

CHAPTER 2

LITERATURE REVIEW AND BASIC THERORY

2.1. Literature Review

A literature review serves as a step in the process of studying published research literature that shares similar research concepts. Preparing a literature review serves the purpose of conducting a more mature search for the root of the problem in the conducted research, generating alternative solutions, and providing an overview of the techniques or methods used. At this stage, a search for related literature is carried out. To find the related literature, several keywords are used on different sites, namely Scopus and Google Scholar. The keyword used are related to waste reduction at warehouse operation, overtime at warehouse operation, and business process mapping.

2.1.1. Research Related to Warehouse Operation

Warehouse operations are a critical component of the supply chain that can affect the whole production process. However, warehouses often face challenges related to non-value-adding activities and waste. Nonvalue-adding activities refer to activities that do not contribute to improving warehouse performance or customer satisfaction (Prasetyawan & Ibrahim, 2020). Waste, on the other hand, is defined as excessive or unnecessary activities that do not add value to the completion of tasks. Toyota identified seven types of waste in manufacturing or processes which includes transportation, inventory, motion, waiting, overproduction, overprocessing, and defects (Shingo, 1989). This implementation of seven waste not only can be used in the manufacturing process but also can be used in warehouse operation (Salhie et al., 2019).

Identifying these wastes is crucial for improving warehouse operations. Studies have shown that quantifying the seven wastes can lead to better warehouse performance (Salhie et al., 2019). For example, de Jesus Pacheco (2023) employs the Value Stream Mapping (VSM) and Genba Shikumi technique to identify waste in Danish distribution warehouses. The study reported a 41.4% reduction in lead time and an 81.5% reduction in total value-added time, improving operational efficiency and reducing employee stress. Another approach, Fitriadi and Ayob (2022) is using Waste Relationship Matrix (WRM) and Waste Assessment Questionnaire (WAQ) to quantifying waste in shipbuilding company.

Suwandi and Suhada (2025) also able to reduce cycle time by 10.92% and increase of production capacity by 262 unit using the combination of PAM (Process Activity Mapping) and VSM (Value Stream Mapping)

Several researches have also focused on 3PL company warehouse (Adeodu et al., 2023; Jum'a & Basheer, 2023). Jum'a & Basheer (2023) used Pareto analysis to identify key delay factors (lack training, inefficient space utilization, lack of automation, and lack of planning) to cut cost and improve service level. Adeodu (2023) demonstrated that combining VSM and lean six sigma (DMAIC) can increase the process cycle efficiency in 3PL warehouse by 30%. Similarly, Abideen and Mohamad (2021) integrated value stream mapping and discrete event simulation to reducing warehouse supply chain lead time where improvements are seen related to total lead time, process time, value and non-value-added percentage. Another study also successfully eliminate of non-value-added activities and waste with a lead time and cycle time reduction using similar method (Ali et al., 2022).

More similar research by Mostafa and Essam (2024) demonstrated the use of lean tools to address inefficiencies in a warehouse within the electronics retail sector. Their study highlighted issues such as long lead times, non-value-added activities, and poor layout, which were mitigated through the application of Value Stream Mapping (VSM), 5S, and a Kanban board. The results showed a reduction of lead time by up to 25% and non-value-added time by as much as 33%. Similarly, Perez-Canchanya et al. (2023) applied lean manufacturing practices in a Peruvian SME food company, focusing on order fulfilment performance. By employing VSM, SMED, and a Kanban board, the company increased its order fulfilment rate by 13% and reduced cycle time by 19%. Both studies reinforce the effectiveness of lean methodologies in eliminating waste and improving process efficiency across different sectors.

Several previous final projects or theses were also found to use waste reduction approaches to solve various warehouse problems. Research by Dhayana (2023) revealed that waste reduction can reduce product preparation time by 15%, improve Manufacturing Cycle Effectiveness (MCE) by 66 percent, and increase value added by up to 55%. These results were obtained using the lean six sigma method with ECRS (Eliminate, Combine, Rearrange, Simplify) as the prototyping phase method. Another study by Balahanti (2024) found that a waste reduction

approach can increase work productivity and achieve time savings of 7.94%. This research combined Process Activity Mapping (PAM) and 5S to reduce processing time and increase the production rate.

Further research strategies also have been proposed for time reduction in warehouse operation. Kovac and Djurdjevic (2020) developed a simulation-based analytical model to assess optimal storage assignment policies, routing strategies, picking methods, and layout variations. The research is resulting in reduced in travel distance, completion time, and waiting time. Haouassi et al. (2022) offers a detailed study on optimizing order picking processes in e-commerce warehouses which implementing splitting orders reduced the total picking time by 30% on average. To solve the problem of manually searching for goods with no direction sign, Octaviani (2020) proposed the use of Bluetooth Low Energy (BLE) beacons for real-time tracking which reduces search time and improves employee productivity.

Specifically related to warehouse operation overtime, Ariyanti and Paramaputra (2023) found that overtime can be reduced by up to 11% through redesigning the warehouse layout using a class-based storage policy and by scheduling employee shifts with the help of linear programming. Another approach, proposed by Sari et al. (2021), demonstrated that overtime could be reduced and productivity increased by balancing staff workloads through the use of work sampling and workload analysis methods.

Tabel 2.1. Literature Review Warehouse Operation

No	Research	Industry/System Characteristic	Root Problem	Solution Design	Method	Note
1	Jum'a and Basheer (2023)	Pharmaceutical 3PL	High time waste resulting inefficient warehouse value added service (VAS) operation	Automation of ticket preparation, training for staff, utilizing warehouse space, and optimizing routes.	Pareto Diagram	Reduce operational waste (waiting, movement) and improve service efficiency and pricing accuracy.
2	Adeodu et al .(2023)	Manufacturing companies 3PL	High non-value added activities leading to low process cycle efficiency	Creation of standard task for each main process	Lean six sigma (DMAIC) and Value Stream Mapping (VSM)	Process cycle efficiency improved of up to 70.4%. Reducing lead time by 43.5%. NVA time reduced by 72.1%. Daily order processing increased by 18%.
3	Abideen and Mohamad (2021)	Pharmaceutical warehouse	Excessive lead times and non-value-added activities as well as inventory delays and build-up at temporary storage zones.	Facility layout design and the used of Kanban (Pull System)	Value Stream Mapping (VSM) and Discrete Event Simulation (DES)	Provided a quantifiable, visual, and validated method for improving warehouse performance. Improvements on to total lead time, process time, value and non-value-added percentage.
4	de Jesus Pacheco (2023)	Distribution Warehousing	Insufficient research on reducing operational waste and eliminate nonvalue added activity	Implementation of Warehouse Management System, use of SOP, and sales forecasting.	Unified Modelling Language (UML), VSM, Genba Shikumi Technique	Identifies primary waste (Waiting for processes, unnecessary motion, and transportation). Reduce warehouse lead time by 41.4% and total value added by 81.5%

Tabel 2.1. Continuation

No	Research	Industry/System Characteristic	Root Problem	Solution Design	Method	Note
5	Salhieh et al. (2019)	Warehousing and Logistic	Lack of an integrated approach to quantify, rank, and prioritize waste-reduction practices in warehouse operations	Initial approach to find problem that need to be solve first	Delphi technique, survey, statistical analysis	The study identified and ranked the "7-Deadly" Wastes in warehouses, with "Waiting," "Defects," "Transporting," and "Overproduction". The wastes significantly improve warehouse operational performance
6	Ali et al. (2022)	Automotive company warehouse	Inefficiencies in warehouse operations namely long lead times, high inventory levels, and errors	Implementing Lean principles and Continuous Improvement Process (CIP) techniques	Value Stream Mapping (VSM) and Plan-Do-Check-Act (PDCA) cycle	Elimination of non-value-added activities and waste with a lead time and cycle time reduction.
7	Fitriadi and Ayob (2022)	Shipbuilding and shipyard operations	Waste related to labour usage, product quality, costs, and production time	Implement lean manufacturing principles	Waste Relationship Matrix (WRM) and Waste Assessment Questionnaire (WAQ)	Identifies types of waste and their percentages with inventory as the highest.
8	Haouassi et al. (2022)	E-commerce warehouse	Total picking time while ensuring deadlines for customer orders are met	Programming for order picking schedule	Route First-Schedule Second (RFSS) Heuristic	Splitting orders reduced the total picking time by 30% on average, with up to 60% reduction in some cases

Tabel 2.1. Continuation

No	Research	Industry/System Characteristic	Root Problem	Solution Design	Method	Note
9	Kovac and Djurdjevic (2020)	Distribution centers	High warehouse operational costs due to low-level picker-to-part order-picking systems (OPS	Implementation of Storage assignment policies, routing strategies, order picking methods, and layout variants	Simulation-Analytical Model	Reduction in the number of order-pickers, travel distance, completion time, and waiting time.
10	Octaviani and Ce (2020)	Paper manufacture warehouse	Challenges in locating goods in large warehouse	Usage of real time tracking system	BLE (Bluetooth Low Energy)	Real-time inventory tracking reduces search time and improves employee productivity
11	Ariyanti and Paramaputra (2023)	Distribution Centre	High overtime exceeds 40 hours per week	Redesign warehouse layout and employee scheduling	FMEA, class based storage, and linear programming	Decrease in total travel distance by 17%, overtime by 17%, and labour cost by 48%
12	Sari et al. (2021)	Dairy and Milk Processing Warehouse	High overtime rates (more than 56 hours/month) in the spare parts and raw materials warehouse due to uneven workload	Revise job descriptions and increase staff	Work Sampling Method and Workload Analysis	Reduction of overtime due to balanced workload. Decrease of workload for warehouse feeder and increase of productivity for warehouse leader.
13	Suwandi and Suhada (2025)	Mattress Manufacturer	Long cycle time causing target cannot be reached	Line balancing, SOP control, and layout redesign	Process Activity Mapping and Value Stream Mapping	10.92% reduction of cycle time and increase of production capacity by 262 unit.

Tabel 2.1. Continuation

No	Research	Industry/System Characteristic	Root Problem	Solution Design	Method	Note
14	Dhayana (2023)	Warehouse	Delay in delivery of goods	SOP improvement with waste reduction approach	Lean six sigma with Process Activity Mapping (PAM), ECRS (Eliminate Combine Rearrange Simplify, and Simulation Model	Reduced product preparation time by 15%, Manufacturing Cycle Effectiveness (MCE) by 66%, and Value Added by up to 55%.
15	Balahanti (2024)	Sofa Manufacturer	Production targets were not achieved for 4 months	Waste reduction on the production floor	Process Activity Mapping (PAM), Value Stream Mapping (VSM), and 5S	Increased work productivity and production time efficiency from 1,272 minutes to 1,171 minutes, as well as time savings by 7.94%.
16	Mostafa and Essam (2024)	Electronics Retail Sector	The warehouse had inefficiencies leading to waste, including long lead times, non-value-added activities, and suboptimal layout.	Reduction of waste	VSM, 5S, and Kanban Board	Reduction if lead time up to 25% and NVA time reduction up to 33%.
17	Perez-Canchany a et al. (2023)	Food Industry	Low order fulfilment rate below the industry minimum standard	Application of lean manufacturing	VSM, SMED, and Kanban Board	Order rate fulfilment increases by 13% and reduction of cycle time by 19%

2.1.2. Research Related to Business Process Mapping

Business Process Mapping is an essential technique that enables organizations to visualize, analyse, and understand their internal workflows. By providing a structured representation of activities, inputs, outputs, and interactions, it allows stakeholders to identify inefficiencies and opportunities for improvement. In the literature, various methods and notations have been adopted to represent business processes, each offering different levels of detail and suitability depending on the organizational context and objectives.

Choudhary and Riaz (2023) addressed the limitations of existing simulation tools in the banking and manufacturing sectors by integrating reverse engineering techniques with BPMN. Their framework enabled a more reliable conversion of simulation models, which reduced the manual workload and minimized errors in business process reengineering. Similarly, Bocciarelli et al. (2019) focused on reducing the inefficiencies of manual derivation by applying Model-Driven Engineering (MDE) for BPMN modelling. Their study demonstrated that the use of automated model generation not only accelerated the modelling process but also reduced the risk of error, resulting in the successful development of a fully automated toolchain for BPMN-based simulation.

Several studies have demonstrated the application of service design tools such as Service Blueprinting to improve organizational performance. Susanto and Wurjaningrum (2019) examined service quality issues in hospitals, where patients often experienced suboptimal levels of service. Their study applied Service Blueprinting in combination with QFD to redesign business processes and identify priority areas for improvement. As a result, five critical service attributes were identified as requiring immediate attention, thereby providing a structured foundation for targeted service quality enhancement. Similarly, Buics (2020) analysed public service processes in the Hungarian guardianship. The main challenge observed was the lengthy and complex administrative procedures that frequently exceeded established deadlines. By employing Service Blueprinting, the authors proposed a modernization of the process, emphasizing the need to shorten processing times and simplify procedures.

Aschwaden (2017) adopted the combination of vertical swim lanes and flowchart based on ISO 5807:1985 method to assist micro and small enterprises in documenting and managing their processes more effectively. The results showed

clear benefits in terms of improved efficiency, stronger communication channels, and easier identification of risks within workflows. Similarly, Da Silva et al. (2019) applied Business Process Management (BPM) in the shipbuilding and offshore construction sector, using ANSI flowcharts to map processes and address issues such as purchase order delays, procedural breaches, and inaccurate stock records. Their study demonstrated that BPM enabled a clearer understanding of workflows and the identification of key improvement points, supporting more systematic process optimization.



Table 2.2. Literature Review Business Process Mapping

No	Research	Industry/System Characteristic	Root Problem	Solution Design	Method	Note
1	Aschwanden (2017)	Micro and Small Businesses (SMEs)	Micro and small businesses struggle to expand due to limited resources, lack of process documentation, and inefficient workflows.	Creation of flowchart using software	Swim lanes diagram and ISO 5807:1985 flowchart	Improved process efficiency, better communication, and easier identification of risks
2	Choudhary and Riaz (2023)	Banking and Manufacturing	Simulation tools lack interoperability and cannot handle complex processes	A framework to automatically convert simulation models to BPMN using reverse engineering and re-engineering concepts	Reverse engineering and BPMN	Reduce manual effort and errors in BPR
3	Bocciarelli et al. (2019)	Not specified	Manual derivation of simulation models from BPMN is error-prone and time-consuming	Automated BPMN Modelling	Model-Driven Engineering (MDE)	Successful development of a fully automated toolchain for BPMN-based simulation
4	Susanto and Wurjaningrum (2019)	Hospital	Investigated is the suboptimal service quality received by patients	Create business process to design improvements for service quality	Service Blue printing and Quality Function Deployment	Identification of five key service attributes that require the most urgent improvement
5	Buics (2020)	Hungarian guardianship office	Lengthy and complex administration process that exceed the determine deadline	Modernization of the process	Service Blue Printing	Shorten the time process and simpler procedures
6	Da Silva et al. (2019)	Using the view of Business Process Management (BPM) for process improvement in the shipping industry and offshore construction sector: a case study of the Rio Grande (RS) naval pole.	Shipbuilding and Offshore Construction.	Delays in Purchase Order (PO) approvals and frequent procedural breaches documentation due to urgency but leading to double payments and incorrect stock information.	Business Process Management (BPM) methodology for process mapping and analysis	Flowchart ANSI standard

2.2. Basic Theory

In the context of research, basic theory serves as a conceptual framework, offering a foundational structure to guide inquiry and analysis. This framework consists of established principles or models that help in understanding and contextualizing the problem being investigated. In the context of this final project the problem and solution raised is related to several courses namely Warehousing (TIND69603) and Supply Chain Management (TIND45602). Warehousing provides an overview of the role, management, and activities of a warehouse as a storage system for goods, both raw materials and finished products, with the principles and rules of warehouse management. While supply chain provides an overview of the flow of goods and information from suppliers to customers. It is because warehouse management is one part of the supply chain that focuses specifically on the storage, handling, and movement of goods within the network.

2.2.1. Warehouse Definition

A warehouse is a goods storage place for raw materials, semi-finished goods, and finished products. Warehouses have a role in the success or failure of a company's supply chain. In addition to serving as a storage facility, warehouses also play a crucial role in production activities such as acquiring materials and managing their entry and exit (Tompkins et al., 2010). Handling materials effectively and efficiently in a factory requires maintaining every part of the accessible storage space, choosing the right placement for each inventory, and implementing storage policies and controls related to these policies (Diaz et al., 2013).

2.2.2. Warehouse Functions

According to Tompkins et al. (2010), warehouses have several functions as follows:

a. Receiving

Receiving refers to the procedure of accepting all the ordered goods into the warehouse. During the receiving process, both the amount and quality of items are verified prior to their allocation to storage.

b. Repackaging

Repackaging is the process of dividing bulk products into smaller sizes for customers or combining multiple materials into one kit. This may include breaking down bulk shipments into smaller units, combining different items into kits, or reconfiguring packaging to improve handling, labelling, or presentation.

c. Put Away

Put away is the activity of moving and placing goods from receiving area into their designated storage locations within the warehouse. It ensures that goods are stored safely, easy to retrieve, and logically arranged.

d. Storage

Storage refers to a state in which materials are not being utilised or are awaiting retrieval. It includes the proper placement of goods in designated racks, shelves, or bins.

e. Order picking

Order picking is the process of selecting items from storage to fulfil a customer's order. It is also including the process of product retrieval from storage.

f. Packaging or pricing

Packaging refers to the process of packaging products to facilitate shipment. Packaging operations are frequently linked to pricing to differentiate or consolidate for price variations.

g. Sortation/Accumulation

Sortation refers to the process of categorising batches into distinct requests. Meanwhile, accumulation is the process undertaken when an order comprises multiple items.

h. Packing and shipping

Packing and shipping refer to a sequence of tasks that include verifying order correctness, packaging into the shipping container, producing shipping documentation, weighing for cost assessment, consolidating orders, and loading items onto trucks.

i. Cross-docking

Cross docking is a receiving operation that is directly proceeded by delivery, with no prior material storage involved.

j. Replenishing

Replenishing is the process of replenishment products to be shipped from the warehouse.

2.2.3. Type of Waste

Waste is defined as excessive or unnecessary activities that do not add value to the completion of tasks (Shingo, 1989). Toyota identified seven types of waste in manufacturing or processes which includes transportation, inventory, motion, waiting, overproduction, overprocessing, and defects. The detail description for each waste is described below.

a. Transportation

Transportation refers to waste resulting from the excessive movement of workers, information, products, or materials that do not add value to the process. This type of waste is often linked to poor facility layout, which leads to unnecessarily long travel distances for material handling or material movement.

b. Inventory

Inventory waste is caused by the presence of unnecessary stock or supplies. It typically occurs due to overstocking, which not only consumes valuable warehouse space but also results in increased storage costs and the risk of obsolete inventory.

c. Motion

Motion waste arises from unnecessary or inefficient movements by workers. Common causes include searching for items, sorting materials, or relocating products. These additional movements extend lead time and reduce overall process efficiency.

d. Waiting

Waiting is a form of waste that results from the inefficient use of time, often caused by delays between process steps. This may involve waiting for materials, equipment, or the completion of a preceding task before the next can begin.

e. Overproduction

Overproduction occurs when more products are produced than are needed at a given time. This type of waste often leads to other forms of waste, such as excess inventory, additional transportation, and delays in subsequent activities due to storage constraints.

f. Overprocessing

Overprocessing refers to performing more work or using more resources than necessary to produce a product. This can include repeated rework or unnecessary process steps, ultimately leading to increased lead time.

g. Defects

Defects are a form of waste that occurs when products fail to meet quality standards, resulting in rework or scrapping. Producing defective items requires workers to repeat tasks to meet the desired specifications, which consumes time, labour, and materials.

2.2.4. Waste in Warehouse Operation

The seven types of waste were initially introduced by Toyota as part of their production system. However, this concept has since been widely adopted across various sectors, including warehousing. Numerous studies have identified and classified different forms of waste in warehouse operations that align with these seven categories. For instance, Abhishek and Pratap (2020) identified several examples of waste commonly found in warehousing activities.

In warehouse operations, overproduction refers to the storage of excess stock, which can negatively affect lead. A common example of this waste is maintaining large quantities of low-demand items, which not only increases inventory costs but also reduces available space for high-demand products. Another frequent type of waste is waiting, often caused by inefficiencies in the order fulfilment process. This waste includes delays in picking, packing, or documentation that result in postponed deliveries.

Transportation waste occurs when goods are moved excessively within the warehouse, typically due to a poor layout or the absence of visual indicators for locating products. These issues compel workers to spend unnecessary time searching and moving items from one place to another. Similarly, inappropriate processing refers to the use of overly complex procedures for simple tasks. For instance, verifying a single order may take an excessive amount of time due to redundant checks or unclear workflows.

Inventory waste is also a major issue, contributing to longer lead times and higher storage costs. This can include excessive safety stock or large volumes of damaged, non-moving items that occupy valuable warehouse space. Unnecessary motion is another form of waste, occurring when workers perform avoidable physical activities, such as repeatedly accessing high-demand items stored on hard-to-reach upper shelves. Lastly, defects in warehouse operations are

commonly linked to human error. A typical example is picking mistakes, where workers select the wrong item variant or quantity compared to what was ordered.

2.2.5. Process Activity Mapping

According to Hines and Rich (1997), Process Activity Mapping (PAM) is a lean analysis tool rooted in industrial engineering, used to identify and eliminate non-value-added activities in each step of a given process. The example is presented in Figure 2.1. In PAM, activities are classified into three categories: Value-Added (VA), Non-Value-Added but Necessary (NNVA), and Non-Value-Added (NVA). Value-Added (VA) refers to activities that directly add value to a product or service from the customer's perspective. Non-Value-Added but Necessary (NNVA) includes activities that do not add direct value but are required under current conditions. Non-Value-Added (NVA) refers to activities that neither add value nor are necessary and therefore can be eliminated without affecting the final output.

#	STEP	FLOW	MACHINE	DIST (M)	TIME (MIN)	PEOPLE	O-P-E-R-A-T-I-O-N	T-R-A-N-S-P-O-R-T	J-N-S-P-E-C-T	S-T-O-R-E	D-E-L-A-Y	COMMENTS
1	RAW MATERIAL	S	RESERVOIR				O	T	I	S	D	RESERVOIR/ ADDITIVES
2	KITTING	O	WAREHOUSE	10	5	1	O	T	I	S	D	
3	DELIVERY TO LIFT	T		120		1	O	T	I	S	D	
4	OFFLOAD FROM LIFT	T			0.5	1/2	O	T	I	S	D	
5	WAIT FOR MIX	D	MIX AREA	20	2	1/2	O	T	I	S	D	
6	PUT IN CRADLE	T		20	2	1/2	O	T	I	S	D	
7	PIERCE/POUR	O	MIX AREA 12		0.5	1	O	T	I	S	D	
8	MIX (BLOWERS)	O			20	1/2	O	T	I	S	D	BASH MATERIAL, BLOW & ADDITIVES
9	TEST #1	I			30	1+	O	T	I	S	D	SAMPLE/TEST
10	PUMP TO STORAGE TANK	T	STORE TANK	100		1	O	T	I	S	D	DEDICATED RESERVOIR
11	MIX IN STORAGE TANK	O	STORE TANK		10	1	O	T	I	S	D	
12	I.R. REST	I			10	1+	O	T	I	S	D	STAMP & APPROVE
13	AWAIT FILLING	D			15		O	T	I	S	D	LONGER IF SCREEN LATE
14	TO FILLER HEAD	T		20	0.1	1	O	T	I	S	D	
15	FILL/TOP/TIGHTEN	O	FILLER HEAD		1	1+	O	T	I	S	D	1 UNIT
16	STACK	T	PALLET	3	0.1	1	O	T	I	S	D	1 UNIT
17	DELAY TO FILL 1 PALLET	D			30		O	T	I	S	D	
18	STRAP PALLET	O			2	1	O	T	I	S	D	
19	TRANSFER TO STORE	T		80	2	1	O	T	I	S	D	
20	AWAIT TRUCK	D	STORE		540		O	T	I	S	D	BATCH 360/ QUEUE 180
21	PICK/MOVE BY FORK LIFT	T		90	3	1	O	T	I	S	D	FORK LIFT
22	WAIT TO FILL FULL LOAD	D	LORRY		30	1+	O	T	I	S	D	1 OPERATOR, 1 HAULER
23	AWAIT SHIPMENT	D	LORRY		60	1	O	T	I	S	D	1 HAULER
	TOTAL		23 STEPS	443	781.2	25	6	8	2	1	6	
	OPERATORS				38.5	8						
	% VALUE ADDING				4.93%	32%						

Figure 2.1. Process Activity Mapping Chart

(source: Hines and Rich (1997))

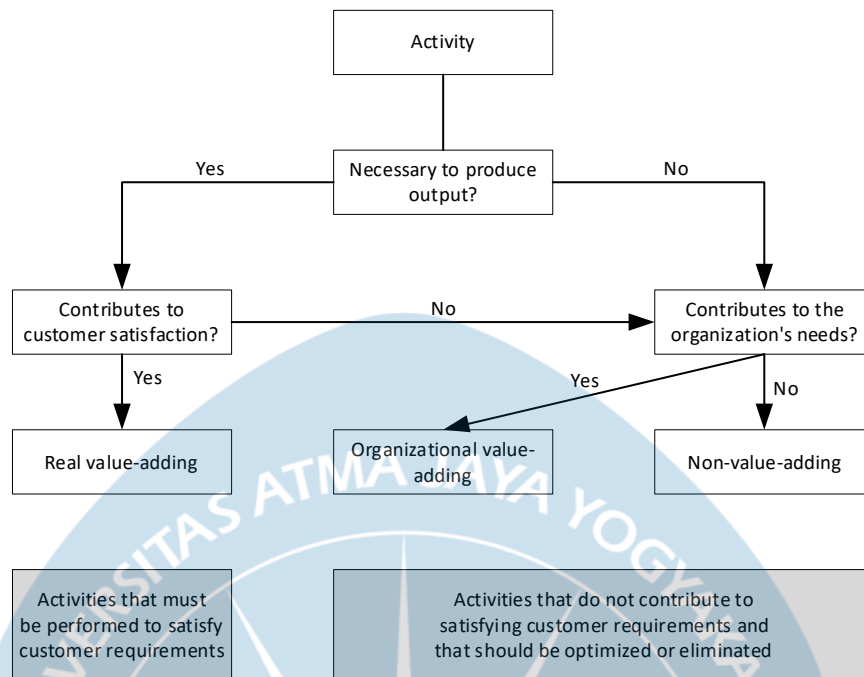


Figure 2.2. Value Added Analysis Questions

(Source: Harrington (1999))

The classification of activities can follow the following flowchart in Figure 2.2. The classification process begins by determining whether an activity is necessary to produce the output. If it is, the next consideration is whether the activity directly contributes to customer satisfaction. Activities fulfilling both criteria are categorized as Value-Added (VA), as they are essential to meeting customer requirements. Activities necessary for production but not directly affecting customer satisfaction are classified as Necessary but Non-Value-Added (NNVA), which support operations and should be optimized for efficiency. In contrast, activities not required to produce the output are identified as Non-Value-Added (NVA), representing waste that should be minimized or eliminated.

In practice this process follows five main steps:

- Analyse the process flow
- Identify source of waste
- Evaluate if the process sequence can be optimized
- Explore alternative flow patterns or layouts
- Assess whether all current activities are essential, and consider eliminating unnecessary steps

PAM begins with a preliminary assessment of the process, followed by detailed documentation of every required activity. Each activity is then classified into several types, namely: operation, transport, inspection, storage, and delay. In PAM, information such as the machine or area used, distance moved, time taken, and number of people involved must be recorded. These recorded data such as total distance, processing time, and labour used are then calculated to support further analysis

2.2.6. Value Stream Mapping

Value Stream Mapping (VSM) is an analytical tool derived from the Lean concept. It is used to map the flow of materials and information throughout a production or operational process (Reyes et al., 2018). VSM consists of two main types of mapping the current state map and the future state map. The current state map is used to understand how the process currently operates, identifying inefficiencies and waste. In contrast, the future state map focuses on redesigning the process based on Lean principles to improve the current condition. Figure 2.3 illustrates the example of value stream mapping.

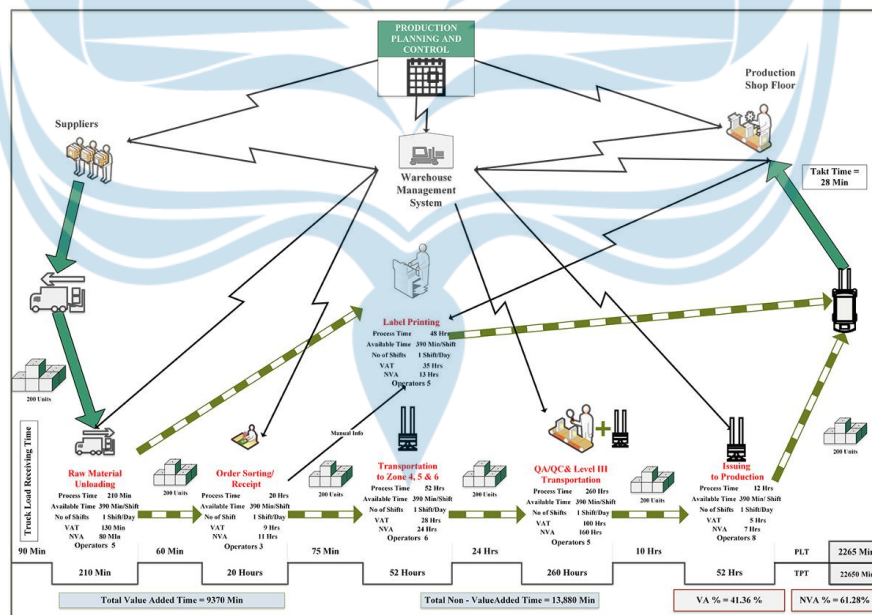


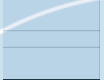
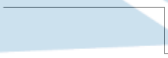
Figure 2.3. Value Stream Mapping

(source: Abideen & Mohamad (2021))

In the creation of a Value Stream Map, various symbols are used to represent different elements of the process. These symbols serve to illustrate the flow of

materials and information in both the current state and future state maps. Each symbol provides a visual description of specific conditions or activities within the process. According to Langstrand (2016) the symbols, along with their corresponding explanations, are presented in the Table 2.3 below.

Table 2.3. Symbols in Value Stream Mapping

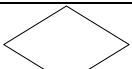
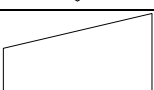
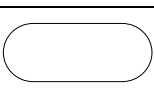
No	Name	Symbol	Function
1	Customer/supplier		Represents external entities that receive or provide material /information. Supplier as the beginning and customer as the end.
2	Process		Indicates a process, operation, machine, or department.
3	Data Box		Displays relevant data for a process.
4	Operator		Shows the number of workers needed in a process.
5	Buffer/Inventory		Represents inventory or waiting area between processes.
6	Timeline		Illustrates value-added and non-value-added time across the process. The function is to calculate lead time and total cycle time.
7	Push arrow		Material is pushed downstream regardless of need.
8	Shipment arrow		Represents movement of material to customer or another location.
9	Production control		Central area for scheduling, planning, and controlling production.
10	Electronic Information		Information flow that occurs digitally.
11	Manual Information		Paper-based or verbal information flow.
12	Improvement effort		Highlights an area targeted for Kaizen or improvement activities.

2.2.7. Business Process Mapping

There are various methods available for business process mapping, and one of them is the swim lane diagram (Jeyaraj & Sauter, 2014). A swim lane diagram is a process map that divides activities into distinct “lanes,” each representing a specific role, department, or stakeholder. Within each lane, standard flowchart symbols are

applied to illustrate the sequence of steps. One of the most common sets of symbols used for this purpose comes from the ANSI (American National Standards Institute) standard flowchart, which defines widely recognized symbols. By combining the swim lane structure with ANSI flowchart symbols, organizations can create process maps that not only clarify the sequence of activities but also make responsibilities and handoffs between roles more visible. The detailed of symbol used for the business process mapping is presented in the following Table 2.4 (American National Standard Institute, 1971).

Table 2.4. Business Process Mapping Symbol

No	Name	Symbol
1	Document	
2	Manual Process	
3	Computerized Process	
4	Data Storage	
5	Archived Documents	
6	Undefined Process (Including physical activity)	
7	Terminations that represent certain symbols to be used on other pages	
8	Decision-making	
9	Manual data entry	
10	Termination signifies the beginning and end of a flow	
11	Termination that represents a specific symbol to use on the same page	

2.2.8. ECRS Analysis

The ECRS method is a systematic approach that aims to analyse and improve inefficient processes (Xin, 2018). The acronym stands for Eliminate, Combine, Rearrange, and Simplify, which are systematic steps to analyse and improve inefficient processes. The detail about each step is described below.

a. Eliminate

Eliminate focuses on removing tasks or procedures that are unnecessary and do not contribute value.

b. Combine

Combine seeks to merge duplicate or closely related activities to reduce redundancy.

c. Rearrange

Rearrange emphasizes reorganizing the sequence of tasks or responsibilities to achieve a more efficient flow of work.

d. Simplify

Simplify involves refining tasks or procedures to make them easier, faster, and less resource intensive.

Several research used ECRS analysis to improve inefficient processes in various industry. For example, Phruksaphanrat and Duangburong (2019) applied lean techniques, including the ECRS method, to improve efficiency in a wood plastic composite manufacturing system. The research demonstrated the ECRS analysis provided meaningful efficiency gains such as shorter cycle times, reduced waste, and higher profit. Dhayana (2023) also used the ECRS analysis to improve Manufacturing Cycle Effectiveness (MCE) in warehouse setting.