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Productivity Increase in Peruvian Chemical SMEs: A Proposal with 5S, SLP, and TPM Tools

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Abstract* – In the current context, efficiency is crucial for small and medium-sized enterprises (SMEs), driven by an increase in demand that forces them to remain competitive. Throughout 2022, the chemical products sector experienced a notable growth of 16.2% compared to 2020. The lack of organization in the facilities, downtime, and the production of products that do not meet quality standards negatively impact productivity and lead to economic losses. Therefore, engineering tools can provide numerous advantages that will be key to gradually improving the high levels of non-compliance in order deliveries to customers. The main objective of this study is to improve productivity by using SLP and TPM tools, identifying critical factors such as the presence of damaged products (29%), products delivered that were not requested (24%), poor warehouse layout (19%), and machine breakdowns (15%). Additionally, the 5S methodologies were implemented to improve order and cleanliness (13%), which the company currently lacks. The model proposed in this research is based on the implementation of these methodologies and tools (5S, SLP, and TPM), aiming to increase the efficiency of the production process, reduce downtime, and decrease the proportion of products that do not meet quality standards. As a result, this model increases productivity by reducing travel time to a maximum of 20 minutes. It is concluded that this method can be applied in other scenarios and help close the gap between current and desired efficiency levels.

***Keywords* – 5S, Productivity, SLP, SMEs, TPM**

I. INTRODUCTION

A small chemical company analyzed in this case study shows a decline in demand fulfillment from 2021 to 2022, reflected in an annual loss of 8.1% in sales value. Within the chemical industry landscape in Peru, significant diversity is revealed through an extensive network of manufacturing facilities covering a wide range of categories, such as chemical compounds, basic chemicals, fertilizers, pesticides, synthetic polymers, coatings, personal hygiene products, rubber items, and plastic products. This heterogeneity reflects the multifaceted and omnipresent importance of the chemical industry in daily life and key economic sectors. In particular, the category of industrial chemicals experienced a notable increase of 16.2%, highlighting a significant average growth of 0.9% annually for basic chemicals, with an upward trend [1].

These figures offer a glimpse into the resilience and adaptability of the chemical industry in the face of changing circumstances. Various researchers have focused on workers' perceptions of the application of Lean Manufacturing tools when analyzing their implementation. The introduction of these tools has led to increased staff performance and higher job satisfaction in the workplace [2]. Furthermore, the significant reduction in cycle times and machine setup times through the incorporation of techniques such as 5S and VSM has substantially contributed to productivity improvements in companies applying them, thus emphasizing the importance of establishing and maintaining good practices related to 5S [3]. Additionally, the need to measure and evaluate the implementation of these practices to ensure their effectiveness and benefits is emphasized. It is important to highlight the crucial role manufacturing companies play in job creation and growth in Latin America [4]. The implementation of the SLP method has proven to be a highly effective tool for boosting production [5]. Concrete examples of its success include reducing production times, decreasing defective product rates from 7% to 2.84%, and a significant 24% increase in productivity, thus demonstrating the tangible benefits derived from adopting these efficient practices in the manufacturing sector [6]. On the other hand, different distribution models have been validated through the CRAFT tool, optimizing the flow of materials and personnel to increase production and determine the most suitable model for the plant [7].

Consequently, the impetus behind this research lies in the aspiration to improve the operational efficiency of the company, with the goal of effectively addressing all forecasted demand and reducing both downtime and the presence of defective products. Specifically, in the context of our company of interest, this challenge represents 21% of the demand that has not been met, highlighting the importance of applying industrial engineering tools to strengthen its position in the market [8]. Obstacles affecting the effectiveness and quality of the solvent production process have been identified, and the implementation of continuous improvement tools such as 5S, SLP, and TPM has been proposed. The analytical techniques used included the use of Pareto charts and the problem tree, followed by the 5 Whys methodology to identify the problems and their root causes [9]. Improvements have been proposed to optimize the production process and increase productivity, addressing aspects such as reducing downtime, improving machine efficiency, optimizing production processes, and reducing costs. The ultimate goal is to implement these improvements and evaluate their results to determine their effectiveness in enhancing the production process and overall company productivity [10].

This study begins with an introduction, which outlines the problem that motivates the research. Next, the scientific literature is reviewed, analyzing various relevant articles on the topic. Then, the justification for the contribution is presented, providing details on the tools used in the proposed improvement model. Finally, simulation validation is carried out, during which these tools are implemented, and their application is observed. In the first phase, the implementation of 5S, SLP, and TPM tools will focus on addressing and solving the identified issue related to low productivity. This phase will allow for the evaluation of the effectiveness and feasibility of these tools in the specific context of the company, paving the way for future phases of the study.

II. State of the Art

The main objective of this research is to propose improvements to increase efficiency in the production of solvents in a small and medium-sized enterprise, through the application of tools such as 5S, SLP, and TPM. To carry out this study, a thorough search and analysis of scientific articles was conducted using the research methods acquired throughout the course of the degree program. This allowed us to develop a detailed analysis based on the standards established by the research, supported by a solid scientific foundation.

The research began with a specific search for contributions related to inventory management challenges in manufacturing companies. From this point, research was conducted to identify the most common causes in this area, with the aim of finding the tools and solutions needed to effectively address the identified issues.

As a first typology the following was analyzed:

A. *Study of Indicators Using the Lean Warehousing Methodology*

The evaluation of supply chain performance in warehouses is a topic of great importance and complexity, addressed through various methods and models. The authors focus on the analysis of multicriteria methods and innovative tools aimed at the immediate evaluation of key indicators. These articles emphasize the importance of predictive analysis within the context of big data architecture.

In particular, one of the articles adopts a hybrid approach that combines methodologies such as BWM and QFD. This approach allows for the assessment of the maturity of wisdom and sustainability, evaluating the indicators studied in the article [11]. Together, they offer a deeper and more detailed understanding of performance evaluation, providing a conceptual framework that can be beneficial to both companies and the academic community.

Additionally, 5S is introduced as part of strategies aimed at reducing costs and minimizing waste (both time and materials invested), with the goal of improving service efficiency and optimizing patient safety, particularly in the pharmaceutical industry [12].

Finally, recommendations in Lean methods are extended. Tools such as One Minute Mold Exchange, Kaizen, 5S, and Value Stream Mapping (VSM) are used to reduce setup time and improve machine design and productivity [13]. Lean manufacturing models are proposed, including methods like 5S, SMED, TMP, and Jidoka, to effectively address the identified problems. These approaches provide concrete solutions to improve efficiency and productivity in the supply chain and manufacturing sectors.

As a second typology, the following is analyzed:

B. *Analysis of Work Strategy for Logistics Problems*

The evaluation of specific logistics problems involves the use of tools aimed at solving challenges in warehouse management, utilizing various methods and models. In this context, the articles combine stochastic optimization methods and machine learning models to determine the optimal size of the ABC region in natural stocks [14]. Specific programs are also used to perform annual operational simulations of specific processes in the warehouses of public service companies [15].

In the following article, computational experiments support the efficiency of the proposed algorithm. Additionally, the numerical studies presented in the seventh article highlight the importance of considering quantitative supply constraints when optimizing reorder points in multilevel systems, as neglecting this can result in high backorder costs and poor customer service [16].

On the other hand, the results demonstrate that the use of a hybrid model to address this issue reduces total costs by 8% and decreases product damage by 20%. Moreover, it highlights the potential savings of the proposed model, particularly in cases of high demand.

These articles were identified through SCOPUS and WOS, and they contribute to the academic knowledge at UPC by providing relevant information to address specific issues. This analysis has concluded on how to optimize inventory and warehouse management using 5S, SLP, and supporting tools, aiming to achieve adequate order levels and improve delivery efficiency to customers. Finally, a critical and comparative analysis was conducted for each of the 10 articles across all genres, confirming that these articles provide valuable support and seek effective solutions to the posed problems.

III. Methodology

A. *Explanation of the Model*

In this study, various methods, such as Situation Analysis (PSL) and the Deming Cycle, are applied to the field of industrial engineering, with a specific focus on the chemical industry. The process begins in the planning phase, where objectives are clearly defined, and detailed strategies are developed to achieve them. In this context, an in-depth analysis of the logistics processes is conducted, highlighting the identification of areas that require substantial improvements.

During the execution stage, the planned activities are implemented, and fundamental changes are introduced into the logistics processes. This involves careful resource allocation and detailed training for the relevant staff, ensuring the successful implementation of the proposed improvements.

The verification phase focuses on the collection and analysis of relevant data to assess the effectiveness of the logistics processes. Statistical tools and quality control methods are used to compare the obtained results with predefined objectives, allowing for the identification of deviations that require immediate corrective actions.

During the action phase, corrective measures are implemented to address the deficiencies identified during the review phase. The main goal is to optimize logistics processes and maximize operational efficiency. In addition to addressing the identified problems, preventive measures are adopted to address the root cause of the issues. Furthermore, efforts are made to standardize solutions, ensuring sustainable and lasting improvements in logistics. This comprehensive approach aims not only to correct existing deficiencies but also to prevent their recurrence and establish improved long-term practices.

B. Proposed Model

The structure of the study aligns with the design of the PDCA cycle (Plan, Do, Check, Act). In the Planning stage, an extensive investigation of the sector is conducted, exploring the Gross Domestic Product (GDP) and its environment. Additionally, a review of the state of the art is carried out through the analysis of research articles, categorizing them into four groups according to their contribution and impact on the research work. This phase concludes with the collection of historical data for subsequent analysis.

In the Implementation stage, a project study is conducted, reflected in the justification of the project and the definition of the proposed solution. This stage also incorporates the use of specific tools such as 5S, SLP, and TPM, which are essential for the effective execution of the project.

However, during the Verification phase, new calculations of supply metrics, such as OEE (Overall Equipment Efficiency) levels and DPMO (Defects Per Million Opportunities) values, will be carried out to make before-and-after comparisons. Additionally, an evaluation of the proposed method will be conducted to determine its effectiveness. This stage allows for the validation and assessment of the interventions made.

Concluding the cycle, in the Decision-Making phase, it is recommended to create a TPM (Total Productive Maintenance) component to identify potential improvements and record errors for effective tracking. This additional component provides a solid foundation for informed decision-making and the continuity of the improvements implemented. The adoption of this cyclical and systematic approach ensures not only the effective implementation of improvements but also the ability to continuously adjust and optimize processes in response to the results obtained and new opportunities identified (see Fig. 1).

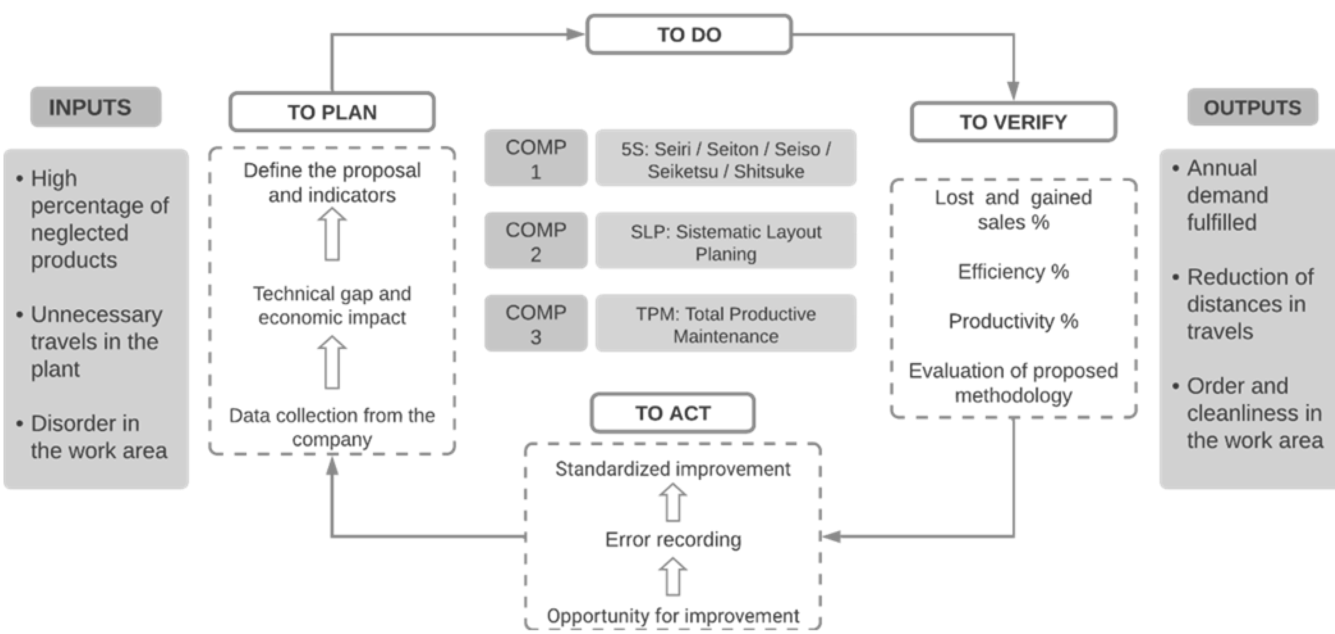

Fig. 1 Proposed Model

C. *Model Details*

The proposed solution to address the problem is based on a thorough analysis of the reviewed articles, with a crucial focus on evaluating the alignment of the tools according to their contribution. In this context, the detailed description of the model consists of three essential components. The first component refers to the 5S method, the second component is related to SLP, and the third component corresponds to TPM.

The 5S method, as the first component, focuses on organizing and ordering the work environment, establishing a setting conducive to efficiency and quality. The second component, SLP (Systematic Layout Planning), focuses on identifying and eliminating unnecessary processes, thereby optimizing resources and increasing operational effectiveness. Finally, the TPM (Total Productive Maintenance) component focuses on optimizing machinery and equipment, aiming to maximize performance and reduce downtime.

This tripartite approach provides a comprehensive strategy to address the identified problem, leveraging the strengths and synergies of each component. The careful selection and combination of these tools are based on a deep understanding of their impact and effectiveness, as evidenced by the analysis of the reviewed articles. This approach not only aims to resolve the current issue but also seeks to establish a solid foundation for sustainable and continuous improvements within the field of study.

1) Phase 1: 5S

The 5S methodology focuses on establishing an organized and safe work environment, aiming to improve quality and optimize productivity by organizing manufacturing processes efficiently and free from waste. The primary focus of this tool lies in creating a workspace that facilitates operational efficiency while ensuring safe conditions.

The main goal of this research is to explore how to achieve a functional and user-friendly way to eliminate non-value-added activities, while also improving safety, functionality, and productivity in a specific production cell. This involves identifying and eliminating redundant or unnecessary activities that do not contribute to the final product value, while seeking substantial improvements in safety and operational efficiency within the production cell in question.

The effective implementation of the 5S tool thus becomes a key factor in achieving a work environment that not only maximizes operational efficiency but also ensures safety and improves the quality of manufactured products. The combination of organization, waste elimination, and a focus on continuous improvement promoted by the 5S methodology contributes to creating a more effective and sustainable production environment.

2) Phase 2: SLP

SLP, as a tool, is presented as a valuable solution to address various challenges faced by small and medium-sized enterprises, such as inefficient workspace arrangement and the root causes of management problems.

Its core focus is on optimizing the layout of operations, encompassing the flow of materials, with the goal of increasing productivity by reducing the time spent by staff on these activities. The fundamental purpose of SLP is to achieve this goal through the minimization of waste, improvement of operational flow, and reduction of distances that materials and products must travel. This methodology demonstrates its versatility by being applicable in various contexts, from manufacturing environments and warehouses to distribution points. The planning of activities to implement this technique is based on previous research, such as that conducted by Silvestre et al.

Thus, SLP positions itself as a key tool to address inefficiencies in space arrangement and management, highlighting its ability to improve operational efficiency and optimize processes in different business environments. The adoption of this methodology is supported by previous studies, emphasizing the scientific and practical basis of its application.

3) Phase 3: TPM

TPM, known as Total Productive Maintenance, represents a Lean manufacturing strategy that focuses on optimizing the overall efficiency of the equipment used in production processes. Its main objective is to ensure the constant availability of the machinery, and its implementation methodology involves continuous improvements that lead to a reduction in losses. This approach not only seeks to maintain the machinery operating efficiently but also plays a crucial role in improving quality. TPM is configured as an essential initiative that supports the initiatives established to improve quality, such as Lean production [17].

TPM, by ensuring the availability and efficiency of machinery, helps reduce downtime, improve equipment reliability, and decrease defects in production. When integrated with Lean approaches, such as Lean production, it creates synergies that drive operational efficiency and product quality. The implementation of TPM not only translates into proactive maintenance of machinery but also aligns with broader goals of continuous improvement and operational excellence in the manufacturing environment.

IV. VALIDATION

After becoming familiar with the proposed model and its theoretical basis, the next step was to validate the provided explanations by comparing them with the initial diagnosis. This validation process was essential to verify the coherence and effectiveness of the model in relation to the initially identified situation. The aim was to assess how the suggested implementations have influenced the improvement of indicators and, ultimately, the optimization of the company's operational situation. The comparison between the initial state and the results obtained after applying the model allowed for the determination of the impact and effectiveness of the proposed interventions.

1) Phase 1: Organization, Cleaning, and Signage of the Plant

To validate the 5S methodology, the company's labeling area was chosen as the site for implementing the pilot model. This process began with an initial audit, followed by the application of all the steps of the tool detailed in the previous section.

Initially, a pilot model of the 5S methodology was executed in the selected plant, starting with the formation of a 5S committee and the implementation of a training plan. Subsequently, an initial 5S audit was conducted for the work area of each sealing machine, yielding an initial score of 43 points. Additionally, areas for improvement were identified based on the current state of the workspaces, highlighting non-conforming products, spills, and other unnecessary items on the worktable [18].

After cleaning and staff training, specific spaces were assigned for each item. To maintain this system, a verification checklist was implemented at the end of each workday, along with periodic audits to ensure the sustainability and effectiveness of the 5S approach. This integral process addresses not only the physical organization of the space but also the creation of sustainable habits and practices that contribute to continuous improvement in the labeling area (see Fig. 2).

Category	Item	Rating Level					Remarks
		L0	L1	L2	L3	L4	
Sort (Organization)	Distinguish between what is needed and not needed						
	Unneeded equipment, tools, furniture, and so on, are present						
	Unneeded items are on walls, bulletin boards, and so on						
	Items are present in aisles, stairways, corners, and so on						
	Unneeded inventory, supplies, arts, or materials are present						
	Safety hazards (water, oil, chemical, machines) exist						
Set in Order (Orderliness)	A place for everything and everything in its place						
	Correct places for items are not obvious						
	Items are not in their places						
	Aisles, workstations, equipment locations are not indicated						
	Items are not put away immediately after use						
	Height and quantity limits are not obvious						
Shine (Cleanliness)	Cleaning and looking for ways to keep it clean and organized						
	Floors, walls, stairs and surfaces are not free of dirt, oil, and grease						
	Equipment is not kept clean and free of dirt, oil, and grease						
	Cleaning materials are not easily accessible						
	Lines, labels, signs, and so on are not clean and unbroken						
	Other cleaning problems of any kind are present						
Standardize (Adherence)	Maintain and monitor the first three categories						
	Necessary information is not visible						
	All standards are not known and visible						
	Checklists don't exist for cleaning and maintenance jobs						
	All quantities and limits are not easily recognizable						
	How many items can't be located in 30 seconds?						
Sustain (Self-discipline)	Stick to the rules						
	How many workers have not had 5S training?						
	How many times, last week, was daily 5S not performed?						
	Number of times that personal belongings are not neatly stored						
	Number of times job aids are not available or up-to-date						
	Number of times, last week, daily 5S inspections not performed						
	TOTAL						

Number of Problems	Rating level
3 or more	Level 0 (L0)
3-4	Level 1 (L1)
2	Level 2 (L2)
1	Level 3 (L3)
None	Level 4 (L4)

Fig. 2 5S Diagnostic Checklist to be Examined in the Workplace.

2) Phase 2: Reorganization of the Plant

To validate this phase, a discrete variable simulation was carried out using Arena software. To process the data, a sample consisting of 1,500 time records taken during the travel between stations over the past three months was used. Additionally, it was ensured that the distributions were appropriate to meet the requirements of a robust statistical distribution through Arena's Input Analyzer. This comprehensive approach ensures an accurate and reliable representation of the variables under study, providing a solid foundation for validating the phase. The combination of discrete variable simulation and detailed analysis of the collected data contributes to the rigor and validity of the validation process [19].

Distributions were defined for the material arrival intervals in the "Arrival" section. On the other hand, each "Order" is characterized by specific statistical distributions, which are adjusted according to the type of order and the corresponding activity. Once the orders pass through each activity, the total time in the system is recorded.

For the initial validation, 40 executions were performed with a 95% confidence level, considering an 8-hour workday. This rigorous approach ensures the capture of variability and provides a solid base for evaluating the effectiveness of the system. Attention to the specifics of each attribute and consideration of multiple executions with a high confidence level strengthen the validity and reliability of the results obtained during the validation process [20].

With these times and the routing matrices, the goal is to find the best redistribution of the work areas to reduce the "TSystem" (total system time) by addressing unnecessary travel.

3) Phasse 3: TPM Validation

To validate the effectiveness of TPM, a pilot simulation was carried out to analyze variations in OEE (Overall Equipment Efficiency). This analysis began with meetings with senior management, followed by discussions on the improvement opportunities to be addressed.

- First Stage: Preparation

Management approved the implementation of TPM to reduce unplanned downtime through a maintenance plan and training for operators in pre-machine inspections. Informational campaigns were conducted through posters, and training sessions were scheduled, with the plant manager informing staff about the dates. A coordination committee was established, and responsible persons were appointed following a meeting with volunteers, setting policies, goals, and emphasizing the importance of indicators for evaluating performance in training sessions..

- Second Stage: Implementation

Introductory talks were held to help operators understand the importance of indicators and metrics, comparing them to global standards. This aimed to ensure that workers valued TPM and understood its impact on job performance, fostering their commitment to maintenance operations.

- Third Stage: Implementation

An initial inspection was carried out using an anomaly record form and a pre-inspection checklist for machinery. Identified anomalies were promptly addressed, and additional training was provided if discrepancies were found during inspections. Based on the data collected, a preventive maintenance plan was formulated, ensuring rigorous documentation management to comply with future procedures for machine cleaning, lubrication, and adjustment [21] (See Fig. 3).

MACHINE	JAN				FEB				MAR				APR				MAY				JUN				JUL				AUG				SEP				OCT				NOV				DEC			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
DISTILLER																	x																								x							
MIXER												x																								x												
PACKING				x				x				x				x				x				x				x				x				x				x				x				x

Fig. 3 TPM Schedule.

This thorough approach not only ensures accuracy in the system representation but also lays the foundation for a comprehensive evaluation of how the adoption of TPM influences operational efficiency. The valuable insights obtained through this simulation not only highlight the direct benefits in terms of efficiency and performance but also provide valuable information on potential areas for improvement and optimization. Ultimately, this comprehensive process contributes to informed decision-making, supported by data, regarding the implementation of TPM.

In order to compare and analyze the data obtained from both types of simulations implemented in the case study, the indicators used in the development of this research project through the implementation of Lean Manufacturing and SLP methodologies are first identified.

For the first indicator, the 5S Order and Cleanliness Index, the goal was to achieve 15% employee satisfaction with the order and cleanliness quality. The result achieved was 14.86% satisfaction. Although close to the target, further actions are needed to improve order and cleanliness in the workplace, which will increase employee satisfaction and improve productivity.

For the second indicator, the Space Reduction Index (SLP), the goal was to reduce unused space to 37%. As a result, a reduction of 38% was achieved, which is very close to the target. This demonstrates significant progress in optimizing the use of available space, improving operational efficiency.

Finally, for the third indicator, the Inefficient Equipment Index (TPM), the objective was to reduce the number of inefficient machines from 87.88% to 70%. With the application of the corresponding tool, the inefficient machines were reduced to 75%. Progress has been made in optimization, but continuous preventive and corrective maintenance actions are necessary to further reduce inefficient machines and improve their availability.

The structure of the study aligns with the design of the PDCA cycle (Plan, Do, Check, Act). In the Planning phase, an in-depth investigation of the sector is conducted, exploring Gross Domestic Product (GDP) and its environment. Additionally, a review of the state of the art is carried out by reviewing research articles, which are classified into four categories based on their contribution and impact on the research work. This phase concludes with the collection of historical data for subsequent analysis.

To evaluate the economic viability of the proposal, a cash flow analysis over a 12-month period will be conducted.

In preparing the economic cash flow, the following aspects were considered:

- The company's monthly average revenue is S/. 150,000.00.
- An annual revenue increase of 2.5% is estimated, based on sector growth.
- The monthly revenue increase was evenly distributed over the 12 months, at a rate of 0.2% per month.
- The income tax rate is 29.5% starting from 2022.
- The income generated from the proposal's implementation will be included in the cash flow calculation.

- Month 0 is considered the start of the proposal's implementation.

To calculate the Opportunity Cost of Capital (COK), the following formula was used:

$$COK = rf + \beta proy \times [rm - rf] + riesgo\ país \quad (1)$$

Using the equation (1), COK is 29.59% by year. The initial investment is S/. 28,000.00, with an interest rate of 22%. Based on this, the Net Present Value (NPV), Internal Rate of Return (IRR), and Return on Investment (ROI) of the project will be evaluated. The project will be assessed approximately over 12 months.

By using the annual revenues, annual costs, administrative expenses, and sales expenses, the gross profit and operating profit are calculated to develop the economic cash flow.

As a result, the Net Present Value (NPV) is S/. 102,878.33, and the Return on Investment (ROI) is approximately 368.85%. This suggests that the project is viable and profitable, as the NPV is positive and the ROI is significantly high.

The calculation of the RBC comes from the NPV and the flow, which is 6.21, greater than 1, therefore, it is viable. The calculation of the Payback Period (PDR) comes from the projected economic cash flow divided by the normal flow, which gives 2.31, indicating that the company will recover its investment in the next 2 months with some additional days.

Overall, the financial results are positive and suggest that the project is viable and profitable from a financial perspective. The positive NPV indicates that net cash flows would be generated over time, the IRR suggests the investment would generate a return higher than the cost of financing, and the ROI shows a significant return on the initial investment. However, it is important to consider other factors such as risks, market, competition, and operational factors for a complete evaluation of the project's viability.

The implementation of the 5S, SLP and TPM tools has generated various positive impacts in the environmental, social, and economic areas of the company under study. Environmentally, there has been a significant reduction in hazardous and non-hazardous waste due to improved organization and cleaning of the work area, particularly reducing waste generated from spills and leaks. Moreover, the implementation of control measures in processes has contributed to a reduction in particulate matter generation, thereby minimizing the emission of polluting particles into the air. Proper cleaning of the machines has also optimized the use of water resources, reducing both water consumption and contaminant discharge.

From a social perspective, working conditions have improved significantly. The implementation of these tools has created a safer and healthier work environment for operators, substantially reducing the risk of accidents and occupational diseases. This organization and order in the work area have also contributed to a better work climate, increasing motivation and employee commitment. As a result, productivity has increased, allowing for higher production and reduced delivery times, which translates into higher revenues for the company.

Regarding product quality, cost reductions have been evident. The reduction in waste, optimization of resource use, and improved efficiency have generated significant savings for the company. Product quality has significantly improved, reducing costs associated with rework and waste. Additionally, the implementation of these tools has increased the company's competitiveness, improving its market image thanks to the adoption of sustainable and responsible practices.

V. DISCUSSION

The study yielded interesting results that indicate the metrics based on the literature [22]-[24] fall within acceptable ranges. At the start of the implementation, several problems and a lack of significant commitment from the selected operators were identified. However, the results reflect an average where the percentages are relatively optimal, and others fall within the acceptable range, as indicated by the aforementioned authors.

Initially, the case study identified five significant problems, which were divided in such a way that they could be addressed using the three implemented tools. The most significant issue found was the presence of defective products, along with products that were not as requested, and the disorder in the warehouse and poorly utilized spaces. These issues were resolved with the implementation of the 5S methodology, with the main indicator being the order and cleanliness index, as this is the primary reason to eliminate poor results.

It is noted that the index improved from 14% to 14.9%, being just 0.1% short of the expected result, which indicates that although a good result was achieved, further improvements can still be made as the methodology continues to be applied.

Finally, it is recommended to maintain and enhance training programs, as well as conduct regular audits (weekly, bi-weekly, and monthly). It is essential to seek new ways to raise employee morale and commitment to improve their daily performance. Continuous monitoring of competitors will allow the company to quickly adapt to market trends and changes, enhancing its competitiveness.

To optimize efficiency and coordination, it is recommended to strengthen internal communication and assign department heads within the company. This will help establish clear leadership and avoid errors in information transmission, improving coordination in the production of synthetic thinner. Additionally, it is crucial to pay special attention to the application of the 5S technique to maintain cleanliness and order in the main work areas, which is essential for the success and continuous improvement of operational processes.

VI. Conclusion

A proposal for productivity improvement was developed using tools such as 5S, SLP, and TPM, with the goal of reducing unnecessary travel and decreasing the high percentage of non-conforming products on the company's main production line. A pilot validation and simulation were subsequently carried out, yielding positive results in the desired indicators. The proposed model improved the indicators related to each component.

The main issue—defective products, along with products that were not requested and disorganization in the warehouse—was stabilized by applying the 5S methodology. It was evaluated through training and audits, resulting in an improvement of 4.2 points compared to the initial value. This tool provides a clear reference for improving processes in the chemical company, demonstrating its effectiveness in optimizing and standardizing operations.

The long travel distances were resolved with the implementation of SLP, achieving a reduction of 2 hours in the daily travel time by selecting the appropriate activities and linking them to the corresponding areas. After the simulation, a functional layout design was implemented, which significantly optimized operational efficiency.

Machine breakdowns in the filling machine were addressed using TPM, which showed a notable impact on our research by optimizing process efficiency, as well as the amount of resources used, including labor, work methods, and machinery. This approach significantly improved the overall performance of the studied company.

The reduction in the use of chemicals and preparation times has improved air quality and the pulmonary function of the staff. The company, aware of these effects, has implemented a comprehensive waste and discharge management plan, ensuring the proper and safe handling of hazardous waste and refrigerant liquids, protecting both the environment and its employees.

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