ISSN 2087-3336 (Print) | 2721-4729 (Online)

TEKNOSAINS: Jurnal Sains, Teknologi dan Informatika
Vol. 11, No 2, July 2024, page. 342-354
http://jurnal.sttmcileungsi.ac.id/index.php/tekno
DOI: 10.37373

Reducing overnight charges in the loading process of finished goods using FMEA method at PT. XYZ

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Submitted: 20/03/2024 Revised: 21/05/2024 Accepted: 29/05/2024

ABSTRACT

As a part of the supply chain, the logistics department plays a crucial role in the operational activities of a company. Like other departments, the logistics department also incurs costs that do not add value, such as overnight charges. Failure in the loading of finished goods process can result in a dwell time exceeding 18 hours per vehicle, leading to overnight charges. This occurrence can be prevented by identifying risks and failure modes using Failure Mode and Effect Analysis (FMEA). The FMEA methodology is widely utilized across various industries, including manufacturing, for product development. Additionally, FMEA is frequently employed in failure analysis in service industries, food services, construction, mining, agriculture, and healthcare. The research was conducted to identify failure modes and potential causes in the loading of finished goods process. In PT. XYZ, there are five finished goods storage areas. From the process of weigh-in time, loading finish goods, and weigh-out time, 25 activities were analyzed, and seven activities with the highest Risk Priority Number (RPN) were selected for solutions. The activity with the highest RPN, scoring 512, was the queuing of trucks exceeding loading capacity. The why-why analysis technique was employed to assist in finding solutions. From the seven activities with the highest RPN, 9 solution plans were derived. The recommendation to reduce queue trucks is to organize and monitor the vehicles dispatched by the Freight Forwarder. As a result, the dwell time per vehicle decreased from 9.23 hours to 6.36 hours, and the overnight charges reduced from 148,145 USD to 12,345 USD.

Keyword: FMEA; logistic; why why analysis; RPN

1. INTRODUCTION

According to its development, Failure Mode and Effect Analysis (FMEA) was initially introduced around the 1940s in the military domain [1]. The initial purpose of FMEA was to identify failure modes in the development of expensive rocket weapons. Subsequently, around the 1970s, FMEA was extended to the automotive industry, and by the 1980s, it had been adopted in nearly all types of manufacturing industries [2]. The American Society for Quality (ASQ), in its book "The Certified Six Sigma Black Belt Handbook," has incorporated FMEA as a tool for analysis.

Fundamentally, to ensure a company remains competitive and sustainable, it is crucial to maintain revenues consistently higher than expenditures. In the operational aspect, it is imperative to manage and reduce costs arising from operational activities. Identifying and addressing waste is a mandatory step in achieving this goal FMEA is an approach aimed at evaluating processes and anticipating all types of failures within a standard activity [3]. By estimating the likelihood of potential failures, contingency plans can be promptly determined.

DOI 10.37373/tekno.v11i2.1103

Risk management is not confined solely to the manufacturing domain; in the context of supply chain management, controlling risks associated with process failures throughout the supply chain activities can significantly impact a company's performance. Supply Chain Risk Management is a condition and effort to minimize the likelihood of risks arising in the entire supply chain flow by engaging in collaborative activities and coordination across all involved aspects. This optimization contributes to achieving goals and ensuring the continuous improvement of processes [4]. Inconsistent forecasting, currency fluctuations, and shifts in customer demand are common forms of risk that frequently arise in supply chain activities [5]. Failures in the logistics field can manifest as increased costs, loss of time, and disrupted customer satisfaction [6].

Logistics itself is a part of the supply chain, encompassing activities that involve planning, implementing, and controlling the flow, storage, services, and information efficiently and effectively from the point of origin to the point of consumption to meet customer demand [7]. Logistics activities have several primary objectives [8]. Logistics activities themselves have several main objectives, including operational goals, which means that logistics activities provide the right quantity and quality of goods. It is crucial to conduct a comprehensive analysis of the logistics chain, identifying and evaluating all relevant constraints for a thorough assessment of potential limitations in the supply chain [9]. Furthermore, financial objectives aim to fulfill operational goals with the lowest possible cost. The true value of inventory is reflected in the accounting system. Security objectives aim to prevent inventory disruption caused by damage, wastage, unauthorized use, theft, and other undue depreciations.

In the actual operating conditions, the supply chain flow within a company encounters varying levels of risks [10]. This will heavily depend on the level of complexity within the supply chain flow. Previous studies have indicated that poorly managed levels of supply chain complexity can lead to various risks, causing constraints in both inbound and outbound logistics processes (supply chain risk). In other words, controlling supply chain risks is closely related to the mitigation of deviations that occur in supply, demand, production, information, and workplace safety management [11].

FMEA is regarded as a technique for analyzing failures, identifying the primary causes of failure, eliminating them, reducing the likelihood of failure, and enhancing the quality of products and processes. The success of FMEA in various industrial sectors has yielded significant benefits after implementing this technique. There are four types of FMEA currently in use: system, process, design, and service [12]. System FMEA represents the highest level in the analysis hierarchy, while design FMEA aims to examine the functions and usability of a product. Failure to determine the materials used is a common failure mode in this type of FMEA. Process FMEA focuses on the manufacturing and assembly processes of a product. Common failure modes include operators incorrectly placing parts, process variations exceeding standards, and potential defects. Service FMEA aims to analyze the services provided to customers.

In the application of FMEA the primary objective is to reduce the risk priority number (RPN) obtained from the assessment of Severity (S), Occurrence (O), and Detection (D). This is used to measure the likelihood of defects in the process, and variations that occur, and to take necessary preventive actions [13]. Tingkat The Severity level is an assessment of the degree of severity caused by the failure, evaluated based on the impact of the occurrence. The occurrence level represents how often the failure occurs, and meticulous recording of the failure frequency is essential for assessing occurrence [14]. The detection method assesses the ability to control the occurrence of failure. The risk priority number (RPN) is calculated as the product of Severity (S) multiplied by Detection (D) and Occurrence (O). This numerical value serves as a quantitative measure to prioritize and address potential risks, to reduce the overall risk associated with a specific failure mode [15]. The effects of a failure in an activity are depicted with severity rated on a scale from 1 to 10, where 1 represents the lowest and 10 is the highest severity, expressed by the variable S. For frequency or occurrence level (occurrence), it is a ranking of the likelihood of the failure occurring rated on a scale from 1 to 10, where 1 indicates the least frequent and 10 the most frequent occurrences, expressed by the variable O. Detection can be interpreted as how well a company can develop controls over its processes or can also be defined as the ability to detect product failures in customers [16]. Detection is valued on a scale from 1 to 10, where 1 signifies the easiest detection and 10 the most challenging to detect, expressed by the variable D.

As for the advantages of the FMEA technique, when conducted accurately and appropriately, they include [17]. A warehouse is a storage facility for various types of products, encompassing units of varying quantities, both large and small, during the period between the production of the product by the manufacturer (seller) and the time when the product is needed by the customer or workstation within a production facility. A warehouse serves as a facility tasked with the responsibility of storing goods to be used in production until the items are requested according to the production schedule. Warehouses or storage facilities, in general, play a crucial role in maintaining the smooth operation of a factory **[18]**. Warehouses can be broadly categorized into two types, among them are: general warehouses, which are storage facilities for inventory over extended periods [19]. The objective is to maintain the condition of goods until they are utilized; and distribution warehouses, which receive diverse types and quantities of goods (potentially from varied sources), store them, and sort them according to various consumer demands [20]. FMEA can also be utilized to assess ergonomic risks occurring in work areas. Redesigning work area layouts is one potential improvement that can be implemented.

The process of loading finished goods is an activity categorized under outbound logistics [21]. In this process, the company collaborates with other businesses Shipping Cargo Expedition (Ekspedisi Muatan Kapal Laut/EMKL) to assist in the shipment activities to customers. XYZ Company itself is a manufacturing company specializing in paper production located in West Java. One form of waste that occurs and results in unnecessary costs is the overnight charge. This cost may arise when the vehicles stay longer than the planned duration, with the standard being 18 hours. Every month, the company has to pay a certain amount to the EMKL as a penalty due to the prolonged presence of their vehicles within the PT. XYZ area.

The objective of this research is to identify potential failures in the process of loading finished goods and rectify them to eliminate hindrances in the loading process. Ultimately, this will reduce instances of extended stays beyond the planned duration, leading to a decrease in the incurred overnight charges.

2. METHOD

In this research, the general research design involves observation and assessment by experts. The observational approach is employed to explore and comprehend the actual conditions through process mapping and actual data per process in Figure *1*. Meanwhile, expert assessment is utilized to determine the indicator values of FMEA by evaluating personnel, machinery, materials, methods, and the environment [22]. For the Solution phase, the Why-Why analysis technique is employed.

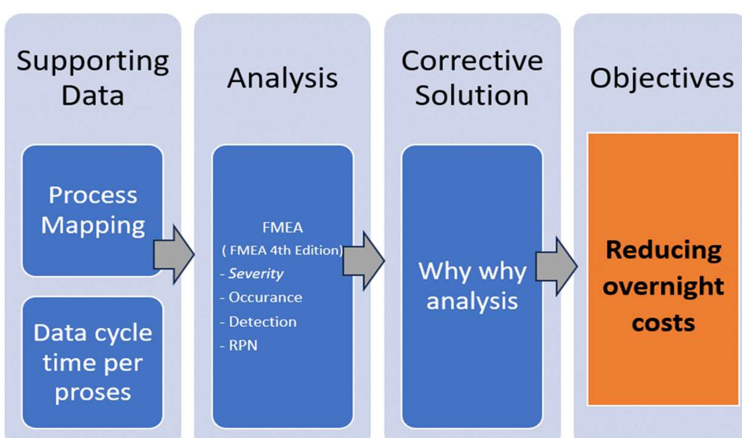

Figure 1. Research framework.

a. Supporting data
b. Supporting data is obtained through observational techniques and the collection of existing data. To comprehend the occurring processes, process mapping employed to illustrate the activities

DOI 10.37373/tekno.v11i2.1103

involved in the loading of finished goods comprehensively [23]. Meanwhile, cycle time data per process is acquired by collecting historical data.

c. Analysis
The technique employed is failure mode and effect analysis (FMEA). The goal is to assess the Risk Priority Number (RPN) for each activity obtained through process mapping.

d. Corrective solutions
Following the determination of RPN values, the next step is to identify corrective solutions to reduce the existing RPN values. The technique employed involves using Root Cause Analysis with why analysis [24].

e. Objectives
This research aims is to provide precise and optimal solutions, ultimately leading to a reduction in the monthly overnight charge expenses incurred by the company.

3. RESULT AND DISCUSSION

In Figure 2, it can be explained that the activities that can be controlled internally include speeding up the process from weighbridge in to weighbridge out. The results of this process mapping also define the scope of the research conducted.

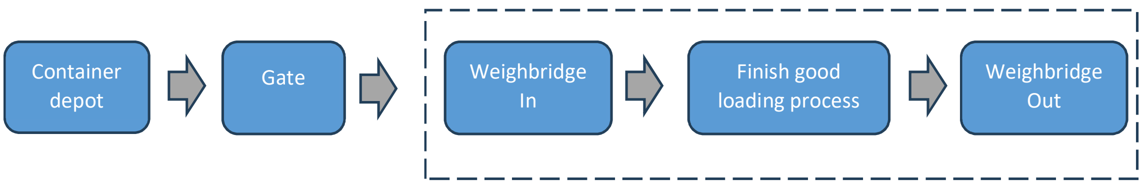

Figure 2. Process mapping loading finish good.

Description:

a. Container depot
The origin of the vehicle/container. Generally, this is where the EMKL mobilizes and schedules the departure of containers for the collection of goods and their delivery to customers.

b. Gate
The first checkpoint before entering the company's area. At this gate, incoming containers are inspected for documents and their overall condition.

c. Weighbridge in
The empty weight of the vehicle is measured using a weighbridge as initial vehicle weight data.

d. Finish a good loading process
The activity of placing finished goods into the container.

e. Weighbridge out
The loaded container is weighed again using a weighbridge to determine the weight of the vehicle filled with finished goods.

The difference in time between the weigh-out data subtracted from the weigh-in data constitutes the dwell time. An extended dwell time for a container can lead to the accumulation of containers in the company's area. This, of course, poses challenges to outbound logistic activities. Issues that are likely to arise include queues at the loading bay, limited availability of forklifts, and, due to their constraints, a waiting process for containers to undergo the loading of finished good sequentially.

These circumstances can result in overnight charge expenses. The overnight charge is incurred when a vehicle exceeds the 18-hour limit of its stay. The agreed-upon duration for containers in the company's area is 18 hours. Figure *3* based on data collected throughout the year 2022, the average monthly total for overnight charge expenses amounted to 148,145 USD. The highest-contributing area is Area 1.

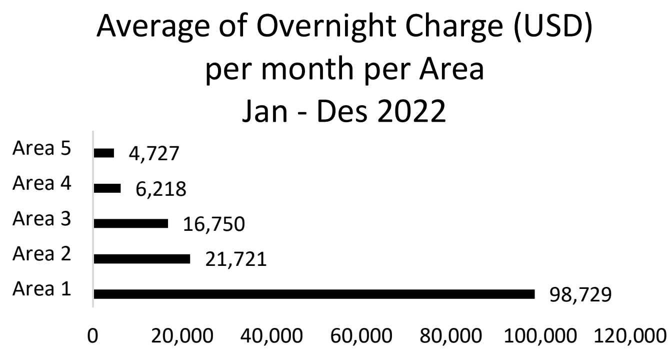

Figure 3. The average monthly overnight charge expenses per area.

Development of FMEA for each process and activity

The next step is to map the activities of each process before conducting the FMEA analysis. FMEA is used to assess the risks of each process and activity performed. The indicators evaluated are severity, occurrence, and detection.

Table 1. List of activities per process.

No	Process	Activity
1	Weighbridge in	7
2	Loading finishes good	14
3	Weighbridge out	4
	Total	**25**

In Table 1, each activity is then analyzed using FMEA. Severity, occurrence, and detection values are assigned using a range of 1-10, referring to the table in the FMEA 4th edition. Out of the 25 created activities, 7 activities with the highest RPN values were selected, and the data is presented in Table 2. The RPN values can be expressed using the following equation:

$$\text{RPN} = \text{S } \textit{(severity)} \text{ x O } \textit{(Occurance)} \text{ x D } \textit{(Detection)} \quad (1)$$

In determining the RPN values, a team consisting of 5 members was formed with the composition of 2 Logistics Managers, 2 Logistics Supervisors, and 1 Senior Logistics Manager.

Table 2. Data risk priority number (RPN).

No	Process	Potential failure mode	Potential effect of failure	S	Potential cause(s) of failure	O	Current control	D	RPN
1	Loading Finish Good¬ (stuffing process)	Trucks queuing exceed the loading capacity	Dwell time will increase due to the queue	8	Trucks arrive simultaneou sly	8	Dispatcher report	8	512
2	Loading Finish Good¬ (Contain er combo rotation process)	The container needs to go for a rotation	Dwell time will increase as it is necessary to exchange empty containers using a	9	Inappropriat e use of tools and equipment.	7	Checklist for the availabilit y of tools and equipment	8	504

No	Process	Potential failure mode	Potential effect of failure	S	Potential cause(s) of failure	O	Current control	D	RPN
			dedicated forklift						
3	Loading Finish Good¬ (Preloading)	One container undergoes loading processes at multiple warehouse locations	Dwell time increases due to the need for relocation	8	The container consists of various types of goods	8	Planning the transfer of containers between warehouses for loading	7	448
4	Loading Finish Good¬ (stuffing process)	Overload loading occurring for a specific type of finished goods product	The loading queue becomes longer due to the limitation of suitable working tools	8	The availability of tools and space	8	Delivery forecast from sales	7	448
5	Loading Finish Good¬ (stuffing process)	Overloading during the loading process for a specific type of finished goods product	Loading queue becomes longer due to the limitation of loading bays	8	Simultaneous release of containers with the same type and in large quantities	8	Arrangement of containers being loaded by the dispatcher	7	448
6	Loading Finish Good¬ (stuffing process)	Lengthy search for the goods to be loaded	Loading time became longer	8	Position of goods obstructed or blocked by other product	7	Stock taking data	7	392
7	Loading Finish Good¬ (stuffing process)	Lengthy search for the goods to be loaded	Loading time became longer	8	Goods not prepared in advance and the actual physical state does not match the data in the system	7	Stock taking data	6	336

From the data table above, it is evident that the loading of finished goods process is the one with the highest RPN values. The next step is to identify the root causes for each RPN in Table 2 using the why-why analysis technique.

Potential failure mode: Truck queuing exceeds the loading capacity

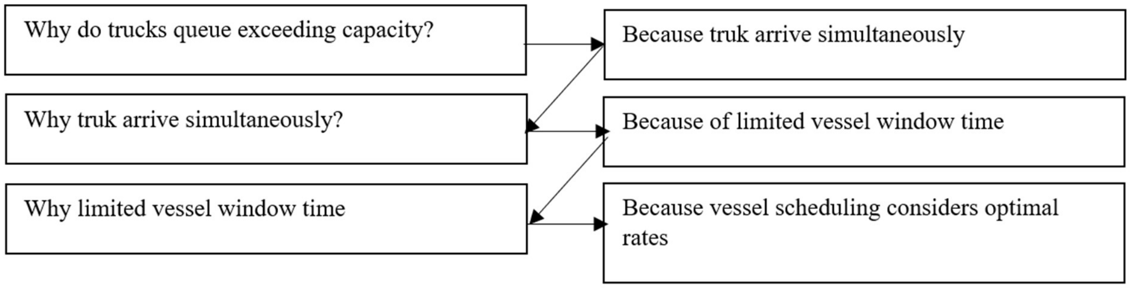

Figure 4. Why Why Analysis Example.

Solution: Truck (container) arrival scheduling

The why-why analysis technique aims to uncover the root cause of a problem by asking "why" repeatedly until no further answers can be provided in Figure *4* [25]. Using the same technique as before, a solution is obtained. For each activity, the solutions can be seen in Table 3. Table 3 presents a list of solutions obtained using the why-why analysis technique.

Table 3. List of solutions.

No	Potential failure mode	Why-1	Why-2	Why-3	Solution
1	Trucks queuing exceeding load capacity	Trucks arrived simultaneously within a short timeframe	Due to the limited vessel window time	Because vessel selection takes into account the most optimal rate and freight cost	The arrangement of container arrival and entry from the depot to the warehouse
2	Trucks queuing exceeding load capacity	Trucks arrived simultaneously within a short timeframe	Because the cargo (products) became available close to the Estimated Time of Departure (ETD)		The coordination of container arrival and entry from the depot to the warehouse
3	Trucks queuing exceeding load capacity	Trucks arrived simultaneously within a short timeframe	Due to the method of retrieving container delivery orders from the shipping line being divided among several Freight Forwarding	Due to the limited trucking units of the Freight Forwarding Company (EMKL) for large quantities simultaneously	Informing the Freight Forwarding Company (EMKL) to bring in containers according to their scheduled arrival time

ISSN 2087-3336 (Print) | 2721-4729 (Online)
DOI 10.37373/tekno.v11i2.1103

No	Potential failure mode	Why-1	Why-2	Why-3	Solution
			Companies (EMKL)		
4	Containers need to go for a detour	Loaded combo containers must be directed and maneuvered in a designated area	Because the front containers need to be moved to the back, and the rear containers, which are already loaded, need to be moved to the front	Because the loading process of finished goods can only commence when the empty container is positioned at the rear	Providing a turning area for combo containers
5	A single container undergoes the loading process at multiple warehouse locations	Because the finished goods in one container consist of items from multiple shipping points, the loading process is carried out at several different shipping points Consequently, the container must wait in line at each shipping point	Because of the product mix that needs to be produced in several areas	Because of adapting to the specifications of existing equipment and machinery	Engaging in preloading activities, which involve consolidating several finished goods in one area before loading them into containers
6	A single container undergoes the loading process at multiple warehouse locations	Because the placement of goods in the warehouse is far from the loading bay	Due to insufficient warehouse capacity and improper placement of goods not by the existing layout	Because production continues uninterrupted while there is no shipping plan at the beginning of the month	Moving finished goods with longer delivery times to a less crowded warehouse area
7	An overload in loading	The lack of sufficient space and the	Because the warehouse capacity is		Design changes to the forklift to make it usable for

No	Potential failure mode	Why-1	Why-2	Why-3	Solution
	occurred for a specific type of finished goods product	limited availability of loading equipment	no longer sufficient and the placement of goods does not align with the existing layout		multiple types of products
8	An overload in loading occurred for a single type of finished goods product	The shipment is conducted simultaneously for one type of product and in large quantities	Due to simultaneous order releases from customers and limited availability of shipping vessels		Exploring several alternative vessel schedules to avoid congestion on a single vessel
9	The search time for items to be loaded is prolonged	The items to be loaded are obstructed by other goods	Due to insufficient warehouse capacity and improper placement of goods that do not adhere to the existing layout	Because the loading process of finished goods predominantly occurs in the third and fourth weeks	Reorganizing the warehouse layout according to the type of product
10	The search time for items to be loaded is prolonged	The items to be loaded are not prepared in advance	The instruction to make new items is issued at 15:30 pm, thus leaving insufficient time		Moving finished goods that do not require pallets to the warehouse areas that do not need loading bays

Solution implementation

From the 7 potential failure modes, 10 solutions have been identified for implementation to reduce the time required for the finished goods loading process. This stage also represents a phase where efforts are made to enhance the quality of a process by eliminating contributing factors to the issues.

Arrangement of container arrival and entry from the depot to the warehouse

Previously, container data regarding those yet to leave the warehouse or those departing from the depot was only communicated through a WhatsApp group, leading to inaccurate coordination and resulting in long queues. The improvement involves utilizing an application developed by the IT department, where container scheduling aligns with available loading capacities. Additionally, this new system facilitates monitoring. Furthermore, the readiness of newly available cargo nearing its shipping date may cause incoming containers to wait. With the implementation of this monitoring system, any changes in container arrival plans will be communicated to the freight forwarding companies (EMKL).

Informing the Freight Forwarding Companies (EMKL) to bring in containers according to their scheduled arrival time**.**

Before the improvement, the scheduling of arrivals from the freight forwarding companies (EMKL) was made for a planned period of 3 days. However, in practice, many incidents occurred where containers arrived not by the previously planned schedule. The solution provided was to reiterate to the EMKL the importance of sending containers according to the agreed-upon plan from the outset. If a container arrives earlier than planned, it will be held in the parking area. This solution successfully reduced the accumulation of containers during the finished goods loading process.

Providing a turning area for combo containers.

The previously available turning area was approximately 700 meters away from the warehouse location, resulting in longer turnaround times. The implemented solution involved preparing a turning location only 200 meters from the warehouse. Additionally, within the warehouse area, three loading bays have been designated specifically for loading combo containers that are already loaded. With these loading bays, combo containers no longer need to turn when preparing for loading.

Engaging in preloading activities, which involve consolidating several finished goods in one area before loading them into containers

Previously, containers had to make multiple trips to various warehouse areas to undergo the finished goods loading process. This was because a single container contained items from distant warehouse areas. The solution involved consolidating finished goods to be shipped in one container within a single area. This would reduce the need for containers to travel back and forth.

Moving finished goods with longer delivery times to a less crowded warehouse area

Due to limited warehouse capacity and continuous production operations, the warehouse may become full, hindering the search process for items to be loaded. Implementing a policy to move items with longer delivery plans addresses this issue. It is expected to eliminate the need to search for items in the warehouse, which could potentially lead to shipping errors to customers.

Design changes to the forklift to make it usable for multiple types of products

The available forklifts faced challenges when transporting certain types of products, often causing delays in the finished goods loading process as specific forklifts with the required design were awaited. Most forklifts used have a weight capacity of 2.4 tons and fork lengths of 3.7 meters, while only two forklifts have forks longer than 4 meters. The solution was to redesign the forklifts to make them suitable for handling all types of finished goods. This change increases the flexibility of forklift usage, enhancing their efficiency as loading aids.

Exploring several alternative vessel schedules to avoid congestion on a single vessel

The congestion of shipments at one time can be caused by scheduling multiple shipments on the same vessel. The solution involves finding alternative shipping schedules. This is achieved by collaborating with freight forwarding companies (EMKL) to get information on available vessels. Additionally, enhancing communication with customers allows the company to offer various timing and vessel options for shipping.

Reorganizing the warehouse layout according to product types

The current situation involves products piling up in the warehouse without adhering to established standards and product identification. This issue hampers the finished goods loading process due to the time-consuming search for items, and sometimes items are not found at all. The reorganization of the layout involves recalculating the allocation for each type of finished good so that no product occupies an inappropriate area due to insufficient allocated space.

Moving finished goods that do not use pallets to warehouse areas that do not require loading bays

In the loading process, some types of products are not stored or distributed using pallets, thus they do not require a loading bay for their loading process. By relocating these non-palletized products to warehouse areas that do not need loading bays, capacity is increased for products that do require loading bays for their loading process.

As a result of these improvements, the average loading time per container decreased from 9.23 hours to 6.36 hours. Throughout 2022, the average monthly total overnight charge was 148,145 USD. After the improvements, data from July-August 2023 showed an average monthly overnight charge of 12,345 USD. This represents a decrease of 8.33%.

4. DISCUSSION

The risks in supply chains vary widely due to the extensive scope of the supply chain itself. These risks range from micro-level risks, such as movements within the workspace, to macro-level risks, such as changes in currency values. Risks can occur on the producer side, such as equipment or machine breakdowns, as well as on the consumer side, such as changes in initial demand. Nowadays, organizations tend to develop operational risk analysis models rather than focusing solely on strengthening production forecasts. Rapid changes are better anticipated by building operational models that can identify existing risks. Failure Mode and Effects Analysis (FMEA) is a widely used tool for risk identification. Although initially developed for the military and later adopted by the manufacturing sector, FMEA can effectively assess risks within supply chains.

The implementation of the improvements took place over 6 months. The challenges faced included communication issues between departments, particularly between the export (SCM) and production departments. Differences in work targets were seen as obstacles to synchronization. Additionally, the role of Freight Forwarding Companies (EMKL) as an external factor also had a significant impact. Previously, EMKL primarily considered the availability of its fleet. After the improvements, they started to use the schedules provided by the production department as a guideline for dispatching their fleet.

The Risk Priority Number (RPN) is an aggregate value that can be used as a parameter for assessing risk. In many cases, determining the values for severity, occurrence, and detection is crucial. Consistency and subjectivity in assessments are two aspects that need to be carefully considered. To anticipate potential issues in these areas, an RPN assessment team should be formed, involving stakeholders deemed competent. Initially, the highest RPN calculated was for the activity of Loading Finished Goods, with a value of 512. However, the RPN calculation after the improvements has not yet been performed.

5. CONCLUSION

The FMEA method provides a clear and logical overview of the potential failures in each process and activity included in the dwell time calculation, starting from the inbound weighing process and ending with the outbound weighing process. Based on the risk identification results and analysis of potential failures in truck dwell time exceeding 18 hours, the loading finished goods process was found to have the highest potential failure rates. In general, there are 25 activities divided into 7 activities in the inbound weighing process, 14 activities in the loading finished goods process, and 4 activities in the outbound weighing process. Based on their RPN values, 7 activities with the highest RPN values were selected from the 25 activities, and their solutions were then sought using the why-why analysis technique. Truck queuing exceeding capacity emerged as the activity with the highest RPN value, at 512. The solutions obtained include: arranging the arrival and entry of containers from the depot to the warehouse and informing the Freight Forwarding Companies (EMKL) to bring in containers according to their scheduled arrival time. From the results of this research, the average waiting time per container decreased from 9.23 hours to 6.36 hours. This resulted in a reduction in the monthly overnight charge from 148,145 USD to 12,345 USD. A recommendation from this study is to implement FMEA for reducing delay costs, which can also be applied to the loading process onto ships.

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