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Research Article

Analysis of the Effect of Quay Container Crane Available on Dwelling Time at Jakarta International Container Terminal

Ridho Hans Gurning[1], Feby Gusti Dendra[2], Adinda Rahmah Shalihah[1]

[1] *Automotive Engineering Technology, Polytechnic STMI Jakarta, Jl. Letjen Suprapto No. 26, Cempaka Putih, Central Jakarta, Indonesia, 10510*

[2] *Automotive Industrial Engineering, Polytechnic STMI Jakarta, Jl. Letjen Suprapto No. 26, Cempaka Putih, Central Jakarta, Indonesia, 10510*

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CORRESPONDENCE

E-mail Corresponding Author: ridhohans@stmi.ac.id

A B T R A C T

The efficiency of loading and unloading dwelling time at the port has been widely done. The problem at PT JICT is that there has been a decrease in throughput over the past three years, this has affected operational performance. Another problem is terminal operational equipment that has begun to be obsolete, which hampers loading and unloading operation time, lack of operational equipment that supports the loading and unloading process. The operational equipment studied is the Quay Container Crane which is seen from the available conditions. All of these problems will have an impact on dwelling time at PT JICT which can affect operational performance. This study aims to develop a strategy to reduce dwelling time through improving the maintenance process and knowing the development of a dynamic system model with QCC treatment scenarios and its impact on dwelling time, as well as providing recommendations to PT Jakarta International Container Terminal to prepare adequate operational equipment so that the resulting dwelling time is known. This research method uses a dynamic system model and a validation test with a behavior pattern test. The results of the validation of the dynamic system model obtained a dwelling time between 2.79 - 4.56 days, a mean error of 3% and a standard deviation error of 11%. The maintenance of a quay container crane has an influence on unloading productivity which has an impact on dwelling time. Based on 60 data, the variable of available container crane quay is seen based on quartile values consisting of quartile 1 (Q1), quartile 2 (Q2) and quartile 3 (Q3). In the variable of the available container crane turn, the dwelling time value in quartile one is 1.34 days, quartile two is 1.47 and quartile three is 1.51 and the dwelling time value in quartile one is 14 units, quartile two is 12 units and quartile three is 10 units.

INTRODUCTION

Ports are one of the economic supports in Indonesia. With the existence of a port, it is very adequate to have a role in supporting various fields such as supporting the mobility of goods and people in Indonesia. According to Article 1 number 1 of Government Regulation No. 69 of 2001 concerning Ports, a Port is a place consisting of land and surrounding waters with certain boundaries as a place for Government activities and economic activities that are used as a place for ships to dock, dock, board and disembark passengers and/or load and unload goods equipped with shipping safety facilities and supporting activities of the Port as well as a place for intra and intermodal movement transportation. Conditions for handling the movement of goods both in and out of the port are carried out at the terminal (Verawati, 2020). Terminals are the most important main element of the Port in serving ships when carrying out unloading and loading of goods. Various facilities are needed in carrying out unloading and loading activities that are adjusted to the type of goods, the packaging of goods to be handled and the type of ship to be served. The services provided can be in the form of loading and unloading activities, arranging and storing goods in transit warehouses or arranging goods or containers in the stacking field, receiving goods to be put on the ship (loading) and handing over goods after leaving the ship (discharge) to the owner of the goods or related companies. A container terminal is a complex system with dynamic interactions between various handling, transportation and storage units (Kim and Gunther, 2007).

Inside the terminal, all containers are lifted with different equipment and all containers can be grouped into three types, namely export containers, import containers and transhipment containers (Witjaksono, 2016). A well-managed transportation and port system is the main component in economic competition, especially the competence of the logistics industry (P. International P. Tanjung, 2015). One of the best terminals in Indonesia is PT. Jakarta International Container Terminal (JICT). Currently, PT JICT has developed into the largest and busiest container terminal in Indonesia, especially in Tanjung Priok, Jakarta. In the last four years, PT JICT has continued to receive awards as the best container terminal in Asia in terminal capacity of under four million TEU's. PT JICT partners with more than 25 countries in the world and for the last five years PT JICT has been the master of container loading and unloading management in Tanjung Priok (Simamora, 2017). The problem at PT JICT is that there has been a decrease in throughput over the past three years, this has affected operational performance. According to (Gao et al, 2013) that operational performance is a representation of the achievement of all targets, thus the company always has the goal of improving its operational performance. Another problem is terminal operational equipment that has begun to be obsolete, which hampers loading and unloading operation time, lack of operational equipment that supports the loading and unloading process. All of these problems will have an impact on dwelling time at PT JICT which can affect operational performance (Oktavia, 2020).

There are many ways to streamline the loading and unloading process and reduce dwelling time, especially at PT JICT Port such as Fault Tree Analysis based on the reference "Analysis of the Causes of Not Achieving the Dwelling Time Target Using the Fault Tree Analysis Method, Case Study: Tanjung Priok Port (Ruwantono, 2016) and "Import Dwelling Time Analysis at Tanjung Priok Port Through the Application of Theory of Constraint (Anita, 2017). In this study, a dynamic system method is used, namely a system is a collection of entities that have a role and interact in achieving certain goals (Jaelani, 2015). In the application of the dynamic system method, a mathematical model is needed that supports data processing. Mathematical models are logical representations and quantitative relationships, which are then manipulated to see systems react or run. An analytical solution is possible if the model used is simple, so that it is possible to create a solution analytically, if the model is complex or complex, then simulations are used, so that the model can be trained with various inputs and see the impact on the output (Teknik, 2007). So that from this research it is hoped that it can have a good contribution, namely by reducing dwelling time at the Port of Jakarta International Container Terminal. In addition, with the influence of infrastructure where the maintenance of a container quay crane with a small value will reduce the dwelling time and if the maintenance value of the quay container crane is large, it will increase the dwelling time at PT JICT Port.

METHOD

1.1. Research Materials

This study uses dwelling time using data from January 2016 – December 2020 and data on facilities or infrastructure at the Port of Jakarta International Container Terminal, namely Quay Crane Container Available data for 5 years (January 2016 – December 2020). The data used tends to be more stable and consistent in simulations because it reduces anomalies that may be caused by extraordinary events such as the Covid-19 pandemic, besides that the data for this period is very complete and has been verified compared to the latest data and can help in future policy planning. The proposing of the data and information needed in this study can also be done with deepth interview or observation (Oktavia, 2020).

1.2. Research Methods

The research method was carried out to reduce the dwelling time at the Jakarta International Container Terminal Port. Dwelling time data and container crane turn data are available which are used for modeling simulations with dynamic systems. According to Andhika (2019), the dynamic system model is a useful method in designing for complex and structured system considerations in better decision-making.

This method uses more complete data for the model, including real-time operational data at the Port, in addition to this model is able to simulate more complex and realistic scenarios. There is a study that uses data after the event in analyzing the model, but in this study the model is improved in prediction and data collection in real time.

1.3. Data Analysis

In this study, the dwelling time analysis at the Jakarta International Container Terminal Port is prepared in a dynamic model that needs to be considered to describe the causality relationships required in the decision formulation process and also includes large causal relationships in the causality effect (Figure 1)

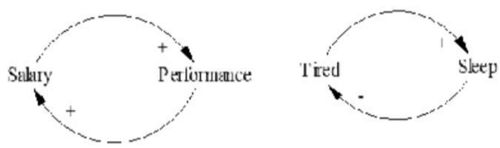

Fig. 1. Example of a caustic diagram

Dynamic systems utilize the concept of cause and effect and stock and flow modeling and have a great influence on

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the function of time. In the stock and flow survey, there are several types of variables used in the diagram as shown in table 1.

Table 1. Variable Types and Stock Flow Chart Symbols

Variabel	Symbol	Description
Level		It is a variable that states the accumulation of an object over time. It can be human, stuff, or something else. Accumulated rate can change its value
Rate		It is an activity or movement or flow that moves to the change of time. This rate can change the state from level to next level.
Auxiliary		It is a variable that represents a formulation that can affect the rate or other variables.
Source/Sink		Source is a variable that defines the system outside

The use of dynamic systems models can establish causal relationships that are necessary in the policy formulation process, and also include the main relationship entities of causal effects. Therefore, this dynamic system is also a supporting tool in making practical decisions that allow to test the effectiveness of various policy scenarios (Rashedy, 2015).

1.4. Model Validation

Model verification is a check on the results of the model so that it has a clear conceptual and free from errors. Model verification is carried out mainly to avoid errors – logical errors so that the model can provide a reasonable solution. Validation is a prolonged and complicated process, involving formal/quantitative and informal/qualitative tools. The formal aspect of validation is obtained from various aspects and validation steps (Barlas, 2002).

In the model verification, a check is carried out on the model with a conceptual system that is free from errors. Validation can be done if the simulation model has been verified. The test used to validate the model uses the behavior pattern test method, which is useful to check that the model is able to produce acceptable behavioral output by comparing the average result and error variance.

Behavior pattern test is a form of test carried out on a simulation model to assess how accurate the output of the model's behavior pattern is with the actual behavior pattern. The process is carried out by comparing the mean comparison and the comparison of the amplitude validation (% error variance). The formulation used in the behavior pattern test can be seen in figure 2.

Average comparison (*Mean comparison*)

$$E1 = \frac{|S - A|}{A}$$

Description:
S = average value of simulation results
A = average data
The model is considered valid when E1 ≤ 5%

Comparison of amplitude variations (*% Error Varianc*

$$E2 = \frac{|Ss - Sa|}{Sa}$$

Description:
Ss = Standard deviation model
Sa = Standard deviation data
The model is considered valid when E2 ≤ 3Sta

Fig. 2. Average comparison formula (mean comparison) dan amplitude variation comparison formula (% error variance)

RESULT AND DISCUSSION

Simulation is a collection of methods and applications to imitate the real system without the need to create an original system and can be done using certain computers and software (Ekoanindyo, 2011). Computer simulation refers to a method to study various models of real-world systems with numerical evaluation using software designed to mimic the operation and characteristics of the real system (Firmansyah, 2017). Regarding the stages included in the design and implementation of the research carried out, it includes several stages such as collection data collection, casual pie chart design and stock flow diagram, and model validation. Data collection was carried out to take field data and make observations at the Port of PT. The Jakarta International Container Terminal is the result of simulations and the results of the National Logistics Ecosystem based on occupancy time value, container flow and quantity unloading.

2.1 Dynamic System Model

In the dynamic system model, it can be seen that the impact of infrastructure explains the availability of equipment infrastructure used in the unloading process, namely quay crane containers, rubber tyred gantry containers, and head trucks and has an impact on the flow of container movement to yard. Both the impact of available infrastructure, and the impact of infrastructure maintenance are influenced by the amount of infrastructure available or available for use, and the variables of head truck available, rubber tyred gantry container available, and quay crane container available are affected by the number of each infrastructure minus the number of infrastructure that is undergoing maintenance, as can be seen in Figure 3.

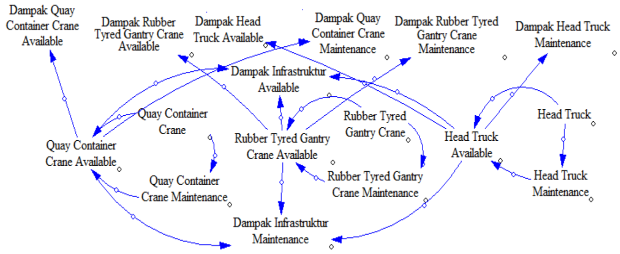

Fig. 3. Dynamic System Model

2.2 Dwelling Time

In Figure 4, it can be seen that the simulation results of the base model dwelling time continue to fluctuate over time. The longest time is 4.56 days and the lowest is 2.79 days, the value is at an average of 3.61 days which can still be said to be close to the actual value of 3.52.

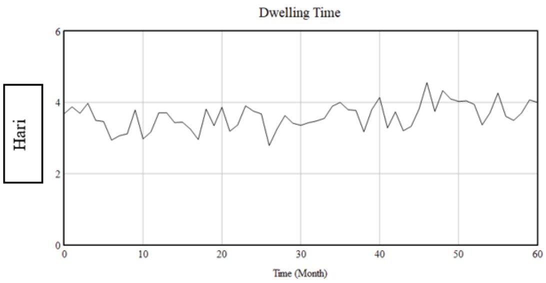

Fig. 4. Dwelling Time Chart

2.3 Actual Validation and Dwelling Time Validation

The comparison of the data of the dwelling time simulation results carried out on the Vensim PLE application shows a comparison graph between the actual dwelling time data and the simulation data seen in the figure 5.

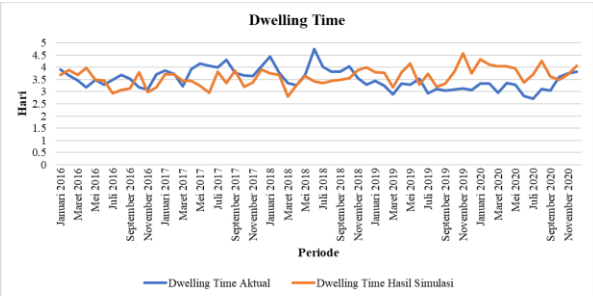

Fig. 5. Dwelling Time Comparison Chart

Based on the results of actual data validation and data from the simulation of dwelling time, it can be said to be valid because it has a mean comparison value below 5%, which is 2.6% and error variance data below 30% of 11%.

2.4 Validation of Quay Container Crane Available Sub Model

The comparison between the actual data and the simulated data of the quay container crane available carried out on the Vensim PLE application shows the comparison between the actual quay container crane data and the simulated data seen in the figure 6.

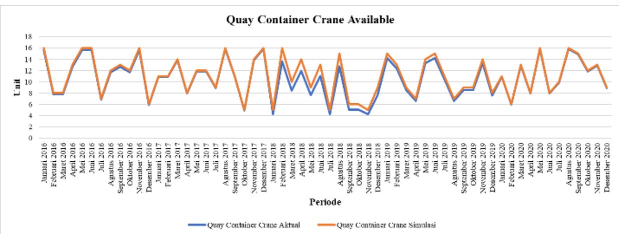

Fig. 6. Comparison Chart of Quay Container Crane Available

Based on the results of the validation of the actual data and the data from the simulation results of the available rotary container crane, it can be said that it is valid because it has a mean comparison value of below 5%, which is 4.7% and the error variance data is below 30% of 0.9%.

2.5 Effect of Quay Container Crane Maintenance on Dwelling Time

Maintenance quay container cranes have an influence on unloading productivity which has an impact on dwelling time. To determine how much influence maintenance quay container cranes have, it is necessary to do data sensitivity. The initial step in conducting data sensitivity is to input the available quay container crane field data in the SPSS application and determine the quartile one (Q1), quartile two (Q2) and quartile three (Q3) values of the data and review the cumulative precent value based on the quartile value used in the national logistics ecosystem simulation model in the Vensim PLE application. Based on 60 data, the first quartile value is in the 16th data with a cumulative percent value of 31.7%, the second quartile is in the 31st data with a cumulative percent value of 53.3%, and the third quartile value is in the 46th data with a cumulative percent value of 76.7%. The average of quartile one is 14 units, the average of quartile two is 12 units and the third quartile is 10 units. In addition to obtaining the quay container crane available, the dwelling time of each quartile is also obtained.

2.6 Analysis of the Effect of Quay Container Crane Maintenance on Dwelling Time

The effect of maintenance quay container cranes will have an impact on dwelling time. The formulation used in the maintenance of quay container cranes is carried out three times the repetition of data, where it was explained earlier that the data input is based on the value of quartile 1, quartile 2 and quartile 3.

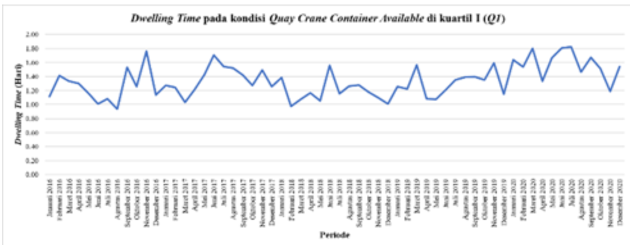

Fig. 7. Dwelling Time on Quay Container Crane Available in Quartile 1

Based on the figure above Dwelling Time on Quay Container Crane Available in Quartile 1, the average dwelling time is 1.34 days with the lowest dwelling time of 0.94 days and the highest dwelling time of 1.83 days. In addition, the average quay container crane available data is 14 units with the lowest available quay container crane of 11 units and the highest available quay container crane of 16 units. Furthermore, the second scenario simulation results that have been made based on quartile two value data show dwelling time and quay container crane

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available data and Figure 8 shows the dwelling time graph in quartile 2 starting from the period January 2016 to December 2020.

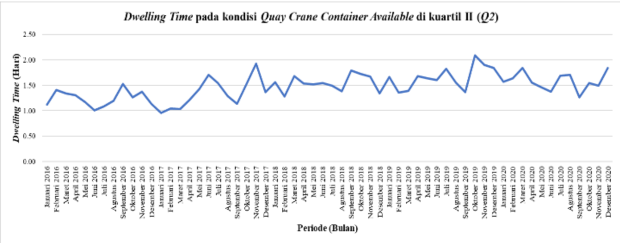

Fig. 8. Dwelling Time on Quay Container Crane Available in Quartile 2

Based on the figure above, the Dwelling Time on Quay Container Crane Available in Quartile 2 is 1.47 days with the lowest dwelling time of 0.96 days and the highest dwelling time of 2.09 days. In addition, the average data of available quay container cranes was 12 units, with the lowest available quay container crane of 8 units and the highest available quay container crane of 16 units. Furthermore, the results of the third scenario simulation that has been made based on the data of the second quartile value shows the data of the dwelling time and the available container crane turn and Figure 9 shows the dwelling time graph in the 3rd quartile starting from the period of January 2016 to December 2020.

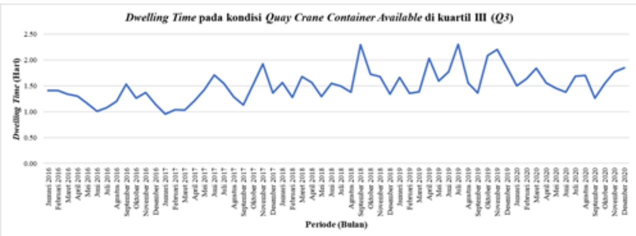

Fig. 9. Dwelling Time on Quay Container Crane Available in Quartile 3

Based on the picture above, Dwelling Time on Quay Container Crane Available in Quartile 3 is 1.51 days with the lowest dwelling time of 0.96 days and the highest dwelling time of 2.30 days. In addition, the average quay container crane available data is 10 units with the lowest quay container crane available of 4 units and the highest quay container crane available of 16 units. Next, the results of the simulation scenario that has been made based on the average data (mean) of all quartile values show the dwelling time and quay container crane data in the three quartiles and Figure 10. shows the dwelling time graph in the three quartiles.

Table 2. Dwelling Time in Quartile 1, Quartile 2 and Quartile 3

Quartiles	***Dwelling Time***	***Quay Container Crane Available***
Q1	1.34	14
Q2	1.47	12
Q3	1.51	10

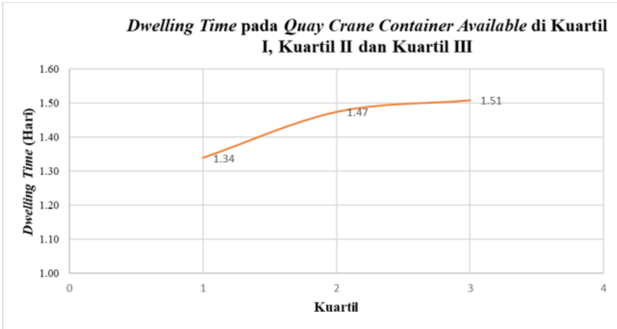

Fig. 10. Dwelling time graph at Quartile 1, Quartile 2 and Quartile 3

Looking at the data above, the average value of each quartile is obtained, the average of the first quartile is 1.34 days, the average of the second quartile is 1.47 days and the third quartile is 1.51 days and the available container turn is obtained in the first quartile of 14 units, the second quartile of 12 units and the third quartile of 10 units. It can be concluded that the more Quay Container Crane available, the smaller the dwelling time, while the fewer Quay Container Crane available the higher the dwelling time at the port.

CONCLUSION

The results of the base model dwelling time simulation continue to fluctuate over time. The longest time is 4.56 days and the lowest is 2.79 days, with an average value of 3.61 days which can still be said to be close to the actual value of 3.52 days. The test of the influence of infrastructure maintenance can be seen based on the variable of the available quay container crane and the dwelling time value is seen based on the quartile value consisting of quartile 1 (Q1), quartile 2 (Q2) and quartile 3 (Q3). In the variables of dwelling time in quartile one of 1.34 days, quadrant two of 1.47 days and quartile three of 1.51 days and the value of available container crane quay in quartile one is 14 units, quartile two is 12 units and quartile three is 10 units. So that the higher the available container crane turn, the lower the dwelling time value, while the higher the available container crane turn, the higher the dwelling time value. Therefore, optimizing the maintenance process of a rotary container crane can reduce the container stacking process and accelerate the movement of containers, so that dwelling time is reduced.

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