Increased productivity of storage and picking processes in a mass-consumption warehouse applying Lean Warehousing tools: A Research in Peru

Ernesto Figueroa-Rivera, BSc[1], Andres Bautista-Gonzales, BSc[1], Juan Quiroz-Flores, PhD[1]
[1]Facultad de Ingeniería, Programa de Ingeniería Industrial, Universidad Peruana de Ciencias Aplicadas, Lima, Perú,
u201515802@upc.edu.pe, u201511755@upc.edu.pe, pciijqui@upc.edu.pe

Abstract*– In recent years, the warehouse logistics sector in Peru has shown a considerable increase proportional to the country's economic growth, however, this increase in the sector has not been accompanied by large technological investments. This deficiency implies that logistics operators that provide warehousing service keep staff labor as their main resource, generating operational inefficiencies that lead to cost overruns and a low level of competitiveness. This research focuses on the application of tools of the lean warehouse methodology in a 3pl warehouse with the final objective of obtaining a continuous improvement model that optimizes the use of resources used in operational processes, reducing cost overruns related to excessive use of labor in the process of picking and storage. The model uses tools such as standardization through 5S, route optimization with SLP, reduction of rework through FEFO, and flow optimization with operator load balancing. The proposal was executed through pilots and simulations in the sand software, obtaining as results an increase in picking productivity by 26.7% and storage productivity by 33.8%.

***Keywords*-- Massive consume, picking, productivity, storage, Lean Warehousing.**

I. INTRODUCTION

Nowadays, the variations that occurred in the global economy and specifically in the systems of production and distribution of merchandise, have resulted in the change of logistics, which has become the impetus of industry and commerce. That is why logistics performance is the axis that directly affects the growth of the country, as much as it rises competitiveness it also increases opportunities locally, regionally, and globally. Logistics can connect consumers and companies with the local, regional and national, or international market, making it a critical component for the country's competitiveness and growth. Efficient logistics enables effective integration between economies. According to the World Bank (WB), activities that are framed in the logistics for foreign trade generate more than the US $ 4.3 billion each year, therefore, it is very important to understand the results through the biannual Logistics Performance Index (LPI) report [1].

The category of logistics operators is very important in Peru, logistics costs represent 13% of GDP. Worldwide, we are ranked 83rd, and logistics costs represent up to 34% of the value of the product [2]. That is why is important the correct use of tools and methods to reduce these costs.

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The tools and optimizations under the Lean methodology have been adopted by companies for a long time ago, in search of improving the efficiency and results of their operations. This is why Lean thinking is one of the most important philosophies in the business world. [3], [4], [5].

One of the main successful factors in the implementation of the Lean methodology is the reduction of waste, which consists on the use of activities that do not add value to the system under study. For this reason, the waste reduction has become a topic that has been widely discussed in logistics research [6]. Likewise, it has been seen that one of the main causes that cause the generation of non-added value is the poor coordination and lack of integration of the different activities that take part in the logistics chain [7]. The advantage of implementing the Lean methodology in warehouses is that any improvement in these operations will be reflected in the results of the logistic of the last links in the logistics chain [8]. Warehouses are usually seen as the source of activities that do not add value within the logistics chain, due to the critical processes that occur within them [9]. However, they are an important part of the logistics in any company. Within a warehouse, different processes and activities can be recognized, among which, the main ones are [10]: Receipt, storage, picking and dispatch.

Of these four main processes, the picking process can be highlighted as the most important. The improvement of this process can mean a great reduction of the costs of warehouse and therefore of the costs of the logistics chain. It is estimated that the cost of the picking process can be 65% of the total cost of warehouse operations [11]. That is why the productivity of the picking process is very important for the entire warehouse operation and its economic performance. But the efficiency of picking is directly related to the storage strategy used by the warehouse and the types of products to be dispatched [21]. For this reason, it can be inferred that the optimization of the storage method would lead to an improvement in the productivity of the picking process, reducing the number of meters traveled and the order preparation time. However, only few scientific investigations have focused on studying these two processes together [7]. This situation generates a motivation to carry out this research where we analyze the improvement of the productivity of the storage and picking processes in parallel, understanding the relationship that these two maintain within the operational flow of the warehouse, thus seeking the optimization of the operational flow to prepare orders. and the increase of the profitability of the warehouse.

This academic article is based on the implementation of the Lean Warehousing methodology through four tools, the content shown in this work consists of an introduction, state of the art, the contribution proposed in the research, the validation of the implementation, discussion and the observed conclusions.

II. Literature Review

A. *Warehouse management*

Correct warehouse management has to be based on the constant optimization of warehouse resources such as handling equipment, machinery, personnel and generating innovative solutions [10].

In the warehouse there are key decisions that have to be made to ensure its proper functioning. There are four fundamental decisions for a warehouse:

- Layout design: there are two considerations in the design of a warehouse. First, where the loading and unloading areas, cross-docking, aisles, storage area, etc. will be defined. And second, the designation of the picking location.
- Picking policies: the most common is when the picking operator walks or drives through the storage area to pick the products.
- Storage allocation policies: one of the most efficient ways of storing products in a warehouse is the reserve zone, where the reserve zone is differentiated from the picking zone.
- Routing policies: problems such as operator congestion in the corridors when more than one operator travels on the same route must be addressed. There are different models proposed for routes such as S-shape, meandering, U-shape, etc.

On the other hand, Silva refers that warehouse management should be summarized in two main variables: the correct allocation of storage and picking policies. [7] He explains that these two processes are fundamental for the correct management of the warehouse, since the fulfillment of orders, economic profitability and warehouse capacity depend on the management of these processes.

Van Gils explains that two priorities need to be taken into account for proper warehouse management: picking planning and the integration of storage and picking policies. Based on having multi-zone storage, he refers that the integration of policies would generate an optimization of both processes. [12]

B. *Lean Warehouse Methodology*

In recent years, there has been a growing interest in investigating the application of Lean Warehousing methodology in warehouses of different characteristics [10]. The need to reduce logistics costs has led warehouses to take measures to eliminate activities that do not generate value.

The term Lean Warehousing is relatively new in the literature and has been mainly aimed at reducing the level of waste in an organization [10]. According to Abushaikha Lean, Warehousing seeks to maximize the use of available resources and activities in a warehouse through the elimination of slack in the logistics system. They point out that Lean contributes significantly to cost reduction, staff productivity and achieving a higher level of service quality.

In the same line of waste reduction, Salhieh explains how Lean Manufacturing allows the identification and elimination of the 7 main wastes in an organization [6]:

- Excess inventory
- Transport
- Waiting
- Overproduction
- Over-processing
- Defects
- Ergonomics

This reduction of non-added value is of utmost importance in the context of global competition, which is becoming more and more aggressive and is constantly developing.

Likewise, Nofrimurti understands the Lean Warehousing methodology as a driver of the company's competitiveness, mainly increasing the productivity of processes and production per person. In an environment where technology scarce in an operation, and where the main resource is manpower, the application of Lean Warehousing is often crucial to ensure the effectiveness and efficiency of the warehouse. [5]

C. *Lean warehousing tools*

Lean Warehousing tools are nothing more than the adaptation of the tools applied in the Lean Manufacturing methodology [5]. Reis shows the different effects of Lean Warehousing tools in a warehouse operation [13]:

- Value Stream Mapping and Gemba - increase in available warehouse space.
- Balance Scorecard, 5S and process standardization - Increased order fulfillment and cycle time reduction. [23]
- SLP - optimization of material distribution and storage locations.

D. *Productivity improvement models in warehouses (success stories)*

Successful cases will be presented where the companies involved have a similar behavior than a distribution center of mass consumption products as the case under study. The objective is to validate the functionality of the material planning and error reduction tools proposed to solve the problem.

The first case is a study conducted by Pedro Marcos Palacios and Kevin Bonilla Ramirez with the company Atienda S.A.C called "Implementation of Lean Warehousing to Reduce the Level of Returns in a Distribution Company". In this case of the company Atienda S.A. where they achieved an increase in picking productivity by reducing their time from 5 hours to 3 hours, i.e., reduced 40% of the initial value. In addition, they used in their inventory management a FEFO system where they reduced 20% of products in poor condition. [19].

The second case is a paper published on October 10, 2012, by Felix Melchor Santos Lopez and Eulogio Guillermo Santos de la Cruz entitled "Practical application of BPM for the improvement of the picking subprocess in a logistics distribution center" where a proper BPM of the picking subprocess is performed where the operational key and strategic processes were correctly identified. It also provides important data for the understanding, scope, measurement and control of the sub-processes. [20]

The third case is a paper published on October 20, 2020 by Cristian Aranda, Makarena Ramos, Juan Quiroz and José Álvarez entitled "Proposal for improvement in the management of the productive process to increase profitability in an SME of confections applying lean tools". The results of the application of the Lean methodology were the reduction of the cycle time in an 8%, reprocesses were reduced by 10%. In addition, all costs were reduced by 11.2% in the first semester of application [29].

III. INNOVATIVE PROPOSAL

A. *Model Basis*

After reviewing the literature [15] [16] [17] [18] we defined the Lean Warehousing philosophy tools to be used for each of the identified causes that contribute to the problem of low productivity in the storage and picking processes.

The following is the analysis that shows the process of building the contribution and adding value based on the research of existing literature through the review of previous success stories, to define the scope and objectives to be set in this research. Problems concerning the lack of standardization of processes, low availability of machinery, high levels of waste and inefficient distribution or layout of the warehouse were investigated.

According to Veres in the case study "Implementation of the 5S methodology in an agro-industrial microenterprise", the 5'S tool helped in standardization, increased availability of machinery and eliminate waste [15]. The SLP tool according to Rabanal [16] and the FEFO tool according to Espinoza [17] will help us with the decrease of waste and proper distribution of the warehouse to optimize time, finally the OBC tool in the study "Implementation of adjusted tools in an automotive industry to improve productivity: a case study" will make a standardization in storage processes and increase the availability of machinery to reduce overtime [18].

The conclusion provided by the analysis shows that although there are cases where tools are applied under the Lean methodology in warehouses in other countries, the application of these tools in 3PL distribution centers of mass consumption products is very scarce and limited, especially in the implementation of sustainable improvements in countries of the region, reinforces the intention to improve the performance of this sector of the industry.

B. *Proposed model*

Figure 1 shows that the conceptual model of the proposal is focused on a continuous improvement system applying the Lean Warehousing methodology in a distribution center. This methodology is based on 3 sequential stages, which guarantee the standardization of work, elimination of waste, quality and safety of products and workers, process stability and increased productivity. This sequence will be adapted to the reality and variables of the case study through the application of tools to solve the causes that generate the identified problem.

C. *Model details*

The design of the model contemplates the implementation of the Lean Warehousing methodology with the tools that develop this improvement model. The proposal begins with the

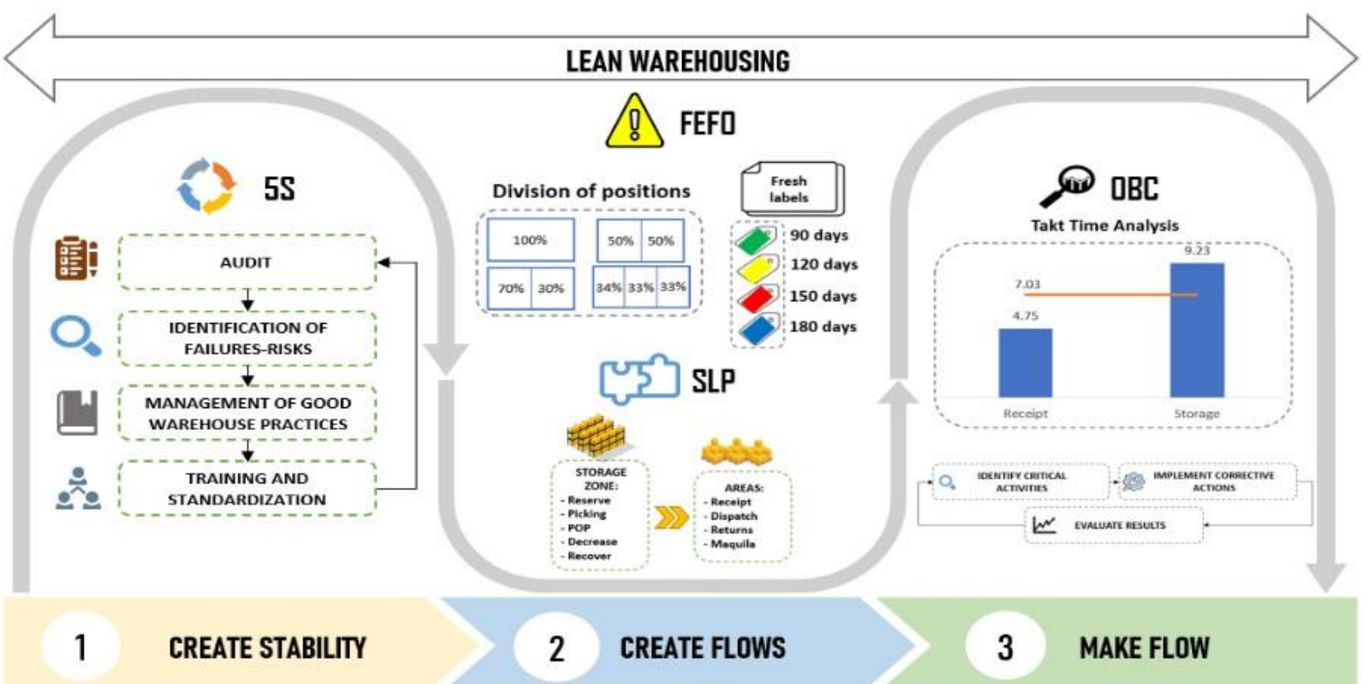

Figure 1: Proposed model

first stage of implementation entitled "Creating stability", here, the application of the 5S tool will be developed, and will establish guidelines for order and cleanliness in both administrative and operational areas for the use of tools, machinery and materials, where staff will be trained on the methodology and actions to be taken.

Then, there is the second stage called "Create flows" with a focus on standardization aligned to increase the productivity of the processes through the application of the tools "Systematic Layout Planning" (SLP) and "First Expires, First Out" (FEFO) with adaptations required for the case study. These two tools will reduce waste such as unnecessary routes, downtime and reprocessing.

Finally, the application continues with the third stage "Make flow" where not only waste is eliminated but also the process is shaped as required by the external and / or internal customer, for this purpose will apply the tool "Operator Balance Chart" (OBC) that will allow us to balance the workloads of operators and machinery to meet the requirements of the processes on time.

IV. VALIDATION

A. *Validation scenario*

The present research shows an optimization model which will be validated through the implementation of a pilot for the development of the 5S and OBC tools, and a simulation with Arena software for the implementation of the FEFO and SLP tools. First, for the development of the pilot model, the optimal sample number was calculated through an analysis, which resulted in a sample size of 2,435 repetitions equivalent to 1 month of operations to evaluate the results. Also, the simulation of the implementation of the FEFO and SLP tools is proposed through the evaluation of the picking process to observe the development of the process with the implemented improvements.

B. *Initial diagnosis*

The case study is a logistics company that provides 3PL services to organizations in different industrial sectors. This work is based on the warehousing and inventory management services offered to a company that produces mass consumption food products.

During the evaluation period on which this research is based, the company obtained as a result a gross margin of 2.99% for the mentioned operations, being well below the organizational target of 10%. An in-depth analysis was conducted to identify the main operating cost overruns that the company presents, noting that overtime costs are 79% above the budget for that period. In addition, it was found that the storage and picking processes concentrate 89% of the overtime generated in the warehouse, which represents 3.59% of sales.

From the analysis evidenced in the previous point, it can be inferred that there is a problem in the storage and picking processes that causes cost overruns in the operation. Therefore, we proceeded to evaluate the behavior of the productivity of each process, to observe the performance of these and compare them with similar optimal operations in the region, finding that the storage process is 27% below the expected productivity index [24], while the picking process is 44% below the optimum, concluding that the main problem that the company presents is the low performance of storage and picking processes, which is evidenced with a productivity index below the optimum in similar processes in the region.

After evaluating the productivities of both processes, an analysis of these was carried out by means of an Analysis of Added Value (AVA) matrix, which allows us to identify activities that present waste or add non-added value to the process under study. In addition, the Technique of Systematic Interrogation (TIS) was executed to identify unnecessary activities and possible opportunities for improvement. This analysis allowed us to identify 2 main reasons that generate the low level of productivity: inefficient picking management and excessive delays in storage activities. These two reasons are segregated into 3 main causes that generate them: 1. Lack of space in the pre-dispatch area, 2. Lack of stock according to the expiration date in the picking locations and 3. Low availability of machinery for the storage of merchandise.

The first main cause, has two root causes: the pre-dispatch area is occupied by materials and equipment poorly located and this area is occupied by pallets pending to be stored due to low availability of equipment, as evidenced in the third main cause. In order to attack these causes, the implementation of the 5S tool was devised to solve issues of order and cleanliness in the operational areas. The first audit conducted in the warehouse showed compliance of 71% and it is expected to obtain 100% after the implementation of the improvements.

The second main cause, has the following root causes: the WMS does not identify expiration dates greater than 90 days generating reprocesses in the picking routes and there is no reclassification of picking locations according to product rotation taking into account the days until the expiration date. The tools to eliminate these root causes are the FEFO and SLP tools. The first, will allow us to propose a reclassification of products in the picking positions to present the amount of merchandise needed according to the variables of expiration date and codes. Currently, 21.6% of picking runs are affected by incidents related to the expiration date. The second tool will be implemented to optimize the distances traveled between the storage areas and the reception and dispatch areas. It was identified that the average distance traveled in each order preparation is 548.2 meters.

The third main cause has the following root cause: The machinery is busy performing reception activities. This occurs because both processes use the same machinery, but the receiving process is a priority to use this resource. The implementation of the OBC tool is proposed to balance the workloads in these two processes and increase the availability of machinery for the storage process. Currently, overtime costs generated in the warehousing process represent 1.25% of sales. Table 1 shows in root cause analysis.

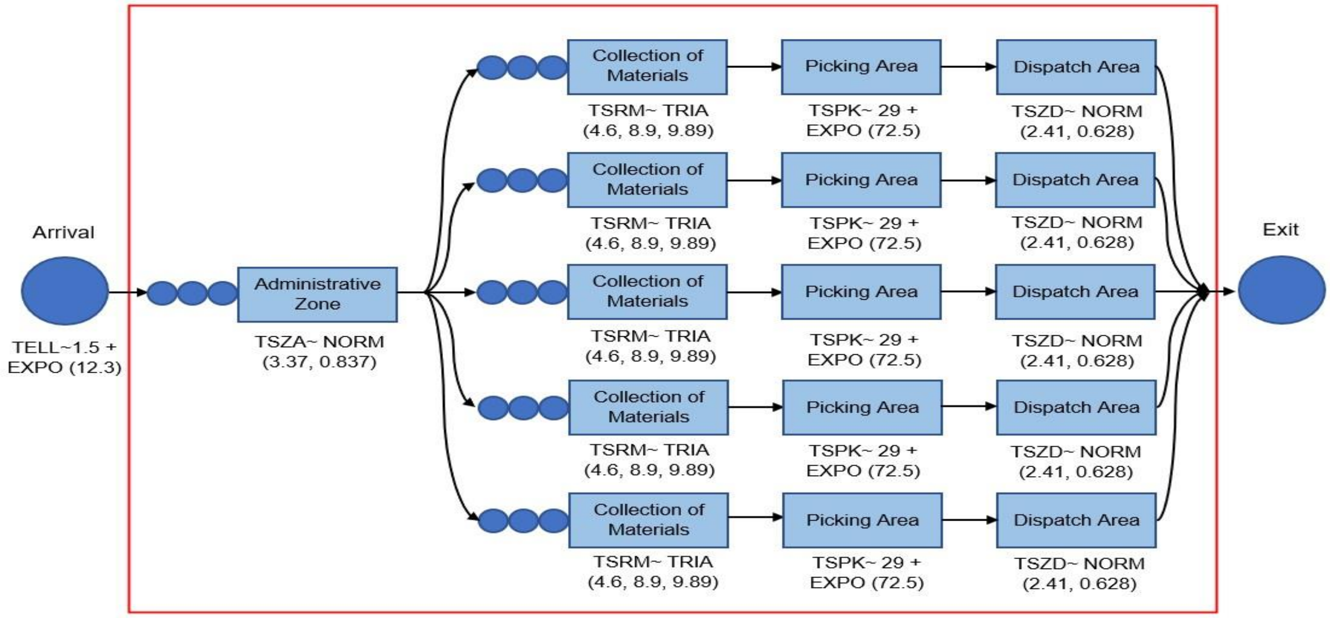

Figure 2: Graphical representation of the picking process model

TABLE I

ROOT CAUSE ANALYSIS.

CENTRAL PROBLEM: LOW PRODUCTIVITY IN STORAGE AND PICKING PROCESSES		
MOTIVES	CAUSES	INDICATORS
Inefficient picking management	Lack of space in the pre-dispatch area	5S Audit: 71% compliance
	Lack of stock by the due date in the picking bins	Incidences by expiration date: 21.6%
		Distance traveled in picking: 548.2 m
Excessive delays in storaging activities	Low availability of machinery for warehousing	Amount of overtime: 1.25% of sales

Finally, after having identified the root causes that provoke the main problem, we will proceed with the implementation of the proposed optimization model, in order to reduce and improve the results shown by the indicators in each cause.

C. Validation design

1) Preparation:

For the implementation of the model, it was necessary to communicate the proposal with the people who would be directly and indirectly involved in the project, explaining the changes to be made in the operational flows and obtaining the commitment of the workers to have their total disposition. A meeting was held, with the head of operations and the supervisor in charge of the warehouse, to support the implementation and have their support with the communication and direction of the staff.

Based on this, the implementation schedule was drawn up and the measurement indicators for the established objectives were presented. Table 2 shows the project indicators.

TABLE II

PROJECT INDICATORS

Indicator	Measurement	Current Value	Expected Value
Storage productivity	$\frac{Pallet}{H-H}$	6.5	8.6
Picking productivity	$\frac{Box}{H-H}$	101	131
5S Compliance	$\frac{Points\ obtained}{Total\ points}\%$	71%	100%
Incidents by the expiration date	$\frac{Incidences}{Total\ points}$	21.6%	0%
Picking distance travelled	Meters traveled	548.2	493.4
Storage overtime	$\frac{Overtime\ cost}{Sales}$	1.25%	0.44%

In addition, the graphical representation of the picking and adjustment process for the simulation was performed where the sample was taken randomly in a period of 12 months for each process to obtain the most suitable distribution for the simulation. [14]. Figure 2 shows the system representation for the simulation in the Arena Simulator software.

2) Implementation:

- Stage 1: Create stability

In this first stage, organization of the operation in the areas of order, cleanliness and organizational culture focused on waste reduction and continuous improvement are developed. In order to do this, the 5S tool is used, this tool identifies the actions that meet and do not meet the pillars of this methodology and proposes actions for improvement. Figure 3 shows the initial audit of the 5s tool.

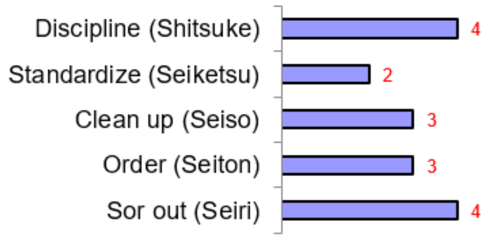

Figure 3: Checklist 5'S

The first audit conducted in the warehouse resulted in 16 points out of a possible 23, with a 71% participation.

There was evidence of the disorder that occurs in the warehouse when materials and equipment are left in different places, obstructing the flow of operations or delaying the activities being performed. Evidence of the clutter found in the warehouse is shown in Figures 4 and 5.

Figure 4: Manual transpallet and pallet out of place

Figure 5: Cluttered materials and pallets in an inappropriate location.

After the evaluation of the current situation, the responsible for each area of the warehouse were established with the purpose of involving the staff with the objectives of this implementation and generate an organizational culture that maintains order and cleanliness in the operational areas.

A tidiness and cleanliness checklist were implemented, which each person in charge has to complete at the beginning of his or her shift. Figure 6 shows the checklists developed to check the order and cleanliness of the areas.

CHECK LIST: ORDER AND CLEANING

DUTY MANAGER		DATE	
SUPERVISOR		HOUR	

ITEM	YES	NO
1. The floors are clean and without unnecessary materials.		
2. The roads are free.		
3. The machinery is in place.		
4. Each work tool is in its place.		
5. The canal area is free of materials or waste.		
6. The pallets are stacked correctly.		

Figure 6: Orde and cleaning checklist

In order to mitigate the clutter of key equipment and materials in the operation, we coordinated with the warehouse supervisor to establish specific locations where implements should be left when not in use.

It was established for equipment such as transpallets and electric lifts that when they were no longer being used during a shift, these should be parked at the height of door 2 of the warehouse and when the work shift ends signage was implemented on the floor for the parking of this equipment in the aisles between the racks. The materials, such as office supplies, should be left in the drawers that contain the established label so that these are located quickly. On the other hand, the pallets that are not being used should be stacked on the docks of reception and dispatch to not obstruct the flow of operations within the warehouse. Figures 7 and 8 show the designation of the parking area and the arrangement of tools and materials respectively.

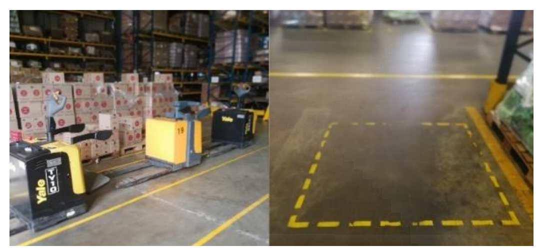

Figure 7: Equipment Parking

Figure 8: Arrangement of tools and materials.

Finally, new guidelines were established that the staff must follow to maintain the order and cleanliness of the warehouse over time in order to become an organizational culture based on discipline [25] [26]. The staff was trained and the commitment of each one of them was taken to carry out the new changes.

The evaluation was executed again by means of the checklist after one month of implementing the improvements, obtaining 23 points and 100% compliance. This accomplishes the completion of this first stage that will contribute to the main objective of improving productivity by ensuring the order of materials and essential equipment that allow fluidity in the processes of picking and storage. Figure 9 shows the final audit of the 5S tool.

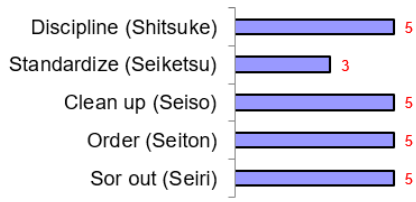

Figure 9: 5'S audit result

- Stage 2: Create flows

In this second stage, the standardization of flows and the elimination of waste in the operational processes of the warehouse is sought, that is why the implementation of FEFO and SLP tools for the optimization of the Picking process is carried out. This implementation was done by simulating the process in the Arena software, which allows us to analyze the impact of improvements in an optimal period of time.

First, the simulation of the current process with the variables that occur daily in the warehouse was performed, in order to observe the results of the current situation as analyzed in the diagnosis of the problem. For that, the taking of times was carried out for its analysis with the Input Analyzer software which allows us to identify the statistical distribution that presents the observed frequency; in addition, the conditions of the activities involved in the process and personnel variables such as work schedules, set up times, rest times and times used in other processes were compiled. Figure 10 shows the representation of the current situation in the Arena Simulator software.

Secondly, the improvement situation is estimated with the implementation of the FEFO and SLP tools, in which the assignment of picking items by each product family and days to expiration (freshness) is performed. Table 3 shows the assignment of picking items.

TABLE III
PICKING ITEM ASSIGNMENT

FAMILY	FRESHNESS	%	POSITIONS
CANDIES	90	9.42%	16.5
	120	11.40%	20.5
	150	0.26%	0.5
	180	3.78%	6.5
BATHED	90	12.43%	22.0
	120	7.77%	13.5
	150	0.18%	0.5
	180	3.89%	7.0
GUMS	90	3.46%	6.5
	120	6.46%	11.5
	150	0.24%	0.5
	180	2.07%	3.5

In addition, the new layout of the warehouse was made with the new distribution of the storage areas and channel area. The picking area was assigned in aisles 8 to 12 and the dispatch area in channels 24 to 39.

With the improvement situation established, the simulation was carried out to evaluate the new scenario where the process will be developed.

Finally, the simulation allowed us to demonstrate the improvements proposed theoretically in the previous analysis. The incidences presented in the picking by expiration date were reduced by 100% and the time to process order was reduced by 26% due to the decrease of the average distance traveled in each picking route, which implies an increase in the productivity of this process. Figure 11 shows the new layout developed to improve product storage.

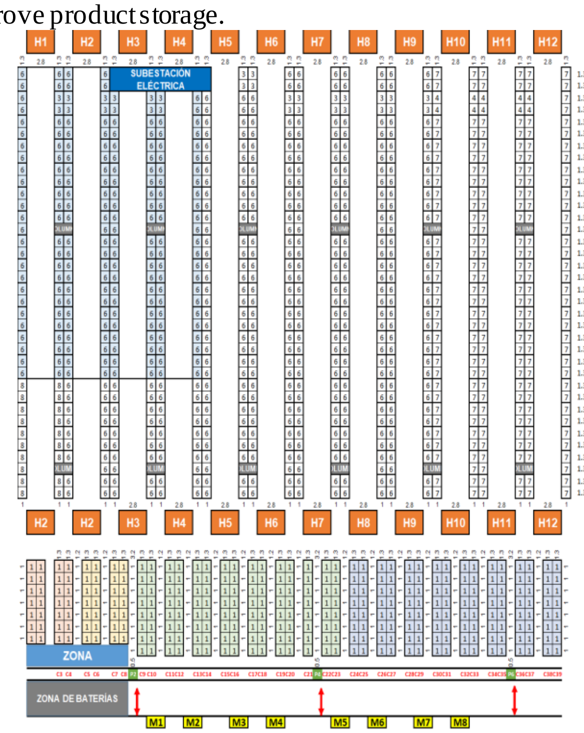

Figure 11: New Lay Out

- Stage 3: Make it flow

In this third and final stage, the aim is to ensure that the warehouse operation flows according to the customer's needs, optimizing existing resources to improve performance. For this purpose, a balance of workloads of the machinery used between the processes of reception and storage is performed by implementing the OBC tool. First, the critical activities are identified in each of the processes reviewed by means of the Process Activity Diagram (PAD) which allows us to visualize

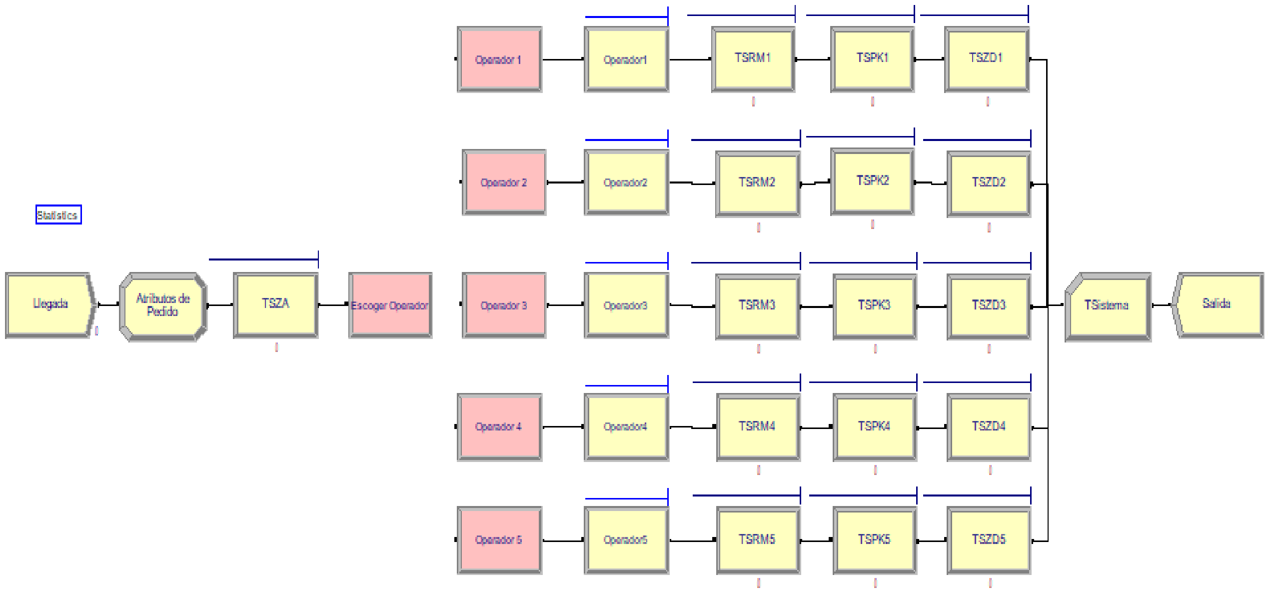

Figure 10: Representation of the current situation in the Arena Simulator software

the time it takes to execute each activity and its classification, in addition to graphing the sequence of the process.

As well, the cycle time of the two processes is evaluated by comparing them with the takt time (1) which is calculated with the following formula:

$$Takt\ Time = \frac{!"\#\$\%\ '()*\ +\#,-\ "."\#\$"/\$-}{!"\#\$\%\ 0-,"10} \quad (1)$$

TABLE IV
TAKT TIME

DEMAND	111	Pallets/day
TIME AVAILABLE	780	Min/day
TAKT TIME	7.03	Min/pallet

Table 4 shows the information required for takt time determination. With the calculated takt time, the calculated cycle times for the receiving and storage processes are analyzed to evaluate their performance according to the customer's requirements.

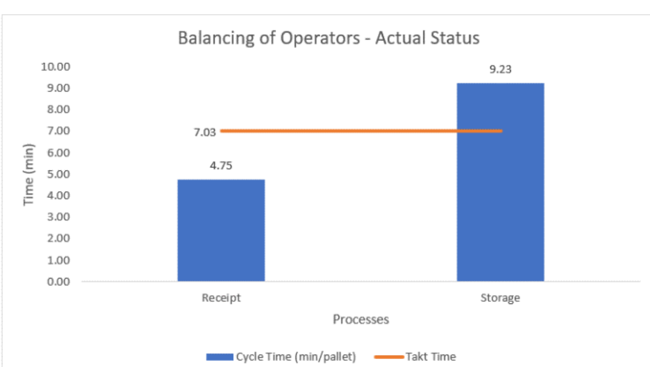

Figure 12: Takt time vs actual cycle time

Figure 12 shows the time analysis of the current situation, showing that the storage process has a cycle time excessively higher than the pace required by the operation, while the receiving process has a clear time slack for its activities. For this reason, improvement actions imply distributing the time used in both processes with the purpose of increasing the cycle time of the reception and decreasing the same in the storage. The creation of a waiting queue in the storage process for the unloading of goods with the machinery while it performs the storage of a pallet in the racks was implemented; in this way, it is possible to finish the storage process in the established work shifts and avoid overtime that generates a raise in the cost of operation.

Furthermore, the pilot of the implementation of the analysis carried out with the OBC tool is carried out during one month taking the information generated during this process. Figure 13 shows the development of the OBC tool implementation pilot.

Figure 13: OBC pilot

Finally, the results obtained during the pilot period are evaluated and the situation obtained with the implementation of the improvement is graphed. This result is shown in Figure 14.

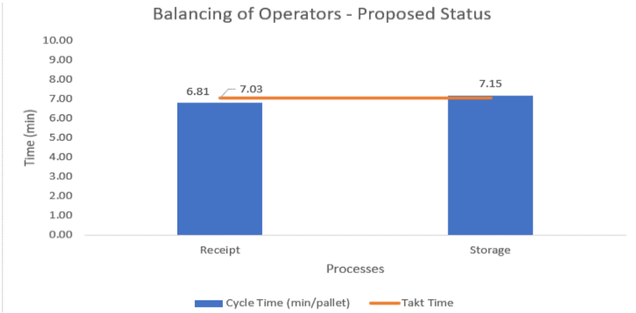

Figure 14: Result of the implementation of the OBC pilot

As shown in the graphic above, the objectives as the reduction of the cycle time of the storage process through load balancing with the receiving process were achieved. In addition, during the pilot, the amount of overtime generated in the month of implementation was analyzed in order to be able to quantify it.

3) Results:

Once the implementations were finished, we proceeded to compile the results obtained and proceeded to analyze them in order to measure them with the proposed indicators. Table 5 shows the results obtained through the project indicators.

TABLE V
PROJECT INDICATORS

Indicator	Current Value	Expected Value	Result obtained
Storage productivity	6.5	8.6	8.7
Picking productivity	101	131	128
5S Compliance	71%	100%	100%
Incidents by the expiration date	21.6%	0%	0%
Picking distance traveled	548.2	493.4	497.2
Storage overtime	1.25%	0.44%	0.64%

As it can be seen in the previous box, the productivity of storage manages to increase by 33.8% while picking productivity increases by 26.7%. On the other hand, compliance with the 5s audit reaches 100%, evidencing the order and cleanliness established in the operation. The incidences by expiration date in the picking process are reduced to 0% and the average distance in the picking route decreases by 9%. Meanwhile, the implementation of the OBC tool achieved the reduction of the ratio of overtime between sales by 0.61%.

V. DISCUSSION

A) News scenarios vs results

The following, is the validation of 3 classified scenarios of data collection. The first scenario represents the month of April 2021, the second scenario represents the month of May 2021 and the third scenario represents the month of June 2021. For the comparison and subsequent verification of these scenarios, the main indicators previously mentioned were taken into account. It is important to note that the implementations were carried out in the second quarter of 2021 where some possible contingencies were contemplated due to the new pandemic protocols.

1) First scenario: This scenario represents the beginning of the data collection in the proposal. All the data was collected within the first period indicated obtaining the following results:

- Compliance with the 5s audits performed weekly yields a monthly average of 97%.
- The number of picking trips with incidences per due date among the total number of picking trips is reduced to 3%.
- The amount of overtime in the warehousing process was diminished and represents 1.05% of monthly sales.
- The distance traveled in order picking was reduced to an average of 498.4 meters.

From the first month, the positive impact of the implementations is evident, however in this period the staff goes through a stage of adaptation to change and reinforcement of training.

Finally, the productivity indicators of the storage and picking processes increased as each of the implementations was strengthened. Table 6 shows the indicators of the current situation versus the implemented improvement of Scenario 1.

TABLE VI
INDICATORS OF PREVIOUS VS. IMPROVED PROJECT

Indicator	Measurement	Previous Value	Enhanced Value
Storage productivity	$\frac{Pallet}{H-H}$	6.5	7.9
Picking productivity	$\frac{Box}{H-H}$	101	125

In this first month, the involvement of the operative personnel of the warehouse was achieved so they maintain the disposition before the changes and the constant control. There were some mishaps related to staff turnover, which were caused by the entry of new operators that presented results corresponding to the beginning of the learning curve.

2) Second scenario: In the second month of implementation, there is evidence of acceptance of the changes made and their inclusion in the organizational culture of this working group. Involvement is evidenced by self-criticism within the same staff.

The control is carried out naturally through checklists, audits and inventories. The results of this second period of application are contrasted with the results of the first month, showing an improvement in the indicators, some of which have already reached the expected value.

Compliance with the 5s audits performed weekly yields a monthly average of 100%.

- The number of picking trips with incidents per due date among the total number of picking trips is reduced to 0.86%.
- The amount of overtime in the warehousing process was reduced and represents 0.71% of monthly sales.

- The distance traveled in order picking is also reduced to an average of 497.9 meters.

Finally, the main indicators of the project are analyzed, showing the trend towards improvement. Table 7 shows the indicators of the current situation versus the implemented improvement of Scenario 2.

TABLE VII
INDICATORS OF PREVIOUS VS. IMPROVED PROJECT

Indicator	Measurement	Previous Value	Enhanced Value
Storage productivity	$\frac{Pallet}{H-H}$	7.9	8.5
Picking productivity	$\frac{Box}{H-H}$	125	127

3) Third scenario: For this third month, the control and follow-up of the previous months continued, showing an improvement in the learning curve for the personnel involved and no resistance to change. Verification of the correct application of the standardized flows and a new data collection was carried out to analyze the new situation of improvement in accordance with the proposed indicators.

- Compliance with the 5s audits performed weekly yields a monthly average of 100%.
- The number of picking trips with incidents per due date among the total number of picking trips is reduced to 0%.
- The amount of overtime in the warehousing process was reduced and represents 0.64% of monthly sales.
- The distance traveled in order picking is reduced to an average of 497.2 meters.

Finally, the main indicators of the project are analyzed, showing the trend towards improvement. Table 8 shows the indicators of the current situation versus the implemented improvement of Scenario 3.

TABLE VIII
INDICATORS OF PREVIOUS VS. IMPROVED PROJECT

Indicator	Measurement	Previous Value	Enhanced Value
Storage productivity	$\frac{Pallet}{H-H}$	8.5	8.7
Picking productivity	$\frac{Box}{H-H}$	127	128

The variation in the results of the indicators is not very significant, but they are closer to the expected values.

B) Analysis of results

With the results obtained in the three periods reviewed, we proceeded to compare each of these to analyze the evaluation of each indicator and to identify the achievement of objectives or opportunities for improvement. Table 9 shows the comparative table of indicators for the three scenarios.

The table above shows the evident positive impact that the improvements implemented in the company have had. The result of each indicator is within the acceptable range and some of them even achieve the proposed objective.

TABLE IX
CUADRO COMPARATIVO DE RESULTADOS.

Indicator	Previously	1st Month	2nd Month	3rd Month
Storage productivity	6.5	7.9	8.5	8.7
Picking productivity	101	125	127	128
5S Compliance	71%	97%	100%	100%
Incidents by thr expiration date	21.6%	3%	0.86%	0%
Picking distance traveled	548.2	498.4	497.9	497.2
Storage overtime	1.25%	1.05%	0.71%	0.64%

C) Future works

- The logistics sector in Peru as in Latin America still operates the warehouses manually, so it is necessary to deepen more studies of the use of the Lean Warehousing methodology in different types of warehouses both as mass products, appliances, etc. This methodology works adequately in warehouses.
- For the sustainability of improvements over time, periodic audits should be adapted as part of the organizational culture, which should include all staff to encourage discipline and commitment to the objectives of the project and the company.
- The study in future investigations recommends the integration of tools and technologies that allows greater control in purely manual processes, which would also allow an improvement in time and use of resources such as packaging materials, adhesive tapes, etc.
- Warehouse logistics companies in Peru and the Latin American region focus their main operational resource on low-skilled labor, which generates low productivity and the latent opportunity for human error. The implementation of modern technologies focused on this industrial sector, would allow a great increase in the competitiveness of these companies and the consequent improvement in the level of service.

VI. CONCLUSIONS

The main purpose of this research work was to solve a relevant problem within the field of industrial engineering, based on the logistics sector of warehouses showing its influence and importance in the national GDP by 13% and its contribution to the economic development of the country.

- Analysizing the diagnosis and current situation of the company was evidenced as the main problem the low productivity rate in the processes of storage and picking, resulting in the use of overtime to not affect the level of service to the customer-impacting on the cost overrun of S / 107,828.00 annual representing 3.59% of annual sales.
- The main root causes of the problem were identified, being the lack of space availability in the pre-dispatch area, low stock level according to the expiration date in the picking locations and the low availability of machinery for storage the

most significant with 34%, 31% and 24% respectively. From this, an improved design was proposed based on an analysis with the support of scientific articles and implementations of Lean Manufacturing tools such as 5s, SLP, FEFO and OBC integrated by the Lean Warehousing methodology.

- The pilot implementation of the 5s tool has the scope of continuous improvement to facilitate work performance through order and cleanliness in operational areas. For this reason, it was proposed to monitor this implementation through compliance audits, obtaining a result at the end of the implementation of 100%.
- The implementation of load balancing by means of the OBC tool allowed the establishment of new standard procedures for the reception and storage processes, obtaining a 23% reduction in cycle time in the latter process, and also a 49% reduction in the number of overtime hours used.
- The implementation of the FEFO and SLP tools, through simulation in Arena software, allowed us to demonstrate the effectiveness of these two Lean Warehousing techniques. We observed the reduction of the time to process a picking order by 26% and the elimination of incidents due to due dates.
- Based on the integration of Lean tools such as 5S, FEFO, SLP and OBC, it was possible to increase the productivity rates of the storage and picking processes by 33% and 27% respectively.

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