GROSTLOG 2022
Global Research on Sustainable Transport & Logistics

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

Analysis of capacity Performance of Semi-Automatic Stacking Fields at the Lamong Bay Container Terminal Tanjung Perak Port Surabaya

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Abstract: Teluk Lamong Terminal is a multipurpose terminal that operates under the Surabaya Tanjung Perak Port Authority. Teluk Lamong Terminal implements a semi-automatic system in the form of the use of an Automated Stacking Crane (ASC) in the container yard. Teluk Lamong Terminal is one of the terminals that implements the first system in Indonesia. Every year, container throughput at TelukLamong Terminal has increased significantly. In 2020-2021, there was a 15% increase in container throughput from 678,208 TEUs to 780,160 TEUs. Container throughput which is always increasing, it is necessary to analyze the container field at Teluk Lamong Terminal to determine the condition of the existing container field.Using quantitative data analysis methods, the results of the study show that theuse of tools in the field and the use of the Teluk Lamong Terminal field are in optimalconditions for now. With container throughput for the next 5 years using the average increase in throughput for the last 5 years, in 2026 Teluk Lamong Terminal requiresthe addition of 7 new field blocks to handle throughput of 1,135,760 TEUs.

Keywords *: Automated Stacking Crane (ASC), Terminal Teluk Lamong,Container Throughput, Yard Occupancy Ratio*

Introduction

The port is a place for ships to dock which has water and land areas with certain limitations where there are economic activities in it, both managed by the government and other entrepreneurs and equipped with security and safety facilities.(Kementrian Perhubungan, 2008). In general, a port consists of several terminals where the terminal is built with the needs of the port or the master plan of the port. A port terminal has the meaning of a port facility which usually consists of a dock/dock pool, a dock, a stacking yard, a place for passengers to get on/off and a place for loading/unloading goods. (Budiyanto & Gurning, 2017). One of the existing terminals in Indonesia is Teluk Lamong Terminal.

Teluk Lamong container terminal is a terminal located in the development area for the reclamation of the Lamong River estuary and in the waters of the Madura Strait. This terminal is located right on the border between Gresik Regency and Surabaya City. Container is a container used as a means of transporting or storing goods that can be transported by various modes of transportation. A container must meet an International Organization for Standardization (ISO) standard before being used. A container is a medium or box for storing goods that can be said to be like a warehouse but can be transported (Lasse, 2012). Teluk Lamong Terminal is a terminal operator engaged in the port service business by using new and high-tech technology and is environmentally friendly.

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Teluk Lamong Terminal is a subsidiary of PT. Pelindo 3 which serves multipurpose port services with a main focus on containers and dry bulk with environmentally friendly and semi-automatic concepts. The application of a semi-automatic system at Teluk Lamong Terminal is applied at the container stacking field using the Automated Stacking Crane (ASC). Every year, this terminal has an increase in the number of Container thorughput. There is an increase of 15 percent in 2021 from 678,208 TEUs in 2020 to 780,160 TEUs in 2021 (Hidayat, 2022).

If viewed in terms of the capacity of the terminal's stacking yard with a capacity of 16,000 TEUs, it is necessary to do an analysis of the performance of the stacking yard, which can be ascertained with the existing stacking yard into consideration for handling cargo which has an impact on the effectiveness of the stacking yard capacity. Therefore, the author conducted research on "Analysis of capacity Performance of Semi-Automatic Stacking Fields at the Lamong Bay Container Terminal, Tanjung Perak Port, Surabaya".

Method

The study uses some of the following data :

1) Teluk Lamong Terminal Container Throughput Data 2017 – 2021
2) Data on loading and unloading equipment activities at the stacking yard
3) Stacking yard capacity and layout

Based on these data, this research uses quantitative data analysis method, which is a technique of processing data that contains numbers or statistics. In addition, in this quantitative data analysis technique, descriptive statistical methods are used. Descriptive statistics is a series of activities by carrying out data and information description activities.

There are 3 (three) variables measured in the study, including:

1) Operational time equipment
2) *Throughput* peti kemas
3) *Dwelling time*

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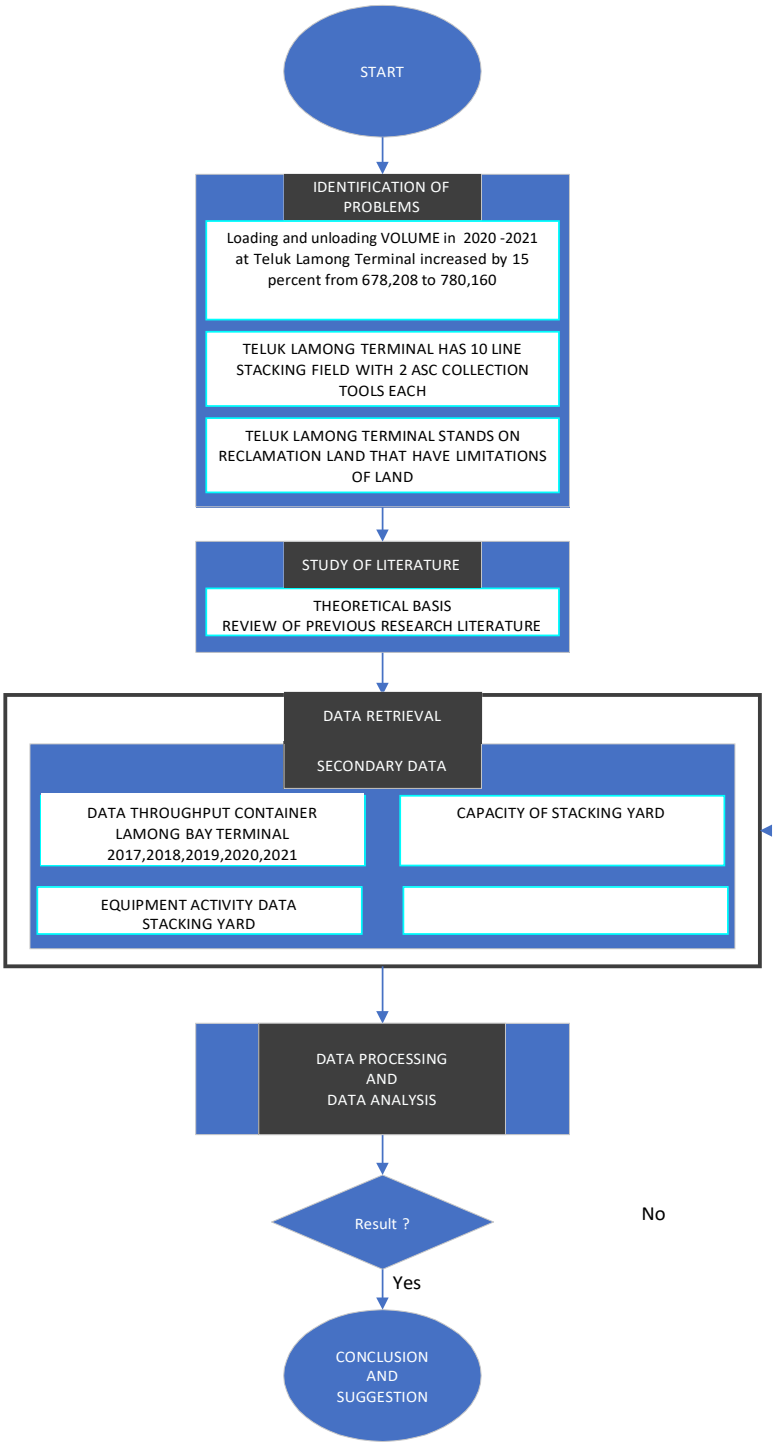

Figure 1. Research flowchart

The performance of a stacking yard in a terminal is something that every terminal needs to pay attention to, the performance in question involves several aspects, namely the utility of using container stacking equipment, the capacity of the stacking field, the length of containers in the stacking field,

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the level of usage of the stacking field, and container throughput in the field. The accumulation of these aspects is an indicator that needs to be monitored because when this indicator has a low value, the stacking field does not run optimally.

To determine the utility level of the use of tools in the stacking field, a ratio of the level of use of the tools in the stacking field is needed where this utility is a comparison of the amount of time using the tools with the time of availability of tools and expressed in the form of a percent (%). So, the equation of the utility of the use of the tool is as follows:

$$Utilitas = \frac{perational\ time\ equipment\ (operation)}{Available\ time\ equipment}\ X\ 100\% \text{ ..... equality (1)}$$

Tool availability time is the amount of time (hours) available on the tool in a state that the tool is ready for use. For the time of availability of the tool has the following formula:

$$available\ time\ equipment\ = possible\ time - downtime \text{ ..... equality (2)}$$

$$Availability\ = \frac{available\ time\ equipment}{available\ time}\ X\ 100\% \text{ ..... equality (3)}$$

Based on this equation, possible time is the amount of time that is calculated to be used by the needs of the user of the tool (such as breaks or changing shifts). While for Downtime is the amount of time used to repair tools or maintenance on tools. To determine the productivity of the tool, it is necessary to calculate using the following formula:

$$productivity = \frac{Number\ of\ Boxes\ in\ one\ period}{operational\ time\ in\ one\ period}$$

....equality (4)

With this equation, it is known how many tools can load and unload in 1 hour.

Another indicator that determines the performance of a port is the container yard occupancy ratio (CYOR). CYOR is the level of use of the available stacking field. The calculation results are obtained from the comparison between the number of stacks in TEUS/day divided by the capacity of the Container Yard by the number of days and the number of days in one year. The equation for Container Yard Occupancy Ratio is obtained as follows :

$$YOR = \frac{Throughput\ TEUs\ x\ average\ dweling\ time\ (days)}{Yard\ Container\ Capacity\ x\ days\ in\ 1\ year}\ x\ 100\% \text{...equality (5)}$$

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To plan the needs of the stacking field, the following equation is used:

$$L = \frac{C \; x \; D \; x \; F}{H \; x \; W \; x \; K}$$

....equality (6)

explenation :

L = Number of ground slots in a year

C = number of container throughput in a year

D = Average Dwelling Time of a container in the field
F = Peak Factor (F > 1 , usually ranges from 1.1 to 1.3)
H = the average height of container stacking in the field
W = number of active working slots (usually 0.7)
K = number of working days in 1 year

Therefore, to solve this research problem, this equation is used to find out how the operational performance of loading and unloading at the Teluk Lamong Terminal stacking yard by applying the Semi Automatic system.

Discussion and result

Container throughput is the number of container flows in and out of a terminal in a period determined in TEUs (Twenty Foot Equivalent). The container throughput is divided into 2 parts, namely international containers which are containers for export or import activities and domestic containers which are containers for domestic shipments. The following is the container throughput data for Teluk Lamong Terminal in 2017 to 2020.

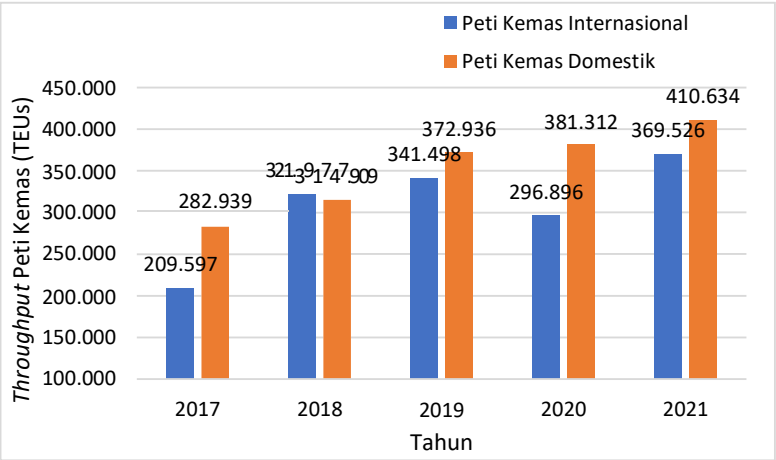

Figure 2. Container throughput statistics

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Base on decision Direktur Jendral Perhubungan Laut (DJPL) numberr: HK.103/2/18/DJPL-16 years 2016. Teluk Lamong Terminal has the following operational performance standards :

Table 1. Lamong Bay Terminal operational performance standards

NO	Nama Pelabuhan	Utilitas Fasilitas			Kesiapan operasi Peralatan (%)
		BOR (%)	SOR (%)	YOR (%)	
52	Pelabuhan Tanjung Perak				
	a. Terminal Jamrud	70	65	50	80
	b. Terminal Nilam	70	-	50	80
	c. Terminal Mirah	70	50	50	80
	d. Berlian Jasa Terminal Indonesia	70	70	70	80
	e. Terminal Peti Kemas Surabaya	70	-	60	80
	f. Terminal Teluk Lamong	70	-	60	80

Based on the table above, it is known that Teluk Lamong Terminal has a YOR standard of 60% and the readiness of the equipment to operate is 80%. If the YOR value exceeds the standard, then the flow of goods in the terminal begins to congest, so that the addition of a new stacking field is considered.
The stacking field operation at Teluk Lamong Terminal uses 3 operational equipment, namely:

1) *Automated Stacking Crane*
2) *Container Transport Trailer*
3) *Stradlle Carier*

Of the three tools have the following data:

Table 2. equipment activity average

No	Equipment	Avarager available time (Hour)	Avarager equipment available time (Hour)	Avarage equipment Down time (Hour)	Average equipment operation (Hour)	Average Box Handled (Box)
1	*ASC*	738	728,00	10,00	206,32	3064
2	CTT	738	652,94	85,06	210,84	682
3	STRADDLE CARRIER	738	685,26	52,74	216,69	3969

Based on the activity table, to determine the utility and availability of tools using equations (1), (2), and (3), the utility of the tools in the stacking field in 2020 is as follows:

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Table 3. average utilitas dan availability

No	Equipment	Utilitas (%)	Availability (%)
1	*ASC*	28,34	98,64
2	CTT	32,45	88,35
3	STRADLE	31,53	92,82

Based on the utility and availability data above, when compared with the decision Direktur Jenderal Perhubungan Laut (DJPL) nomor: HK.103/2/18/DJPL-16 years2016 namely the operational performance standard of the Teluk Lamong Terminal where the equipment readiness at this terminal has a value of 80%, so in 2020, the readiness of the equipment is still above the decision, which indicates that the equipment is ready to operate at any time and when the equipment is to perform downtime or minor repairs.
The stacking field at Teluk Lamong Terminal has an area of 25.20 Ha which consists of 10 blocks and has an average dwelling time of 4 days. Based on Figure 2 which is the container throughput in 2017 to 2021 using the equation (5) Yard Occupancy Ratio as follows:

Table 4. YOR Value for 2017-2021

No	Years	Throughput (TEUs)	Dwelling Time (days)	Stacking Yard capacity (TEUs)	YOR (%)
1	2017	492.536	4	16.000	33,74%
2	2018	636.886	4	16.000	43,62%
3	2019	714.434	4	16.000	48,93%
4	2020	678.208	4	16.000	46,45%
5	2021	780.160	4	16.000	53,44%

From the table, it was found that from 2017 to 2021, the YOR average was 45.24%, so it can be said that the YOR value at the Teluk Lamong Terminal stacking yard is still far from the maximum limit set in the Decree Direktur Jendral Perhubungan Laut (DJPL) so that there is no need for an additional stacking field because with the existing stacking field, it can still accommodate incoming containers.
Based on Table 2, it is informed that ASC has an average workload in 2020 of 206.32 hours and can load/unload at the stacking yard with a total of 3064 boxes using the following equation (4):

$$produktiviy = \frac{3064\ Box}{206{,}32\ Jam}$$

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then the loading/unloading productivity in the stacking field is 15 boxes/hour, so in one stacking cycle, the Automated Stacking Crane only takes 4 minutes to move and stack. When compared to research (Agus Triati & Rahmayanti, 2020) where RTG at Terminal PT. Berlian Jasa Terminal in Surabaya within 1 hour can only accumulate 11 boxes/hour with an average time of 5 minutes 46 seconds.
In addition, here are some comparisons between the use of RTG and Automated Stacking Cranes in the stacking field:

Table 5. comparison of the use of ASC with RTG

Automated Stacking Crane	RTG
ASC uses electricity so it is environmentally friendly	RTG uses fuel so that there are exhaust emissions
Crane operators do not need to go to the field so as to reduce the number of work accidents	Crane operators need to come to the field
An operator can control as many as 4-6 tools	Each tool requires 1 operator
ASC maintenance costs are less because it only needs transformer maintenance	RTG maintenance costs are quite large because they need tire and generator maintenance
ASC's operating costs are cheaper because it uses PLN's electricity consumption	The operational costs of RTG are quite large because there are diesel and lubricant costs
ASC can perform stacking by itself because the tool is integrated with the data storage server	Doing stacking manually so it takes more time

The results of the comparison between ASC and RTG above can be concluded that using Automated Stacking Crane has an impact on operational and maintenance costs and by using ASC can do loading and unloading faster than using RTG where ASC can load/unload more than 15 boxes/hour .
This study tries to project the future container throughput in the next 5 years. The calculation of the YOR of the container stacking field is carried out using the projected container throughput. The projection uses an average increase in throughput every year where the average increase in container throughput at Teluk Lamong Terminal during 2017-2021 is 9%. then the throughput is obtained as follows:

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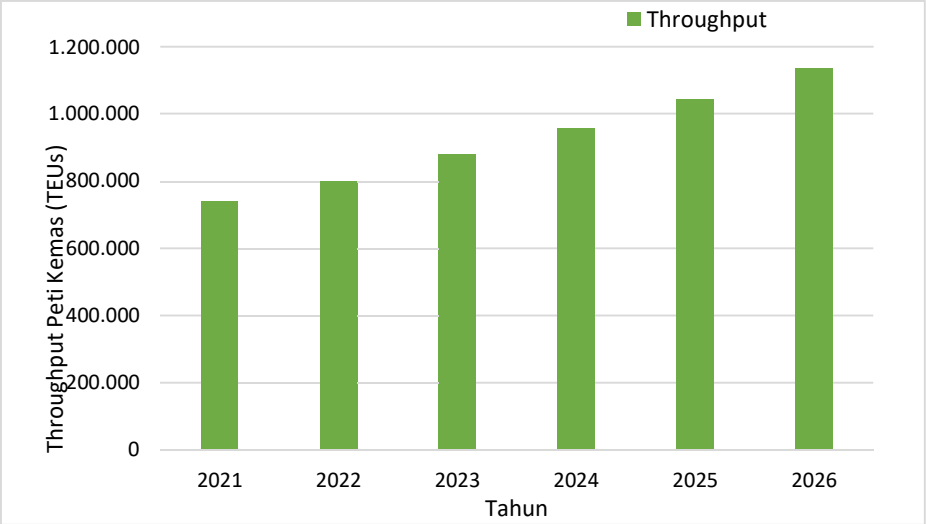

Figure 3. Projected container throughput 2021- 2026

Figure 3 shows that with an average increase in containers of 9% per year, in 2026 the container throughput of Teluk Lamong Terminal reaches 1 million TEUs. With the projection data, the YOR forecast value can be obtained as follows :

Table 6. Proyeksi YOR pada tahun 2021-2026

No	Tahun	Thorughput (TEUs)	Dwelling Time (Hari)	Kapasitas Lapangan Penumpukan (TEUs)	YOR (%)
1	2021	780.160	4	16.000	53,44%
2	2022	805.278	4	16.000	55,16%
3	2023	877.496	4	16.000	60,10%
4	2024	956.203	4	16.000	65,49%
5	2025	1.041.982	4	16.000	71,37%
6	2026	1.135.760	4	16.000	77,79%

Table 6 shows that, from 2023 to 2026 the YOR value of the Teluk Lamong Terminal container yard is already at the maximum limit that has been set in the DJPL decision. So in that year, planning considerations can begin to handle the YOR value that exceeds the DGST's decision.
Teluk Lamong Terminal in 2026 has a projected thorughput of containers of 1,135,760 TEUs, has an average dwelling time of 4 days with an average stacking height of 4 Tier, the area required for land is as follows:

$$L = \frac{1.135.760\ x\ 4\ x\ 1{,}15}{4\ x\ 0{,}7\ x\ 365}$$

$$= 5112\ TEU\ GS$$

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The results of these calculations obtained groundslot as much as 5112 TEU GS. With the groundslot, if each turn uses the arrangement of rows and columns that already exist at Teluk Lamong Terminal, namely 9 rows and 39 columns, the number of stacking yard blocks is obtained as follows:

$$BLOK = \frac{5112\ TEU\ GS}{351\ GS}$$

$$= 15\ Blok$$

Teluk Lamong Terminal currently has 10 stacking yard blocks so that 5 additional blocks are needed to accommodate container thorughput in 2026 with a total new block area:

$$Area = 190{,}5\ x\ 416{,}31 = 79.308\ m^2$$

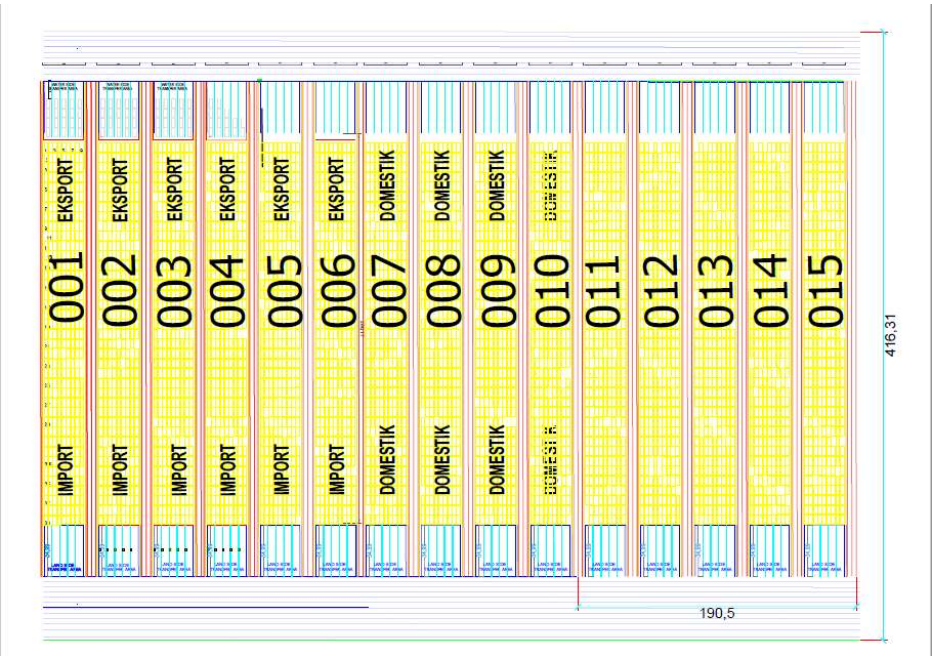

Figure 4. Layout of adding a new stacking field

In addition to adding the capacity of the stacking yard, Teluk Lamong Terminal has the option of lowering the average dwelling time. Researchers reduce the dwelling time to 3 days, then Teluk Lamong Terminal has the following YOR value :

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Table 7. YOR projection with dwelling time of 3 days

No	Tahun	Thorughput (TEUs)	Dwelling Time (days)	Stacking yard capacity (TEUs)	YOR (%)
1	2021	780.160	3	16.000	40,08%
2	2022	805.278	3	16.000	41,37%
3	2023	877.496	3	16.000	45,08%
4	2024	956.203	3	16.000	49,12%
5	2025	1.041.982	3	16.000	53,53%
6	2026	1.135.760	3	16.000	58,34%

Based on the table, using an average dwelling time of 3 days, Teluk Lamong Terminal has an optimal stacking field utility value. With a throughput of 1,135,760 TEUs accommodated by a capacity of 16,000 TEUs, the Yard Occupancy Ratio value of Teluk Lamong Terminal only reaches 58.34% so that the development of a new stacking field is still not needed if Teluk Lamong Terminal reduces dwelling time.

Conclusion

Based on the results of the analysis and discussion of the research, several conclusions were obtained as follows:

1) The factor that affects the high utility of the tool is the operating time of the tool. The implementation of semi-automatic systems at Terminal Teluk Lamong for the Automated Stacking Crane (ASC) utility was 28.34%, Container Transport Trailer and 32.45%, and Straddle Carrier 31.53%. Factors that affect the utility of the stacking yard are throughput and dwelling time. In 2021 Teluk Lamong Terminal with a dwelling time of 4 days and a storage capacity of 16,000 TEUs has a Yard Occupancy Ratio value of 53.44%. Teluk Lamong Terminal has a stacking yard that works optimally and still doesn't require the addition of a new stacking yard.
2) The application of Automated Stacking Crane has advantages over the application of RTG in stacking field operations. The implementation of Automated Stacking Crane has 2x faster productivity compared to the implementation of RTG. Automated Stacking Cranes can also reduce stacking site operational costs due to low maintenance costs, using electricity, and not requiring an operator on each tool.
3) Based on the projected Thoroughput 2021 - 2026 with an average increase of 9%, Teluk Lamong Terminal in 2026 has a throughput of 1,135,760 TEUs with a YOR value of 77.79%, so if viewed from the

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DJPL standard, it is necessary to add a stacking field with a total of 7 blocks. new stacking yards to anticipate increased container throughput. Another alternative is Teluk Lamong Terminal, which can reduce the average dwelling time to 1-3 days.

Based on the results of this study, there are suggestions that can be given by the author as follows:

1) Before adding a new stacking area, Teluk Lamong Terminal can try to reduce the existing dwelling time to a maximum of 3 days. The emphasis on dwelling time can help reduce the value of the existing yard occupancy ratio so that it can reduce budget costs for the procurement of new stacking yards.
2) The results of this study can be further developed into a study with a deeper discussion of the application of the Internet of Things and ASC in the Lamong Bay Terminal stacking field.

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