Improving the Loading and Unloading Process Efficiency with Lean Manufacturing Approach using Value Stream Mapping in Jakarta Container Yard

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Abstract. Facilities and infrastructure of maritime logistics activities such as ports, vessels, and containers are important indicators for developing national export-import activities. Maritime Logistics activities in container terminals has a big problem of dwelling time while apparently there are also bigger problems in Container yards. This leads to process and time efficiency problem. Container utilization can be improved in the loading and unloading process at Container Terminals and Container Yards. The Loading and Unloading processes at container yards happen to be the longest duration of all logistics activities. Therefore, increased loading and unloading efficiency at container yards are needed as an effort to increase export-import activities. The study was conducted by observing the loading (lift-on) and unloading (lift-off) process flow to identify waste using the Value Stream Mapping (VSM) method. Waste of Waiting is identified both in Loading and Unloading processes. VSM design results in an increased level of efficiency up to 84.89% for the unloading process and 80.51% for the loading process. The VSM method is needed as waste identification and efficiency improvement efforts for container service in Jakarta container depot. The VSM method is needed as waste identification and efficiency improvement efforts for container service in Jakarta container yard.

1. Introduction

Based-on data processing conducted by UNCTAD (United Nations Conference on Trade and Development), the increase in global trade activities through the maritime route is influenced by the growth of the global container industry which continues to experience a significant increase. In 2017, the Government of Indonesia provided information on container service procedures in which the loading and unloading process took the longest time when experiencing deposition that could occur at the Container Terminal and the Container Yards. This leads to Efficiency problems of fulfilling container demands of various principal line. Process efficiency of container loading and unloading processes needs to be increased to encourage Indonesia's competitive level in global trade competition through maritime routes. Research on loading and unloading activities at container terminals has been conducted [1] and Lean Manufacturing in the process of shipping containers have also been carried out [2] but there has been no research on Container Yard related to increased efficiency using the Lean approach. The purpose of this study is to improve the efficiency of the loading and unloading process at container depots as a company's effort to meet unmet demands including the special demands of the shipping company MAERSK. The process of observing the loading and unloading process flow is most often
done at the container terminal because of the direct activities that generally occur at the port and the process of container transfer which is quite easy. According to research on loading and unloading activities conducted by Franzen, S., and Streling, the most influential loading and unloading activities on the achievement of overall container service efficiency are in the operational backend or in this case the container yard (Depo) [3]. Based on research by Olesen, P, Powell, D., Hvolby, HH, Fraser. K. the reduction in the number of loading and unloading activities can be used as a reference in reducing waste in the loading and unloading process that exists at the container terminal. This research needs to be conducted in order to solve the process efficiency problem at Jakarta Container Yard by shortening the duration of each activities of loading and unloading process that are identified with waste of waiting [4].

2. Literature Review
A detailed understanding of Lean Manufacturing and the Value Stream Mapping method is needed in understanding the waste that exists in the loading and unloading process at the Jakarta container depot. According to Hines and Taylor, there are several stages in Lean thinking, namely, to understand waste, set goals, understand Big Picture, Detailed Mapping, involve suppliers and customers, to review plans made. The concept of Lean Manufacturing and Value Stream Mapping is also applied to the automotive industry at Ford Motor located in Taiwan, to improve the quality and cost aspects.

Understanding of Lean Manufacturing, Value Stream Mapping, Waste as a waste of loading and unloading activities in container depots will be explained further in the following literature study:

2.1. Lean Manufacturing
Based on the book "Lean Six Sigma for Manufacturing and Service Industries" by Vincent Gaspersz and Fontana [5], Lean manufacturing is a way of thinking, philosophy, methods and management strategies to improve efficiency in manufacturing or production lines. This method is adapted from the Toyota Production System (TPS) which aims to maximize value for customers and increase company profitability by eliminating activities that do not provide added value (waste).

2.2. Value Stream Mapping Method
Value Stream Mapping used to assess and examine the waste that occurs. With this concept, the company can build a sense of urgency that includes several members of an organization and is also used as a communication tool to facilitate the implementation of the Lean.

2.3. Waste (Wastes)
Based on a book entitled "Lean Six Sigma" by Gaspersz V Waste can be defined as any work activity that does not provide added value (Value Added) in the process of transforming inputs into outputs along the Value Stream (the process for producing both goods and services to the market). According to Taiichi Ohno as a pioneer of the Toyota Production System (TPS), he succeeded in defining wastes by dividing into 7 categories consisting of Transport, Inventory, Motion, Waiting, Overproduction, Overprocessing, and Defects [7].

2.4. Process Efficiency
Based on a study entitled "Process Efficiency - Adapting Flow to the Agile Improvement Effort" Sutherland, J. Process efficiency is defined as the percentage of output that can provide an explanation of production performance on a shop floor. Another understanding of Process Efficiency is also explained by Kovacs, G. with an explanation of Percentage of Process Efficiency (PCE) in the manufacturing industry which can be calculated based on Cycle Time and Lead Time. Calculation of waiting time can be understood through Value Added Time and Non-Value-Added Time [8].

\[
\text{Percentage of Efficiency} = \left( \frac{W_{\text{bst}}}{W_{\text{bmax}}} \right) \times 100\% \tag{1}
\]

\[
PCE = x \times 100\% \left( \frac{\text{Value Added Activity (VAT)}}{\text{VAT} + \text{Non Value Added Activity (NVAT)}} \right) = \left( \frac{\text{Cycle Time (C/T)}}{\text{Cycle Time} + \text{Waste (Lead Time)}} \right) \tag{2}
\]
3. Research Method
Research on the Jakarta container yard was carried out in the flow of container services for the loading and unloading processes. Lean Manufacturing approach with Value Stream Mapping method is used to identify the presence of waste. The study was conducted by collecting secondary data in the form of movement data in-out container, complete repair data, lead time data on each loading and unloading activity, as well as shift data and operator schedules. Secondary data validation with experts on the Jakarta container depot was also carried out. The design of Value Stream Mapping is based on secondary data input from October to December 2019 for the “International” shipping line company as the company with the highest container demand at the Jakarta container depot. Based on the design of Value Stream Mapping As-Is, some waste was identified in container survey activities, cost estimation, and cleaning. Efforts to improve the efficiency of the loading and unloading process are carried out by considering a reduction in overall process lead time. The adjustment process such as combining loading and unloading activities and adjusting the number of operators at each workstation is done. The design of Value Stream Mapping To-Be is used to improve efficiency in the loading and unloading processes at Jakarta Container Yard [9].

In this study, there are 4 attributes that are used as indicators of increasing efficiency, namely Throughput Rate, Lead Time, Number of Operators, and Waste Reduction. Efforts to improve the efficiency of the loading and unloading process are carried out by considering a reduction in overall process lead time. The adjustment process such as combining loading and unloading activities and adjusting the number of operators at each workstation is done. The design of Value Stream Mapping To-Be is used to improve efficiency in the loading and unloading processes at Jakarta Container Yard. In this study, there are 4 attributes that are used as indicators of increasing efficiency, namely Throughput Rate, Lead Time, Number of Operators, and Waste Reduction [10]. Efforts to improve the efficiency of the loading and unloading process are carried out by considering a reduction in overall process lead time. The adjustment process such as combining loading and unloading activities and adjusting the number of operators at each workstation is done. The design of Value Stream Mapping To-Be is used to improve efficiency in the loading and unloading processes at Jakarta Container Yard.

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3.1. Data Collection and Processing
Preliminary data collection is the data of loading and unloading process data available at Jakarta Container Yard. The data collection process is continued with secondary data collection such as data movement in-out container, complete repair data, Lead Time data loading and unloading process for the last 3 months (October-December 2019). The following is the flow of the loading and unloading process at Jakarta Container Yard:
The Unloading Process consists of 7 stages that could be broken down into 5 main activities of Administration Check, Gate-In, Cleaning, Container Survey, and Lift-Off. The process of administration check is the process where there the requested documents are checked by administrators. Gate-In is the process where container trucks lead the way to input container and trucking number. The next process is cleaning where the container gets cleaned within chemical reaction and water solid reaction. After the container truck gets cleaned, the next process is container survey where the surveyor and yardmen are inspecting the container to check the container damage. Container Survey also consist of cost estimation activity, where then it leads to the last process of Lift-Off. Waste of Loading process commonly happen in container survey.

Figure 1. Process flow of empty container unloading

The Unloading Process consists of 7 stages that could be broken down into 5 main activities of Administration Check, Gate-In, Cleaning, Container Survey, and Lift-Off. The process of administration check is the process where there the requested documents are checked by administrators. Gate-In is the process where container trucks lead the way to input container and trucking number. The next process is cleaning where the container gets cleaned within chemical reaction and water solid reaction. After the container truck gets cleaned, the next process is container survey where the surveyor and yardmen are inspecting the container to check the container damage. Container Survey also consist of cost estimation activity, where then it leads to the last process of Lift-Off. Waste of Loading process commonly happen in container survey. There are similar activities that on the Loading process such as administration check and container survey. The difference between Unloading and Loading process are located when the loading process goes through container security check and the process leads to waste of waiting.

Figure 2. Process flow of empty container loading
3.2. Designing Value Stream Mapping As-Is

The Design of Value Stream Mapping As-Is is a step taken in the data processing in an effort to identify waste and increase efficiency in the loading and unloading process at the Jakarta container depot. Based on the design of as-is value stream mapping, waste of waiting is identified in the container survey process for the unloading process and container availability check in the loading process. Waste identification can be seen when the Non-Value Added is quite high. The efficiency level at 66.33% still has not reached the efficiency target of Jakarta Container Yard at 80% so that the improvement of Value Stream Mapping is needed in an effort to achieve efficiency targets.

3.3. Designing Value Stream Mapping To-Be

Based on data processing using the Value Stream Mapping method in both the loading and loading process, the efficiency level has not reached the target at 80%; therefore an effort to increase efficiency based on waste identification by designing Value Stream Mapping To-Be needs to be done. The design of Value Stream Mapping To-Be considers the aspect of waste of waiting that is resolved through a combination of the loading and unloading processes. Some activities that cause waiting in the activities before and after are done by adjusting the number of operators and combining activities to reduce Lead Time. Based on the design of Value Stream Mapping to-be with various adjustments for loading and unloading activities, the increase in efficiency to achieve the 80% efficiency target is accomplished on the percentage of 84.89% for unloading process and 80.51% for the loading process. The increasing efficiency from the previous design of Value Stream Mapping As-Is are determined by the adjustment of the numbers of operators and the shift assigned to the operators on every workstation [12]. Activities such as Container Survey and Container Availability Check on both Loading and Unloading process are the root cause of the long duration of the Lead Time therefore, several adjustments needs to be developed in order to achieve the expected efficiency target. Several activities in Loading process such as Cost Estimation and Container Survey can run parallel and merged but with the proper operators and shift it is expected to meet the efficiency target so it will decrease the lead time generally [13]. The important thing of designing the Value Stream Mapping to-be is to increase the process efficiency. Increased efficiency will be explained further at the analysis stage of Value Stream Mapping As-Is and To-be.

The following are the results of the design of Value Stream Mapping To-Be for the unloading and loading process:

![Container Lift-Off Process Diagram](image)

**Figure 3.** Value Stream Mapping To-Be unloading process
4. Results & Analysis

The process of designing Value Stream Mapping (VSM) of the actual conditions (As-Is) and conditions after an effort to increase efficiency (To-Be) to evaluate the decrease in Lead Time of the loading and unloading process. The difference in VSM, both the loading process and the container loading process resulted in a significant decrease in waiting time and lead time. Efforts made to improve efficiency are by simplifying the Survey Container activities by Surveyor and Cost Estimation by operational staff. These 2 activities can be done parallel, so the merger of these activities is actually beneficial to increase the process efficiency and decrease the lead time as a whole. The design of Value Stream Mapping to-be showed that the efficiency has increased, and the lead time has decreased. An analysis to compare the current state condition and future state condition are done by comparing the design of the Value Stream Mapping As-Is and Value Stream Mapping To-Be. Several factors that needs to be concerned are the total operation time and how much will it be decrease in time. The following is a table that explains the analysis of improvements to data processing with Value Stream Mapping As-Is and Value Stream Mapping To-Be loading and unloading processes:

| Operations Number | Operations Name  | Total Reduced (Time in seconds) | As-Is (Current State) | To-Be (Future State) |
|-------------------|------------------|---------------------------------|----------------------|----------------------|
| 1                 | Administration   | 28 s                            | 240 s                | 212 s                |
| 2                 | Gate-in          | 12 s                            | 144 s                | 132 s                |
| 3                 | Container Survey | 222 s                           | 624 s                | 552 s                |
| 4                 | Cost Estimation  | -                               | 150 s                | -                    |
| 5                 | Cleaning         | 11 s                            | 246 s                | 235 s                |
| 6                 | Lift-off         | 80 s                            | 150 s                | 70 s                 |
| Total             |                  | 18.56% (Increased Efficiency)   | 329 s                | 1542 s               | 1213 s               |

* The number of unloading processes is reduced from 6 processes to 5 processes.

* Increased efficiency up to 18.56% from 66.33% to 84.89%.

* Overall lead time reduction of up to 329 s (5 minutes 9 seconds).
Table 2. Value Stream Mapping Analysis Table Load As-Is and To-Be.

| Operations Number | Operations Name                  | Total Reduced (Time in seconds) | As-Is (Current State) | To-Be (Future State) |
|-------------------|----------------------------------|---------------------------------|-----------------------|----------------------|
| 1                 | Administration                    | 12 s                            | 96 s                  | 212 s                |
| 2                 | Gate-in                           | 48 s                            | 72 s                  | -                    |
| 3                 | Security Check                    | -                               | 260 s                 | 284 s                |
| 4                 | Container Availability Check      | 26 s                            | 240 s                 | 214 s                |
| 5                 | Gate-out                          | 42 s                            | 184 s                 | 62 s                 |
| 6                 | Final Inspection                  | -                               | -                     | 80 s                 |
| Total             |                                   | 10.68% (Increased Efficiency)   | 128 s                 | 724 s                |

a the number of processes is still the same as 6 processes but there are some adjustments in the merging process.
b Increased efficiency up to 10.68%, from 71.83% to 80.51%.
c Overall lead time reduction of up to 128 s (2 minutes 8 seconds).

5. Conclusions
Based on the analysis using the Value Stream Mapping method, the efficiency improvement for the loading and unloading process increased by 18.56%. This efficiency increase was obtained after making efforts to reduce waiting time, lead time, and simplify the overall loading process. Activities that experienced a significant increase in efficiency include Cost Estimation and Lift-Off activities with efficiency increases of 28.62% and 53.33%. The reduction in Lead Time for the unloading process is obtained by 5 minutes 29 seconds. The efficiency of the container unloading process specifically for the MAERSK Line shipping company for 20ft containers has been successfully increased from 66.33% to 84.89% based on Value Stream Mapping. Meanwhile in the loading process efficiency calculation there was a decrease in Lead Time of 2 minutes 8 seconds with an increase in the efficiency of the loading process was at 10.68% starting at 71.83% experiencing an increase of up to 80.51%. Both the unloading process and the container loading process have experienced an increase in process efficiency.

Research on maritime logistic activities especially in Indonesia could be done in cities which has international standard ports for international trades. Further Research could be done by comparing both Frontend activities which is located on Container Terminals and Backend activities which is located on Container Yard. The balance of their lead times by concerning the detention and demurrage rate could solve the national issue on dwelling time and ports efficiency problem.

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