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*Original Article*

# Warehouse Management and Order Picking Optimization in Spare Parts Distribution: An Empirical Study from Peru on Continuous Improvement Strategies

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***Abstract -*** *Small and Medium-sized Enterprises (SMEs) in Peru's spare parts distribution sector face persistent inefficiencies in warehouse management and order picking, leading to increased operational costs and reduced service levels. Previous research has examined optimization techniques separately, yet their integrated application in this industry remains underexplored. This study implemented Systematic Layout Planning (SLP), multi-criteria ABC analysis, Methods Engineering, and Voice Picking to improve warehouse organization and streamline picking processes. The outcomes revealed a 47.8% decrease in picking time, an 88.86% reduction in picking mistakes, and a 43.26% increase in order processing efficiency, greatly improving service levels. These results enhance the existing knowledge of logistics in warehouses by supporting a systems approach model for SMEs that have comparable logistical issues. The study also highlights the importance of continuous improvement techniques in the workflow and resource distribution optimization process. More studies should be conducted about the prospects of modern technologies, like WMS and AI, in increasing efficiency and sustainability in operations within the industry.*

***Keywords –*** *Inventory Control, Logistics Efficiency, Process Standardization, Supply Chain Performance, Operational Productivity.*

## 1. Introduction

The role of small and medium-sized enterprises (SMEs) in the region's economy is especially relevant in global economics, along with Latin America and Peru, where these SMEs play a vital role in distributing heavy machinery spare parts. In addition to providing job opportunities, this sector is highly important for the proper functioning of many economic activities, such as construction, agriculture, and mining. Because mining is a crucial pillar of the economy of Peru, the competitiveness of domestic firms hinges on the operational availability of heavy machinery spare parts [1]. These SMEs within this industry grapple with distinct issues, such as utilising available resources while quickly responding to market shifts effectively. This underscores the importance of improving warehouse logistics and operations [2].

These SMEs have logistics and storage problems that are of great importance due to high unproductive times in the picking process. In addition to the lack of standardization, the cluttered warehouse's inadequate allocation of spare parts causes long search times for the parts. This not only harms the efficiency of operations but could also lead to extra costs and customer dissatisfaction [3]. Research has shown poor warehouse organisation can increase waiting time and reduce productivity [4]. Thus, SMES must formulate policies that deal with inventory arrangement and enhance the picking activities for better efficiency [5].

These measures are vital in fostering the sustainability and progress of SMEs that deal with heavy machinery spare parts. Enhanced picking efficiency reduces operational expenses while improving customer satisfaction due to faster and more precise product fulfillment [6]. Advanced methodologies like Methods Engineering or Systematic Layout Planning (SLP) can be used to solve the challenges related to warehouse design and workflow optimization [7]. Furthermore, inventory management can be improved by using tools like ABC analysis and Voice Picking, enabling companies to respond more quickly to changes in demand [8].

Nonetheless, the literature is scant concerning using these tools in the context of SMEs that distribute spare parts for heavy machinery. Although studies have been done on warehouse optimization and improving logistics processes, only a handful of studies have focused on how these methodologies can be applied in this industry [9]. In this case, the gap is supported by creating a production model incorporating Methods Engineering, Systematic Layout Planning (SLP), multi-criteria ABC analysis, and Voice Picking. In doing so, the gap not only aids in achieving operational efficiencies but also aims to provide an achievable solution that interfaces SMEs with logistics optimization issues [10].

When contrasting with current studies, the new angle of the approach is its relevance to SMEs dealing with heavy machinery spare part sales, which has received scant attention in the literature [11].

This novel approach involves having multiple management tools incorporated into one model, which provides the opportunity to view the processes of warehouse operations and order preparation optimally. This will not only serve the purpose of operational efficiency but also provide an efficiency model that other SMEs within the industry can utilize in meeting such issues [12].

The noteworthy mention concerning SMEs is their contribution to distributing heavy machinery spare parts. It is crucial to resolve the logistics and storage issues for achieving sustainability and growth. This particular research effort aims not only to address a particular lacuna in the literature but also to provide applicable solutions to enhance the efficiency and competitiveness of these firms in a highly challenging market.

## 2. Literature Review

### *2.1. Application of the Systematic Layout Planning Methodology in the Storage Process*

Methodology Systematic Layout Planning (SLP) has received special attention in optimising warehouse spaces, especially in SMEs that deal in heavy machinery spare parts. An SLP strategy aims to achieve the most logical and operationally efficient storage space arrangement, which translates to improved accessibility and reduced travel time to an area. [13] notes that space utilization in spare parts networks is optimized under a partial pooling structure, which is useful for SMEs with a heterogeneous inventory.

Driessen et al. [14] created a planning and control framework for maintenance spare parts and posited that the SLP design should be of greater value for inventory control in SMEs. Furthermore, Wong et al. [15] agree that a good layout design facilitates prompt service delivery by lessening waiting time to access the highly demanded spare parts while, at the same time, improving operational efficiency. Finally, the work of Eruguz et al. [16] brings out the need for less emphasis on layout details in maintenance logistics, arguing instead that a systematic layout approach for these arrangements can greatly support cost-reduction efforts in SMEs.

### *2.2. Application of the Multi-Criteria ABC Methodology*

The Multi-Criteria ABC Methodology has been an integral technique for categorizing and controlling spare parts inventories in small and medium-sized enterprises. This technique offers firms the opportunity to classify goods by value and requirement, which is crucial for effective inventory control fundamentals. Sarmah & Moharana [17] provide a multi-criteria classification technique that assists firms in making rational decisions towards spare parts inventory management. This is supplemented by Khan's [18] work, which shows how adopting an inventory control system designed using the ABC classification improves service levels while lowering average inventory investment. Zhao and Yang [19] also adduce that proper classification of spare parts reduces maintenance costs while increasing product availability. Finally, the study by Mezafack et al. [20] illustrates the usefulness of ABC classification in the sustainability of logistics operations, which is especially pertinent for SMEs that want to increase the effectiveness of their processes and reduce operational costs.

### *2.3. Application of Methods Engineering in Picking Processes*

Methods Engineering is essential for improving picking processes in SME warehouses. This field specializes in analysing and improving work methods that can lead to productive increases and decreases in picking times. Jumali et al. [21] explain how reorganizing storage layouts with the FIFO (First-In, First-Out) method improves picking efficiency, which makes the most frequently requested parts easier to access. Drent & Arts' [22] work on inventory management underlines the role of methods engineering in ordering spare parts, recommending that picking process improvements be approached by way of continual development. Also, research by Rahimi-Ghahroodi et al. [23] demonstrates how combined scheduling of certain spare parts with service personnel can lead to useful savings, which turns attention to methods of engineering for operational efficiency. Lastly, the work of Howard et al. [24] indicates that replenishment process order information usage can benefit pick management, hence, more productive warehouse work.

### *2.4. Application of Voice Picking in Spare Parts Distribution Warehouses*

In spare part distribution warehouses, the implementation of Voice Picking technology has emerged as a novel measure to enhance picking process productivity. Instructions are conveyed to employees through voice devices, which minimizes paper use and enhances the precision of product picking. According to Capodieci et al. [25], machine learning methods to assess productivity in ordering spare parts should be integrated with Voice picking technologies to optimise the selection procedure. Additionally, Khan's [18] work argues that adopting automated warehouse management systems with voice picking can optimize spare parts management in the oil and gas industry and be applied to other fields. On the other hand, Wingerden et al. [26] comment on the shifts towards further industrial efficiency and cost reduction resulting from the implementation of advanced technologies in picking tasks. Finally, Ali et al. [27] argue that implementing voice-based technologies in picking processes would enhance service delivery while minimizing stock outlays, which is necessary to improve competitiveness for small and medium enterprises.

### *2.5. Continuous Improvement in Spare Parts Distribution Warehouses*

In order to stay competitive and efficient, spare parts distribution warehouses need to improve ceaselessly. This strategy suggests a systematic search for process optimization and cost reduction. Hernandez's research [28] emphasizes how Lean Six Sigma projects can help improve spare parts inventory management orders, especially in the post-pandemic environment. In addition, Durán et al. [29] argue that perpetual approaches to inventory cost control of spare parts tend to improve economic sustainability over time. Nevertheless, Karim and Nakade's study [30] illustrates that combining spare parts planning with service engineering management leads to improved operational efficiency. Lastly, Tang et al. [31] pointed out the need to factor in consumers' environmentally friendly attitudes in the unfettered improvement of logistical functions, which is valid for small and medium enterprises that wish to be more responsible in their inventory control policies.

## 3. Contribution

### *3.1. Proposed Model*

The advanced version of the processes management model presented in Figure 1 combined different continuous improvement tools to effectively organise and distribute spare parts in warehouses and the picking and transportation processes. This model was designed in two main phases. The first phase addressed warehouse organization through tools such as Systematic Layout Planning (SLP), which allowed for analysing and reconfiguring the physical layout based on logical and efficient flows. Additionally, a multi-criteria ABC analysis was incorporated at a general level and by the spare parts family, facilitating the prioritization of items according to their criticality and frequency of use. In the second phase, aimed at optimizing picking processes, Methods Engineering principles were applied to standardize tasks and eliminate unnecessary activities, complemented by a benchmarking analysis to identify best practices in the industry. Finally, Voice Picking technology was implemented, improving accuracy and reducing time in spare parts selection. These phases were designed to enhance the level of service in on-time deliveries, minimize errors, and optimize resources, aligning with the logistics system's efficiency and productivity objectives.

### *3.2. Model Components*

The proposed improvement model, illustrated in the attached figure, represents a comprehensive solution designed to address inefficiencies observed in the organization and distribution of spare parts and the picking and transfer processes associated with logistics systems.

This model aims not only to increase the service level in spare parts delivery but also to optimize available resources by applying proven tools and philosophies in continuous improvement. The relevance of this approach lies in its ability to reduce operation times and minimize errors in critical activities, directly contributing to greater operational efficiency and customer satisfaction.

Furthermore, it integrates SLP, Methods Engineering, and Multi-criteria ABC Analysis as a system that yields positive results within a specified timeframe. In the next parts, the stages that form this model are given, indicating what each stage sets out to achieve and the methods that were used to deliver the intended results.

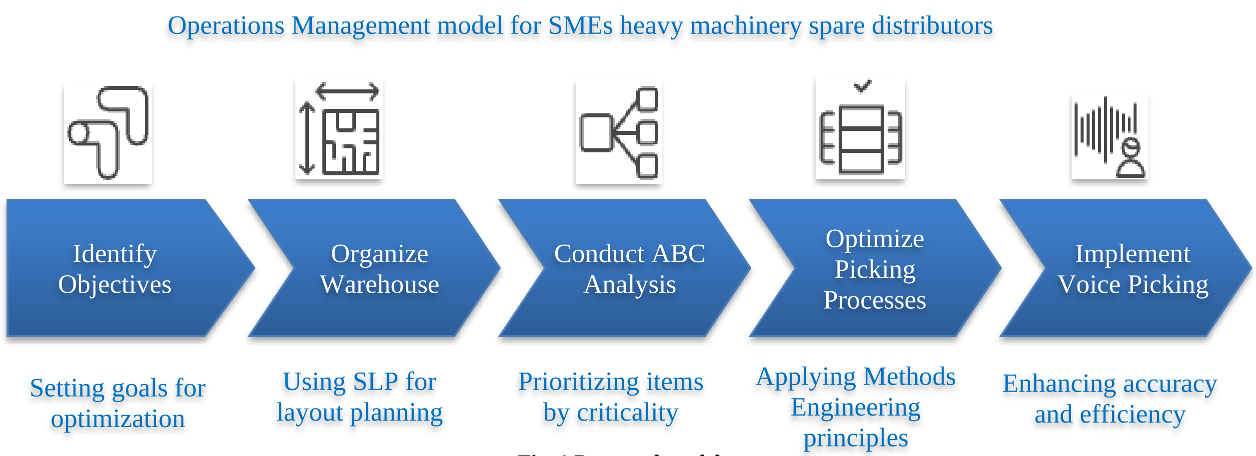


**Fig. 1 Proposed model**

*3.2.1. Phase 1: Organization and Distribution of the Spare Parts Warehouse*

*Redesigning Layout with Systematic Layout Planning*

The first step involves implementing the systematic layout method to redesign the features of the warehouse. This facilitates the reviewing of flows of materials, which, in turn, sets the best configuration that reduces invalid actions and enhances retrieval of vital parts. The study commenced with assessing the degree to which the functional zones interact with other zones and how often these interactions occur. Using this information, design options were created and tested via modelling to confirm their practicality and functionality. This stage provided a basis for better allocation of the spaces, which translates to enhanced productivity in the warehouse.

*Strategic Classification through Multi-criteria ABC Analysis*

Next, a multi-criteria ABC analysis was performed to classify spare parts by importance and criticality. Two levels were established for this analysis: a broader level aimed towards capturing aspects that have the most influence on the system and a more focused level that analyzed each spare parts family in detail. At the broader level, key parameters included economic value and frequency of use, while the more focused level involved other parameters such as turnover rates and replenishment time for the specific parts families. This classification enabled some class A spare parts to be assigned central storage locations, improving access and minimizing handling time.

*3.2.2. Phase 2: Analysis and Optimization of Picking*

*Standardizing and Improving Processes through Methods Engineering*

In this stage, the methods of engineering principles were employed to evaluate and redesign picking-related activities. First, severe delay-causing tasks were identified, and non-value-adding tasks were removed. This analysis involved time and motion study in addition to process observation.

New norms were set with regard to operational standards based on the collected data to make the work simpler while improving the reliability of the outcomes. In so doing, the operational instructions were more consistent in the results guaranteed. The employees were also trained on these changes so that they could put them into practice.

*Adopting Best Practices through Benchmarking*

As a primary tool analysis, benchmarking was used to compare internal processes with those of industry leaders. This exercise helped to pinpoint practices that could be transformed to fit the needs of the case study. Among the implemented improvements were advanced techniques for order organization and complementary technologies for inventory management. Application of these practices greatly improved picking efficiency and lowered operational mistakes.

*Implementing Voice Picking Technology*

Ultimately, Voice Picking technology was developed to improve efficiency and precision in the spare parts selection process. With this system, operators received instructions verbally, reducing the number of workflow interruptions associated with using paper lists. This technology was implemented through pilot tests that verified productivity and accuracy gains. Voice Picking also reduced the use of manual devices, which led to improved ergonomics in the workstation.

The model provided integrated tools for continuous improvement, which solved the operational issues of parts management. It attempted to restructure the warehouse and optimize the picking processes, which enabled the strategy to improve the service level and reduce operational costs sustainably. The results obtained illustrate how far-reaching the impact of thoughtful engineering and modern technology on logistics processes is and why a thorough approach is necessary to lay the groundwork for further study in the area.

### *3.3. Model Indicators*

In order to assess the suggested operations management model for Small and Medium-sized Enterprises (SMEs), which are involved in the distribution of spare parts for heavy machinery, indicators were defined based on specialized literature and empirical evidence from the sector. This documentation was the backbone for analyzing key logistics processes. The criteria chosen allowed for a thorough evaluation of the model's effectiveness and feasibility while enabling tracking and improvement of competitiveness and efficiency of operations undertakings.

*3.3.1. On-Time Delivery*

The metric tracks how many orders were delivered within the anticipated timeframe. A higher value shows an increase in the effectiveness of the spare parts delivery process. Increased customer satisfaction and logistics performance are associated with higher values.

$$OTD = \left(\frac{\text{Orders delivered on time}}{\text{Total orders delivered}}\right) \times 100$$

*3.3.2. Average Order Picking Time*

This metric accounts for the average time needed to process an order while factoring in unproductive picking processes, poor item allocation, and unorganized warehouse space. Lowering this value increases efficiency within the operations.

$$T_{\text{avg}} = \sum \text{Time to pick up orders}$$

*3.3.3. Order Picking Error Rate*

This measure assesses the share of wrong orders picked and indicates the reliability of the operations. Lower percentages mean better picking and less rework.

$$E_p = \left(\frac{\text{Incorrectly picked orders}}{\text{Total picked orders}}\right) \times 100$$

*3.3.4. Order Picking Rate*

This indicator evaluates the productivity of the picking process by relating the total orders picked to the working hours within a specified period. The higher the ratio, the better the efficiency.

$$P_r = \frac{\text{Number of picked orders}}{\text{Operational hours}}$$

## 4. Validation

### *4.1. Validation Scenario*

The validation scenario was part of a case study of a Small and Medium-sized Enterprise (SME) in Lima, Peru, that specializes in providing spare parts for heavy machinery. The company's business focus was marketing and supplying key parts needed in the construction and mining industries, which provided the most vital resources for the functioning and maintaining big industrial machines.

The company had operational problems with the efficiency of its parts storage and delivery system, which resulted in a service level of only 85.49%. This value showed a technical gap of 8.51% with respect to the competitor, who had a service level of 94%.

The problems were related to customer order execution lead time, poor warehouse layout, and inaccurate picking, resulting in poorly satisfied customers and uncompetitiveness in the market.

### *4.2. Initial Diagnosis*

The assessment performed in the case study discovered a critical shortcoming in the customer service component of the heavy machinery spare parts delivery service, which had a whiplash delivery level of only 85.49%. This was below the industry standard by 8.51%, which is 94%. This problem caused a nominal economic effect of $78,750, which amounts to 4.43% of the company's yearly revenue.

The primary cause was unproductive times in the picking process, which accounted for 84% of the problem, with failures in picking activities being the most critical factor at 48%. Additionally, the inadequate distribution of spare parts within the warehouse contributed 25%, while warehouse disorganization and unnecessary search times added another 11%.

Furthermore, inefficiencies in the commercial area had a 16% impact, mainly due to order generation during weekends, which disrupted the planning and execution of logistics operations. These findings confirmed the need for management to optimize warehouse organization and operational efficiency to close the identified service gap.

### *4.3. Validation Design*

The pilot validation method was employed to assess the effectiveness of the proposed production model, which integrates various process improvement tools. This case study executed the method for four months, implementing all suggested techniques.

The methods included Systematic Layout Planning (SLP), ABC Classification, Methods Engineering, and Voice Picking, focusing on enhancing warehouse structure, stock control, productivity, and order fulfilment precision. This cursory summary reports the results from the application of the various components of the model with corresponding integrated changes in production and logistics system performance.

The model's goals in the case study were to improve warehouse control and picking operations to reduce cycle time and reduce mistakes to fulfil the requirements. This was accomplished through two strategically defined phases: reorganization of the spare parts warehouse and process optimization of the picking activity, both under the influence of industrial engineering and IT. These phases resulted in lower travel times for the workers, higher performance in the accuracy of spare parts retrieval, and improved company service level.

*4.3.1. Phase 1: Organization and Distribution of the Spare Parts Warehouse*

The first warehouse design had significant spare parts allocation errors, resulting in high retrieval times and excessive movement by the operators. To solve this problem, Systematic Layout Planning (SLP) combined with a classification-based ABC redistribution was employed so the inventory could be sorted by turnover and internal warehouse paths could be optimized.

*Implementation of ABC Classification*

The analysis of the demand showed that the stored spare parts were categorized as follows:

Category A is classified as having high turnover, with 20% of inventory but representing 80% of movement in warehouses.

Category B consists of medium turnover spare parts, making up 30% of the inventory and contributing 15% of the movement in the warehouse.

Category C is classified as low turnover items, with 50% occupying the inventory and only 5% of demand.

It was observed from the analysis that for category A, the spare parts need to be moved toward the picking and shipping areas, which makes these items easier to reach for relocation. This resulted in a lowered retrieval time of 35% when compared to the other arrangements.

*Warehouse Layout Redesign*

Implementing the SLP methodology enabled a more efficient reorganization of storage space. New movement routes for workers were established, optimizing workflow and reducing travel times by 25%. Additionally, structured signage was incorporated to facilitate quick identification of spare part locations, contributing to a 15% reduction in misplacements.

*Impact of Reorganization*

Inventory redistribution and warehouse layout optimization significantly improved operational times:

Average spare part retrieval time: 35% reduction, decreasing from 3.5 minutes to 2.2 minutes per item.

Number of unnecessary trips: 28% decrease, optimizing operator productivity.

Total picking time: 30% improvement, streamlining workflow efficiency.

Figure 2 illustrates the new warehouse layout based on ABC classification, optimizing accessibility and operational efficiency. Three zones were established: Zone 1 (green)**,** designated for high-turnover spare parts **(**A**),** strategically placed near picking and dispatch areas to reduce retrieval times. Zone 2 (yellow) groups medium-turnover parts (B), ensuring optimized accessibility. Zone 3 (red) is allocated for low-demand parts **(**C) in less frequently accessed areas. This reorganization reduced worker travel distances by 35%**,** enhancing picking efficiency and minimizing errors in product selection.

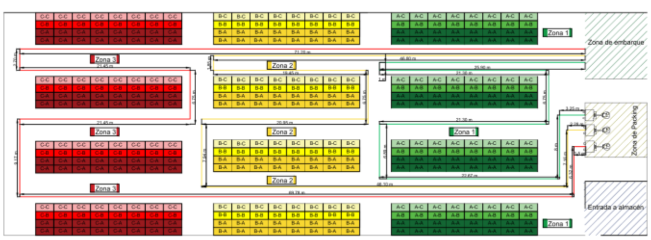

**Fig. 2 Optimized Warehouse Layout Based on ABC Classification**

*4.3.2. Phase 2: Picking Process Analysis and Improvement*

The picking process in the case study was initially performed manually, leading to long operation times and a high error rate in product selection. Methods Engineering techniques were applied with Voice Picking, a technology that guides workers through order preparation with real-time voice instructions to optimise this process.

*Picking Process Standardization*

The first step was to analyze the activities performed during order preparation. Non-value-added tasks, such as repeated verifications and unnecessary warehouse trips, accounted for 20% of total picking time. By applying Methods Engineering, inefficient movements were eliminated, and standardized procedures were established for each operator.

The main implemented changes included:

Assigning specific picking zones to each worker, reducing travel distances by 22%.

Introducing a new verification procedure to minimize selection errors.

Implementing QR code labels to facilitate quick spare part identification.

Figure 3 presents the proposed scenario for the Process Analysis Diagram in the order picking operation, highlighting efficiency improvements. The optimized workflow reduces total process time from 148 to 94 minutes, achieving a 54-minute reduction. Operational distances decreased from 266.27 to 216.20 meters, optimizing worker movements. The number of operations was adjusted while maintaining essential control points, improving sequencing and eliminating inefficiencies. The picking phase, which previously required 162.22 meters of travel, was reorganized using an area-based workload distribution: Zone A (117.06 m), Zone B (159.28 m), and Zone C (210.32 m), minimizing unnecessary displacement.

| CURSOGRAMA ANALÍTICO | ~~OPERARIO~~ / MATERIAL / ~~EQUIPO~~ | | | |
|---|---|---|---|---|
| DIAGRAMA núm: 1 Hoja num: 1 de 1 | RESUMEN | | | |
| Objeto: Repuestos | ACTIVIDAD | ACTUAL | PROPUESTA | ECONOMÍA |
| Actividad: Proceso de picking | Operación | 08 | 06 | 02 |
| | Transporte | 03 | 03 | 0 |
| Método: ~~ACTUAL~~/PROPUESTO | Espera | 0 | 0 | 0 |
| | Inspección | 02 | 02 | 0 |
| Lugar: Almacén de Repuestos | Almacenamiento | 0 | 0 | 0 |
| Operarios(s): Pedro Pérez Ficha num: 1 | Distancia | 266.27 metros | 216.20 metros | 50.07 metros |
| | Tiempo | 148 minutos | 94 minutos | 54 minutos |
| Compuesto por: Juan Castillo Fecha: 14/04/2 | Costo Mano de obra | | | |
| Aprobado por: Jefe de almacén Fecha: 14/03/2 | Material | | | |

| DESCRIPCIÓN | C | D (m) | T (min) | ○ | ⇨ | D | □ | ▽ | Observaciones |
|---|---|---|---|---|---|---|---|---|---|
| 1. Recepción de orden de pedido | | | 12 | ● | | | | | |
| 2. Elaborar guía de pedido | | | 5 | ● | | | | | |
| 3. Asignar operarios de almacén para picking | | | 2 | ● | | | | | Se asigna aleatoriamente a los operarios y todos los operarios tienen la misma carga laboral |
| 4. Traslado a zona de almacén (Para hacer picking) | | 7.5 | 2.5 | | ● | | | | |
| 5. Picking | 16 | 162.22 | 25 | ● | | | ● | | Se realiza la búsqueda de 16 pedidos, con mediante el uso de zonas para distribuir la carga de trabajo: Zona A=117.06 m; Zona B=159.28 m; Zona C= 210.32 m |
| 6. Traslado a zona de embalaje | | 20.78 | 10 | | ● | | | | |
| 7. Sellar paquetes | | | 15 | ● | | | | | Se realiza el sellado en cajas sobre pallets (Paletizado) |
| 8.Colocar nombre y número de pedido de cliente en el paquete | | | 6 | ● | | | | | |
| 9. Registrar número de bultos en las notas de pedido | | | 5 | | | | ● | | |
| 10. Trasladar a zona de despacho | | 19.50 | 11 | | ● | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Total | | 210 | 94 | 06 | 03 | 0 | 02 | 0 | |

**Fig. 3 Optimized process analysis diagram for order picking operations**

*Voice Picking Implementation*

Various technologies were evaluated to improve picking accuracy, with Voice Picking being selected due to its ability to reduce errors and increase operational efficiency. This system uses audio devices that provide real-time instructions to workers, eliminating the need for visual references or paper lists.

The benefits of Voice Picking included:

Reduction in picking error rate from 8.8% to 0.98%.

Increase in operator productivity, from 1.41 to 2.02 orders per hour.

There was a decrease in average picking time from 177.8 minutes to 92.82 minutes, representing a 47.8% improvement.

*Validation of Solution Impact*

Performance indicators were established to assess the effectiveness of the implemented improvements, comparing the initial situation with the results obtained after applying the management model. The key outcomes were:

On-Time Delivery: Increased from 85.49% to 94.75%, approaching industry standards.

Order preparation time: Reduced by 47.8%, from 177.8 to 92.82 minutes.

Picking error rate: Drastic decreased from 8.8% to 0.98%.

Picking rate: Increased by 43.26%, from 1.41 to 2.02 orders per hour.

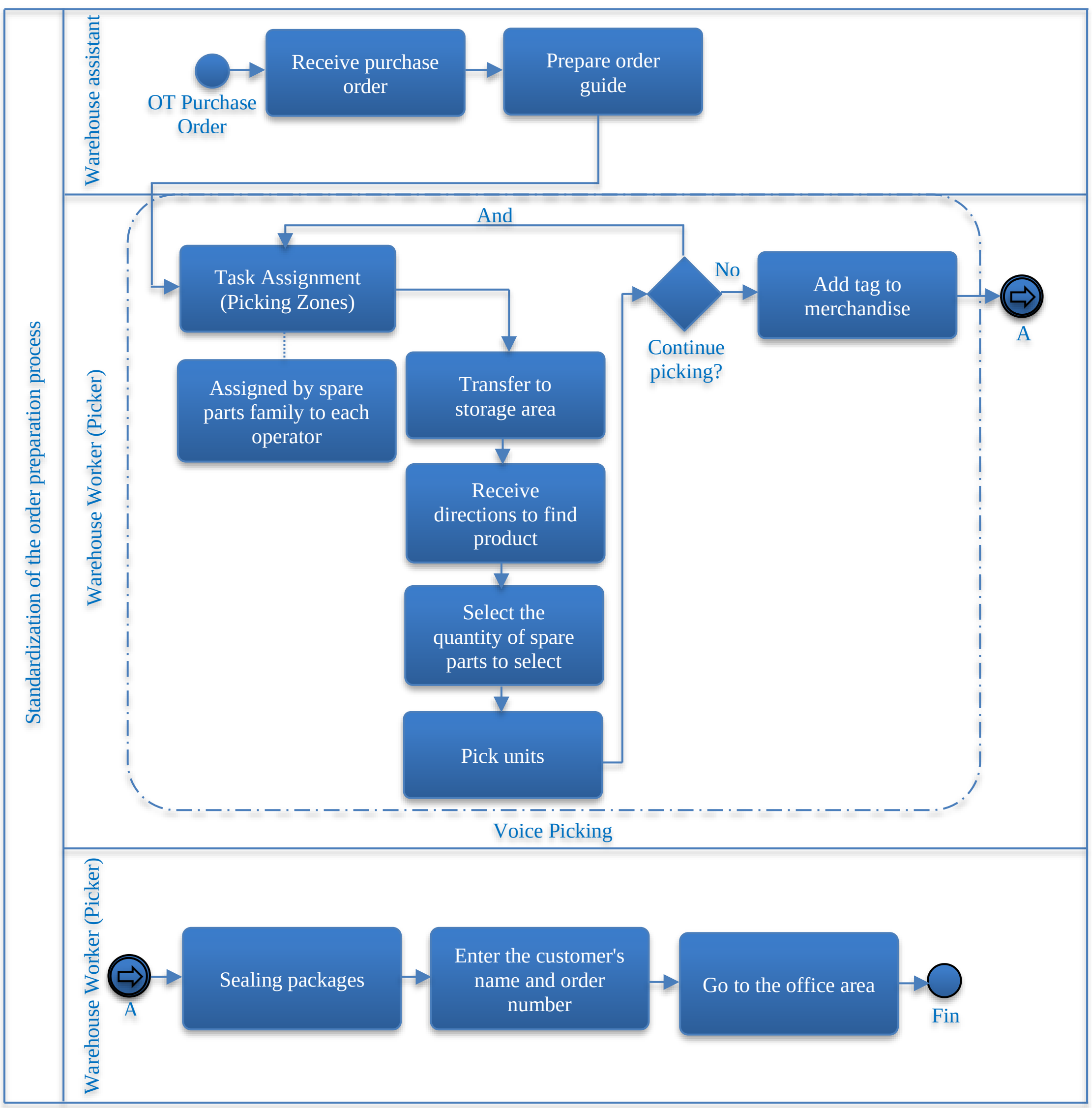


**Fig. 4 Standardized order picking process with voice picking integration**

Figure 4 illustrates the proposed standardized order-picking process, integrating Voice Picking to enhance efficiency and accuracy. The process begins with order reception and task assignment, where each operator is designated a specific picking zone based on spare part families. Operators receive voice-guided instructions to locate products, select the required quantity, and confirm each pick. The system ensures real-time verification, minimizing errors. Once picking is completed, labels are added, and the order is transferred for packaging. The final stage involves sealing, labelling, and dispatching orders. This workflow optimization significantly reduces errors and improves order fulfillment speed.

Implementing the proposed solution significantly improved warehouse operational efficiency and reduced deficiencies in the picking process. Inventory reorganization through SLP and ABC Classification optimized retrieval times and reduced unnecessary trips, while Voice Picking reduced errors and enhanced order preparation speed. To ensure the sustainability of these improvements, it is recommended that the company implement a continuous monitoring and maintenance plan, along with periodic staff training. Additionally, integrating a Warehouse Management System (WMS) is suggested to complement process digitalization and enhance operational traceability.

### *4.4. Results*

Table 1 presents the validation of the proposed operations management model, demonstrating significant improvements in key logistics process indicators. The on-time delivery rate increased from 85.49% to 94.75%, approaching industry standards. The average order picking time was reduced by 47.80%, decreasing from 177.8 to 92.82 minutes, optimizing response times.

Additionally, the order picking error rate drastically declined from 8.80% to 0.98%, reflecting greater accuracy in order preparation. Furthermore, the order picking rate improved by 43.26%, reaching 2.02 orders per hour, enhancing operational productivity. These results validated the effectiveness of the implemented model, highlighting its positive impact on logistics management and the company's overall competitiveness.

**Table 2. Results of the pilot**

| Indicator | Unit | As-Is | To-Be | Results | Variation (%) |
|---|---|---|---|---|---|
| On-time delivery | % | 85.49% | ≥ 99% | 94.75% | 10.83% |
| Average order picking time (Based on a typical order) | minute | 177.8 | 84 | 92.82 | -47.80% |
| Order picking error rate | % | 8.80% | 1.00% | 0.98% | -88.86% |
| Order picking rate | order/hour | 1.41 | 2 | 2.02 | 43.26% |

## 5. Discussion

The results obtained in this study confirm and expand on previous contributions regarding warehouse optimization in Small and Medium-sized Enterprises (SMEs) specializing in spare parts distribution for heavy machinery. The application of the Systematic Layout Planning (SLP) methodology improved efficiency in spare parts distribution, reducing search times by 35%, which aligns with previous studies highlighting the importance of rational warehouse design in minimizing travel distances and enhancing accessibility [13].

Additionally, multi-criteria ABC analysis facilitated the prioritization of high-demand items, optimizing their placement in the warehouse, consistent with the findings of Sarmah and Moharana [17], who demonstrated that strategic inventory classification can reduce operational costs and improve product availability. Furthermore, the integration of Voice Picking in the picking process led to an 88.86% reduction in errors, outperforming previous studies on voice-assisted picking technologies in industrial warehouses [25]. However, unlike previous research that analyzes these tools individually, this study proposes an integrated model that combines multiple methodologies, offering a more robust and replicable solution for logistics optimization.

### *5.1. Study Limitations*

Although the results show significant improvements in key logistics performance indicators, certain limitations must be considered. First, the model validation was conducted in a single case study, limiting the generalizability of the findings to other companies with different operational structures.

Furthermore, in the monitoring period of 4 months, such evaluations could not be carried out that would analyze long-term achievement or the impacts of variation in demand. Furthermore, an additional notable aspect is that they need to invest if they want to implement some of the technologies, such as Voice Picking, making it difficult for financially constrained companies. Ultimately, this research did not consider other digital tools, such as a Warehouse Management System (WMS) which could have been integrated to better the results obtained from the study.

### *5.2. Recommendations for SMEs Based on Results*

The results from this investigation offer direct guidance for the logistics management of small and medium-sized enterprises that focus on the distribution of heavy machinery spare parts. Implementing an integrated model that relies on continuous improvement tools reduces non-productive times, resource optimization, service level enhancement, and, ultimately, competitiveness improvement. SLP and ABC analysis facilitated warehouse reorganization, enabling quicker access to the most sought-after spare parts, lowering search times and picking errors. Also, the use of Voice Picking not only increases order preparation accuracy but also decreases the mental effort required from operators, thus leading to a more ergonomic work environment. These results stand to help other companies in the industry that wish to enhance their procedures without needing to invest large amounts of money or implement overly complex measures.

### *5.3. Future Works*

Building on the insights of this study, subsequent research could aim to apply the model to different organizations in the industry while taking into account changes in warehouse configuration and demand volume. Moreover, it would be helpful to assess the effects of adding new technologies, such as WMS or AI, to enhance picking and stock location assignment and system performance. Another interesting research topic could be an evaluation of the economic effectiveness of Voice Picking in different kinds of warehouses about ROI and the operational learning curve of warehouse personnel. Lastly, some studies should be conducted with a time dimension to evaluate the changes' permanency considering the employee attrition rate, demand fluctuations, and the operational cost trends.

## 6. Conclusion

The study demonstrates that integrating methodologies such as Systematic Layout Planning (SLP), multi-criteria ABC analysis, Methods Engineering, and Voice Picking effectively optimizes storage management and picking processes in spare parts distribution companies for heavy machinery. The results show significant improvements in key performance indicators, including a 47.8% reduction in average order preparation time, a 43.26% increase in the number of orders processed per hour, and an 88.86% decrease in the picking error rate. These enhancements have raised the service level from 85.49% to 94.75%, closing the gap with industry standards. Additionally, warehouse reorganization based on ABC classification and implementing optimized picking routes has reduced spare part search times by 35% and unnecessary travel by 28%.

The importance of this research lies in its ability to provide concrete solutions to logistical challenges faced by Small and Medium-sized Enterprises (SMEs) in this sector, where operational efficiency is a key factor in competitiveness. Empirical evidence supports the effectiveness of combining continuous improvement tools for optimizing storage and distribution processes, ensuring lower operational costs and higher customer satisfaction. Moreover, the proposed model not only enhances internal warehouse efficiency but also contributes to business sustainability by minimizing idle time and errors in order preparation.

The study's main contribution is the integration of multiple methodologies into a management model adaptable to various industrial contexts. Unlike previous approaches that analyze each tool individually, this model offers a comprehensive perspective, simultaneously addressing warehouse organization and picking efficiency. Its practical application validates its potential for replication in other sectors with similar logistics optimization needs. As a final observation, it is recommended that Warehouse Management Systems (WMS) be implemented to complement process digitalization and improve operational traceability. Additionally, future research could explore the automation of picking operations through collaborative robots or artificial intelligence to optimize response times further and reduce dependence on human intervention in repetitive tasks.

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