Journal of Industrial Engineering
Scientific Journal on Research and Application of Industrial System
Volume 08 No 2 - September 2023
http://e-journal.president.ac.id/presunivojs/index.php/journalofIndustrialEngineering
ISSN 2527-4139 (*online*) – ISSN 2503-3670 (*print*)

Reducing Inbound Warehouse Operation Waste Through Lean Manufacturing: A Case Study of Small and Medium Enterprises (SME).

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ABSTRACT

A third-party producer, Company A, partners with a multinational corporation to package and transport the finished goods produced for its customers. To meet customer demand, Company A must maintain a considerably low lead time and an adequate level of inventory. To reduce lead times and non-value-added (NVA) activity times in warehouse operations, especially in inbound processes at an SME Manufacturing Facility, this research will analyze the impact of implementing lean manufacturing. The current operation's lead time and NVA time are 9045 minutes and 275 minutes, respectively. Value stream mapping (VSM) is selected as the tool to identify process waste and launch an improvement strategy to achieve the research objective. Creating the current state mapping and evaluating the future state mapping will be the first steps in the implementation approaches. The proposed improvements include creating and implementing a VBA application as a data entry form for supplier shipment booking, an information system for material reception, an operational report, and remodeling the staging area by incorporating a gravity roller. The lead time is decreased by 5% as the improvement strategy is put into action, while the NVA time is dramatically decreased by 47.27%. The research conclusions are thus recognized as noteworthy and beneficial in advancing the understanding of the role of value stream mapping methods in improving inbound warehouse performance in SMEs.

Keywords: *Inbound Warehouse Operation, Lean Manufacturing, Lean Warehousing, Value Stream Mapping, Improvement Plan.*

ABSTRAK

Produsen pihak ketiga, Perusahaan A, bermitra dengan perusahaan multinasional untuk mengemas dan mendistribusikan barang jadi yang diproduksi untuk pelanggannya. Dalam upaya untuk memenuhi permintaan pelanggan, Perusahaan A harus mempertahankan waktu tunggu yang sangat rendah dengan mempertahankan tingkat persediaan yang memadai. Untuk mengurangi waktu tunggu dan waktu aktivitas *non-value-added* (NVA) operasi gudang, terutama dalam proses *inbound* di Fasilitas Manufaktur UKM, penelitian ini bermaksud untuk menganalisis dampak implementasi *lean manufacturing*. Waktu tunggu dan waktu NVA untuk operasi saat ini masing-masing adalah 9045 menit dan 275 menit. *Value Stream Mapping* (VSM) dipilih sebagai alat untuk mengidentifikasi pemborosan proses dan meluncurkan strategi perbaikan untuk memenuhi tujuan studi. Penciptaan pemetaan keadaan saat ini dan evaluasi pemetaan keadaan masa depan akan menjadi langkah pertama dalam pendekatan implementasi. Perbaikan yang diusulkan meliputi pembuatan dan penerapan aplikasi VBA sebagai formulir entri data untuk pemesanan pengiriman pemasok, sistem informasi untuk penerimaan material, laporan operasional, dan *remodeling* area staging dengan menggunakan konveyor gravitasi. Waktu tunggu berkurang sebesar 5% saat strategi peningkatan diterapkan, sedangkan waktu NVA berkurang drastis sebesar 47,27%. Kesimpulan penelitian dengan demikian diakui sebagai penting dan bermanfaat dalam memajukan pemahaman tentang peran metode pemetaan aliran nilai dalam meningkatkan kinerja gudang masuk di UKM.

Kata kunci: Operasi Penerimaan Gudang, *Lean Manufacturing, Lean Warehousing, Value Stream Mapping,* Strategi Perbaikan.

1. Introduction

A sizable portion of the global economy consists of small and medium-sized company, that has a significant influence on the manufacturing industry. One of the biggest issues for SMEs is the complexity of the supply chain due to the fact they generally possess fewer resources, smaller budgets, and fewer employees than major organizations (Huin et al., 2002). As a result of other organizations' demands for quantity, fast delivery, and specialized service, SMEs are facing greater pressure to manage their supply chains efficiently (Thakkar et al., 2011). However, SMEs may find this difficult as they lack the technological capabilities or domain expertise to manage their supply chain operations effectively. Supply chain management in manufacturing is mainly driven by inventories, distribution, facilities, and suppliers (Lambert, 2010). These variables significantly affect the performance and optimization framework, which is important for SCM decision-making. Specifically, in the raw material storage facility or inbound logistics, this research intends to adopt the SCM strategy and tools in inventory management. For a firm to overcome fluctuations in markets and supplies, holdings of raw materials become vital. (Richards, 2011). Company A is facing resource and technical support constraints as a small and medium firm, which restricts the production process. In contrast, Company A is demanded by the consumer to meet a substantial demand with minimal time-to-market requirements. To sustain a competitive advantage and minimize lead times, Company A must ensure the company's inbound logistics and warehousing operations are efficient.

Company A has intended to enhance the inbound logistic operation to deliver services with precision and efficiency. Company A's warehousing costs increase due to unnecessary processing, personnel, and equipment. Wherein the labor force, supporting facilities, and material handling equipment have not been appropriately employed. As a result, there are 19,333 hours of lead time and 24% of NVA time relative to the inbound processing time. Operations excellence deteriorates as a result of the functioning management's incapacity to recognize economic and process risks. As a result, the company attempts to ensure that customers acquire their goods on time and enhances the efficiency of the warehousing network. Once cost-saving measures are combined with enhanced customer service, agility, and reactivity, the value of warehouses to a business and its supply chain as a whole grows (Komarova, 2016). As a result, the warehousing goal is to optimize operations by carefully tracking inventory goods, location, equipment, and labor.

The continuous implementation of proven waste-reduction techniques leads to ongoing improvements in performance and customer satisfaction (Sesar & Hunjet, 2021). The application of lean tools in warehousing is referred to as lean warehousing. Lean manufacturing techniques should be applied to investigate, enhance, and eliminate redundant processes in inbound operations (Vamsi Krishna Jasti & Kodali, 2014). Lean warehousing seeks to reduce waste to provide a flow of value to the client (Raghuram & Arjunan, 2022). (Harun et al., 2018) assert that the application of lean approaches to warehouse processes has led to the recognition, mitigation, and eradication of non-value-added activities. According to (Abhishek P.G. & Pratap, 2020), there are seven types of waste or NVA in warehouse operation, namely overproduction, waiting, transportation, processing, excess inventory, unnecessary motion, and defect, Value stream mapping (VSM) and work design analysis are commonly utilized in lean manufacturing to optimize warehousing procedures. Eliminate, Combine, Rearrange, and Simplify (ECRS) is a lean manufacturing technique that functions to optimize process activity once recognizing waste and ideal workflows (Ketchanchai et al., 2021). The change implementation aims to simplify work processes while improving performance and cutting costs. The findings of this research are employed by equipment adaptation, electronic data flow, vendor shipping information systems, and simplified work processes. The components and design of the improvement plan are adapted to the capacity and assets of the company at hand.

2. Methods

Company A is set to undertake this study from August through December 2022. The main areas of observation are the company's inbound logistics operation and the raw material warehouse. The initial observation process yields the current activities and historical data by recognizing the processing flow from the supplier order process, receiving, loading, and storing. For direct observation, time studies and flow mapping analysis are employed. The time study data is further examined to apply value stream mapping, and the spaghetti diagram is crucial for assessing the process flow and area utilization. Over 24% of the entire process time is identified as non-value added in the initial observation, and the lead time for the process accounts for 59% of the cycle time, which resulted from manual and repetitive work methods. It is also found that the warehouse inventory inaccuracy is high due to an inefficient data management system.

To understand the current state of the operation, value stream mapping (VSM) is utilized to visualize the flow process. Value Stream Mapping is a lean manufacturing tool that involves visualizing the production process of a good or service (Azwir et al., 2022). This map establishes the value stream by breaking the process into its component sections and assessing each to decide which steps are crucial and which are not. As a result, it can be used to evaluate current circumstances, identify issues, and develop strategies for improvements in the future (Abhishek P.G. & Pratap, 2020). Before any modification is made, the current state map (CSM), which is the VSM view built with the current processes, is first established. The strategy will be displayed in the Future State Map (FSM) once the development team's vision for the value stream has been established at a certain point in time (Abideen & Mohamad, 2020). The emphasis is on visualizing the future and determining the methods to develop a value stream that is more efficient and has less waste.

A spaghetti diagram is utilised to demonstrate how objects or entities flow through a series of actions. Spaghetti charts are frequently used in the manufacturing process and logistics to evaluate the worth and effectiveness of operations, find bottlenecks, and maximize throughput (Vamsi Krishna Jasti & Kodali, 2014). It can be used to identify areas with high traffic, long wait times, and resource waste. The primary data displayed on a spaghetti diagram is the paths objects or entities take as they move through a process in a particular area of work. The line used for this research will map the movement of both material and non-material handling. By analyzing these lines, it is possible to identify patterns in the movement or workflow, such as areas where individuals or objects are regularly obstructed or areas in which the operation is ineffective.

There are methods to adhere to for collecting the necessary data. The procedures performed to obtain data include direct observation of the inbound logistics and warehousing area, discussions with managers, team leaders, and operators, the compilation of historical data of inbound operations, and documentation of the processing sequence, time, and flow process in the inbound area. To compile the data, the next step is tabulation. The data from a single-month period are averaged out for analysis. Following this procedure, the data gathering is more comprehensible and can be projected to provide an answer to the study problem. The following are the stages necessary to analyze the data:

1. To identify a suitable solution to the right problem while utilizing the right methodology to meet the needs of the company, the existing condition should be well grasped.
2. To create development plans by mapping the cycle time and process activity to a spaghetti diagram and current state map (CSM).
3. To investigate ways supply chain management techniques might be integrated into the current procedure. It should be mentioned that choosing the right improvement strategies requires consideration of organizational capacities.
4. To construct a spaghetti diagram and a future state map to illustrate the effects of the process changes.
5. The warehouse's labor function would launch and deploy the enhanced system during the control process phase.

The steps of data analysis are presented in Figure 1.

3. Result and Discussion

3.1 Initial Inbound Process

The average daily demand for packaging materials in Quarter 4 of 2022 is 50 to 60 pallets. The warehouse operation Takt time is 21.6 minutes. The 24,500 m^2 total warehouse space is divided into three primary areas: transit to the production area, racking, and unloading and staging. The inbound logistic function oversees the supply for manufacturing, inventory management, and raw material receipt (Keller & Keller, 2014). An eight-person team at Company A manages the inbound operation.

Whenever the supplier truck pulls up to the plant, the driver is required to present the security with the purchase order and their company shipment letter to access the building. The shipment document is used to process and record the data of the incoming material. The document flow diagram for the inbound process is displayed in Figure 1. A warehouse staff member would be in charge of manually sorting the stuff in the staging area and opening the door for material to enter the warehouse. After sorting, the operator will open the rolling door to the warehouse, enter, and place the material in the ground storage area for quality control and labeling. The incoming logistic process comes to a close with the put-away stage. The spaghetti diagram of the inbound process is shown in Picture 2. The issue identified during the research is materials are unable to get racking due to the storage space being 84% occupied during this period.

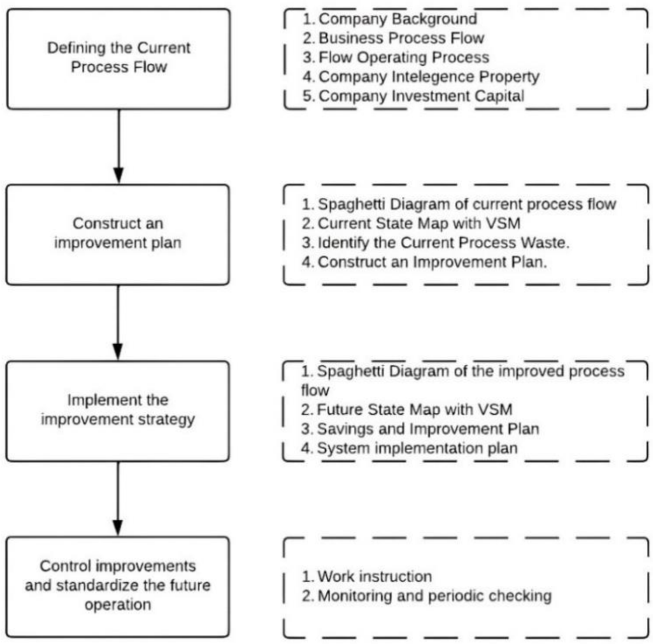

Figure 1. Data Analysis Framework

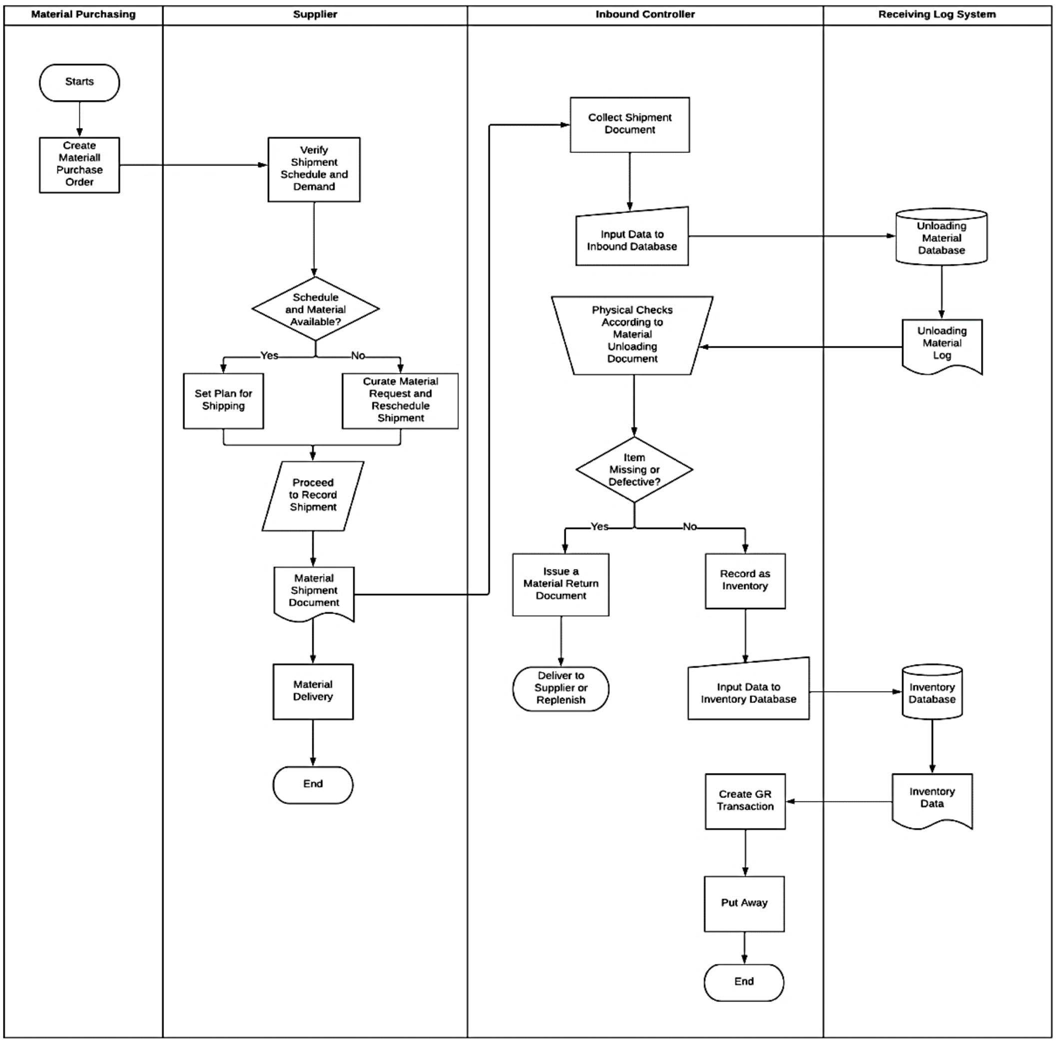

Figure 2. Current Document Flow Diagram

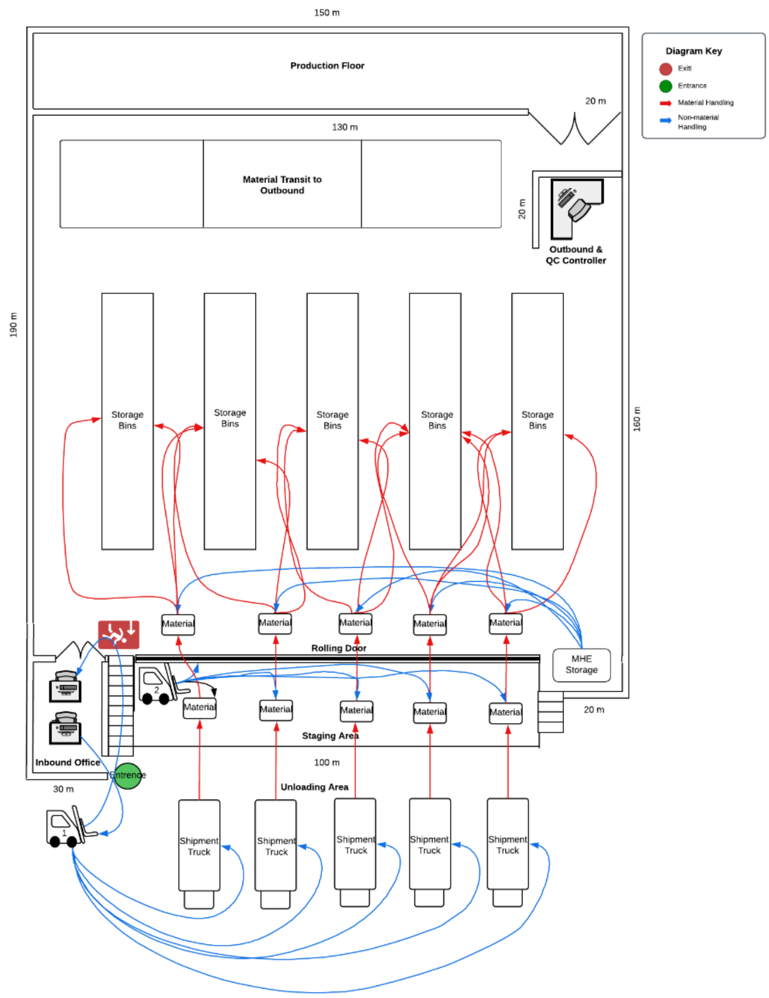

Figure 3. Current Spaghetti Diagram

The current state mapping (CSM) represents the current inbound process. Figure 3 presents the current VSM. Process activity mapping (PAM), a tool to categorize the types of waste produced during operation-related tasks, is shown in Table 1. High non-value-added time, noticeable in the put away, picking, unloading, staging, and material handling processes, is a sign of inefficiency. When the cost and time spent on an activity exceed the value-generating activity, that activity is considered to be non-value. Cost and time evaluations are done in reverse for warehouse procedures (Emmett, 2005).

Table 1. Current Process Activity Mapping

No.	Process	Activity	Tools/Machinery	Process Time (min.)	Resources (worker)	Value (min.)			Type of Waste
						VA	NVA	NNVA	
1.	Supplier Inspection	Operation, Transportation, Inspection		100	1	80	10	10	Unnecessary Motion, Waiting
2.	Material Inspection	Operation, Inspection	Forklift	70	1	20	30	10	Processing
	Unloading	Operation, Transportation	Forklift	110	1	70	30	20	Waiting
3.	Staging to Warehouse Area	Operation, Transportation	Forklift and Reach Truck	100	1	50	40	30	Unnecessary Motion, Transportation
	Sorting	Operation, Transportation	Reach Truck	90	1	35	25	10	Processing
4.	QA and QC Process	Operation, Inspection	-	120	1	90	-	30	
5.	Pallet	Operation	-	100	1	80	-	20	

No.	Process	Activity	Tools/Machinery	Process Time (min.)	Resources (worker)	Value (min.)			Type of Waste
						VA	NVA	NNVA	
	Labeling								
6.	Put away (MHE)	Operation, Transportation	Reach Truck	230	4	130	80	20	Waiting
7.	Picking (MHE)	Operation, Transportation	Reach Truck	240	3	140	60	40	Waiting

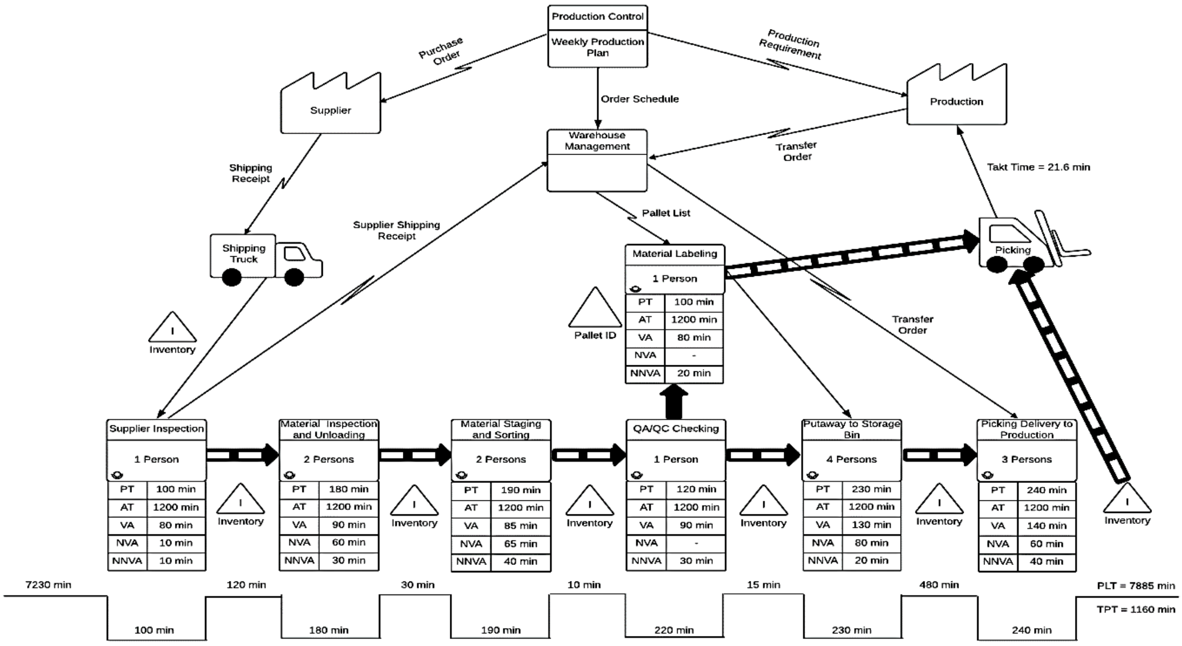

Figure 4. Current Value Stream Mapping

3.2 Waste Analysis

Waste is found to be highly influenced by unnecessary motion, inefficient processing, unnecessary transportation, and waiting time in the inbound logistic operation. The CSM revealed several issues, including the allocation of staging areas, repetitive and unnecessary movement throughout the staging and sorting process, repetitive receiving data entry, and excessive labor utilization. A summary of the inbound operation waste is presented in Table 2.

Table 2. Summary of Inbound Operation Waste

Type of Waste	Activity	Causes
Unnecessary Motion	Manual Document Transfer	Each shipping consignment requires a separate delivery to the inbound controller of the shipping document from the security.
	Entrance from Staging	Each time a shipment is received at the warehouse, a rolling door will be opened and shut. Additionally, frequent opening and closing of the entryway are triggered by insufficient staging space.
Processing	Shipping Document Data Recording	Prolonged processing times and waiting times in the inspection and staging processes are caused by manual data entry from the shipping document into the inbound receiving database.
	Inventory Data Recording	Unloading data to inventory data is manually copied.
	Sorting	Sorting process at the staging area, then sorting again in the warehouse area for storage.
Transportation	Staging	Using material handling equipment only to repeatedly transfer stuff over small distances. the distance between the warehouse entrance and the staging area.
Waiting	Setting The Area, Equipment, and Labor for	The inbound operation was not ready to receive the shipment, thus preparation took place as the shipment arrived, which

Type of Waste	Activity	Causes
	Unloading	caused delays.
	Opening Rolling Door to Send in Material	Before opening the entryway and sending in material, the worker holds off until a specific number of pallets have accumulated in the warehouse, which will delay put away.
	Manual Data Input of The Inventory Data	Due to a longer processing time, the manual input of inventory data before GR causes delays.
	Checking Stock Availability and Storage Location for Picking	When updating the inventory data to be used in picking, the QA/QC process is frequently delayed by manual data input.
	Generating Picking Instructions	Delays in the GR process prevent material from being racked, which causes further picking transfer delays.

3.3 Improvement Plan

The warehouse will employ several improvement actions, including the system enhancement with shipment booking form and conveyor system with gravity roller, to address the issues in the current operation. The supplier shipment booking form is developed in September 2022. While the application is implemented to use, the supplier will have access to the form interface to input the shipping information, whereas only the incoming controller will have access to the data table and reporting page. The input form page will transmit the shipment information directly to the material unloading database. The flow process of the system is shown in Figure 5.

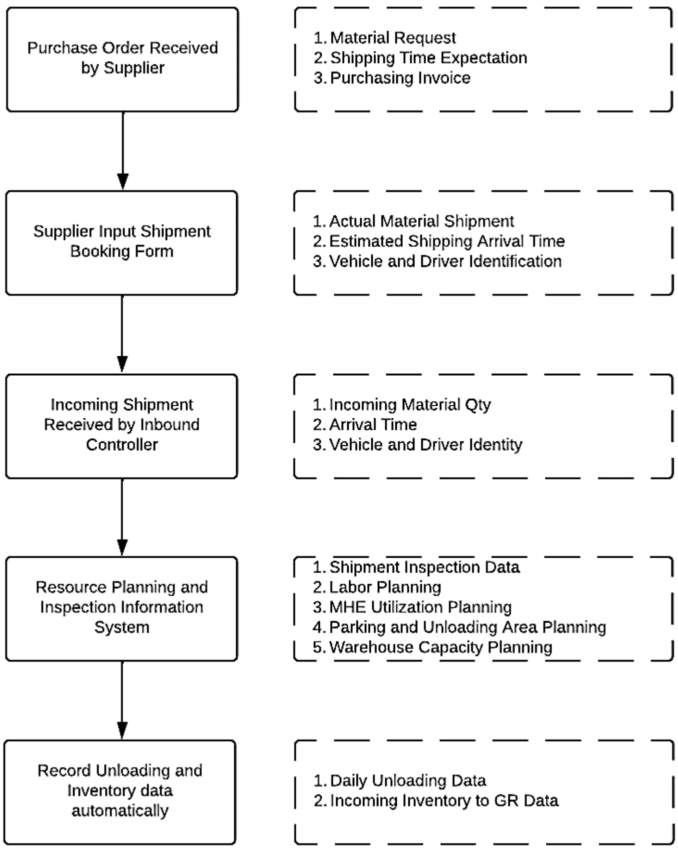

Figure 5. Data Process Improvement Flow Chart

An object is conveyed by the gravity and elevation tilt in a powerless conveyor system referred to as a gravity roller. A 20-degree tilt on the gravity roller will be present from the highest to the lowest point. As seen in Figure 6, the conveyor's arrangement enabled the sorting procedure. As demonstrated in Figure 7, each roller can accommodate 12 pallets with a standard pallet size of 1 m × 1 m. Due to the two-pallet stacking limit, the staging area could accommodate up to 60 pallets simultaneously after the enhancement, sufficient for the anticipated daily material requirement.

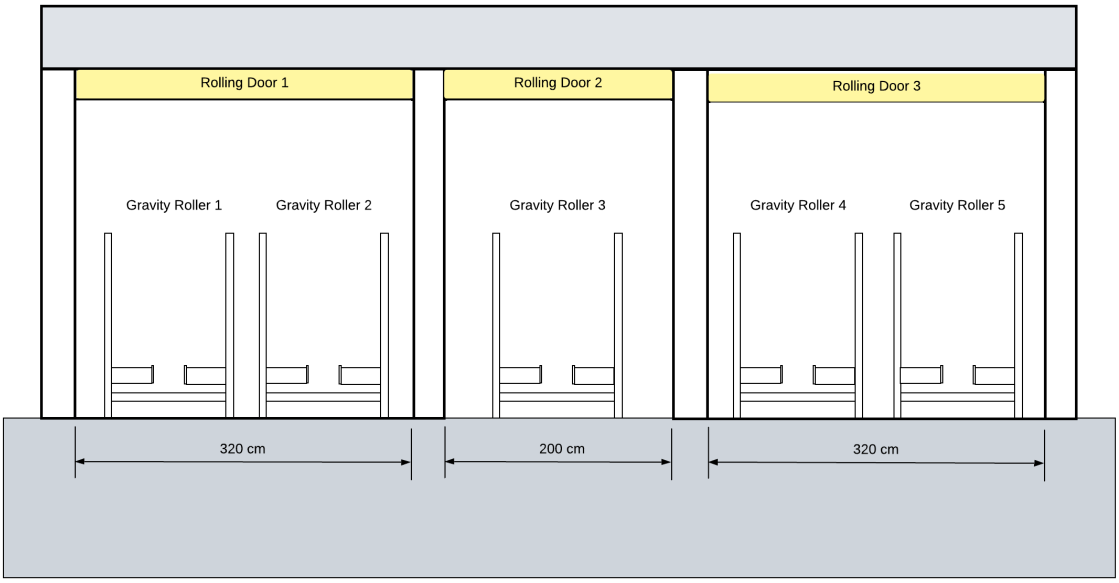

Figure 6. Gravity Roller Installation Scheme

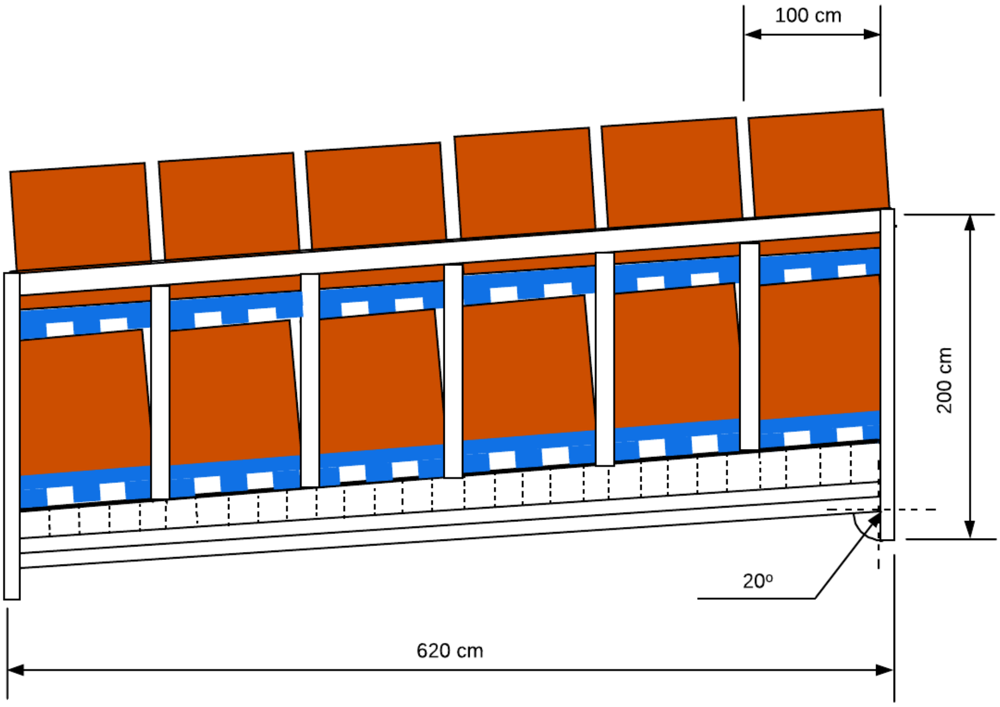

Figure 7. Gravity Roller Capacity Illustration

3.4 Future Inbound Process

Figures 8 and 9 illustrate the improved document flow and spaghetti diagrams. The section of the operation that requires improvement is highlighted in red. All manual data entry is eliminated from the system compared to the current state. Additionally, the utilization of the database could be mapped out more precisely. The saved data from the previous data collection additionally eliminates the need for manual entry and data processing during the input of inventory data. The two activities that are most affected are the shipment inspection and material staging, according to the early observation. The material entry into the warehouse was assisted by the gravity roller's inclusion in the staging area without requiring human intervention or using material handling equipment. The conveyor also assisted the sorting process and increased the staging area capacity to hold more pallets. Hence, the unloading capacity could be increased.

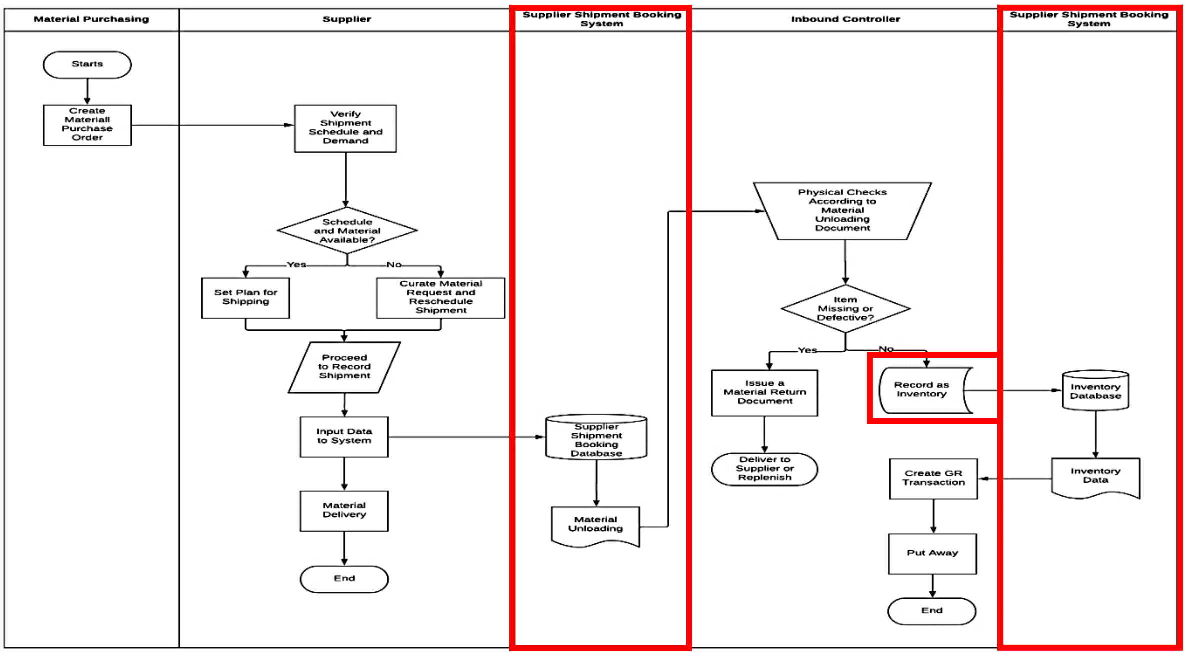

Figure 8. Document Flow Diagram After Improvement

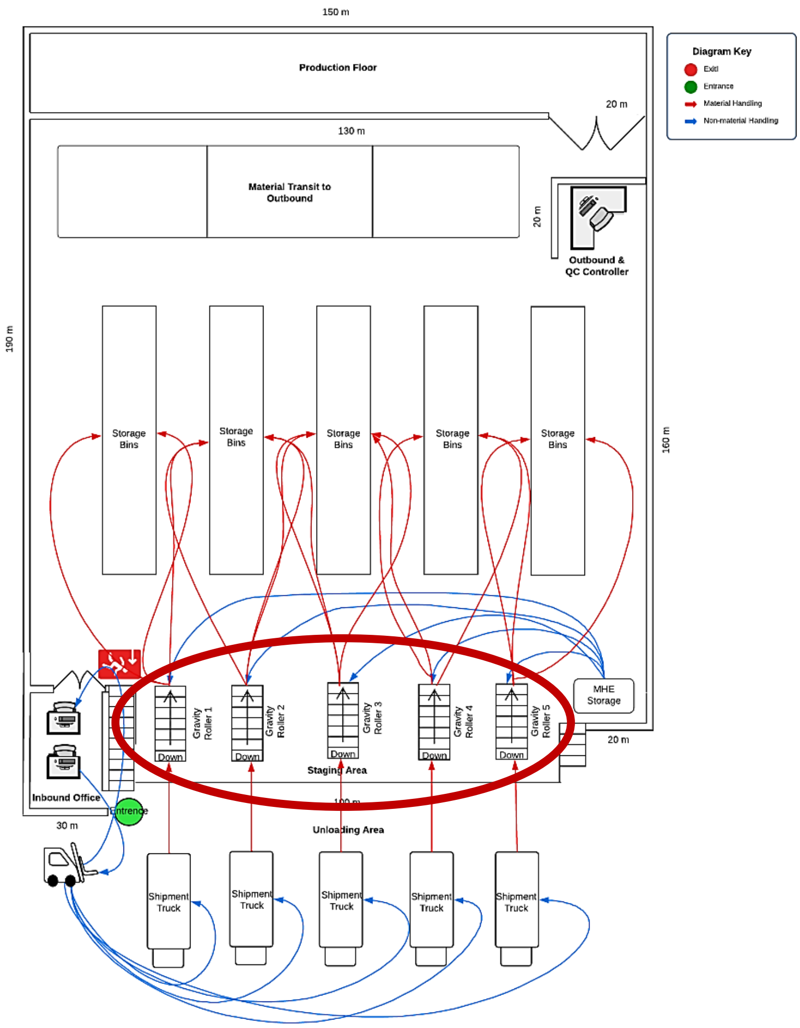

Figure 9. Spaghetti Diagram After Improvement

The entire processing time of the operation is decreased after the improvement plan is implemented. The improved system cut the processing time for inbound operations by 19% or 225 minutes. While taking up only 16% of the total cycle time, necessary non-value-added activity has decreased. The labor and machinery reduction was found to be attainable considering the process mapping in Table 3. The future value mapping (FVM) in Figure 10 illustrates the process of simplification and removal had a systemic impact. The red circle in the future value mapping denotes improvement. Simultaneous electronic information transfer between the supplier and warehouse management is added to the flow process. It has also been proven that cycle time is shortened even with the elimination of the MHE operator.

Table 3. The Improved Process Activity Mapping

No.	Activity	Before					After	
		Type of Waste	Cycle Time (min.)	Resources (Worker)	Act. Value	Improve-ment	Cycle Time (Aft.) (min.)	Resources (Worker)
Shipping Data Form								
1.	Supplier Inspection	Unnecessary Motion, Waiting	100	1	NVA	Simplify	80	1
2.	Material Inspection	Processing	70	1	NVA	Simplify	30	1
	Unloading	Waiting	110	1	NVA	Simplify	55	1
Staging Area Restructuring								
3.	Staging to Warehouse Area	Unnecessary Motion, Transportation, Waiting	100	1	NVA	Eliminate	100	1
	Sorting	Processing	90	1	NVA	Eliminate	30	-
4.	QA and QC Process	-	120	1	NNVA	-	120	1
5.	Pallet Labeling	-	100	1	NNVA	-	100	1
6.	Put away (MHE)	Waiting	230	4	NVA	Simplify	200	3
7.	Picking (MHE)	Waiting	240	3	NVA	Simplify	220	3

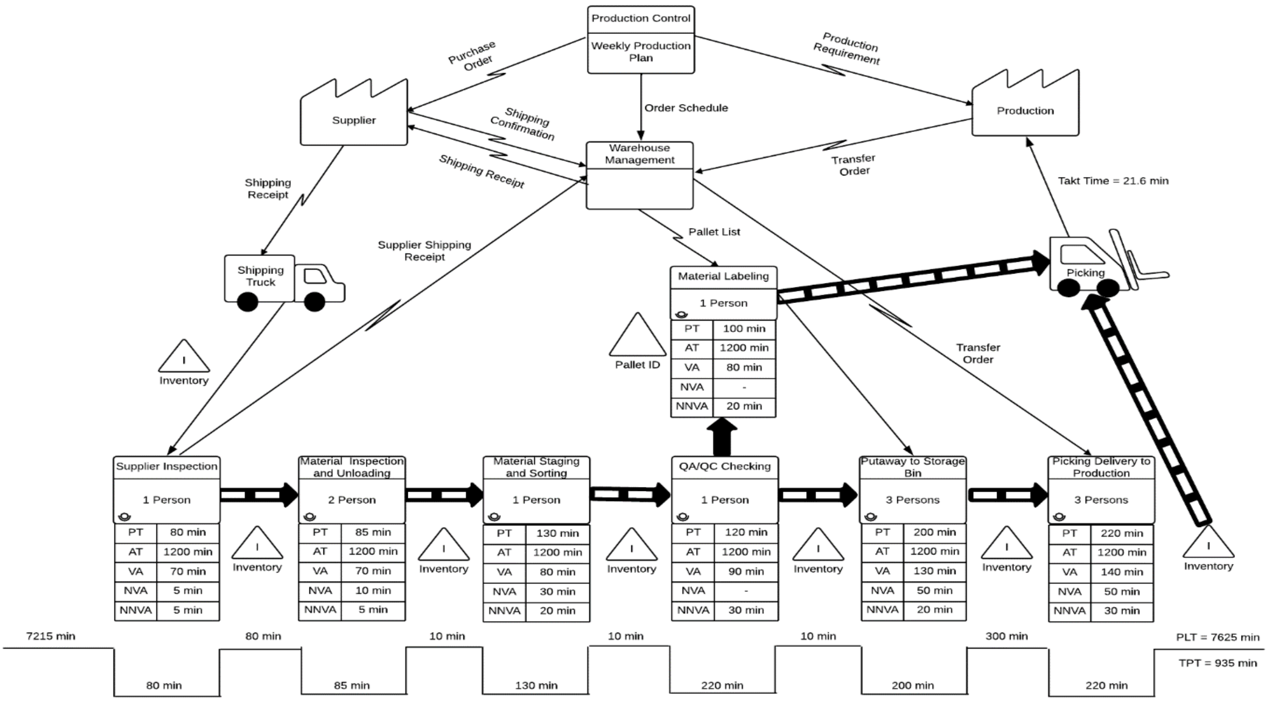

Figure 10. Future Value Stream Mapping

3.5 Improvement Impact

The processing time across the inbound processes has significantly decreased following the alterations. Figure 11 directly compares the present and future state of the supplier inspection activity, showing that the cycle time has shortened by 20 minutes and the lead time has decreased by 60 minutes. The cycle and lead time for the material inspection and unloading operation were reduced by 95 minutes and 115 minutes, respectively. The cycle time for put-away has decreased by 30 minutes, and the cycle time is now 200 minutes, which is over 30% less than the prior condition. The picking activity's future state cycle time and lead time are 20 minutes shorter. The summary of the improvement in the inbound operation time is presented in Table 4.

Table 4. Current and Future Inbound Processing Time

No.	Activity	Cycle Time			Lead Time		
		Current (min.)	Future (min.)	Reduction %	Current (min.)	Future (min.)	Reduction %
1.	Material Purchasing	-	-	-	7230	7215	0.21%
2.	Supplier Inspection	100	80	20%	220	160	27.27%
3.	Material Inspection and Unloading	180	85	52.78%	210	95	54.76%
4.	Material Staging and Sorting	190	130	31.58%	200	140	30%
5.	QA/QC Checking and Material Labeling	220	220	0%	235	230	0.21%
6.	Put away to Storage Bin	230	200	13.04%	710	500	30%
7.	Picking Delivery	240	220	8.33%	240	220	8.33%
Total		**1160**	**935**	**19.40%**	**9045**	**8560**	**5.36%**

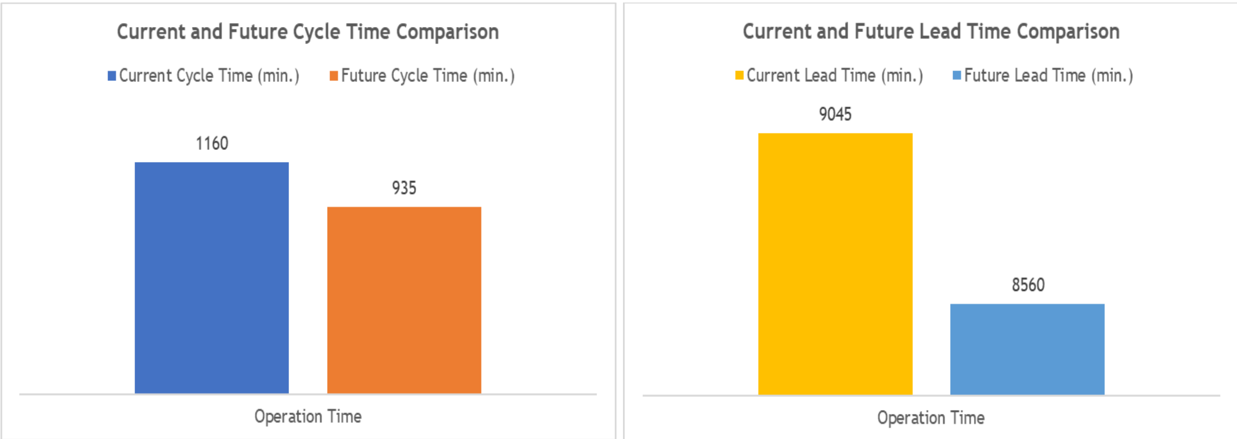

Figure 11. Current vs Future Cycle and Lead Time

4. Conclusion

A couple of points should be underlined as the interpretation of the objective formulation that sums up the research findings. (1) The inbound operation currently consists of seven main tasks carried out by eight employees, who also employ reach trucks and diesel forklifts for material handling. The total cycle time for the current operations is 1160 minutes or 19.333 hours. When the NVA time is 275 minutes, the NNVA time is 190 minutes, and the total VA time is 695 minutes. 9045 minutes, or 6.281 days, is the current lead time, of which five days are necessary for supplier shipping. (2) The improvement practice entails reconstructing the staging area through the elimination of the rolling door and, incorporating a gravity roller, and streamlining the data entry method with the VBA input form. Executing the improvement plan results in the entire cycle time and lead time decrease by 5%, or 485 minutes, and 19%, or 225 minutes, respectively. At the same time, the NVA time is 145 minutes, or 47.27%, less than the current state.

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