



INTEGRATION OF LEAN WAREHOUSING AND LINE BALANCING APPROACHES IN OPTIMIZING LOGISTICS PERFORMANCE TO REDUCE WASTE AND INCREASE EFFICIENCY OF INBOUND-OUTBOUND COIL PROCESSES IN HRC WAREHOUSE SYSTEM

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Abstract

This study aims to optimize the performance of warehousing logistics in inbound and outbound HRC coil activities at PT. XYZ through the integration of Lean Warehousing and Line Balancing approaches. The main problems faced are distribution delays due to operational bottlenecks, imbalance in workload between processes, and the absence of an effective distribution flow management system. The methods used include observation, case studies, brainstorming, and the Root Cause Analysis (RCA) approach supported by Fishbone Diagrams, Pareto Charts, and 5 Whys analysis. The data analyzed includes total warehousing profits from January to October 2024, factors causing delays, and standard time measurements for each work activity. The RCA results identified six dominant factors contributing to 80.44% of delays. Based on these findings, a solution was designed using the 5W + 1H method, including a loading and unloading slot booking system, development of outbound coil buffer areas, standard time measurements, forklift preventive checklists, and line balancing of work activities. The design implementation increased inbound efficiency from 29% to 74% and outbound from 34% to 62%. Inbound idle time decreased from 14,059.21 seconds to 1,988.85 seconds (savings of 201 minutes), while outbound decreased from 15,504.01 seconds to 4,907.28 seconds (savings of 176 minutes). Inbound balance delay decreased from 71% to 26%, outbound from 66% to 38%, and the smoothing index showed a more even workload distribution. These findings prove that integrating Lean Warehousing and Line Balancing reduces waste, accelerates distribution flows, and increases HRC coil warehousing productivity.

Keywords: Lean Warehousing, Line Balancing, Root Cause Analysis, HRC Coil. Total Revenue, Authorized Capital and Corporate Inventories

INTRODUCTION

The increasing competition in the logistics business in Indonesia is marked by the number of international logistics companies established in Indonesia, both in the fields of shipping lines, carrier agents, warehousing, freight forwarding, and so on (Putri et al., 2017). PT. XYZ is the first multimodal Company in Indonesia that operates in business services for transporting slabs, plates, alloys, and other heavy equipment products. The Company must immediately improve the quality of service and warehousing maintenance to strengthen its ability to bid for other projects successfully. In addition, there is an increase in work on the domestic Indonesian shipping process, transfers between warehouses, and exports/imports, which are predicted to increase next year. This increase occurred exponentially in the months of 2024-2025. Therefore, the Company needs to consider the importance of prioritizing service quality to satisfy customers, especially in terms of time for loading delays.

Based on the results of the researcher's observations in January-August 2024, waste in the management of steel materials in warehousing needs to be reviewed, this incident is illustrated that every time there is a sudden delivery request by a customer, there will be a delay in loading until the trailer stays overnight in the warehouse and causes customer complaints. Based on the results of interviews with the stevedoring department manager, it was found that several problems are often faced, namely the late completion time of export loading work, late loading of goods into transportation, operational problems with goods and other things. Moreover, according to the department supervisor, delays will result in material losses experienced by the Company where the density of warehousing activities causes delays, the matching of information and conditions of warehouse goods and the condition of loading vehicles, namely ET, TC, RS, Forklift, Trailer.

According to the WH Management department manager, bottlenecks in the warehouse operational flow are the leading cause of delays and work inefficiencies. The imbalance in the distribution of workloads between operational stations causes points of congestion that hinder the smooth running of inbound/ outbound activities. Some work areas are overloaded, while other parts have high idle time. This results in long queues in loading goods, material accumulation, and an increased risk of late delivery. In addition, this condition also slows down the inbound process because the availability of space and equipment is limited due to unfinished outbound activities. If this bottleneck is not resolved immediately, the Company will continue to experience delays in the supply chain, which can ultimately impact customer satisfaction levels and business sustainability.

To identify the leading causes of delays and waste in warehouse operations, the Root Cause Analysis (RCA) approach is used through several analysis methods. A Fishbone Diagram will help identify the factors causing delays from various aspects. Furthermore, the Pareto Chart is applied to determine the most dominant factor in causing delays so that improvement efforts can focus on the most influential aspects. After the main factors are found, the 5 Whys analysis is used to dig deeper into the root causes of the problem. The analysis results then become the basis for designing solutions using the 5W+1H method, which directs the Company in designing systematic and effective resolution strategies.

Based on the root cause analysis results, the solutions to be designed in this study include several main aspects. One of the proposed solutions is implementing a loading and unloading slot booking system, which aims to reduce density in the warehouse and improve punctuality in loading goods. In addition, a buffer area for outbound coil storage will be designed to ensure that inbound activities do not interfere with the outbound shipping process when the work volume is high. In addition, improvements in communication between warehouse and transportation teams are also a primary focus through developing a more systematic reporting format.

As part of operational optimization and a continuation of the 5W + 1H design, the Line Balancing approach will be implemented to reduce bottlenecks in the warehouse workflow. By balancing the workload between processes, the Company can avoid excessive waiting time at one

stage, thereby increasing overall efficiency. In addition, standard time measurements at each operational stage will also be carried out to ensure that efficiency targets can be achieved. Implementing this strategy is expected to reduce waste, increase productivity, and positively impact the Company's performance in facing the projected increase in activity in 2024–2025.

The novelty of this research lies in the application of Lean Warehousing in the logistics activities of Coil goods in the Warehouse (HRC), focusing on solving the problem of delays that cause waste. Identification of root causes is carried out using Root Cause Analysis (RCA), which is the basis for designing solutions to increase the tonnage that can be processed each period. One of the main results of this design is a slot booking system to optimize inbound and outbound flows and the application of Line Balancing to reduce bottlenecks in the loading and unloading process of coil trailers and ensure a more even distribution of workloads. With this approach, this research is expected to improve warehouse operational efficiency, encourage increased revenue, and strengthen the Company's competitiveness.

LITERATURE REVIEW

Warehousing

Logistics is a crucial aspect for a country, whose success and smoothness depend heavily on good infrastructure, distribution, and warehousing, because without such support there will be delays or problems in delivery, while in practice logistics is always related to the movement of goods, information, and accompanying services (Gunani & Widijawan, 2020 in Tohir et al., 2023). Warehousing has two main tasks: delivering products efficiently without errors and ensuring that products are placed in the correct location at the right time (Tohir et al., 2023). The main objectives of warehousing include improving service order functions, productivity, space utilization, and providing value-added services (Sasmito Muslim et al., 2021).

Lean Warehousing

According to Sarjono (2021) and Pratiwi & Widjajati (2023), lean is a strategy that focuses on efficiency by minimizing the use of resources without adding value to the output, while lean warehousing is a continuous effort to identify and eliminate waste that occurs and increase the added value of products, both goods and services, in order to provide value to customers. In the process, by identifying activities that have added value and those that do not, value-added and non-value-added times can be calculated at each work station (Adrianto, K, 2015, in Sarjono, 2021).

Problems in warehouse workflows, especially in lean warehousing, are addressed through a systematic approach that involves all workers to reduce waste throughout the supply chain, both upstream and downstream, and increase service time efficiency (Ibrahim & Prasetyawan, 2020, in Pratiwi & Widjajati, 2023). One type of waste that commonly occurs is waiting time, as explained by

Liker (2004) in the lean concept in The Toyota Way (Pratiwi & Widjajati, 2023) and without improvement efforts, waste such as excess storage and long waiting times can hinder the smooth operation of the warehouse.

Line Balancing

High daily shipping activities require companies to be able to meet daily demand, where they must implement effective and efficient processes to increase productivity. Line balancing is done by minimising idle time on the line, including minimising idle time determined by the slowest operation, and preventing bottlenecks due to unbalanced lines (Baroto, 2002, in Musthofa & Muhammad, 2024). Line balancing can also balance resources on the production line to achieve high work efficiency at each station by arranging work processes to produce a smooth production flow (Mujahidulloh & Bakhtiar, 2021).

Root Cause Analysis (RCA)

Root Cause Analysis (RCA) is a systematic method used to identify root causes in depth with certain stages, using tools such as 5 Whys Analysis, Fishbone Diagram, and Pareto Chart, in order to provide relevant improvement solutions and prevent similar problems from recurring in the future (Rouf & Muhammad, 2023). In conducting Root Cause Analysis, according to Andersen and Fagerhaug (Mega Astuti DR et al., 2019), provides a systematic approach to solving problems, namely by identifying the causes of the problem, finding ways to reduce or eliminate these causes, and preventing the same problem from happening again in the future. The problem-solving model developed by Andersen and Fagerhaug consists of seven stages: problem understanding, problem cause brainstorming, problem cause data collection, problem cause data analysis, root cause identification, problem elimination and solution implementation (Mega Astuti DR et al., 2019).

At each stage of the analysis, various tools, such as fishbone diagrams, Pareto diagrams, and 5 Whys Analysis, can be adjusted to your needs. These three tools not only help in finding the root cause of the problem in depth but also facilitate researchers in determining the correct form of intervention to address the conditions that are truly affected, not just the symptoms, and prevent the possibility of similar problems recurring in the future (Mega Astuti DR et al., 2019).

According to Rosyidi (2021) in (Arif & Gunawan, 2023), the Pareto diagram identifies the main problems or causes that are key to solving problems and compares all existing causes. This tool refers to the Pareto Principle or the 80:20 law, which states that around 80% of the effects are usually caused by 20% of the causes (Rouf & Muhammad, 2023). Meanwhile, according to Mangindara et al. (2022) in (Arif & Gunawan, 2023), a fishbone diagram or cause-and-effect diagram is a useful visual tool to identify, explore, and graphically depict various causes and sub-causes that contribute to a problem.

The 5 Whys method according to Rouf & Muhammad (2023), is a root cause analysis technique based on the process of asking "why" repeatedly, generally five times or until the root of the problem is found where each answer becomes the basis for the following question to form a chain of causes that leads to the primary source of the problem, so that this method is effective for identifying the root cause of a failure or non-conformity, and provides a solid foundation for long-term improvement.

5W + 1H

The 5W+1H method is a practical approach to gathering information and solving problems by asking a series of fundamental questions to understand a condition or problem as a whole (Al-Abbasi and Al-Shablawi, 2022, in Udonsathian & Worapun, 2024). The 5W+1H method has been widely applied in various fields such as journalism, scientific research, project management, and education to ensure that in-depth analysis fosters critical thinking skills (Udonsathian & Worapun, 2024). As an important tool in problem solving and decision making, this method encourages individuals to explore complex scenarios, consider multiple perspectives, and make mature and comprehensive decisions.

Furthermore, the 5W+1H method is important in developing analytical thinking skills by asking "What, Where, When, Who, Why, and How" questions, strengthening individuals' ability to dissect complex problems, identify important information, and formulate effective solutions. In the context of this research, the 5W+1H approach is used to design solutions to the problem of delays in inbound and outbound activities in the distribution of HRC coils in the warehouse, so that the proposed improvements are more systematic, applicable, and meet operational needs.

METHOD

This study uses qualitative and quantitative data collection methods through observation, case studies, brainstorming, and the Root Cause Analysis (RCA) approach supported by Fishbone Diagram, Pareto Chart, and 5 Whys analysis. The analysis results are then used to design solutions to improve operational efficiency and reduce waste when loading and distributing materials in the warehouse. The object of this study is the operational flow of warehousing at PT.XYZ, with a focus on identifying factors causing inefficiency, delays in the loading and unloading process, and workload distribution. This study will identify the root causes (Root Cause Analysis) that cause bottlenecks in warehouse activities and find optimal solutions through the Line Balancing approach to improve operational efficiency. The subjects of the study are experts who have strategic roles in managing warehouse operations at PT. XYZ. They consist of managers, supervisors, and related personnel with deep insight into operational constraints and efforts to improve efficiency.

RESULTS AND DISCUSSION

Warehouse Initial Performance Analysis (Warehousing)

This Company has several aspects that determine the rate of development of its business life. The most important aspect of Coofy is its Company's housing activities. There are various types of warehousing activities that the Company has for generating income, some of which are Variable Income and Non-Variable Income. Non-variable income is Income from managing warehouse management A (SLAB 1), B (SLAB 2), C (COIL 1), and D (Ferro Alloy). Variable Income includes income from elevation truck activities, total income from reach stacker activities, total marking income, and total inventory income. The total profit obtained by the Company from warehousing activities in January - October 2024 can be seen in Table 1

Table 1. Keuntungan Kegiatan Warehousing Bulan Januari- Oktober 2024

Profit Dashboard			Month									
No	Warehouse	Quantity	January	February	March	April	May	June	July	August	September	October
1	Slab 1	Total Inbound (Tonase)	30,093	29,376	29,467	29,467	28,203	87,057	35,909	61,14	51,328	71,848
		Total Outbound (Tonase)	91,291	30,001	28,02	28,02	43,545	40,284	79,673	30,313	48,935	52,519
		Total Handling (Tonase)	74,062	28,154	30,615	30,294	45,63	61,289	84,562	90,688	40,400	41,539
		Total Income (Rp)	Rp.217,464,049	Rp 115,793,133	Rp 116,292,667	Rp 182,251,262	Rp136,524,194	Rp 289,016,309	Rp 257,769,267	Rp 236,277,929	Rp 171,501,209	Rp 200,271,707
2	Slab 2	Total Inbound (Tonase)	44,3884	42,987	31,073	36,678	29,95	24,798	22,869	40,561	44,884	36,852
		Total Outbound (Tonase)	—	—	—	—	—	—	—	4,465	70,548	102,176
		Total Handling (Tonase)	19,192	15,681	11,231	15,335	13,409	26,384	20,575	23,962	35,023	35,947
		Total Income (Rp)	Rp.210,525,964	Rp 254,909,992	Rp 214,256,846	Rp 166,271,509	Rp 224,476,480	Rp 243,206,952	Rp 254,203,575	Rp 288,465,938	Rp 291,773,094	Rp 259,505,340
3	Coil	Total Inbound (Tonase)	60,754	48,462	55,515	52,209	52,273	50,987	45,274	48,886	52,192	52,095
		Total Outbound (Tonase)	52,866	40,598	47,04	50,959	41,053	43,128	41,460	45,664	53,639	55,179
		Total Handling (Tonase)	51,673	42,454	44,128	39,203	52,451	46,515	48,156	46,832	53,604	53,943
		Total Income (Rp)	Rp.969,598,035	Rp 622,982,927	Rp 690,862,154	Rp 498,157,202	Rp 1,034,621,380	Rp 800,828,876	Rp 837,108,530	Rp 798,632,900	Rp 1,062,627,669	Rp 1,083,720,720
4	Alloy	Total Inbound (Tonase)	6,713	5,946	5,363	7,968	6,335	5,574	6,73	8,590	5,053	6,573
		Total Outbound (Tonase)	5,971	6,309	7,483	6,548	6,747	6,795	5,909	7,135	5,183	6,562
		Total Handling (Tonase)	—	—	—	—	—	—	—	—	—	—
		Total Income (Rp)	Rp 526,524,000	Rp 526,524,000	Rp 526,524,000	Rp 526,524,000	Rp 526,524,000	Rp 526,524,000	Rp 526,524,000	Rp 526,524,000	Rp 526,524,000	Rp 526,524,000

It can be seen in the graph that the most significant income is obtained through activities in the outer coil one warehouse and the outer coil two warehouse, with the highest average amount first, followed by the alloy warehouse. However, in alloy, monthly income is stagnant/unaffected by the difference in monthly tonnage. At the same time, the outer coil one warehouse and the outer coil two warehouse have different benefits, depending on the amount of tonnage obtained. In addition, if you look at the initial agreement regarding Warehouse warehousing by the Customer Company, PT, XYZ is required to have the ability to fulfil the bidding agreement on the project given by the customer, especially the coil project. It can be seen in the picture below that the comparison of the number of coils of the XYZ company can only be 53%, while at the beginning of the agreement, it was required to have a comparison of 70:30 with competitors.

Root Cause Identification

1. Identify The Root Cause Of The Problem

a. Problem understanding

The coil outer warehouse subdivision has three warehouses, but since September 2022, the number of coil outer warehouses, which was initially 3, has decreased to 2. On the other hand, in 2023, the number of inbound and outbound tonnages increased. This subdivision was formed to regulate and manage all warehousing activities in the coil outer warehouse, including administrative and operational work from loading/unloading, moving, remarking, administration, and reporting of warehousing activities. The symptoms of the problem found

here are delays in the inbound and outbound processes of coil goods, resulting in complaints from vendors and customers.

b. Problem cause brainstorming

Brainstorming is the cause of the problem (problem causes brainstorming). At this stage, the researcher brainstormed to identify steps not appropriately implemented by the related subdivisions, namely coil outer warehouse subdivisions 1 and 2. The researcher used the unstructured brainstorming technique to explore ideas or concepts related to existing problems. From brainstorming with managers, supervisors and sub-division leaders, several ideas emerged about delay indicators: inbound, outbound, and moving delays.

c. A problem caused by data collection

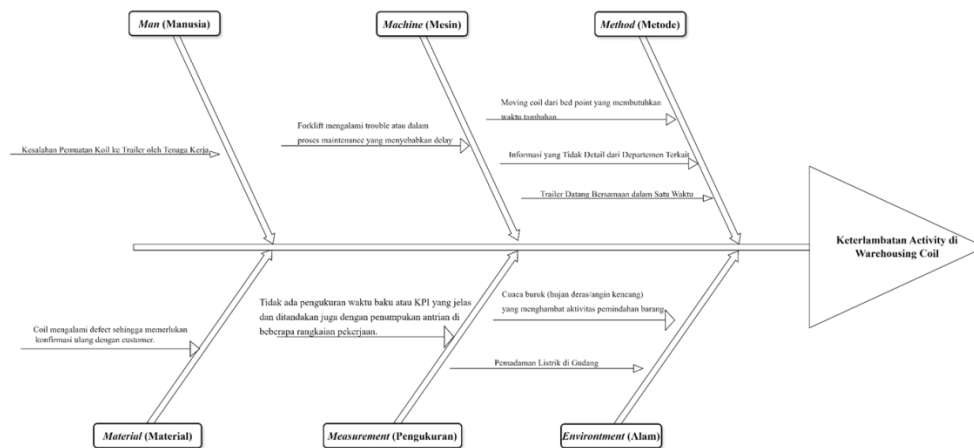
This stage involves collecting data by first interviewing warehousing managers, supervisors, and warehouse leaders.

d. The problem causes data analysis.

The next stage is analysis. This stage is followed by data analysis, where six aspects are called 6M. These six aspects include Man (Human), regarding the human factor, which plays an important role in facilitating warehouse operations. Unpreparedness or human error can cause delays at various stages of inbound, outbound and moving operations, Machine (Machine) regarding the condition of equipment that has a significant impact on the smooth operation of the warehouse, Method (Method) regarding the lack of detailed information from related departments makes the warehouse team have to calculate and compile a list of coils manually in the system & The arrival of trailers simultaneously without a structured schedule causes a backlog of loading activities, Material (Material) regarding poor quality and material management can trigger various operational delays, Measurement (Measurement) regarding operational performance measurement, evaluation and process improvement, Environment (Nature) regarding environmental factors that affect the smooth operation of the warehouse.

2. Problem identification analysis (Fishbone)

In this stage, the problems studied and grouped into causes are arranged in a cause-and-effect diagram, better known as a fishbone diagram. The main problem or effect of the cause of the problem is placed in the head of the fish. The head of the fish in the diagram that will be visualized is the main problem in this study.



Picture 2. Fishbone Diagram: Causes of Delays in Coil Warehousing Activities

The results of the problem identification revealed symptoms of delays in several aspects, namely delays in receiving goods (inbound), sending goods to customers (outbound), and moving goods between warehouse locations (moving). This process involved exploring ideas through brainstorming with managers, supervisors, and warehouse teams to further understand the factors causing the delays.

Furthermore, interviews were conducted to identify factors that influence delays in the inbound, outbound, and moving goods processes and to find bottleneck points that hinder smooth operations. In analysing the root causes of the problem, researchers refer to the systematic approach suggested by Andersen and Fagerhaug, which consists of seven stages: Determining the problem, Collecting data, Identifying possible causes, Identifying root causes, Determining solutions, Implementing solutions, and Ensuring the sustainability of improvement.

This study adopted six initial stages of the seven stages to evaluate the problem thoroughly and systematically. Researchers used various tools such as brainstorming, field observations, interviews, fishbone diagrams, Pareto charts, and 5 Whys to identify the leading causes of delays. This approach helps find the root cause and serves as a basis for determining the right and sustainable solution. From the results of interviews and discussions with the warehouse team, several factors causing the problem were found, namely Bottleneck in the Work Process, Delays Related to Materials and Information, Logistics and Transportation Factors, Machine and Equipment Problems, Environmental Factors and Human Error.

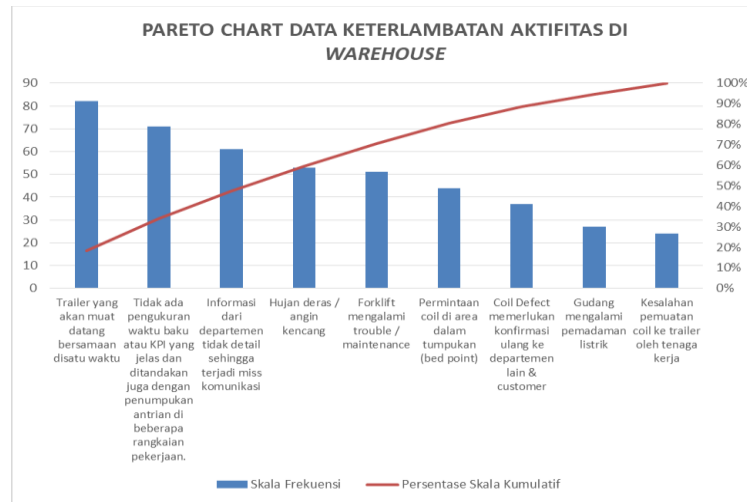
3. Determining the main factors causing delays (Pareto Chart)

This section uses Pareto analysis to determine the leading causes of delays in the warehouse's operational management of steel materials. With the data on the causes obtained, the researcher conducted further analysis in the next stage using the Fishbone approach and 6M analysis to group the causal factors based on the main aspects of warehouse operations.

Nine factors causing delays were obtained and analyzed further. Pareto analysis was used to identify the leading causes of delays in managing steel materials. The Pareto principle states that

80% of problems are usually caused by 20% of dominant factors. Therefore, the Pareto chart focuses improvement efforts on the most significant causes and those that significantly impact delays.

Through this analysis, the leading causes of delays in both inbound and outbound processes can be identified. Thus, efforts to eliminate problems can be directed at factors that contribute the most to delays, thereby increasing operational efficiency and smoothness.



Picture 3. Pareto Diagram of Causes of Delays in Coil Warehousing Activities

Based on the delay frequency scale data for 8 months, 6 out of 9 factors cause the most dominant delays. The results of the Pareto analysis show that six leading causes contribute 80.44% of the total delays. The six dominant factors are: Simultaneous arrival of trailers at one time, No precise standard time measurement or KPI, Information from the department is not detailed, causing errors, communication and data search Heavy rain / strong winds, Forklifts experience trouble/maintenance, Coil requests in the area in the stack (bed point). By improving these six factors, warehouse operational efficiency can increase significantly and minimise activity delays. Furthermore, a 5 Whys analysis was carried out to determine the root cause of these six causes. By investigating deeper through repeated "why" questions, we can uncover various factors that cause delays. It allows for the overall development of a more targeted and efficient improvement strategy.

4. Root Cause Analysis of Delays

Table 1. Root Cause Analysis of Delays: 5 Whys Method

No	Factors	Root Cause (Result of 5 whys)
1	Trailers Arriving Together at One Time	Because there is no digital system for booking arrival slots.
2	There is no precise standard time measurement or KPI, which is also indicated by the accumulation of queues in several work series.	Because management assumes that the queue is only caused by the large number of units arriving. But not from the conditions in the process that cause bottlenecks

No	Factors	Root Cause (Result of 5 whys)
3	Incomplete Information from Related Departments	Because there is no coordination to ensure that the information needs of the warehouse and related teams are aligned to be effective and reduce excessive communication.
4	Heavy rain / strong winds	Because there is no planning or investment in infrastructure to provide these special facilities.
5	Forklifts are having trouble or are in the maintenance process, which causes delays.	There is a lack of understanding of the importance of more frequent preventive maintenance and its impact on smooth operations.
6	Moving coils from bed points requires additional time.	The warehouse does not have a special area (buffer area) to store coils that are ready to be shipped.

Evaluation of Design Proposal/ Operational Process Improvement

The design or process improvement evaluation stage for inbound and outbound delays begins with identifying and eliminating the root cause. The initial step is carried out through brainstorming activities between researchers, warehouse management managers, and HRC coil warehouse leaders to formulate solutions for each root cause that has been previously analyzed using the 5 Whys method. In addition to the brainstorming approach, researchers also use the 5W + 1H method as a tool to design more systematic and applicable solutions. Solutions are designed based on the 5W + 1H approach (What, Why, Who, Where, When, and How) to ensure that every improvement aspect is identified comprehensively and implementably.

1. Trailer Arrival at the Same Time

- a. What: Implement a trailer slot scheduling system for inbound and outbound.
- b. Why: To avoid trailer accumulation and smooth the flow of receiving and sending goods. & Reduce waiting time and increase warehouse operational efficiency.
- c. When: Pilot project in 1 month to test the system. & Full implementation in 3 months with periodic evaluation.
- d. Where: In the inbound and outbound processes in external warehouses.
- e. Who:
 - Warehouse logistics management team → Supervise the implementation and evaluation of the system.
 - Procurement & Transporter Operations → Must follow the SOP for booking slots.
 - IT & management → Prepare a digital or semi-manual system for booking slots.
- f. How:
 - Digital system: Create a simple website or application so that suppliers can book arrival slots.
 - Manual alternative (temporary): Use Google Sheets or a WhatsApp group with a booking slot format.

- Implementation of SOP: Suppliers who do not book slots will be subject to penalties or lower priority in loading.
 - Evaluation & feedback: Conduct evaluation meetings every week to improve the system
2. No Standard Time Measurement or Operational KPI
- a. What: Determine the standard cycle time for inbound and outbound, identify bottlenecks, set KPIs, and track process time using manual or digital tools.
 - b. Why: This helps the warehouse team set clear time targets, reduce unnecessary queues through better time planning, and support performance evaluation and continuous improvement..
 - c. When: In Weeks 1–2, collect work time data using a stopwatch or a simple tracking system. During Weeks 3–4, analyze the data to determine the standard cycle time for both inbound and outbound activities. By Week 5, apply the line balancing method to reduce queue buildup and minimize bottlenecks.
 - d. Where: In the inbound and outbound processes in external warehouses.
 - e. Who:
 - Warehouse & operational team → Record process time and ensure KPI is implemented..
 - Warehouse supervisor & manager → Analyse data and make improvements if necessary.
 - IT or data team → If possible, develop a digital-based recording system.
 - f. How:
 - Use a stopwatch/manual tracking to record the process time of each stage to determine standard time.
 - Know the cycle time based on actual data and historical data.
 - Implement the Line Balancing Method to reduce bottlenecks/queues that accumulate in the inbound and outbound processes.
 - Determine operational KPIs.
 - Socialise KPIs with the team and provide feedback periodically.
3. Insufficient detailed information from related departments
- a. What: Establish a standard information format that related departments must provide before inbound and outbound, including:
 - Special Coil List / Not
 - Tonnage range (45-47 tons, 50-53 tons) for flexibility of bed matching
 - Coil position & condition (storage location, ready to load or needs to be moved).
 - Estimated loading time & queue
 - Create a formal SOP to ensure this information flow is applied consistently.
 - b. Why: The goal is to reduce inbound and outbound delays caused by incomplete information, increase operational efficiency by speeding up coil matching and minimizing unnecessary movements, and avoid time-consuming back-and-forth communication during operations.

- c. When: Week 1–2: Collect work time data using a stopwatch or simple tracking system.
- d. Where: In the inbound and outbound processes in external warehouses.
- e. Who:
 - Warehouse Team → Prepare detailed information needed.
 - Related Department Team (Logistics, Sales, Planning, etc.) → Follow the standard format.
 - Warehouse & Logistics Supervisor → Ensure that this SOP is implemented in a disciplined manner.
- f. How:
 - Determine a more detailed standard information format, including.
 - Socialize this format to related departments so that it is applied consistently.
 - Use a manual or digital recording system to access information quickly and accurately.
 - Conduct periodic evaluations to ensure system effectiveness and make revisions if necessary.

Due to Bad Weather (Heavy Rain / Strong Winds)

- a. What: The absence of a special area for removing and installing tarpaulins forces trailers to enter the warehouse when it rains, hampering the operation of moving goods and increasing the density in the warehouse.
- b. Why: From the beginning, there was no planning to build a special area, and no regulations or SOPs governed the efficient removal and installation of tarpaulins.
- c. When: During the rainy season or when many trailers must be processed simultaneously, forcing the trailers to enter the warehouse for protection from foul weather.
- d. Where: In the loading/unloading area of the warehouse, especially during bad weather conditions such as heavy rain or strong winds.
- e. Who: Forklift operators, inbound teams, outbound teams, trailer drivers, and warehouse management who experience operational delays due to warehouse density.
- f. How: Build a special area with a canopy or shelter for removing and installing tarpaulins so that it does not need to be done inside the warehouse. Allocate a budget for additional infrastructure, such as improving the layout of the trailer parking area with supporting facilities.

Forklift Having Trouble or Unscheduled Maintenance

- a. What: Forklift reliability needs to be improved by increasing the frequency of inspections, proposing remote monitoring systems for early damage detection, and developing management policies for proactive preventive maintenance.
- b. Why: This is important to ensure that any forklift damage can be detected earlier, minimizing downtime. Keeping forklifts in good condition without waiting for serious breakdowns helps avoid delays and supports smoother warehouse operations.

- c. When: This should begin in Week 1 with communication to the vendor. In Week 2, the warehouse can propose monitoring tools. By Week 3, a regular forklift inspection schedule and the implementation of the monitoring system should be established.
- d. Where: These improvements must be applied to all forklifts operating within the warehouse area for inbound, outbound, and internal goods movements.
- e. Who: The operational team and warehouse supervisor coordinate with vendors to ensure forklift readiness. The vendors carry out inspections and install monitoring systems or sensors.
- f. How: Request the vendor to perform forklift checks more frequently, such as every two weeks. Collaborate with them to implement remote monitoring tools or real-time condition sensors. Clear communication protocols regarding repair timelines should also be established, especially if breakdowns happen after working hours.

The Moving Coil Process from Bed Point Takes Additional Time

- a. What: Create a special buffer area for outbound coils so inbound coils do not cover them—Optimise coil placement patterns to allow for more efficient movement and quicker access. Implement dedicated lanes for inbound and outbound movements to prevent forklift obstructions. Adjust the SOP for moving coils to minimize delays during peak warehouse activity.
- b. Why: This improvement prevents outbound coils from being blocked by inbound coils, eliminating the need for repeated movements. It also reduces the number of coil movements required with each request and ensures faster trailer loading by keeping coils in accessible positions..
- c. When: After receiving request releases (morning and evening), outbound coils should immediately be moved to the buffer area before inbound coils arrive. If there are no coil requests within 24 hours, they should be returned to regular storage. When operations are calm, take the opportunity to reset the buffer. The effectiveness of both the storage and buffer areas should be reviewed monthly.
- d. Where: The buffer area should be near the loading zone for quick access to outbound coils. Inbound and outbound forklift lanes should be separated to prevent operational obstructions. The overall warehouse layout should be enhanced to offer flexible zones for frequently moved coils..
- e. Who: The Warehouse & Operations Team is responsible for ensuring that outbound coils are moved to the buffer area before any inbound coils arrive and managing the buffer area to avoid congestion. The Warehouse Supervisor and Manager evaluate the buffer area's effectiveness and improve the SOPs for coil movement as needed.
- f. How: To implement this, first create a dedicated buffer area for outbound coils in an accessible, unoccupied location. Use this area to store coils that will be shipped soon, and tidy it up during

idle times. Adjust the coil placement pattern by putting high-turnover coils near the loading area and low-turnover ones deeper inside. Use labels or barcodes to mark coil priority. Ensure forklift paths are clear by separating inbound and outbound routes and applying a one-way system. Lastly, optimize the SOP by moving outbound coils to the buffer before inbound coils arrive, keeping the buffer accessible, and reviewing the process monthly.

Solution Design Development

Based on the solution mapping using the 5W + 1H approach to the six main problems affecting warehouse operational performance, this section compiles a more structured and integrated solution design. Each previously identified solution is then formulated into improvement steps that can be practically implemented, considering technical aspects, resource availability, and actual conditions in the field. The preparation of this design is also complemented by a further discussion process with the PIC or person in charge of each job to obtain a more detailed calculation of the method and implementation approach. Thus, the solutions formulated are theoretically relevant, realistic, and applicable to answer existing problems effectively. The results of the solution preparation process, which has gone through the identification stage, evaluation with the 5W + 1H approach, and discussions with related parties, produced six main designs that are focused on answering the root of the problem in HRC warehouse operations, especially in inbound and outbound delays. The six designs reflect an approach that is both technical and applicable, with the hope of providing a direct impact on increasing the efficiency and effectiveness of the logistics process. The solution designs include:

1. Design of the Outer Warehouse (HRC) Loading and Unloading Slot Booking System.

One of the leading causes of delays in the outer warehouse (HRC) is the absence of a structured system for scheduling trailer arrivals, so a digital-based loading and unloading slot booking system was designed using Google Forms, Spreadsheet, and WhatsApp API integration. This system schedules trailer arrivals based on the type of activity (inbound and outbound) and the level of coil urgency, with outbound and export coils getting top priority. Time slots are divided into regular slots (70%), priority (20%), and buffer (10%) to anticipate delays, and tolerance and sanctions are imposed on undisciplined vendors. The implementation of this system aims to improve coordination, reduce vehicle congestion, and encourage operational discipline, while opening up opportunities for further development through a monitoring dashboard and automation of slot management. With this design, the efficiency and smoothness of the HRC warehouse logistics flow can increase significantly.

2. Standard Time Measurement and Line Balancing to Reduce Bottlenecks.

Standard time measurement in the external warehouse of PT. XYZ is carried out using the stopwatch method, accompanied by data adequacy testing (95% confidence, 5% accuracy) and

Westinghouse factor correction to determine the standard time for each activity. Of the 23 inbound elements and 25 outbound elements, significant imbalances were found, with inbound having a balance delay of 71%, line efficiency of 29%, and idle time of 14,059.21 seconds, and outbound having a balance delay of 66%, line efficiency of 34%, and idle time of 15,504.01 seconds. To overcome this bottleneck, optimization was carried out using the Ranked Positional Weight (RPW) line balancing method, resulting in a reduction in the number of inbound stations from 5 to 3 and outbound from 4 to 2, with adjustments to the inbound takt time of 2,595 seconds and outbound of 5,570 seconds. The optimization results show an increase in inbound efficiency from 29% to 74% and outbound from 34% to 62%, as well as a decrease in inbound idle time to 1,988.85 seconds and outbound to 4,907.28 seconds. With this line balancing, the workload distribution becomes more balanced, bottlenecks are significantly reduced, and inbound and outbound operations run more efficiently according to the Company's targets.

3. Design of Communication Reporting Format between HRC Coil Transport and Warehouse Team for Inbound and Outbound Activities.

The irregularity of the coil delivery and pickup reporting format causes miscommunication, loading delays, and operational inefficiencies due to unclear tonnage, coil number, special status, and lack of driver and vendor contact information. To overcome this, a WhatsApp-based reporting format was designed with a systematic information structure, precise technical data, including contact persons, determination of specific loading locations, and use of visualizations and emojis to improve readability, without requiring new system investment.

[INBOUND / OUTBOUND] NOTIFICATION

Customer: BUMI KAYA PULOGADUNG 11,7

Kapal Ekspor: COIL MV GOLDEN ACE (optional: Domestik)

No Pol: Z 9152 S

Driver: Ipin | [No HP Driver]

Vendor Transporter: [Nama Vendor] | [No HP Vendor]

Detail Barang (Total: 4 Coil)

◆ Gudang 1: Trikusuma

- Coil 1: [Nomor Coil / Khusus atau Tidak] – [xx] ton

◆ Gudang 2: Hamasa

- Coil 2: [Nomor Coil / Khusus atau Tidak] – [xx] ton

🐘 Range Tonase (jika Non-Khusus): [45–47 ton]

🕒 Estimasi Waktu Pemuatan: [Tanggal & Jam]

📍 Urgensi: [Ekspor / Domestik Jabodetabek / Luar Jabodetabek / Transfer]

🛠️ Alat Muat Dibutuhkan: [Kondisi alat muat – kayu/rantai/saddle/bracket]

📝 Catatan: [Instruksi tambahan jika ada]

📌 Mohon konfirmasi jika ada perubahan atau kendala di gudang tertentu.

Picture 4. Design Results Based on Related Division Requests.

4. Design of Trailer Tarpaulin Opening and Closing Area for Outer Warehouse (HRC).

The absence of a special area for opening and closing trailer tarpaulins in the outer warehouse causes disruption of material circulation, increased risk of accidents, and logistics delays, especially during bad weather. To overcome this, a semi-permanent shelter was designed based on the lean layout principle to minimize non-value-added movements. In the coil two outer warehouse, the tarpaulin area was chosen on the left side of the warehouse due to limited external

space. In contrast, in the coil one outer warehouse, the shelter was built between the trailer entrance and exit to serve inbound and outbound simultaneously, thus supporting operational efficiency. Design of Forklift Checklist by Operator for Preventive Maintenance of Forklift Problems in the Outer Warehouse (HRC).

Operational delays in the HRC outer warehouse are caused mainly by forklifts that are not ready to use due to the absence of a consistent preventive maintenance system. So far, inspections have only been carried out by vendors at long intervals (2–4 weeks) without the involvement of daily operators. To overcome this problem, a Google Form-based preventive maintenance checklist system was developed, which must be filled in by operators every shift. This checklist includes operator identity, technical inspection, condition assessment, problem documentation, and photo uploads. The collected data can be processed as a dashboard to monitor unit conditions in real-time, accelerate repair responses, and support managerial decision-making regarding forklift maintenance or replacement. This approach encourages a change in work culture towards preventive inspections and improves the reliability of warehouse operations.

5. Designing a Buffer Area for Outbound Coil Storage to Avoid Inbound Obstructions during High Activity.

The unavailability of buffer areas in HRC's external warehouses often causes outbound coils to be blocked by inbound coils, increasing the risk of late delivery and forklift workload. Based on historical data and field observations, a special buffer area was designed for outbound coils near the loading dock to shorten forklift travel time and separate inbound-outbound lanes. The design considers a storage capacity of ± 16 coils per day, zoning based on delivery urgency, and two-way forklift lanes to maintain smooth maneuvers. Implementing this buffer area will reduce double-handling activities, increase loading efficiency, and improve warehouse logistics flow. However, this design has not been tested in the field and requires a pilot test for further validation.

Comparison of Line Efficiency Before and After Proposed Improvements (Using Line Balancing)

As part of the evaluation of the proposed work process improvements, workline efficiency measurements were conducted on inbound and outbound activities. This analysis aims to see changes in operational performance after improvements are made, especially in line balance. Measurements are made using indicators of the number of work stations, efficiency, idle time, balance delay, and smoothing index. These values are calculated for conditions before and after improvements to provide a quantitative picture of the impact of the proposed improvements. The complete results of the comparison are presented in the following table.

Table 2. Comparison of Initial and Proposed Line Efficiency on Inbound and Outbound

Comparison of Initial and Proposed Line Efficiency on Inbound

Conditions	Work Station	Efficiency	Idle Time	Balance Delay	Smoothing Index
Before repair	5	29%	14059,21	71%	7050,75
After Repair	3	74%	1988,85	26%	1406,60
Comparison of Initial and Proposed Line Efficiency on Outbound					
Conditions	Work Station	Efficiency	Idle Time	Balance Delay	Smoothing Index
Before repair	5	34%	15504,01	66%	7870,74
After Repair	3	62%	4907,28	38%	4907,28

Line efficiency evaluation was conducted to see the impact of proposed improvements on the performance of inbound and outbound process flows. This analysis includes five leading indicators: number of workstations, efficiency, idle time, balance delay, and smoothing index. Data were obtained through simulations of existing conditions and proposed improvement scenarios. On the inbound side, initial efficiency was recorded at only 29% with five active workstations. Idle time reached 14,059.21 seconds, reflecting suboptimal load distribution between stations. Balance delay reaching 71% showed a significant imbalance between workstations. In addition, the smoothing index was at 7,050.75, indicating high variation in the distribution of work time. After the improved design was implemented, the number of workstations could be reduced to three without sacrificing efficiency. Efficiency increased significantly to 74%, drastically decreasing idle time to 1,988.85 seconds. Balance delay also decreased to 26%, indicating a more even distribution of work between stations. The smoothing index value that decreased to 1,406.60 indicates a more stable and homogeneous system in the working duration of each station.

In the outbound process, the initial conditions are similar to those of the inbound process. There are five work stations with an efficiency of only 34%. Idle time is even higher, at 15,504.01 seconds. The load imbalance is reflected in the balance delay of 66%, and the smoothing index reaches 7,870.74. It indicates an uneven and less effective work distribution. After improvements, the number of work stations was reduced to three, and efficiency increased to 62%. Although not as high as the increase in the inbound process, this increase is still significant. Idle time decreased to 4,907.28 seconds, meaning working time is more optimal. The balance delay also decreased to 38%, and the smoothing index decreased to 4,907.28, indicating improved workload distribution between stations. Overall, comparing data before and after improvements shows that the proposed redesign can positively impact operational efficiency on both the inbound and outbound sides. Efficiency increases, the number of work stations decreases, and work imbalances are successfully suppressed.

Assuming the number of trailers processed remains the same, these savings proportionally affect the processing time per trailer. For example, 10 trailers are processed in the same period. In that case, the efficiency of work time per trailer for inbound activities reaches around 20.12 minutes, while for outbound it is around 17.66 minutes per trailer. It shows that a more structured work distribution

and buffer area design can make a real contribution to smooth operations. Although this analysis is based on assumptions, the results provide a strong basis that layout and work distribution improvements can significantly improve the operational lines' performance in the warehouse.

CONCLUSION

This study aims to identify the causes of delays in the inbound, outbound, and moving processes and to design solutions to improve PT's external warehouse (HRC) operational efficiency. XYZ. Based on the results of the analysis and discussion that have been carried out, several main conclusions were obtained as follows:

1. The analysis results show that a combination of various factors causes delays in coil distribution activities. Of the total nine leading causes, six of them contributed to 80.44% of the total delays, namely: trailers arriving together (18.22%), no standard time measurement (34%), information between departments is not detailed (47%), extreme weather such as rain and strong winds (59.33%), forklifts experiencing problems (70.67%), and coil requests that are at the bed point position (80.44%). Through the Root Cause Analysis (RCA) analysis, which includes a Pareto Chart, a Fishbone Diagram, and Five Whys, the root causes were successfully identified. The root causes include: the unavailability of a digital booking slot system for truck arrivals; management that still considers queues only due to unit volume, not process bottlenecks; lack of structured coordination between related teams; the absence of buffer area infrastructure planning; and the lack of understanding of the importance of preventive maintenance of equipment.
2. In response to the root of the problem, several solutions were designed that focused on the inbound and outbound processes. Using the 5W + 1H approach (What, Why, Where, When, Who, and How), the solutions were systematically arranged to be implementable by actual conditions in the field. Proposed solutions include: designing a loading and unloading slot booking system, measuring standard time and line balancing, developing a reporting format between teams, designing a trailer tarpaulin opening and closing area, a forklift preventive checklist, and a special buffer area for outbound coils. This solution is technical and strengthens the coordination between departments and facility planning.
3. Based on the calculation results of the five leading indicators of line balance with the Line Balancing method, namely the number of work stations, efficiency, idle time, balance delay, and smoothing index, it can be concluded that the proposed improvement design has a significant impact on increasing operational efficiency. In inbound activities, efficiency increased from 29% to 74%, accompanied by a decrease in idle time from 14,059.21 seconds to 1,988.85 seconds, equivalent to a time saving of around 201 minutes. Meanwhile, in outbound activities, efficiency increased from 34% to 62%, with a decrease in idle time from 15,504.01 seconds to 4,907.28 seconds, equivalent to a time saving of around 176 minutes. Assuming that the number of trailers processed remains the same, then the savings proportionally affect the efficiency of the processing

time per trailer. As an illustration, if 10 trailers are processed in a specific period, then the efficiency of the working time per trailer for inbound activities reaches around 20.12 minutes. At the same time, it is around 17.66 minutes per trailer for outbound. These results show that a more balanced work distribution design and the provision of a structured buffer area can significantly improve the smoothness of the process and overall operational efficiency.

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