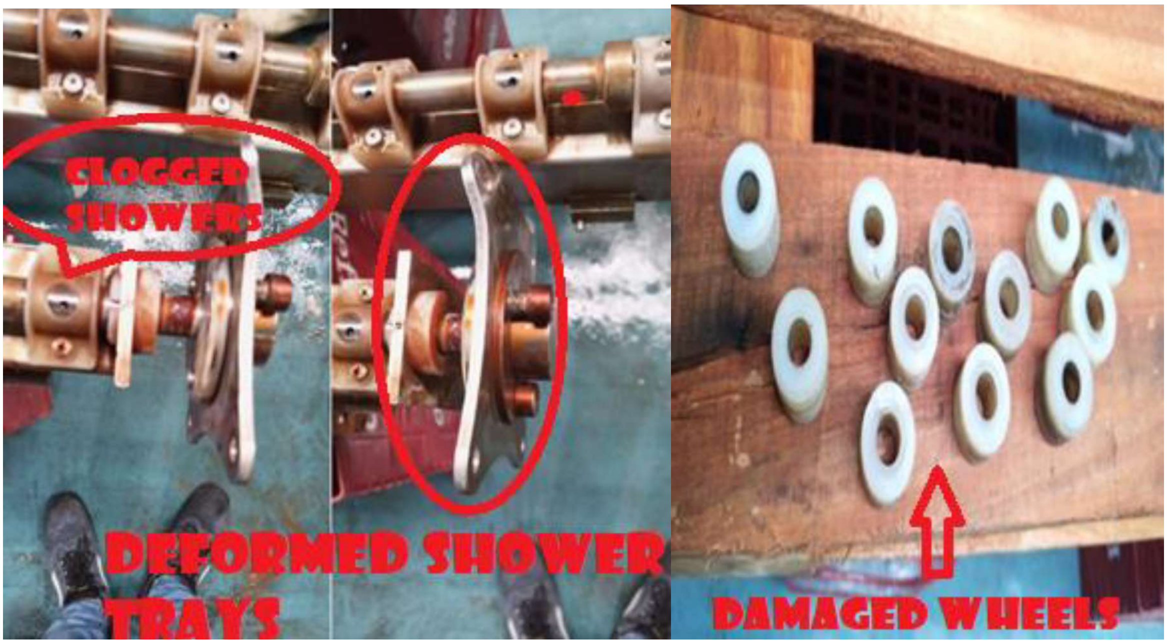

Figure 14 - warped showers and damaged wheels.
(Source: Refriango, 2023)

In addition to the clogging problem, the showers were also warped and with damaged wheels, as shown in figure 14. The bottle washer showers rotate, it was observed that many of them were not rotating, due to the warping of the shower support as shown in the figure and due to the poor condition of the wheels, therefore, it created a prison and made it impossible to shower from do your job.

Figure 15 - Grader and degrader with the lids decentralized on the bottles, the operators tie cloths to centralize.
(Source: Refriango, 2023)

The crater is the machine that places the full bottles (product) in the boxes and the degrader removes the empty bottles from the boxes shown in the figure 15. The degrading machines and the crater are having problems and many bottles were breaking during their operations, so that the line would not stop producing to meet customer demand, the maintenance technicians chose to centralize the wedges by tying them with rope or even cloth.

Figure 16 - Deformation of the crater and degrader head plates.

(Source: Refriango, 2023)

Figure 16 shows the deformations in the head plates of the grader and grader machines. With these deformations, the slides were not centered on the bottles, which caused the bottles to break as soon as the head moved downwards.

Figure 17 - labeler1 servomotors out of synchrony.

(Source: Rrfriango, 2023)

The servomotors are interconnected, that is, they are synchronized, when a servomotor damages or burns out, it generates the desynchronization between them, and consequently the bottles are poorly labeled and coded, which causes the operator to stop production. Labeling machine 1 had this servomotor failure, as shown in figure 17.

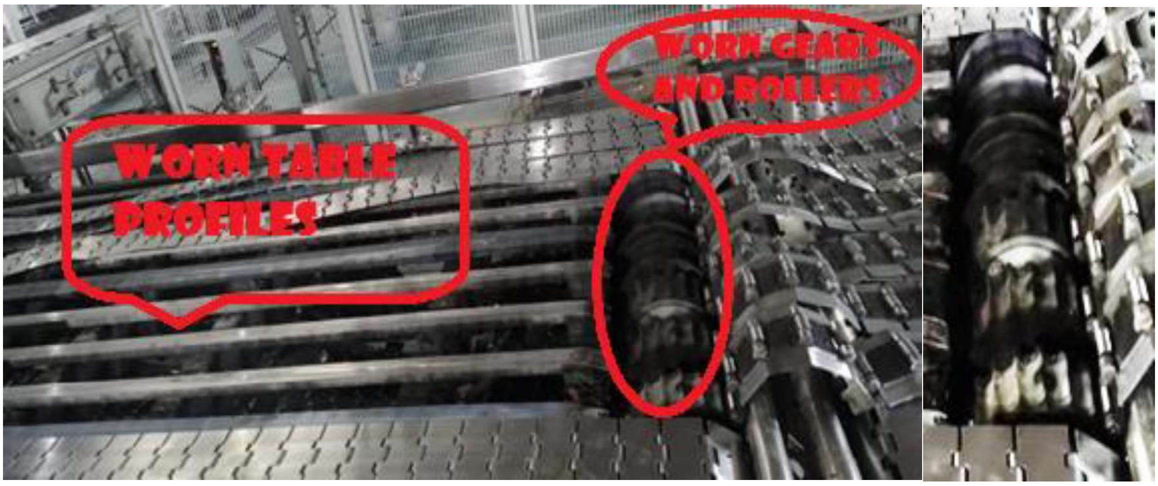

Figure 18 - Worn table profiles, worn gears and rollers.

(Source: Refriango, 2023)

Conveyor conveyors had wear problems. With the conveyor chains uncovered, the figure 18 shows the table profiles and the rollers and gears not in usable conditions, the profiles being worn out, the chains stop the screws of the table profiles, that is, the table profiles are fixed with screws , when the profiles wear out the screw heads, they stop the conveyor chain (sticking), as well as the gears and rollers were all worn out but continued to produce in these conditions due to lack of a preventive and control maintenance plan.

Other problems are related to unskilled labor, lack of preventive maintenance plan and control, non-compliance with the production plan, lack of standardization of activities, lack of stop and control of production and loss of time.

4. METHODOLOGY

This is a prospective, cross-sectional study, carried out from January 1, 2023 to March 31, 2023 at Refriango's company and involved bibliographical research, interviews with company employees, evaluation of the production process, identification of factors affecting operational efficiency and implementation of improvement actions.

4.1 Identification of the factors that affected the operational efficiency of line 27

In order to identify the causes that may be at the origin of this problems, the Ishikawa diagram was used, this was prepared with the help of production operators and maintenance technicians, with the objective of improving the operational efficiency of the line. The 6 M were addressed, considering the causes at the level of the production operators, that is, the method of operation and the time that maintenance technicians took to solve the faults. Causes were identified at the material level, such as the poor condition of the pallets, problems related to the environment and measures, problems related to the method of solving faults, problems at the machine level, such as problems with the bottle washer, filler, degrader and crater, and on conveyors.

4.2 Characterization of the production line

In order to characterize the production line, a technical evaluation of the production process was carried out, from where it starts to where it ends. An interview (Annex) was made with the employees of the production area, they were interviewed; the line manager, line heads, and line production operators. And in the maintenance area were interviewed; the maintenance manager, the shift coordinator and the maintenance technicians, in order to first understand the process and the problems that the line presented.

4.3 Identification of mechanical processes that add value to the production line

There was a two-week stoppage for maintenance, with the intention of eliminating all the problems or failures that the line presented as the main causes of the low efficiency of the line and finally it became clear that the periodic maintenance of the line equipment (preventive maintenance) should be done to prevent such situations of equipment breakage from happening again, therefore, it is about maintenance on the crater and degrader, on the mats, bottle washer and labeller.

4.4 Assessment of the need for improvement and suggestions

To assess the need for operational improvement, opportunities for improvement were identified and improvement actions were implemented, such as; implementation of the production control application (Power BI), training of production operators and planning of preventive maintenance to increase productivity, reduce costs and improve product quality.

5. RESULTS AND DISCUSSIONS OF THE TECHNICAL SIDE

5.1. Quality Control (Ishikawa, 5W2H and GUT matrix)

Line 27 is a line that produces Tigra beer, it is a glass line, that is, glass containers. The line's production process starts at the depalletizer and ends at the palletizer. There are three shifts with 19 employees per shift, that is, 11 employees operating the machines, 2 line managers supervising production, 2 maintenance technicians available on the line, 4 cleaning technicians, 2 cleaning the dry part and 2 cleaning the wet part. The line is managed by a production manager and a maintenance manager and is equipped with two labelers instead of the one that is standard on a production line.

Taking as a starting point the application of quality tools (Ishikawa Diagram, GUT Matrix, and 5W2H), the factors that affected operational performance were identified, using the Ishikawa diagram (figure 19), and according to the analysis the main factors were; untrained staff, waste of time, lack of standardization of activities, poor state of pallets, production operators cleaning while operating, poor compliance with the production plan, delay in resolving faults, lack of preventive maintenance, bottle breakages constants in the crater and degrader, lack of synchrony of the servomotors, bottles coming out of the washer with labels (clogged showers, warped and damaged wheels) and jamming of the conveyor chains.

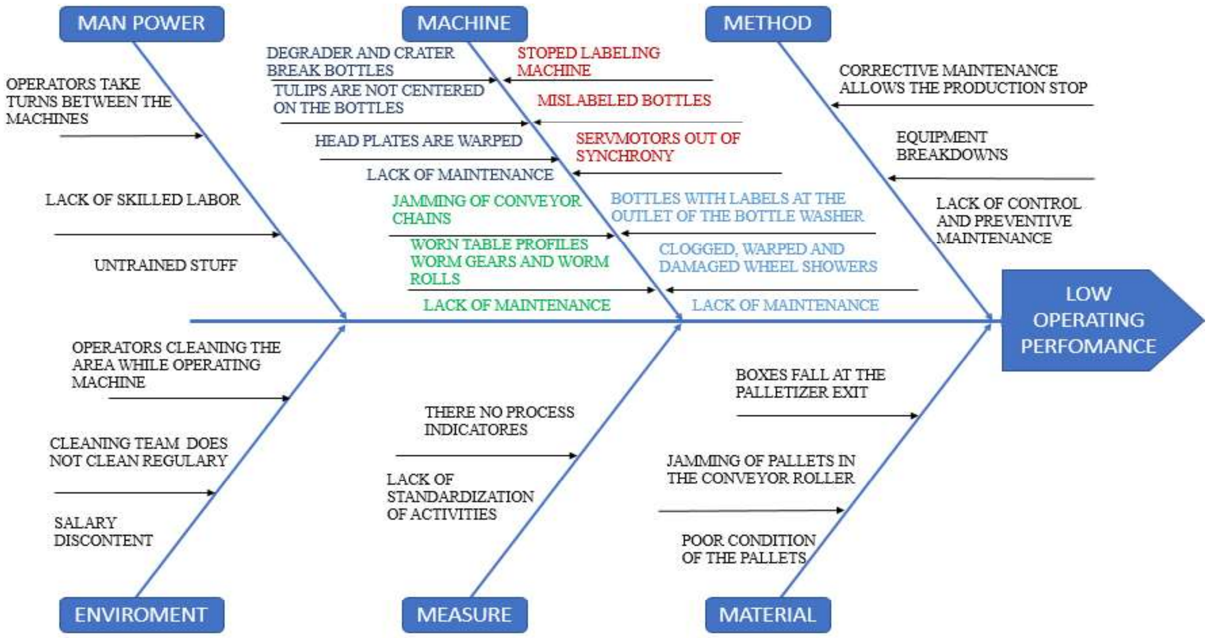

Figure 19 - Ishikawa diagram.

After a previous analysis, the causes with the highest rates were visualized (table 3), that is, the problems with the greatest urgency, severity and tendency. In a rating from 1 to 5, where the values are as follows:

Table 3 - Assessment of problems according to Severity, Urgency and Tendecy

Grade	Gravity	Urgency	Tendency
5	extremely serious	Need immediate action	It will get worse quickly
4	Very serious	It's urgent	It will get worse soon
3	Serious	As soon as possible	will get worse
2	little serious	little urgent	It will get worse in the long run
1	weightless	it can wait	will not change

Table 4 - Themost urgent problems to solve.

Number	Problem	Gravity	Urgency	Tendency	Total result GxUxT	priority level
1	Operators take turns between machines	2	3	3	18	3%
2	Crater and desegrader headstock warped	5	5	5	125	21%
3	servomotors out of synchrony	5	5	5	125	21%
4	Clogged showerheads, warped and damaged wheels	5	4	5	100	17%
5	Jamming of conveyor chains	3	3	4	36	6%
6	Lack of standardization of activities	3	2	3	18	3%
7	Poor condition of the pallets	4	3	3	36	6%
8	Lack of control and preventive maintenance	5	5	5	125	21%

Table 4 is schematically presented with the values attributed to previously identified causes. Thus, those with the highest priorities were checked quickly, so that actions can be implemented to resolve the issues.

According to the graph below, the factors with the highest resolution priorities were; untrained personnel (operators take turns between the machines), constant bottle breaks in the crater and degrader, servomotors out of synchrony, bottles coming out of the washer with labels (clogged, warped showerheads and damaged wheels), jamming of conveyor chains, lack of standardization of activities, poor condition of the pallets, Lack of control and preventive maintenance.

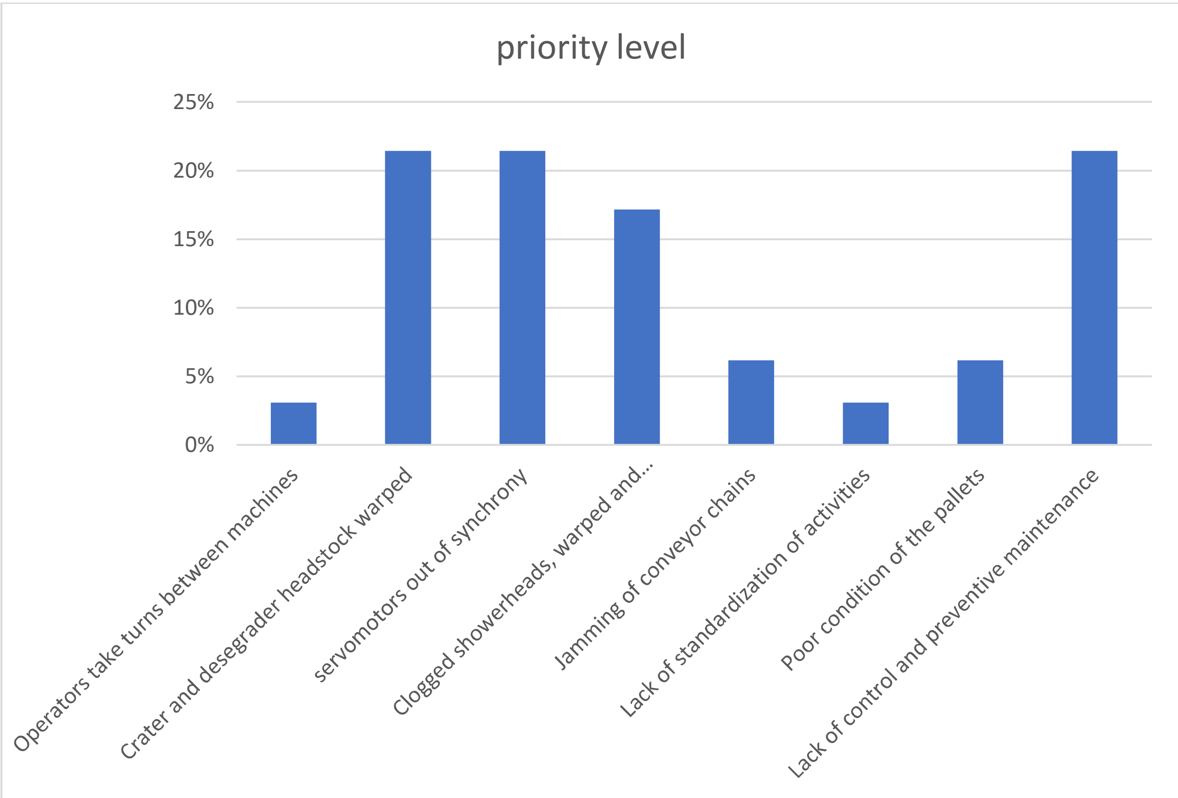

Figure 20 - Factors with higher resolution priorities.

The 5W2H tool was used to create an action plan to solve the root cause that was found through analyzes already made with the later tools. Since most of the causes found that influence the low level of production came from equipment malfunction due to lack of preventive maintenance, the root causes of the GUT matrix were selected, based on the Ishikawa diagram.

Table 5 - Implementation of the 5W2H methodology.

Cases	Crater and desegrader headstock warped	Servomotors discynchronization	Clogged showerheads, warped and damaged wheels	Jamming of conveyor chains
What?	Implement preventive maintenance control	Implement preventive maintenance control	Implement preventive maintenance control	Implement preventive maintenance control
Why?	To ensure the full functioning of the line	To ensure the full functioning of the line	To ensure the full functioning of the line	To ensure the full functioning of the line
Where ?	L27	L27	L27	L27
Who?	Krones and Refriango technicians	Krones and Refriango technicians	Krones and Refriango technicians	Krones and Refriango technicians
How?	for two weeks	for two weeks	for two weeks	for two weeks
How much?	II	II	II	II

In view of the root causes of equipment malfunction problems, it was due to the lack of a preventive maintenance plan for the line equipment, our question was, **Why the low production?** Therefore, our response was to have found an improvement action (Maintenance), the implementation of preventive maintenance control for the production line under study (L27).

5.2. Technical Solutions

Although most of the parts requested from the supplier (Krones company) were out of stock, the maintenance was a success, we had satisfactory results, we were able to largely eliminate the problems of the line, we had to use some existing parts in the warehouse and we removed another one from some Krones line that were not working.

Figure 21 - Degrader and crater head straightened and slides centralized in the box center.

Proper maintenance was carried out on the crater and degrader, replacement parts were requested from the supplier (Krones), the company that manufactures the machines for line 27 of Refriango. Unfortunately, I am not authorized to mention the budget for the new parts required for maintenance on the degrader and the crater (figure 21).

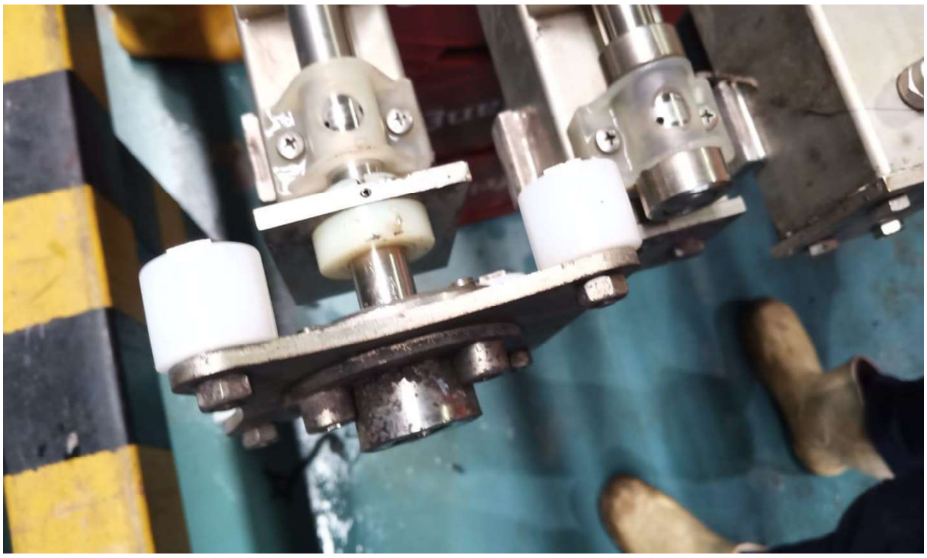

Figure 22 - Straight showers, unclogged and with new wheels.

The warped supports of the washing machine's showers (figure 22) were one of the missing parts, it was requested but it did not arrive in time for maintenance, so we had to straighten it, hitting it with a steel hammer. After straightening the shower support, we mount it with new wheels that are already in stock.

Figure 23 - Labeling machine repaired with replacement of new servomotors.

According to the company, the labeller is one of the most important machines in the line or the machine that deserves special attention (figure 23), it works like a clock and always needs adjustments. After maintenance, we came to the conclusion that the servomotors were all in perfect condition, the main reason for the non-synchronism was the communication board that was burned out, board of 24 servomotors, this meant that there was no synchronism between them.

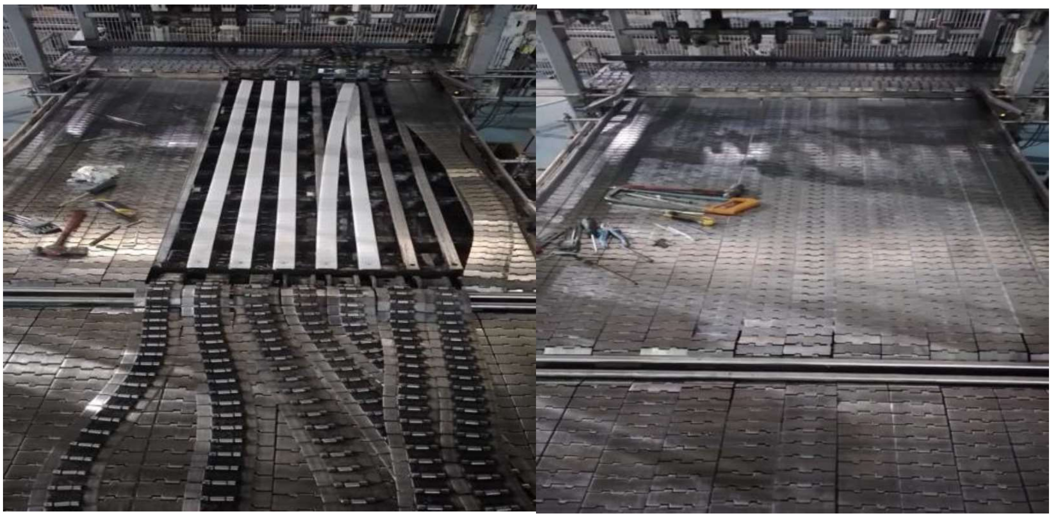

Figure 24 - Table profiles, rollers and gears replaced with new ones.

After two weeks suggested for line maintenance, in equipment (which had constant failures, with long stops) and the implementation of improvement actions, an analysis of results was carried out between the months of January and February, considering data from January before the stoppage , for equipment maintenance (January 1st to 24th) used as a comparison (figure 25).

Figure 25 - Stop and control of low production.

The increase in operational efficiency is also one of the main objectives of this work, firstly presenting the efficiency values before the general maintenance of line 27 (L27), to verify if there has been a comparative increase since the day that line started to turn, that is, (February 26th) after the implementation of improvement actions (maintenance, standardization of activities, training of production operators on line 27, stop and production control, elimination of wasted time), then efficiency values will be presented, to conclude whether there was a change in efficiency, in relation to the efficiency value before the improvement actions, is shown in the figure below.

Figure 26 - Shutdown and production control, with an 8.82% increase in efficiency.

With the presentation of the percentage values of efficiency before and after the shutdown and implementation of improvement actions, it was found that there was indeed a percentage increase on 01/27/2023 of 8.82% in approximately 1 month. Since, the percentage value of efficiency before the implementation of improvement actions was 55.63% while after the implementation of improvement actions, 64.45% of operational efficiency was obtained.

With the presentation of these results, what is desired is to comply with the preventive maintenance plan, the production activities, the proposed improvement actions, to reduce or eliminate the problems that may affect production and so that the efficiency of the line 27 is always maintained with the percentage increase in operational efficiency.

5.3. The implementation of the 5s program

The parts warehouse before the implementation of the 5s program boiled down to a generalized disorganization, this was the impression given to anyone who entered the warehouse, the place was dirty, different pieces together, few partitions, there was rubbish on the floor, the environment it did not provide comfort as illustrated in the figure 27.

Figure 27 - Application of the 5S methodology in the parts warehouse. Comparison between before (left) and after (right) implementation.

Seiri - the selection of what was relevant to the execution of the activities began, all the pieces that would be used in the lines were identified, the pieces were classified and the oldest ones were differentiated from the newest ones and what was unnecessary. Separated the materials that needed to be kept and those that should be discarded.

Seiton - after eliminating what was unnecessary, the identified materials and parts were arranged and organized on the shelves, some were identified with photos and others with writing by their denomination, so that they could be easily identified and accessed when needed.

Seiso - the parts warehouse, it was dirty and with a lot of pieces together and garbage scattered on the floor, so we had to clean and tidy the place, there were not enough shelves for storage, it was urgently manufactured for the disposal and organization of parts . Have cleaning and inspection rules and procedures been defined, detailing what should be cleaned? how should they be cleaned? what materials to be used for cleaning the site and in what period should they be done?

Seiketsu - Standardized the previous activities (Seiri, Seiton and Seiso), to preserve progress.

Shitsuke - through norms and instructions that we implemented in the company about organization, tidiness and cleanliness, employees started to have the 4s as part of their culture.

At different points of the factory, the help of the 5s tool was needed, the four senses were used to respond to the needs that the company had at different points of the factory (Annex).

5.4. Economic evaluation of the standardization of activities

For the standardization of some activities, we had to ask the suppliers of the materials for a quotation, that is, it was necessary to know first how much each material cost and ask for the desired quantity and at the best price. Below I show the table containing the materials used for this task in Refriango.

Table 6 - Economic evaluation of materials used in standardization.

Nº	Description	Quant.	UN	Price Unit	Discount	IVA	Total
1	Yellow Paint	5	Un	172960	30%	14%	605360
2	Grey Paint	5	un	119550	30%	14%	418425
3	Red Paint	5	Un	172960	30%	14%	605360
4	vinyl marker tape(Yellow)	10	Un	5022	30%	14%	35154
5	vinyl marker tape (Red)	10	Un	5022	30%	14%	35154
							1699453

These were the materials that the company was asked to follow with the standardization of activities or signalling. As I do not have access to requests for quotations, because these requests were made in another department, what I will be showing is an approximation of the amounts spent for the purchase of these materials, so we had a total of 1,699,453.65 kz (currency in Angola) which in Euro currency is €3,251.

There were many non-standard activities and many non-signposted places, there was a need to make some markings on the pavements, standardizing the activities, for example; Mold carts were not standardized, markings on the floor of the production line and logistics, product loading trucks were anywhere for loading. In this way, in the figure 28, I show the before and after some of the standardization of some activities.

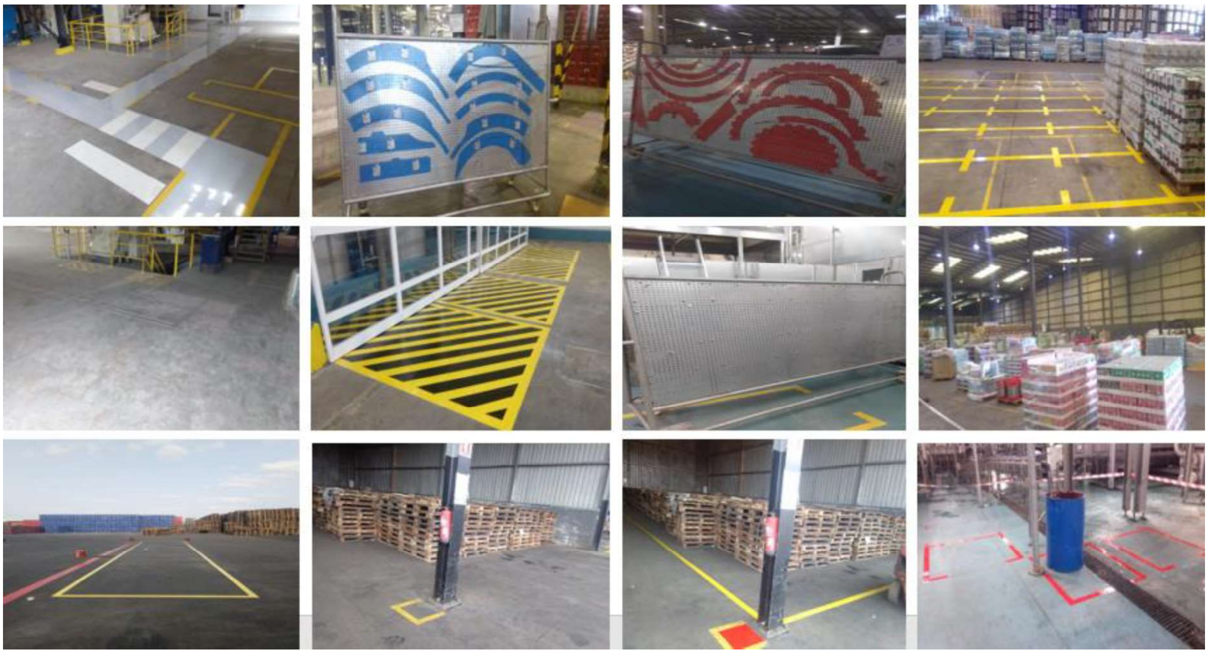

Figure 28 - Pavement marking and signaling and standardization of activities before and after. (Source: Refriango, 2023)

5.5. The implementation of training for line 27 employees

It was clearly visible that some of the production operators had no domain or skills to operate the machines. Since my arrival at the factory, many operators were concerned, because they thought I was a line supervisor and that I was there to make them unemployed. New operators, were cleaning technicians of a company subcontracted by Refriango, depending on the time they were framed in the filling area as production operators. This was one of the factors that affected the operational efficiency of line 27. Training was proposed for production operators as shown in the figure below.

Figure 29 - The first operator training class.

5.6. Implementation of the bench vice on line 27

Another situation occurred in the filler where there were 2 warped filling nozzles, the machine operator ordered the technician to intervene, so they had to stop for a few minutes. it was observed that the technician left the place where he fixed the fault to go to the workshop where he had had the bench lathe, which was 500 meters from line 27, clearly moving from one place to another was a waste of time, he arrived to fix doing approximately 30 minutes to straighten the beak. It was proposed that tables with a bench vise be in line and preferably close to the machine (figure30), when the same problem happened again the bench vice was already in line and close to the filler as shown in the figure, and it took 10 minutes to repair, therefore, there was a difference in the repair time of the first time, which took 30 minutes, and the second time, which took only 10 minutes, there was a 20-minute difference and a lot of time wasted on a production line.

Figure 30 - Placing a bench vise next to the machine.

5.7. Implementation of the bench vice on line 27

The waste of time was a constant variable during the production process, after eliminating the faults, the best and simplest possible way was found to eliminate these losses from small stops that were also influencing the impracticability of operational efficiency. there was a lot of delay for the technicians in the appearance of the breakdown site, because they had to travel with their tool bags, as you can imagine, they are heavy, the time taken for the technician to travel to the breakdown site, not only damages the production but also the physical integrity of the worker. Sometimes there was a lack of tools (wrenches) for a given fault, so I was forced to contact another technician, I could be on another line, and I lost more time when I looked for a colleague's tool bag or waited that the colleague brings the tool he asked for, the figure shows how the tool bags of the company's maintenance technicians are and their arrangement on the line, it is clearly noted that they are left in any corner of the line (figure 31), and there was a situation having left one in the dry part of the line (crater, degrader, labeller, palletizer and depalletizer) and the problem exists in the wet part (filler, pausterizer and bottle washer).

Figure 31 - Maintenance technicians toolbox.

To eliminate these small losses in production speed and small stops, improvements were proposed to combat this waste (figure 32), the acquisition of 5 tool cases as shown in the figure and their installation. It was proposed that each two machines had a suitcase, therefore, it would be a suitcase for the filler, an inspector for empty bottles and an inspector for full bottles, as they were very close to each other. Another would be next to the bottle washer and would also serve for the box washer and the pausterizer as they were close together, the third suitcase would be next to the two labelers, the fourth in the crater and degrader and finally the fifth next to the depalletizer and the palletizer. The box costs 1.317.206,00 kz which is in euro (2.353,41 €) for every 5 tool bags for line 27 alone, which would total 6.586.030,00 kz which is in euro (11.376,3 €).

Figure 32 - Proposed toolboxes for the line 27.

5.8. Proposal for completing the occurrences on the line computer

Filling in the production map sometimes made it difficult to understand the handwriting of some operators (figure 33), some of which were not legible and made it difficult to quickly and efficiently import production data into Excel already connected to Power BI, so the veracity of the values imported into Power BI sometimes changed when checked. The elimination of the "Production Map" filling-in sheet was considered, it was proposed to use the computer with the program connected (Joobs cartel) to Power BI, in order for the data to be disclosed reliably and quickly (figure 34 and 35).

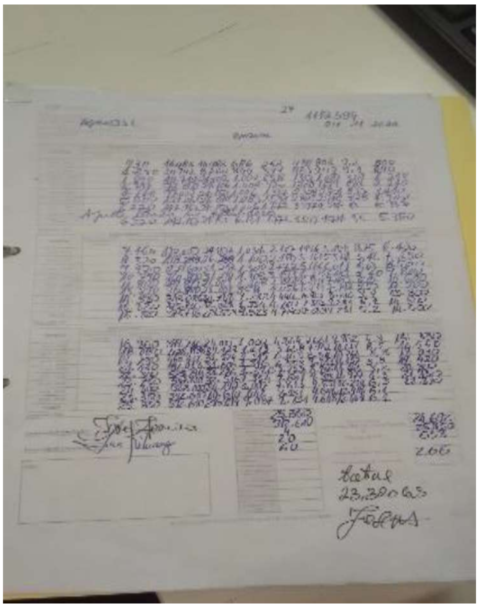

Figure 33 - Production data filling document.

Figure 34 - Joobs Cartel app

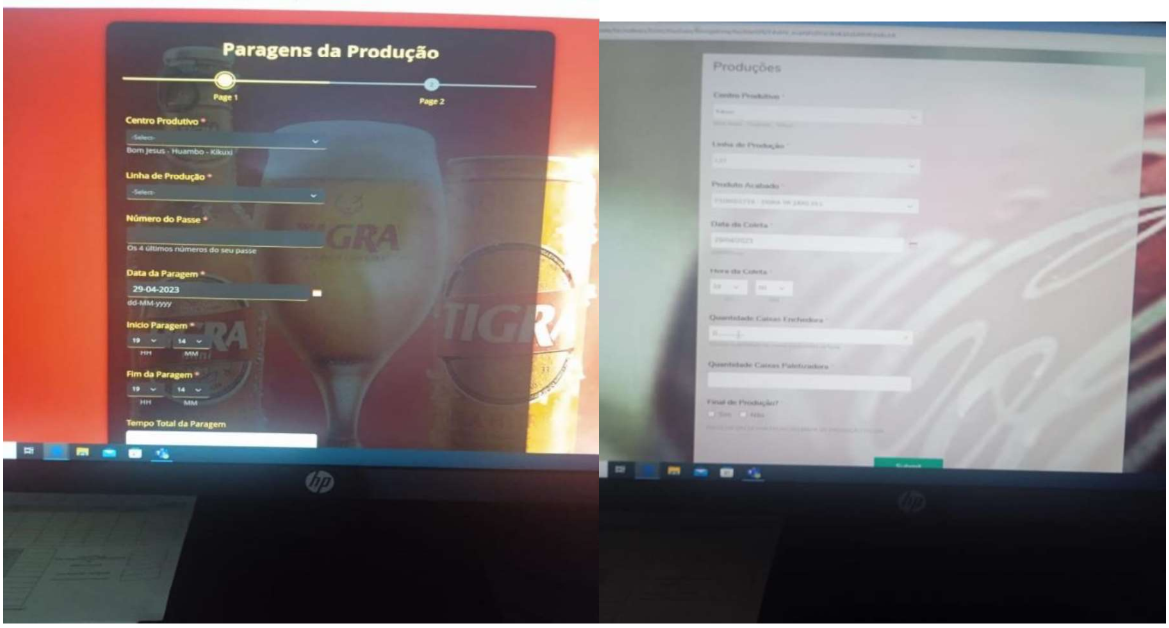

Figure 35 - Joobs Cartel application for filling in production data.

6. CONCLUSION AND RECOMMENDATIONS

The first phase of the project was the analysis of the production process of line 27, in order to know the entire production line from where it starts to where it ends. Then the problems were identified, with a view to reducing waste and the occurrence of breakdowns (factors affecting efficiency), therefore, lean concepts were applied, in order to optimize the operational performance of line 27.

With the presentation of the problem, quality tools were used to solve the problems or factors that affected the efficiency of the line, to minimize or eliminate the occurrences of constant failures in the equipment that presented more failure times, such as; the crater and degrader, the labeller, the bottle washer and the conveyors. Constant breakdowns occurred due to lack of preventive maintenance control, according to maintenance technicians and production operators, a large part of the stoppages and equipment breakdowns on the production line were due to lack of preventive maintenance, because since the line was assembled they only made interventions after the breakage of a piece of equipment or part. Having identified the points most affected by lack of maintenance, the Ishikawa diagram, the GUT matrix and the 5W2H methodology were taken as a starting point. Improvement actions were then implemented, in terms of breakdowns, wasted time, unskilled labor, stoppage and production control, preventive maintenance planning, standardization of activities, 5s and Kanban.

Taking into account the objectives outlined, with the improvement actions, it was possible to obtain results from all the actions implemented, during the practical work at the Refriango's company and the main objective was fulfilled, which consists of identifying the factors that affected the operational efficiency, and through troubleshooting tools eliminate waste and increase the operational performance of the L27. In this way, there was a significant increase of 8.82% in efficiency compared to the month of January before the improvement actions, which presented 55.63%, while in February, after the improvement actions, it presented 64.45%. The results are satisfactory, having contributed positively to the company's needs in increasing the efficiency of line 27.

Within the scope of improvements, emphasis is placed on training line operators to comply with the production plan, qualification and skill in operating machines and simplifying the filling in of legible letters on the production map. Also noteworthy is the implementation of the Gemba Walk, in order to promote continuous improvement, being an added value for the company, and could serve as an example in the implementation of other production lines of the company.

- ✓ The implementation of Power BI on line 27 was fundamental in assessing the quality of the process and task performance. It was suggested that they be implemented in other lines of the factory.
- ✓ The training given to production operators on line 27 was fundamental for increasing efficiency and organization on the line, I suggest that production operators on other lines have this training.
- ✓ In order for occurrences or production data to be released quickly, it is also suggested that other lines have a computer close to the filler
- ✓ The technicians traveling in search of their bags or looking for tools in their colleague's tool bags made them waste time fixing the faults. I suggest that in other lines there was a tool bag in every two machines as proposed for the line 27
- ✓ And finally, a Gemba Walk was suggested, which consists of a walk through the factory floor on line 27 from the depalletizer to the palletizer, in order to always identify problems such as non-compliance with production activities, wasted time, long-term breakdowns, organization, lack of mastery of machines and security. It was decided that the walk around the factory floor and the frequency of this analysis would be weekly, and could be carried out by the assistant to the production manager, with the main focus being to verify compliance with production activities, the relationship between the production operator and the equipment, safety, possible breakdowns, organization and the constant promotion of continuous improvement. What is intended with the implementation of this methodology is to observe with one's own eyes and immediately report to production and maintenance managers. The Gemba Walk report will be communicated at the shift meetings and the respective improvements will also be proposed there.

7. SUMMARY

This research aimed to identify the factors that were affecting the operational efficiency of line 27, with the implementation of lean manufacturing through quality tools (Ishikawa, Matriz GUT and 5W2H), as well as the implementation of improvement opportunities to reduce or eliminate these factors. that made efficiency and waste elimination unfeasible. The practical work was carried out in one of the largest companies in Angola (Refriango Industry and General Commerce), from January 1st to March 31st, 2023 and involved bibliographical research; Characterization of the production line; Interviews with production and maintenance employees; Identification of mechanical processes that add value to the line and Assessment of the need for operational improvement of the line. In order to characterize the production line, a technical evaluation of the production process was carried out, from where it starts to where it ends. An interview (Annex) was made with the employees of the production area, they were interviewed; the line manager, line heads, and line production operators. And in the maintenance area were interviewed; the maintenance manager, the shift coordinator and the maintenance technicians, in order to first understand the process and the problems that the line presented.

In order to identify the causes that may be at the origin of this problems, the Ishikawa diagram was used, this was prepared with the help of production operators and maintenance technicians, with the objective of improving the operational efficiency of the line. The 6 M were addressed, considering the causes at the level of the production operators, that is, the method of operation and the time that maintenance technicians took to solve the faults. Causes were identified at the material level, such as the poor condition of the pallets, problems related to the environment and measures, problems related to the method of solving faults, problems at the machine level, such as problems with the bottle washer, filler, degrader and crater, and on conveyors. There was a two-week stoppage for maintenance, with the intention of eliminating all the problems or failures that the line presented as the main causes of the low efficiency of the line and finally it became clear that the periodic maintenance of the line equipment (preventive maintenance) should be done to prevent such situations of equipment breakage from happening again, therefore, it is about maintenance on the crater and degrader, on the mats, bottle washer and labeller. To assess the need for operational improvement, opportunities for improvement were identified and improvement actions were implemented, such as; implementation of the production control application (Power BI), training of production operators and planning of preventive maintenance to increase productivity, reduce costs and improve product quality.

Line 27 is a line that produces Tigra beer, it is a glass line, that is, glass containers. The line's production process starts at the depalletizer and ends at the palletizer. There are three shifts with 19 employees per shift, that is, 11 employees operating the machines, 2 line managers supervising production, 2 maintenance technicians available on the line, 4 cleaning technicians, 2 cleaning the dry part and 2 cleaning the wet part. The line is managed by a production manager and a maintenance manager and is equipped with two labelers instead of the one that is standard on a production line. Taking as a starting point the application of quality tools (Ishikawa Diagram, GUT Matrix, and 5W2H), the factors that affected operational performance were identified, using the Ishikawa diagram, and according to the analysis the main factors were; untrained staff, waste of time, lack of standardization of activities, poor state of pallets, production operators cleaning while operating, poor compliance with the production plan, delay in resolving faults, lack of preventive maintenance, bottle breakages constants in the crater and degrader, lack of synchrony of the servomotors, bottles coming out of the washer with labels (clogged showers, warped and damaged wheels) and jamming of the conveyor chains. After the previous analysis, the causes with the highest rates were visualized, that is, the problems with the greatest urgency, severity and trend. In an evaluation from 1 to 5, in which the values are evaluated in a table on Severity, Urgency and Tendency. The table is schematically shown with values attributed to the previously identified causes. Therefore, those with the highest priorities were quickly checked, so that actions can be implemented to resolve issues. The factors were presented in a graph, the factors with the highest resolution priorities were; untrained personnel (operators take turns between the machines), constant breakage of bottles in the crater and degrader, servomotors out of s synchrony, bottles leaving the washer with labels (clogged showers, warped and damaged wheels), locking of conveyor chains, lack of standardization of activities, poor state of pallets, lack of control and preventive maintenance. The 5W2H tool was used to create an action plan to solve the root cause that was found through analyzes already made with the later tools. Since most of the causes found that influence the low level of production came from equipment malfunction due to lack of preventive maintenance, the root causes of the GUT matrix were selected, based on the Ishikawa diagram. After two weeks suggested for line maintenance, in equipment (which had constant failures, with long stops) and the implementation of improvement actions, an analysis of results was carried out between the months of January and February, considering data from January before the stoppage, for equipment maintenance (January 1st to 24th) used as a comparison. The increase in operational efficiency is also one of the main objectives of this work, firstly presenting the efficiency values before the general maintenance of line 27 (prodution line number 27), to verify if there has been

a comparative increase since the day that line started to turn, that is, (February 26th) after the implementation of improvement actions (maintenance, standardization of activities, training of production operators on line 27, stop and production control, elimination of wasted time), then efficiency values will be presented, to conclude whether there was a change in efficiency, in relation to the efficiency value before the improvement actions. With the presentation of the percentage values of efficiency before and after the shutdown and implementation of improvement actions, it was found that there was indeed a percentage increase on 01/27/2023 of 8.82% in approximately 1 month. Since, the percentage value of efficiency before the implementation of improvement actions was 55.63% while after the implementation of improvement actions, 64.45% of operational efficiency was obtained.
With the presentation of these results, what is desired is to comply with the preventive maintenance plan, the production activities, the proposed improvement actions, to reduce or eliminate the problems that may affect production and so that the efficiency of the line 27 is always maintained with the percentage increase in operational efficiency.

Keyword: Lean implementation, quality tools, improvement actions, Operational efficiency

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ANNEXES

Figures

(Refriango, 2023)

Figure 36 - Line 27 entrance.

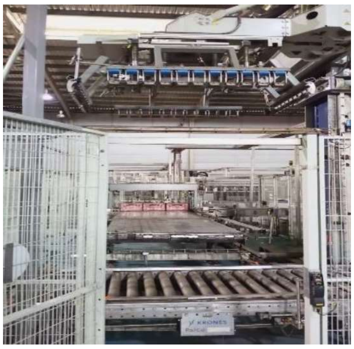

Figure 37 - Depalletizer.

Figure 38 - Degrader.

Figure 39 - box washer.

Figure 40 - bottle washer.

Figure 41 - empty bottle inspector.

Figure 42 - Filler.

Figure 43 - Full bottle inspector.

Figure 44 - Pasteurizer.

Figure 45 - Labeler 1 and labeler 2.

Figure 46 - Crater.

Figure 47 - palletizer.

Figure 48 - Output of full boxes on the crater.

Figure 49 - Bottles filled to desired level.

Figure 50 - Full bottles at the entrance to the Pasteurizer.

Figure 51 - Cleaning the washer filters.

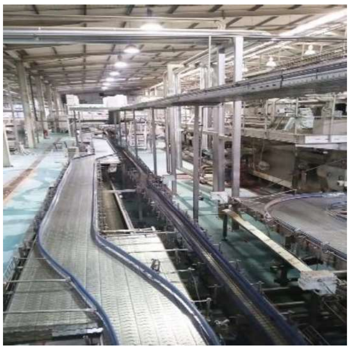

Figure 52 - Work zone.

Figure 53 - Empty bottles on conveyor.

Figure 54 - Poor condition of the pallet.

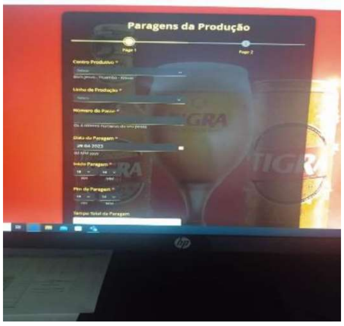

Figure 55 - Joobs at cartel program.

Figure 56 - computer with Joobs at cartel.

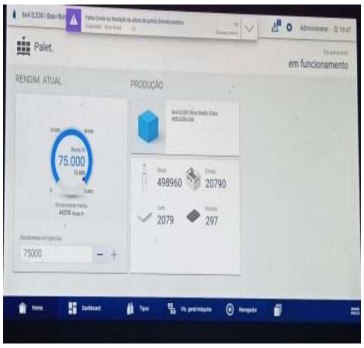

Figure 57 - Palletizer production registration panel.

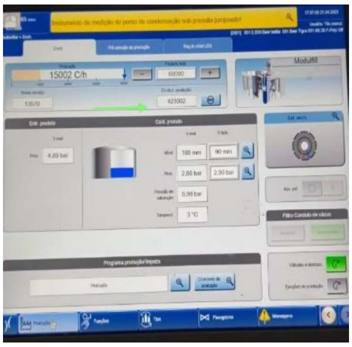

Figure 58 - Filler production register panel.

Figure 59 - 5s in the parts warehouse

Figure 60 - After visual marking on the warehouse floor.

Figure 61 - Before visual marking on the warehouse floor.

Figure 62 - Before mold cart standardization.

Figure 63 - After mold cart standardization.

Figure 64 - After visual marking of pallets and pallet trucks on the line.

Figure 65 - Before visual marking of pallets and pallet trucks on the line.

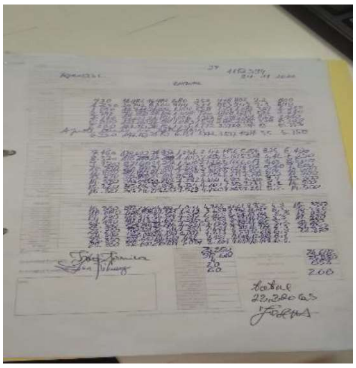

Figure 66 - Production map.

Figure 67 - Filter of the first, second and third bath of the washer.

Figure 68 - Zebra Visual Marking.

Figure 69 - Box center.

Figure 70 - Last shower pressure sensor.

Figure 71 - conveyor roller.

Figure 72 - Maintenance at the outlet of the bottle washer.

Figure 73 - bottle conveyor.

Figure 74 - Servo-motor

Preliminary evaluation of the production process on line 27

Interview

1. Where does the production process start and end?
2. What kind of tool does the company use to assess process quality and task performance?
3. What are the main activities of the sector?
4. What is the level of compliance with the production plan?
5. What is the main difficulty in executing the production plan?
6. What kind of maintenance has the company been doing on the line?
7. What are the machines with the most breakdowns?
8. How are occurrences of failures reported?
9. How long does it take for technicians to show up at the breakdown site?
10. How are technicians notified about a breakdown?
11. About the efficiency of solving a breakdown, what is the evaluation that you would give to the maintenance technicians?
12. What are the most frequent breakdowns on the line?
13. How are line maintenance plans made?
14. Is there a maintenance control on the line?

Proforma Invoices

BARBOT Angola

ORIGINAL

Barbot (Angola) Indústria de Tintas, Lda.
Rua Cónego Manuel das Neves, 53, Luanda
REPÚBLICA DE ANGOLA
Contribuinte : 5403094334
Telefone : 921199998
Email : barbot.angola@gmail.com
Loja Via Exp
Telefone : 931788607
Email : viaexpresso.barbotangola@gmail.com

Documento	
FATURA PRÓ-FORMA	
Data	Número
2023-05-08	OR 108 / 005160

Número Cliente 00089999
Nº Contribuinte
Vendedor 0026
Desconto Global 0,00%
Página 1/1

SR. FELICIANO
LUANDA

Este documento nao serve de factura

Moeda AOA

Código	Descrição	Quantidade	Uni	Preço Unit.	%Desc	IVA	Valor
1 1302 985 15	BARBOMAT COR ***TR EMB. 15 L RAL 3020 VERMELHO	1,00	Uni	172 960,00	30,00	14,00	121 072,00
1 1330 983 15	DIOPLASTE COR*** D EMB. 15L 309 CINZA POMBO	1,00	Uni	119 550,00	30,00	14,00	83 685,00
1 1302 985 15	BARBOMAT COR ***TR EMB. 15 L 737 AMARELO GIRRASSOL	1,00	Uni	172 960,00	30,00	14,00	121 072,00
1 9220 099 30	FITA TESA LISA 38*50mm	2,00	Uni	5 022,00	30,00	14,00	7 030,80

Código	Descrição	Taxa	Incidência	Valor Iva
4	NORMAL	14,00	332 859,80	46 600,37

Total Iliquido	Descontos	Valor IVA
475 514,00	142 654,20	46 600,37
	Total AOA	379 460,17

Operador : *Loja Via Expresso*

CONTA A CREDITAR EM NOME DE: BARBOT (ANGOLA) - INDÚSTRIA DE TINTAS, LDA

BIR	33652210001	AO06 0067 0000 0033 6522 1017 1
VALOR	19588010001	AO06 0062 0000 0019 5880 1012 6
BAI	18454462 10 001	AO06 0040 0000 1845 4462 1015 0
Atlântico	96406487 10 001	AO06 0055 0000 9640 6487 1014 9
BFA	2498853830001	AO06 0006 0000 2498 8538 3018 8
BIC	11074755515001	AO06 0051 0000 1074 7555 1511 1
Finibanco	208932 10 001	AO06 0058 0000 0020 8932 1017 1

Emitido por programa validado n. 197/AGT/2019 ERP_BARBOT.2013A/Barbot Angola

(Proposta válida por 7 dias)

Toolkit proposed by the company for the production line