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Abstract. This article addresses one of the main problems faced by small- and medium-sized business in the non-metallic mining sector in Peru. These companies own warehouses and face the major problem of failing to deliver orders correctly and in a timely manner. This problem usually occurs when the business grows from a small- to medium-sized company in a short span of time; this situation leads to new processes within warehouses that are mostly not standardized. Besides, facilities are no longer optimal in space and the workers are not properly trained. The case study shows that the orders were not delivered on time due to factors such as lack of product identification, although the products have an expiration date and a warehouse without signaling and surrounded by traffic. To tackle this situation, a labeling process has been designed for the products, an adequate distribution technique is used in the warehouse through a newly designed warehouse layout, and a First Expired, First Out system has been implemented. Similarly, the design is accompanied by the 5s tool to provide a basis for order and continuous improvement. The results show that deliveries with delays were reduced from 38% to 10%. These results show that companies can grow rapidly and maintain quality of service through orderly management.

1. Introduction

Over the last 20 years, Peru has experienced significant economic growth. In 2018, growth was 4%, which allowed many companies to develop and thrive during these years [1]. The non-metallic mining sector has grown by more than 150% in the last decade (2008–2018) [2]. Currently, there is significant growth specifically among small- and medium-sized enterprises; however, operational efficiency is quite low [3] because they face many difficulties in developing their businesses due to factors such as non-standardized processes, lack of operating space, and lack of technology used by larger companies. Hence, every one out of four medium-sized companies in Peru shows a 50% drop in sales due to poor management [3] because the abovementioned situations create operational problems. In the specific

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case of non-metallic mining, delays occur in delivering products to the client, most of which are construction and mining companies [4], which could lead to losing these clients. According to the Peruvian government, the construction sector in Peru will continue to grow at a rate of 7% in 2019 [5]. This will continue to boost the demand for non-metallic minerals, and small- and medium-sized companies will continue to face the aforementioned difficulties.

The main motivation for this research lies in the concern that Peru's economic growth is based on the construction and metal mining sectors. This will cause products from non-metallic mining companies to become essential as they are the input for the construction and metal mining sector, and this is normally the standard behavior in developed countries [6]. Therefore, the small- and medium-sized sectors of the non-metallic mining industry must have efficient processes for loading and unloading products so as not to affect operations and, consequently, avoid harming the end customer. The aim of this research is to propose improvements in warehouse management, which are economically viable and can reduce or mitigate delays in shipments to the customer. The proposed model is based on implementing the 5s philosophy as a lean manufacturing tool, a warehouse design with First Expired, First Out (FEFO) logic, and chaotic development to face the technological limitations that ensure the products to be sent are not expired and reach the customer within the expected time framework, thus meeting the final quality standard.

2. State of The Art

2.1. Lean Manufacturing
This work philosophy allows for the reduction of waste in the production system. Simulations show that it is possible to reduce up to 30% of the transit time inside the warehouse. There are also studies that indicate improvements of 82% and 79%, respectively, for the process of loading and unloading products in large companies when using the 5s tool [7] [8] [9] [10].

Most articles and case studies on implementing the lean manufacturing philosophy are developed and focused on large companies whose problems and operations generally differ from those of small- and medium-sized companies. However, it is important to consider that the commitment of business leaders is the most important factor in preventing failure during implementation [11] [12].

2.2. FEFO
Simulations with perishable and non-perishable products have been performed to determine the performance of the different types of methods for managing product entry and exit in both First-In, First-Out (FIFO) and FEFO storage systems. In the non-perishable scenario, FIFO inventory management required 32% of the time used by the FEFO system. In the perishable products scenario, FEFO inventory management reduced waste (expired products) by 50% with respect to FIFO [13] [14].

The inventory system that performs best in managing product storage, supply, and handling with limited shelf life is FEFO. Many companies use the FIFO inventory system for their products regardless of whether the products are perishable. However, these companies show declines because the product's storage time exceeds its shelf life. Nevertheless, a study shows that when implementing the FEFO system in warehouses with perishable products, declines were reduced by 50% due to correctly applying the inventory system for the type of product being handled [14] [15] [16] [17].

2.3. Chaotic Storage
The best-known storage systems are on-demand storage, dedicated storage, and chaotic storage. Warehouses that randomly place their products inside warehouses are called chaotic warehouses. They require less storage space than dedicated warehouses, where products have pre-determined spaces within a warehouse. However, dedicated or on-demand warehouses have less transit time within a warehouse. This can be verified through some studies showing that chaotic storage reduces transit time within warehouses [18] [19]. For example, in one case study, chaotic storage reduced transit time

by 32.8%, but on-demand storage reduces it by 52.5% [18]. Chaotic warehouses need information systems to help identify, track, and manage products within warehouses, and an inventory management model is needed to allocate products in certain spaces [20] [21].

3. Contribution

3.1. Proposed Model
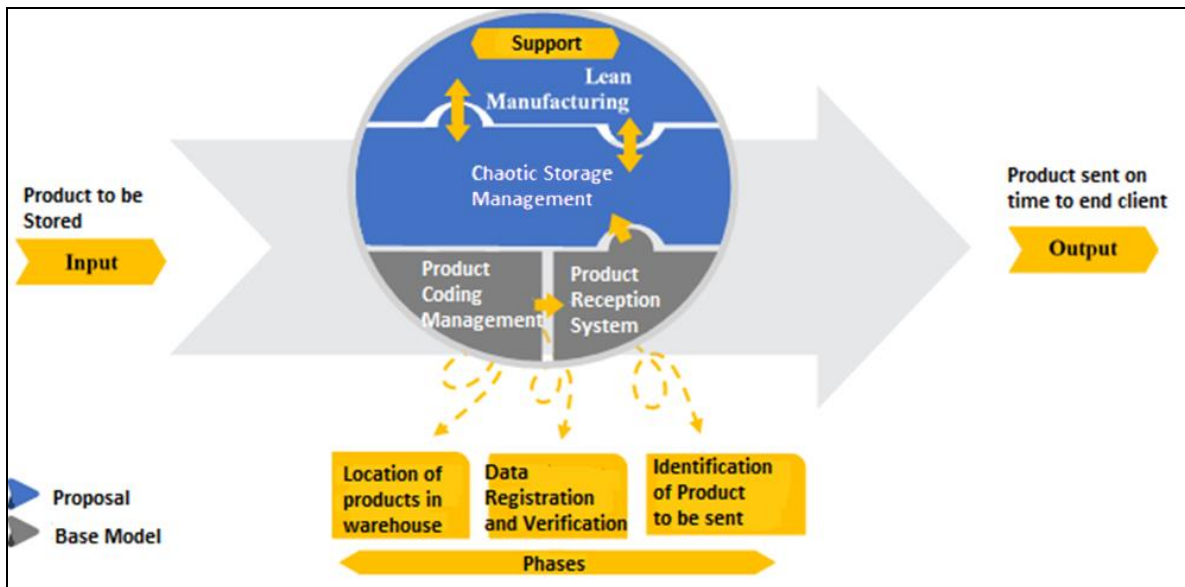
Figure 1. Layout of the model proposed

3.1.1. Managing Product Coding and Receiving. These dimensions use tools designed to create low-cost labels. The goal is to quickly identify shelf life and allow for the management of locations within the warehouse. Similarly, product receiving confirms that the product complies with security measures, has a visible expiration date, and that the order planning is followed. For this dimension, tools such as checklists were used to control label use.

3.1.2. Chaotic Storage Management. This dimension allows for the implementation of a storage system where the chaotic concept is combined with FEFO logic. The main purpose is to know warehouse's stock at all times without having to move the products and manage the future input or output of products for a given period of time by moving identifiers according to time. To guarantee the application of the FEFO technique, traffic light rules are used for inputs and outputs. The main tools used are a stock map, which provides visual instructions to operators who load and unload products in the warehouse, and a matrix where a record of warehouse movements is consolidated daily and saved so that the responsible parties can later make decisions on accepting orders within the warehouse or evaluate its capacity according to fluctuations in demand.

3.1.3. Lean Manufacturing Strategy. This dimension aims to build the foundation for the warehouse to constantly review compliance with its new procedures. The strategy consists of planned audits and analyzing information from the records to make decisions or develop action plans.

3.2. Proposed Method
The process of applying the methodology is sequential and Figure 2 shows the tools that have been applied during implementation.
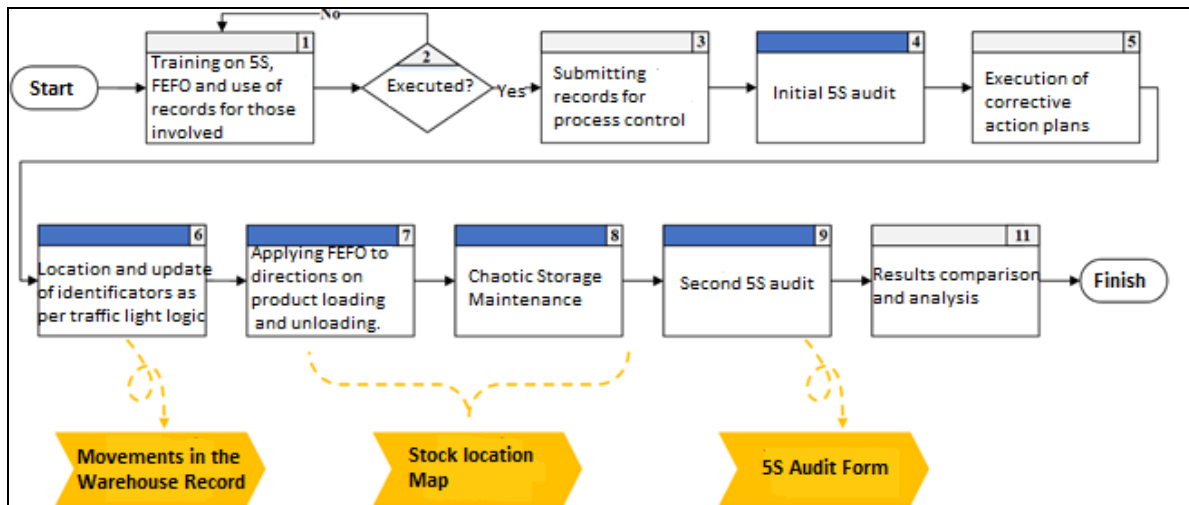
Figure 2. Method to execute the proposed model

3.3. Indicators

- Percentage of monthly shipment delays. This indicator allows for monitoring the problem of delays during shipments to clients.

$$Metric = \frac{(Total\ delayed\ shipments\ in\ the\ month)}{(Total\ shipments\ in\ the\ month)} x\ 100 \tag{1}$$

If the result is 0%, it indicates that the model is serving its main purpose and 100% indicates all shipments are delayed and the techniques applied are not resulting in any improvement.

- Deviation of monthly handling process time with respect to ideal time. This indicator shows the shipment delay time compared to the time the process should ideally take. The metric to calculate this indicator is as follows:

$$M = \frac{(Real\ process\ time - Ideal\ time)}{(Ideal\ time)} x\ 100 \tag{2}$$

When the result is above 0%, this should be interpreted as the process needing to be revised.

- Monthly expired product stock quantity indicator. This indicator tracks the effectiveness of the FEFO system. The metric to calculate this indicator is as follows:

$$Metric = Sum\ of\ expired\ products\ in\ the\ motnh \tag{3}$$

- Results of 5s audits. This indicator makes it possible to identify whether the 5s philosophy is being applied correctly within the company and also allows action plans to be monitored. This indicator is calculated as follows:

$$Metric = Sum\ of\ the\ scores\ for\ each\ "S" - 50 \tag{4}$$

4

These scores are determined with specialized questions for each "S." Possible values range from 0 to 50 points. A score equal to or less than 25 points indicates that the company is not applying the 5s philosophy, a score greater than 25 indicates that the company is applying the tool but has yet to generate action plans for correction or improvement, and finally, obtaining a score of 50 indicates that the tool works successfully.

4. Validation

4.1. Case Study

The company produces, stores, and markets quicklime, carbonate, and hydrated lime to construction and mining companies in Peru and has problems with the quicklime warehouse's shipping process. The company's main objective is to reduce these expensive delays. The scope of the project was to apply the proposed method.

4.2. Initial Results

The initial results found as part of the case study assessment are described below using the defined indicators. Table 1 shows a summary of the initial results.

Table 1. Initial results of the case study

% Delays during shipping	% Deviation from process time compared to ideal time	Amount of expired products (MT)	Audit Result (points)
38%	11.6%	16	10

Initial records showed delays for 217 orders in 2017 and 180 in 2018. However, for the purpose of assessing equivalent periods, data from the first quarter are considered where the percentage of monthly delays during shipping was initially 27% for 2017 and 23% for 2018. With respect to monthly process time, a time study was conducted, where a standard time of 4.87 hours was obtained and an additional margin of 2.6% was considered to find that the ideal time for the process should be equal to or less than 5 hours and less than 6 hours. Thus, initially the process took 5.57 hours, with times of even more than 6 hours. Additionally, within the warehouse, 16 metric tons of expired products were initially found per month, which could be identified only by performing individual quality tests. Finally, with respect to the 5s audit results indicator, the initial score was 10 points out of the 50 required to find that the 5s management system is successfully implemented.

4.3. Applying the Model to the Case Study

The proposed model comprises four dimensions which were implemented following the methodology proposed above. The model's application is detailed below:

4.3.1. Training and handing out forms. More than 20 people involved in the process were trained and evaluated on 5s tools, FEFO, and the use and importance of recording data. 100% of staff attended and the result of written evaluations was also 100%. The frequency for future training was determined to ensure constant discipline and training on this work philosophy. In addition, 22 forms were provided to record data and subsequently calculate indicators.

4.3.2. Performing the Initial 5s Audit. In this task, an initial audit is carried out to find the state of the warehouse and determine the following actions, which in turn allows the classification, elimination, relocation, or disposal of any unnecessary materials within the warehouse. The cleanliness and transport options for vehicles and operators were also reviewed. Finally, the results were used to develop action plans to correct observations. As a result, more than 50 MT of material including

expired products, obsolete tools, empty big bags, etc. were eliminated, reprocessed, relocated, or sold. Moreover, 10 documents were approved, including policies, procedure manuals, and instructions.

4.3.3. Locating and Updating Identifiers as per the Traffic Light Logic. In this task, the products were relocated according to lot and with identifiers in each zone with material. Each identifier follows the rules of the traffic light based on the product's age.

Color	Months	Action
Green	4–6	Ship first
Yellow	1–4	Ship only if there are no green products
Red	<1	Ship only if there are no green or yellow products

Figure 3. Traffic light rules

They are updated daily and before the next day's following shifts using a movement record in the warehouse where the respective control is performed and determines the warehouse's capacity to continue receiving the product or the urgency with which each zone of products must be shipped.

4.3.4. Applying the FEFO logic to loading, unloading and maintaining chaotic storage. In this task, the previous task record is taken as input, and orders for the product's shipping and arrival are transferred. This creates a stock location map where the person in charge of the morning shift specifies the areas where the product must be taken, in the case of shipping, and the areas where the product should be placed when it arrives at the warehouse. This can be seen with the tool defined and shown in Figure 4.
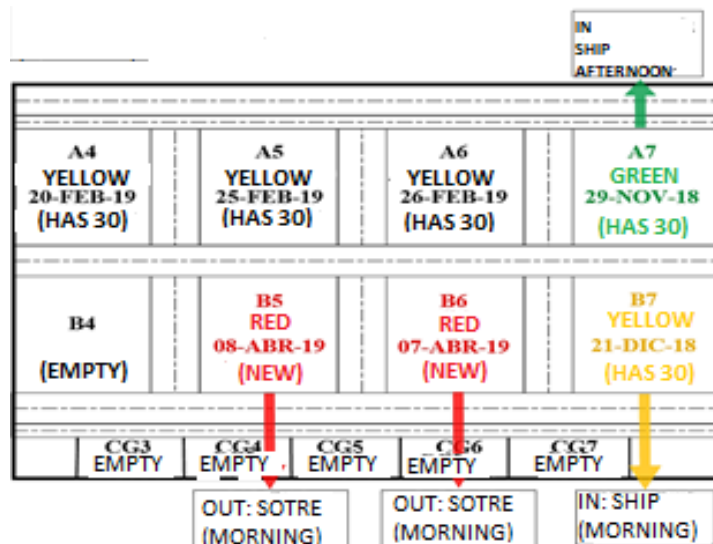

Figure 4. Map of warehouse stock

After the information is delivered to the operators in charge, the manager must update the identifier according to whether it has changed, been separated because the area was empty or if it must be included among the population of areas and again updates the record of the previous activity.

4.3.5. Performing the Second 5s Audit. In this task, an audit was carried out again where the input was the plans released as part of the first audit, which must be implemented or at least in progress. In the last audit, the score was 46 out of 50 points.

4.4. Summary of Results

During the first quarter of the year, the proposed model was implemented. Table 2 shows the results after implementation, using defined achievement indicators:

Table 2. Indicators for validation

Detail / Indicator	% Delays during shipping	% Deviation from process time compared to ideal time	Amount of expired products	Audit result
Initial Result	38%	10%	16	10
Final Result	8%	2%	0	46
Improved?	YES	YES	YES	YES

The results show a dramatic drop in customer delivery delays. Also, the total time of the shipping process is closer to the ideal time of 5 hours, largely because expired products were removed from the warehouse and there is a defined process as well as controls. Finally, the latest audit reveals that the initial action plans have been followed and that some points need to be improved to be fully successful. It is important to mention that results are expected to improve over time as improvements are consolidated and the system continues to be enhanced.

5. Conclusions
The proposed model reduces delays in shipments to the customer by up to 19% and reduces the number of expired products in the warehouse by up to 100%. The proposed model reduced the amount of time in the case study shipping process from 5.55 hours to 5.10 hours. The proposed model is capable of improving warehouse management with a small investment and high effectiveness in reducing shipping delays. This is very useful for small- or medium-sized companies that do not have large investments for improvement.

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