Jurnal Teknik Industri dan Manajemen Rekayasa *ISSN : 3025-5139*
Vol. 3, No. 2, 2025, 109-124

Waste reduction of 3PL warehouse operation to overcome excessive overtime

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Abstract
Excessive overtime was a persistent issue in the warehouse operations of a 3PL company, where employees frequently exceeded the Indonesian government's legal limit of 18 overtime hours per week due to daily working hours surpassing the 11-hour threshold. To analyse and address this problem, several structured methods were applied. Process Activity Mapping was used to classify activities into value-added, non-value-added, and necessary non-value-added categories, followed by Value Stream Mapping to visualize process flow and measure total cycle time. The 5 Whys analysis was then employed to identify root causes of delays and inefficiencies, leading to the application of the ECRS principle (Eliminate, Combine, Rearrange, Simplify) to redesign workflows and propose targeted improvements. As a result, the redesigned processes, supported by the modification of stock card formats, implementation of a kanban board, and development of Standard Operating Procedures, successfully reduced average working hours to 10.72 hours per day and decreased total process cycle time by 16.7 percent (65.9 minutes), demonstrating a notable improvement in warehouse efficiency and regulatory compliance.

Keywords*: overtime, third-party logistics, Value Stream Mapping, waste reduction*

Received: 02-12-2025; *Revised*: 26-12-2025; *Accepted*: 27-12-2025
DOI: https://doi.org/10.24002/jtimr.v3.i2.13358

Citation suggestion:
Asmoro, E. N. & Daryanto, Y. (2025). Waste reduction of 3PL warehouse operation to overcome excessive overtime. *Jurnal Teknik Industri dan Manajemen Rekayasa*, *3*(2), 109-124.

1. Introduction

Distribution plays a vital role in the modern supply chain, as it directly influences logistics efficiency, customer satisfaction, and the overall responsiveness of the supply network. Third-Party Logistics Providers (3PL) serve as crucial intermediaries between manufacturers and consumers, facilitating the seamless flow of goods through transportation, warehousing, and delivery operations. As noted by Jum'a and Basher (2023), 3PL companies have evolved beyond their traditional logistics role by offering value-added services such as order processing, inventory management, and customer support.

This study analyses a local 3PL company in Indonesia that manages the distribution of 19 client brands across various categories including skincare, food, beverages, batteries, and other fast-moving consumer goods. Despite its strategic role in regional distribution, its warehouse operations experience persistent issue. The main problem identified in its warehouse operations is the occurrence of excessive overtime among warehouse staff, which

leads to increased labor costs, reduced performance, and disturbing external stakeholder workflow (principals salesperson).

Early analysis shows that several employees exceeded the normal overtime limit of 18 hours per week. Further calculation shows that, for this critical group, the average daily working hours reach 11.17 hours. This issue is not caused solely by heavy workload but by inefficient workflow design. Inefficient workflow such as long waiting times between interdependent tasks such as order picking, packing, and invoice checking. These process dependencies force certain activities, like packing and loading, to be completed late in the day, extending total working hours. Additional administrative delays in preparing documents and postponing unloading activities after regular shifts further intensify the problem. The inefficiencies also disrupt coordination with external sales staff, who face delays in direct order processing. Overall, excessive overtime stems from fragmented workflows, redundant administrative activities, unstandardized procedures, and idle periods that cumulatively push operations beyond normal working hours (8 hours with maximum 3 hours overtime per day).

Existing studies have widely applied lean and process improvement methodologies to enhance warehouse efficiency across different industrial contexts. For example, Salhieh et al. (2019) and Pacheco (2023) demonstrated that applying Value Stream Mapping (VSM) and lean tools can significantly reduce lead time and operational waste, while Adeodu et al. (2023) and Jum'a and Basher (2023) highlighted how Pareto Analysis and Lean Six Sigma principles improve warehouse performance in 3PL environments. However, most prior studies have focused on large-scale or technology-driven logistics systems, leaving a gap in research addressing small-scale 3PL warehouses that rely heavily on manual operations and limited infrastructure.

The objective of this study is to reduce excessive overtime, to ensure that daily working hours do not exceed 11, which corresponds to the legal maximum of 18 hours overtime per week. Studies focusing on warehouse overtime have shown that layout redesign, workload balancing, and process mapping can significantly reduce excessive working hours. Ariyanti and Paramaputra (2023) reduced overtime by 11% through class-based storage and optimized shift scheduling, while Sari et al. (2021) used work sampling and workload analysis to improve productivity. Complementing these approaches, Business Process Mapping and related visualization tools have become essential for identifying inefficiencies and redesigning workflows.

Various academic studies have also implemented waste reduction techniques to enhance warehouse performance. Dhyana (2023) achieved a 15% reduction in product preparation time and a 66% improvement in manufacturing cycle effectiveness using Lean Six Sigma with ECRS (Eliminate, Combine, Rearrange, Simplify) principles, while Balahanti (2024) increased productivity by combining Process Activity Mapping (PAM) and 5S, resulting in time savings of nearly 8%. Other researchers, such as Kovac and Djurdjevic (2020) and Haouassi et al. (2022), explored simulation-based and process optimization approaches that reduced travel distances and picking times. Meanwhile, Octaviani and Ce (2020) demonstrated that integrating Bluetooth Low Energy (BLE) for real-time tracking can improve warehouse search efficiency and employee productivity. However, there has been no combination of using VSM, PAM, and ECRS to reduce waste in warehouse operations.

This research addresses that gap by applying a combination of PAM, VSM, Why and Why Analysis, and ECRS principles to identify inefficiencies and develop practical improvement designs that can be implemented for small 3PL warehouses. The contribution of this research lies in the formulation of a low-cost, process-oriented improvement framework specifically for small 3PL warehouses. This framework can be effectively applied in non-automated, resource limited environments to reduce overtime, minimize waste, and enhance operational efficiency while maintaining compliance with labour regulations.

2. Method

Data for this study were obtained through direct observation of warehouse operations of a 3PL company located in Central Java, Indonesia. The observation was to document the detailed workflow, duration, and interrelation of key activities, including sorting route, drafting invoice, invoice grouping, order picking, delivered invoice checking, packing and loading, and sales realization. Activities data were collected across different operational days and time periods to capture variations in workload and process execution.

After the completion of data collection, a series of validation and analytical methods were conducted to ensure the accuracy and reliability of the observed data before proceeding with process analysis. The first step involved the application of uniformity and adequacy tests to verify that the time observation data were consistent and statistically sufficient for further analysis. Once the dataset was validated, the PAM method was employed to systematically classify each warehouse activity into three categories: Value-Added (VA), Non-Value-Added (NVA), and Necessary Non-Value-Added (NNVA). This classification provided a structured overview of time allocation within the warehouse operations and helped identify which activities contributed directly to value creation, which were necessary but non-productive, and which generated pure waste.

According to Prasetyawan and Ibrahim (2020), non-value-adding activities are those that do not enhance warehouse performance or customer satisfaction, which are categorized as waste such as transportation, inventory, motion, waiting, overproduction, overprocessing, and defects. These waste categories, originally developed for manufacturing, are also applicable to warehouse operations (Salhieh et al., 2019). Identifying and minimizing such waste is therefore essential for improving warehouse productivity and performance.

The results of the PAM analysis served as the basis for developing the VSM, which was used to visualize the entire order fulfilment process from invoice preparation to delivery realization. The VSM enabled a detailed assessment of process flow, cycle time, and interdependencies between activities, allowing the identification of bottlenecks and excessive waiting or idle periods. To further examine the underlying factors behind these inefficiencies, a 5 Whys Analysis was applied to each major source of delay or waste. Based on these diagnostic findings, the ECRS principles was used to design process improvements aimed at streamlining workflows, reducing non-value-added activities, and improving time efficiency. These improvement proposals were then formulated into a proposed future-state process design, which served as the foundation for evaluating potential reductions in cycle time and working hours across warehouse operations.

3. Results and Discussion

An analysis of the order fulfilment process was conducted to identify and quantify the types of waste contributing to excessive overtime. Each detailed activity within the warehouse

workflow was examined to determine the sources of inefficiency. The analysis focused specifically on warehouse-related operations, covering the process from invoice receipt to the completion of order loading onto delivery trucks. Figure 1 illustrates the business process of the warehouse operation focused on order fulfilment process.

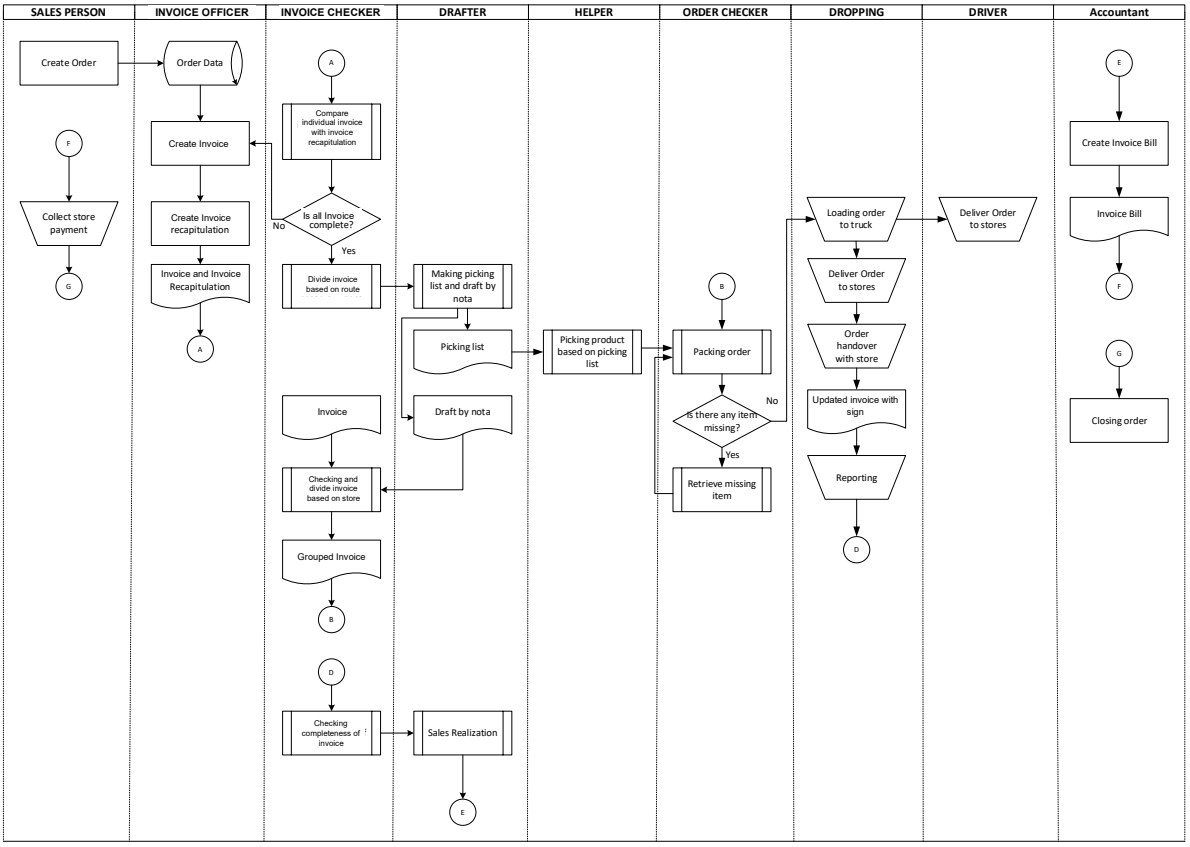

Figure 1. Business process as-is.

The collected data emphasized the duration required by workers to complete each specific task, with several activities recorded continuously from start to finish. In total, 45 activities were documented across seven main warehouse processes. Table 1 presents the detailed activities of each process and the time needed complete each task.

3.1. Process Activity Mapping

In this Process Activity Mapping (PAM), each activity was classified according to its value-added category. The classification of warehouse activities into VA, NNVA, and NVA categories followed the structured framework proposed by Harrington (1999). This framework applies a systematic decision flow to ensure that every activity is objectively evaluated based on whether it directly contributes to customer value, is essential for maintaining process continuity, or constitutes waste that should be reduced or eliminated. Table 2 presents the PAM for Process 1 and 2.

From the analysis, a total of 45 activities were identified, consisting of 32 operations, 8 inspections, 4 transportations, and 1 delay, with no storage activities recorded. Operations made up the majority at 72% of all activities. In terms of value classification, 14 activities (181.6

minutes) were categorized as VA, 20 activities (106.3 minutes) as NNVA, and 11 activities (136.1 minutes) as NVA. Combined, NNVA and NVA activities account for 57.2% of total process time, highlighting a significant potential for improvement through the reduction of non-value-adding work.

Table 1. Warehouse activities data.

No	Process	Code	Activity	Time Duration (Minutes)
1	Sorting Route	1.1	Manually match each invoice number with the recap list and give mark	8.38
		1.2	Sort the invoices manually into piles based on route	9.47
		1.3	Label each bind using paper	1.69
		1.4	Bind each route's invoice pile using rubber	1.29
2	Drafting Invoice	2.1	Prepare printer & check paper/toner	1.25
		2.2	Log into warehouse system	0.68
		2.3	Enter invoice number per route	6.60
		2.4	Generate & print picking list	2.17
		2.5	Print "Draft by Nota"	1.66
3	Invoice Grouping	3.1	Match invoice with recap list and mark invoice	4.99
		3.2	Assign sequence number	2.86
		3.3	Group invoices per store	8.43
		3.4	Staple each store pile	1.87
		3.5	Bind with rubber	0.52
4	Order Picking	4.1	Retrieve picking list from admin	3.99
		4.2	Prepare boxes	8.39
		4.3	Search for items	21.18
		4.4	Update physical stock card	13.61
		4.5	Pick & count ordered items	36.82
		4.6	Transfer picked items to pallet	11.43
		4.7	Move pallet to packing area	9.57
5	Packing and Loading	5.1	Retrieve invoice from admin	5.02
		5.2	Waiting for picking done	60.12
		5.3	Prepare packing boxes	15.05
		5.4	Unload picked items	25.25
		5.5	Retrieve missing items	30.52
		5.6	Count while packing	34.45
		5.7	Verify invoice (mark completeness and unavailable item)	20.29
		5.8	Label with store name	10.17
		5.9	Load into truck	20.47
6	Delivered Invoice Checking	6.1	Discard paper & remove staples	3.48
		6.2	Check invoice completeness	5.78
		6.3	Confirm discrepancies	5.01
		6.4	Separate invoice copies	4.30
		6.5	Sort by number	4.35
		6.6	Cross-check with "By Nota"	3.44
		6.7	Stamp invoice and invoice copies	2.24
		6.8	Bind invoice and copies (rubber)	1.22
		6.9	Note undelivered invoice	1.67
7	Sales Realization	7.1	Verify invoice with "By Nota"	2.55
		7.2	Log into warehouse system	0.45
		7.3	Input invoice numbers	4.68
		7.4	Adjust quantity discrepancies	3.02
		7.5	Separate by brand	2.70
		7.6	Bind invoices per brand (staple)	1.09

3.2. Current state Value Stream Mapping

The current state Value Stream Mapping (VSM) illustrates the actual warehouse operations flow at the company. Since lead time data between processes were not yet available,

the analysis focused solely on the cycle time of each activity to provide a clear view of process efficiency. Figure 2 illustrates the current state VSM.

Table 2. Process Activity Mapping.

Code	Activity	Time Duration (Minutes)	Symbol					VA/NVA/ NNVA
			O	T	I	S	D	
1.1	Manually match each invoice number with the recap list and give mark	8.38			✓			NNVA
1.2	Sort the invoices manually into piles based on route	9.47	✓					NNVA
1.3	Label each bind using paper	1.69	✓					VA
1.4	Bind each route's invoice pile using rubber	1.29	✓					NVA
2.1	Prepare printer & check paper/toner	1.25	✓					NNVA
2.2	Log into warehouse system	0.68	✓					NNVA
2.3	Enter invoice number per route	6.60	✓					VA
2.4	Generate & print picking list	2.17	✓					VA
2.5	Print "Draft by Nota"	1.66	✓					NNVA

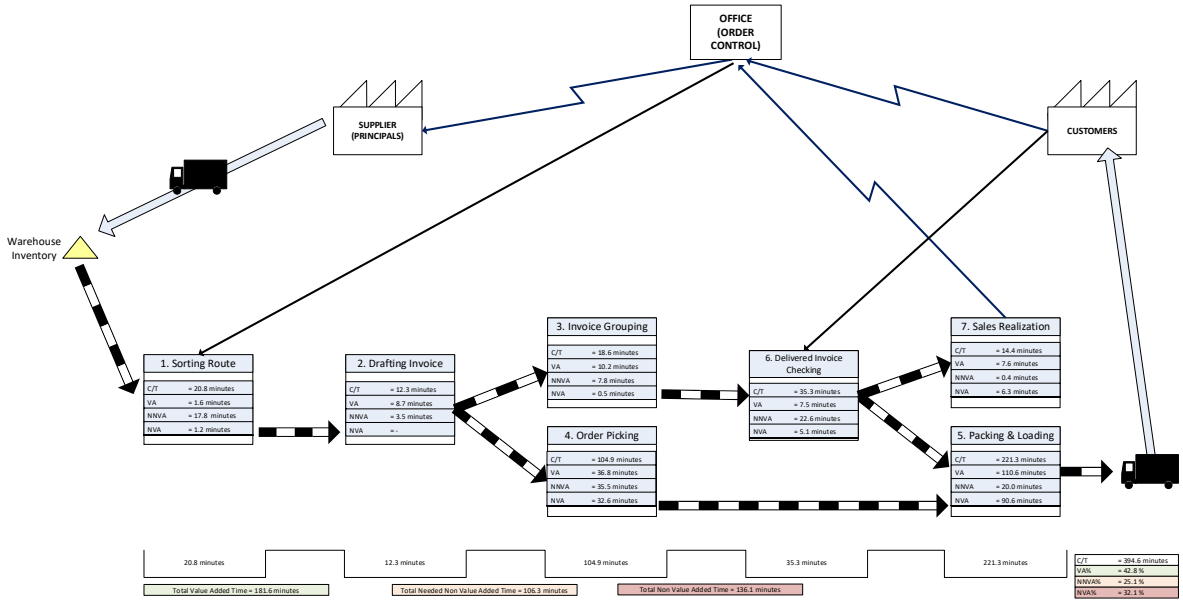

Figure 2. Current state VSM.

The total cycle time for the end-to-end process was recorded at 394.6 minutes, comprising 181.6 minutes of VA activities (42.8%), 106.3 minutes of NNVA (25.1%), and 136.1 minutes of NVA (32.1%). This distribution reveals that less than half of the total time contributes directly to customer value, with over half representing waste or inefficiencies. The order fulfilment process alone accounts for approximately 6 hours and 35 minutes of employees' daily workload (more than half of their average 11.17 working hours per day). The substantial proportion of NNVA and NVA activities significantly contributes to extended working hours, exceeding regulatory limits of 11 hours per day or 18 hours of overtime per week.

3.3. Waste identification

After identifying waste in warehouse operations, a root cause analysis was conducted using the Why and Why Analysis, following the approach of Suwandi and Suhada (2025). The analysis focused on activities categorized as NNVA and NVA to uncover the underlying causes of inefficiency. By repeatedly asking "why," each problem was traced to its root cause, enabling the development of targeted improvement solutions. The results of this analysis are presented in the following section, outlining the main issues, causes, and proposed corrective actions. Table 3 presents the Why and Why Analysis for the sorting route and invoice drafting wastes along with the proposed possible solutions.

The Why and Why Analysis for the sorting route identified two NNVA activities and one NVA activity. The NNVA tasks were found to be redundant due to the company's continued reliance on manual and paper-based processes. Both activities required employees to read the same invoice information twice, creating unnecessary repetition. Applying the ECRS principle, these tasks can be combined into a single-piece flow where each invoice is fully processed before moving to the next. The NVA activity, which involved tying documents with rubber bands for neatness, was identified as pure waste and can be eliminated by introducing a document tray or bin system. This modification reduces unnecessary motion and waste while maintaining organized documentation.

In the drafting invoice process, three NNVA activities were identified. Root cause analysis revealed that printer preparation was performed reactively and repeatedly throughout the day, resulting in wasted motion and inefficiency. This issue stemmed from an absence of structured scheduling within the workflow. Applying the ECRS framework, the task was proposed to be rearranged to an earlier stage of the process. Since printer preparation does not depend on any prior activity, performing it proactively would decouple it from the main operational flow, prevent disruption, and improve task continuity.

The invoice grouping process contained two NNVA activities and one NVA activity. Similar to the sorting route, redundant document handling occurred as staff had to read the same invoice details multiple times. By applying the ECRS principle, these repeated activities can be combined to remove duplication. Meanwhile, the NVA activity (binding documents with rubber bands to keep them tidy) was identified as unnecessary, as it added no value and consumed additional time. The recommended solution is to eliminate this step entirely and replace it with a reusable document tray or bin. This adjustment enhances efficiency and prevents document damage caused by repeated binding and unbinding.

In the order picking process, four NNVA activities and two NVA activities were identified. The first major inefficiency was the reactive preparation of boxes, which caused delays in picking. The proposed solution is to schedule box preparation at the start of the workday, allowing the task to be performed proactively. Another issue was the use of an outdated and overly detailed stock card format that made recording item movement time-consuming and prone to delays. Root cause analysis indicated that this format had not been reviewed for years. The improvement proposal involves redesigning the stock card to be simpler, faster to complete, and easier to interpret, thereby reducing process time while maintaining inventory accuracy.

Table 3. Why and Why Analysis.

Code	Activity	VA/NVA/ NNVA	Why 1	Why 2
1.1	Manually match each invoice number with the recap list and give mark	NNVA	Q: Why is activity 1.1 considered NNVA and overprocessing waste? A: Because it requires manual checking of each invoice number against a list, but it does not directly transform the product or contribute to customer value.	Q: Why is manual checking necessary? A: Because it is needed to confirm that all expected invoices have physically arrived at the warehouse.
1.2	Sort the invoices manually into piles based on route	NNVA	Q: Why is activity 1.2 considered NNVA and overprocessing waste? A: Because the same document is handled more than once.	Q: Why does the same staff handle the document more than once? A: Because the current process does not support multitasking.
1.4	Bind each route's invoice pile using rubber	NVA	Q: Why is activity 1.4 considered NVA and overprocessing waste? A: Because it does not change or improve the function of the invoices or directly support the delivery process.	Q: Why does binding not add functional value? A: Because it is only intended to make the document pile appear neat or easier to carry.
2.1	Prepare printer & check paper/toner	NNVA	Q: Why is activity 2.1 considered NNVA and motion waste? A: Because the same preparation is repeated several times a day without contributing to output quality.	Q: Why does this non-value activity have to be repeated multiple times daily? A: Because printer preparation is not scheduled and is done reactively based on current conditions.
2.2	Log into warehouse system	NNVA	Q: Why is activity 2.2 considered NNVA and motion waste? A: Because it is an administrative task that does not create value.	Q: Why is this activity still necessary? A: Because it functions as a verification step to protect company data and systems.
2.5	Print "Draft by Nota"	NNVA	Q: Why is activity 2.5 considered NNVA and overprocessing waste? A: Because it is still required but only supports internal processes.	Q: Why is it still needed even though it serves only internal purposes? A: Because the document is needed to proceed with the next task.

Table 3. Why and Why Analysis (continuation).

Code	Why 3	Why 4	Proposed Improvement
1.1	Q: Why is the invoice verified manually? A: Because the current system still depends on paper records and manual handling.	Q: Why does the system still rely on paper and manual processes? A: Because of organizational limitations such as low investment capability, informal procedures, and workflows that have not been reviewed or improved.	Apply ECRS to explore opportunities for time reduction.
1.2	Q: Why is multitasking not supported? A: Because of organizational limitations such as informal procedures and workflows that have not been improved.		Apply ECRS to explore opportunities for time reduction.
1.4			Apply ECRS to reduce time waste and consider using a document bin or tray for easier organization.
2.1	Q: Why is the preparation unscheduled? A: Because of organizational limitations, with workflows that have not been reviewed or improved.		Apply ECRS to explore options for reducing time by rearrangement
2.2			No proposed improvement, as this remains a critical activity under current conditions.
2.5	Q: Why is the document needed for the next task? A: Because the current system still depends on printed or physical records.		No proposed improvement, as this is a necessary activity under current conditions.

The packing and loading process consisted of two NNVA and two NVA activities. One key source of waste was idle time caused by poor synchronization between picking and checking teams, resulting in waiting before packing could begin. To resolve this, a visual coordination tool such as a Kanban board was proposed to improve communication and workflow alignment. Another inefficiency was reactive box preparation, similar to the picking process, which can be prevented by scheduling the activity earlier in the day. Additionally, missing item corrections during packing were identified as wasteful because they occurred due to a lack of formal stock-out reporting by helpers. The improvement proposal requires helpers to record stock-outs directly on the picking list, ensuring better coordination and reducing rework.

In the delivered invoice checking stage, six NNVA and two NVA activities were identified. The main issue involved redundant document handling after delivery, where administrative staff tidied and sorted unnecessary papers due to improper handover from droppers. The solution is to reassign this responsibility upstream to the droppers themselves, eliminating corrective work. Another inefficiency was the manual verification of returned invoices and logbook recording, both of which consumed time without adding value. Simplifying the verification process by checking only sequence numbers and using physical invoices as the record can streamline operations. Lastly, repetitive actions such as tying documents for neatness were again eliminated, with document trays recommended for better organization.

The sales realization process included one NNVA activity and three NVA activities. The analysis revealed several overprocessing steps, including redundant verification and sorting tasks that duplicated efforts already performed by other staff. Since these actions provided no additional value to the next process, they were proposed for elimination under the ECRS principle. Additionally, aesthetic-only document handling, such as tying invoices with rubber bands, was again identified as unnecessary and replaced with a tray system. These eliminations reduce process redundancy and help ensure that only essential tasks are retained in the workflow.

3.4. ECRS analysis

The ECRS analysis was conducted as a continuation of the waste identification and root cause analysis to develop feasible improvement solutions for PT XYZ's warehouse operations. This stage involved direct discussions with warehouse staff to ensure that each proposed change was practical and could be implemented.

The Eliminate principle was applied to remove non-value-added activities that contribute to redundancy and unnecessary workload in PT XYZ's warehouse operations. As presented in Table 4 six activities were identified for elimination, including repetitive document binding, excessive note writing, and duplicate verification tasks. These actions, such as tying documents with rubber bands or rechecking invoices already verified in earlier steps, were found to provide no added value to either the customer or internal process flow. The proposed solution is to replace manual document binding with reusable trays, allowing for faster handling and reduced motion waste. In addition, unnecessary notetaking (6.9) and repetitive verification tasks (7.1, 7.5. and 7.6) were removed by consolidating existing records, thereby reducing duplication and simplifying information tracking.

Table 4. Eliminated activities.

Process	Code	Activity	Time Duration (Minutes)	VA/NVA/ NNVA
Sorting Route	1.4	Bind each route's invoice pile using rubber	1.291	NVA
Invoice Grouping	3.5	Bind with rubber	0.518	NVA
Delivered Invoice	6.8	Bind invoice and copies (rubber)	1.219	NVA
Checking	6.9	Note undelivered invoice	1.670	NNVA
	7.1	Verify invoice with "By Nota"	2.550	NVA
Sales Realization	7.5	Separate by brand	2.702	NVA
	7.6	Bind invoices per brand (staple)	1.093	NVA

The Combine principle was employed to address overprocessing caused by the repetition of similar tasks across multiple activities. Analysis as presented in Table 5. revealed that certain activities within the sorting route (activities 1.1 and 1.2) and invoice grouping processes (activities 3.1 and 3.2) involved rereading and rehandling the same invoice information multiple times. By integrating these related activities into a single step, the workflow can be made more efficient and continuous. The combined approach allows staff to process and categorize invoice data simultaneously rather than sequentially, thereby reducing repetitive motion and cognitive load. This adjustment aligns with lean process design principles, which emphasize the importance of single-piece flow to minimize unnecessary handling and improve throughput across administrative and warehouse tasks.

Table 5. Combined activities.

No	Process	Code	Activity	Time Duration (Minutes)	VA/NVA / NNVA
1	Sorting Route	1.1	Manually match each invoice number with the recap list and give mark	8.383	NNVA
		1.2	Sort the invoices manually into piles based on route	9.467	NNVA
2	Invoice Grouping	3.1	Match invoice with recap list and mark invoice	4.994	NNVA
		3.2	Assign sequence number	2.863	NNVA

Table 6. Rearrange activities.

Process	Code	Activity	Time Duration (Minutes)	VA/NVA/ NNVA
Drafting Invoice	2.1	Prepare printer & check paper/toner	1.248	NNVA
Order Picking	4.2	Prepare boxes	8.392	NNVA
Packing and Loading	5.3	Prepare packing boxes	15.045	NNVA
Delivered Invoice Checking	6.1	Discard paper & remove staples	3.478	NVA

The Rearrange principle was applied to reschedule activities that were previously performed reactively, resulting in idle time and workflow interruptions. As presented in Table 6. four activities were identified for rearrangement, including printer preparation, box preparation for picking and packing, and invoice paper disposal. These tasks were originally conducted only when required, creating process delays and inefficient time utilization. The proposed improvement involves moving these preparatory tasks (2.1. 4.2, and 5.3) to the beginning of the workday, allowing staff to perform them during waiting periods before the main operations start. Additionally, responsibility for discarding excess invoice paper was reassigned from administrative staff to droppers, integrating the task earlier in the workflow to prevent bottlenecks.

Table 7. Simplify activities.

Process	Code	Activity	Time Duration (Minutes)	VA/NVA / NNVA
Order Picking	4.4	Update physical stock card	13.612	NNVA
Packing and	5.2	Waiting for picking done	60.120	NVA
Loading	5.5	Retrieve missing items	30.516	NVA
Delivered Invoice Checking	6.6	Cross-check with "By Nota"	3.437	NNVA

The Simplify principle focused on refining complex and communication-intensive tasks to streamline execution and reduce variability. Several activities were targeted, including stock card updates, waiting for picking completion, retrieving missing items, and invoice verification. For stock card updates, the existing format was simplified by minimizing redundant fields, allowing faster and clearer data entry. To address coordination issues between helpers and checkers, a Kanban board was introduced as a visual management tool to track real-time progress, minimize communication delays, and ensure task synchronization. The retrieval of missing items was simplified by assigning helpers the responsibility to record stock-outs directly on the picking list, eliminating unnecessary confirmation loops with checkers. Lastly, invoice verification was improved by shifting from detailed number matching to sequential confirmation, as the invoices were already pre-sorted. These simplifications enhance process clarity, reduce motion and waiting waste, and strengthen coordination between interdependent roles, thereby improving overall warehouse efficiency.

3.5. Implementation and result

Based on the results of the ECRS and Why and Why Analysis, several improvement designs were developed to enhance warehouse operations at PT XYZ, focusing on reducing cycle time and addressing the root causes of excessive overtime. The proposed designs include the introduction of document trays to replace repetitive binding tasks, enabling faster and more organized document handling; a redesigned stock card that simplifies data recording while maintaining accuracy and traceability; and the implementation of a Kanban Board to improve visibility, coordination, and communication between helpers and checkers, thereby minimizing waiting times.

In addition, a set of Standard Operating Procedures (SOPs) aligned with ISO 9001:2015 standards were established to formalize the new processes, define clear responsibilities, and ensure consistent execution across all warehouse activities, including sorting route, drafting invoice, invoice grouping, order picking, packing and loading, delivered invoice checking, and sales realization. Finally, an improved business process (to-be) was developed following the standard of ISO 10244:2010, to integrate all these enhancements into a coherent workflow. Figure 3 illustrates the business process to-be, while the example of detailed sub-process and the changes are provided in the Appendices 1 and 2. While the overall process sequence remains similar to the current state, the redesigned workflow eliminates redundant activities, introduces structured handovers between helpers and checkers, and clarifies task responsibilities, collectively improving operational efficiency.

After the implementation, a detailed time comparison was conducted to measure improvements. Activities that were eliminated or rearranged were not remeasured, as their removal or sequence adjustment inherently contributed to process simplification. For combined and simplified activities, significant reductions in processing time were observed.

The total time across all recorded activities decreased from 424.14 minutes to 375.56 minutes, marking a reduction of 48.57 minutes or approximately 11.5 percent. This result validated that improvements effectively reduced cycle time without transferring workload or causing operational delays.

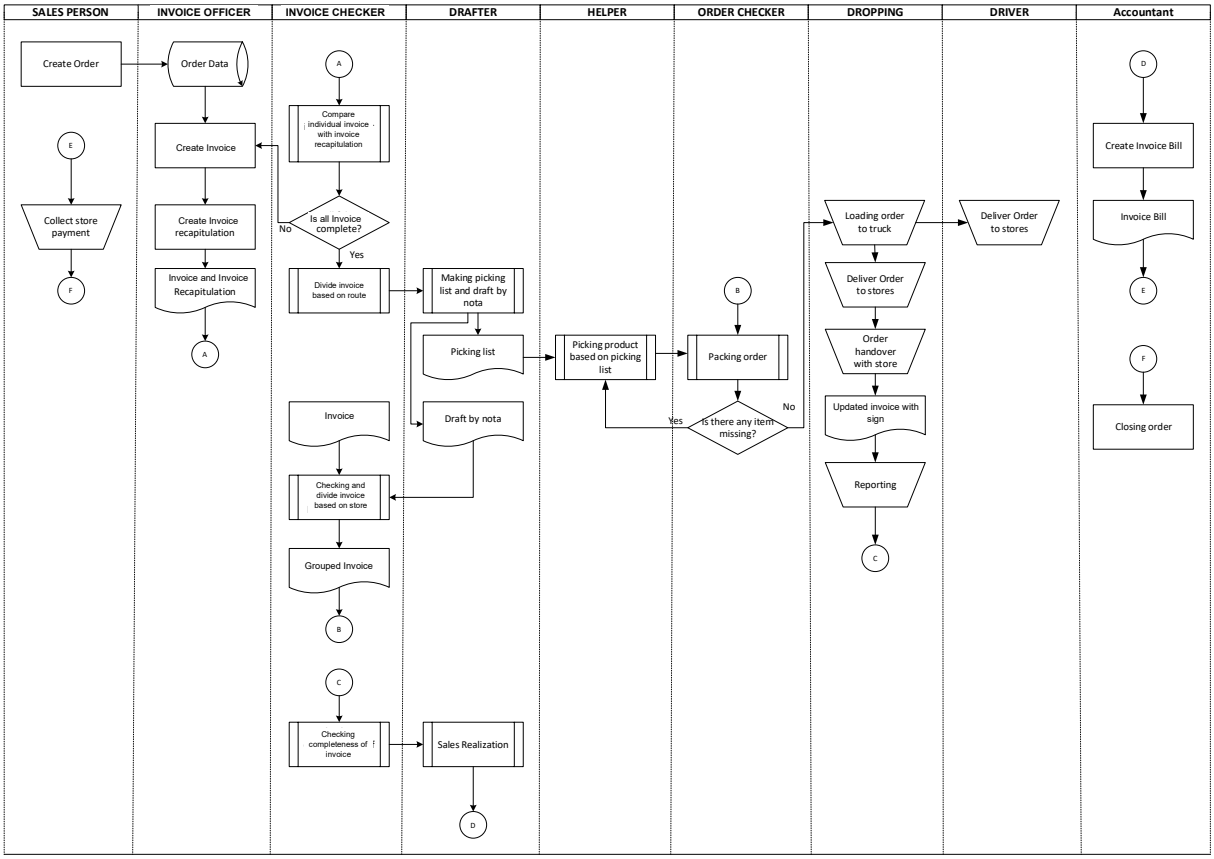

Figure 3. Business process to-be.

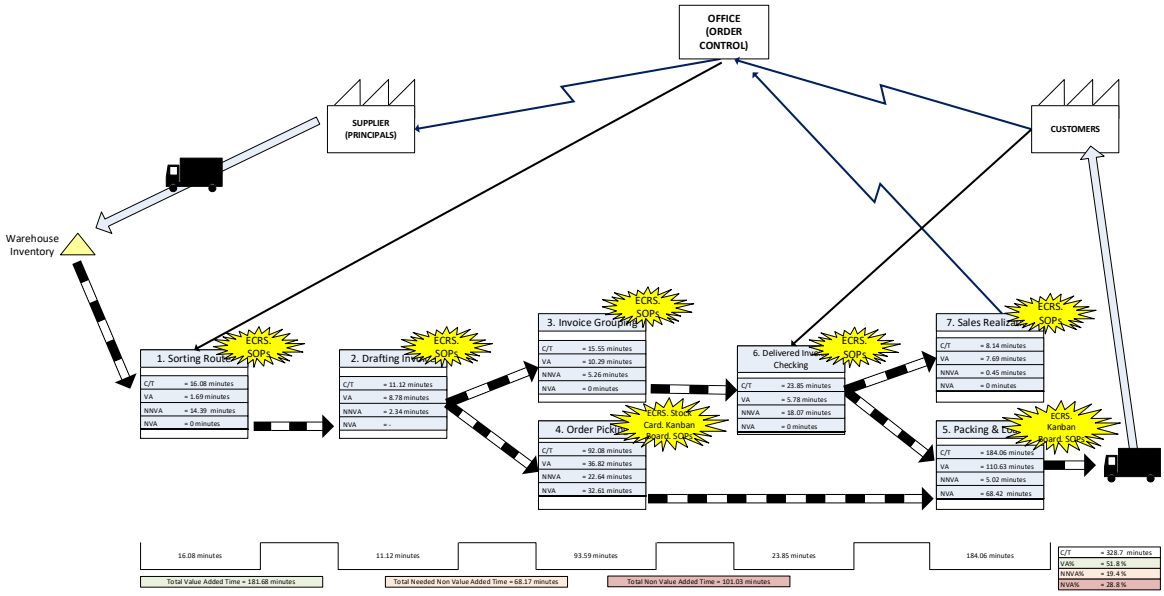

Figure 4. Future state VSM.

Finally, the future state VSM demonstrated the overall effect of the improvements as demonstrate in Figure 4. The total cycle time for the order fulfilment process was reduced from 394.6 minutes to 328.7 minutes equivalent to a 16.7 percent improvement. Value-added time increased to 51.8 percent of the total, while non-value-added time dropped significantly. Consequently, the average daily working hours for warehouse employees decreased from 11.17 to 10.72 hours, bringing the critical group back within the legal threshold of 11 hours per day. This result indicates that the proposed changes not only enhanced process efficiency but also contributed to regulatory compliance.

4. Conclusion

Based on the analysis, design of proposed improvements, and implementation carried out, several key conclusions can be drawn. The implementation of ECRS-based improvements successfully enhanced the overall efficiency of PT XYZ's warehouse operations. The total cycle time of the order fulfilment process decreased from 394.6 minutes to 328.7 minutes, representing a reduction of 65.9 minutes or approximately 16.7 percent. This significant improvement reflects the effectiveness of the redesigned workflows, elimination of redundant steps, and better synchronization between warehouse activities. Furthermore, the total process time was reduced by around 11.5 percent, indicating a more streamlined and balanced operational flow.

The improvement initiatives also had a measurable impact on employee working hours. The time required for order fulfilment decreased from 6 hours and 35 minutes to 5 hours and 29 minutes, contributing to a reduction in total working hours among the critical group of employees to 10.72 hours per day. This represents a 4.03 percent decrease in average daily working time, ensuring that employees remain within the legal limit of 11 hours per day and a maximum of 18 hours of overtime per week. Overall, these outcomes demonstrate that the proposed improvement designs not only optimized process performance and reduced waste but also contributed to better labour compliance.

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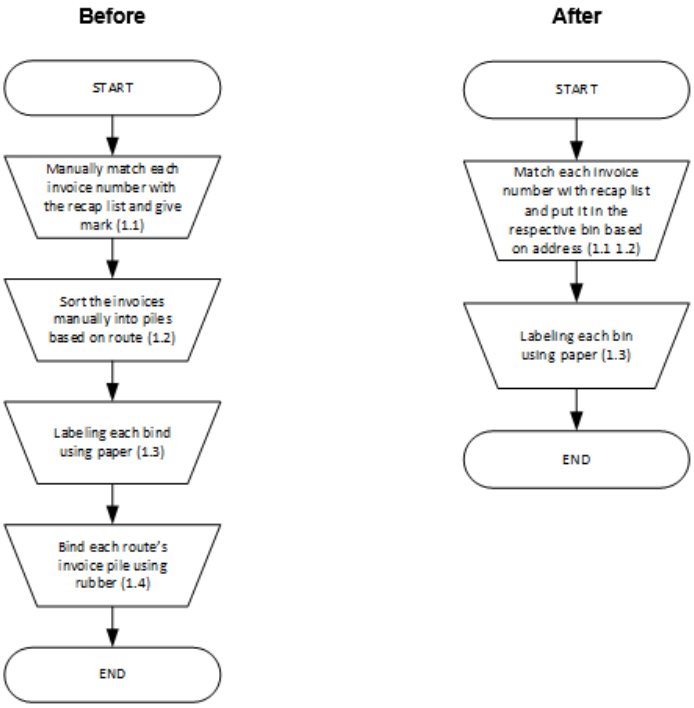
Appendix 1. Sub-process of comparing individual invoice with invoice recapitulation.



Appendix 2. Sub-process of making picking list and draft by invoice (invoice grouping).