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DEVELOPMENT OF MODEL AND HEURISTIC ALGORITHM FOR OPTIMIZING OPERATION OF TWIN AUTOMATIC STACKING CRANE IN AUTOMATED CONTAINER YARD BY SYNCHRONIZING THE ARRIVAL TIME PLANNING OF VESSEL AND TRUCK

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ABSTRACTS

The usage of Twin Automatic Stacking Crane (Twin ASC) at the automated container terminal require proper operation strategy. The existence of two ASC in one block of CY can improve the effectiveness CY (Container Yard). But because the ASC have the same size, the ASC can not pass each other, thus requiring the distance between ASC. At that distance, one of ASC will stop and wait other ASC completed the task and move away. To facilitate the operation, CY is divided into two sides of the landside (near Gate) and the waterside (near berth). The ASC operation depends on the arrival time of vessel and truck. Berthing time of the vessel for loading and unloading affect the schedule reception (receiving) or delivery schedules (delivery) of containers by ASC in the waterside area. While the arrival time of trucks affect receiving or delivery schedule containers by ASC in the landside area. Operation of ASC in serving containers from a vessel or truck also affect the arrival and departure time of vessel and dump trucks. Such information greatly affect the performance and service of the ASC container port. So we need to synchronize twin ASC operation with the planning of arrival of ships and trucks. In this research will be develop a model and a heuristic algorithm to optimize the operation of Twin ASC by synchronizing the arrival time planning of ships and trucks. The purpose of this research is to develop models and algorithms that can optimize the operation of the ASC to produce a total travel distance, total travel time and minimum energy costs.

Keywords*: Twin Automatic Stacking Crane, Vessel and Truck Arrival Time planning, Heuristic Algorithm, Total Travel Distance Total Travel Time*

INTRODUCTION

Container terminal is a place that connects the container ships as a means of sea transport by truck as a means of land transport (Bose, 2011). In 2000, the use of the container terminal to 3.8 million TEUs (twenty-foot equivalent unit) and continues to increase each year to reach 10.79 TEU in 2013 (The World Bank, 2015). This indicates that the container terminal plays an important role in the supply chain in the world. Services container terminal will affect the performance of each element belonging (delivery services). Therefore every container terminal strive to improve their performance in particular to reduce the turn around

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time harbor. Turn around time is the average - average time required terminal for loading and unloading ships. To lower the level around time need for cooperation between all elements in the container terminal.

In the container terminal there are three important parts are integrated main gate, container yard (CY) and the quayside. Gate is the door of the container terminal that serves to identify containers that will be in and out of the container terminal. While the dock is a haven of ships to load and unload containers. And which serves to connect the gate function and the pier is CY. CY is a temporary storage container of the gate and dock. In CY there are four major buildup of activity, namely discharging, loading, receiving and delivering containers. CY often run into bottlenecks in the process of handling containers must remember CY piled containers from the trucks into CY until the freighter come and conversely CY should also save unloading containers from ship to truck comes. We have had many a container terminal that made improvements to the one of which is the system of automated container terminals. CY automated system that is currently widely used is the use of two Automatic stacking cranes (ASC), both of the same size (Twin ASC) or different (Rail Mounted Gantry). In addition, only a block CY only differentiated into two types of container blocks to domestic and overseas. Each block is equipped with a transfer point or input / output points are located at the ends - ends CY. Twin usage between ASC ASC causes are not interchangeable across so that the need for the distance between the ASC to avoid their second meeting of the ASC. a block is divided into two parts: a landside (the mainland) and the waterside (the pier). ASC is located in the landside area called LASC, while residing at the waterside called WASC. In order for both the ASC can operate a maximum of strategy is needed proper operation.

In operating the ASC, ne of the things that is important is knowing when the container arrives to CY and when the container should be out of CY either on the landside and waterside. So it can direncankanan laying position and movement of the ASC. Information related to the arrival of the container is a truck or boat when it comes to delivering containers. When the ship would lean to load and unload containers and when the dump truck will drive (container receiving) or take a container (container delivery) in CY. Such information can be used by ASC to make arrangement with certain criteria. For example, for a container receiving the top priority is the time of arrival of the vessel, while the container delivery is a top priority is the arrival time haul trucks. The arrangement of containers in CY will affect the effectiveness of both CY and good level of service port unloading services at the pier or at the Gate Piers. Because at any given position towards the coordinates or there are two types namely the displacement movements performed by carrying the container or transfer that does not carry the burden or often referred to unnecessary movement (displacement in vain). In addition the level of availability of empty slots (available empty slot) can be a measure of the performance of the ASC. The smaller the value, the level of activity or the use of very high slot.

Currently the information is obtained by the port of the forwarder (cargo) which has a lot of diversity. So that the port can only adjust the schedule with the sc hedule provided by the customer. With proper land-use planning can manage the port where the ship will dock first and trucks which can take up dahulu.Karena containers can not be denied that the use of ASC are not effectively increase the cost of energy used by the ASC. The need for planning the arrangement of each container in CY to minimize the transfer of the waste - waste from the ASC so as to minimize the turnaround time of vessels (Lee, 2007). Related Research typesetting containers with Rail Mounted Gantry Cranes (RMGC) has been carried out by Lee and Hsu (2007). This study aims to classify container based on the size of containers and vessels used to minimize the movement of containers. Containers of different sizes placed in different piles. And container ships the same pengankut put on the block.

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Rei and Pedroso (2012) have developed a mathematical model of the base of the stacking problem and heuristic methods to minimize the displacement of containers with regard arrivals and retrieval of containers. In this system, the displacement only be in one bay.While scheduling Twin ASC-related research has been done by the Park, Choe and Ok (2010), Choe (2011) and Gharehgozli et al. (2014). Park, Choe and Ok (2010) developed a mathematical model of scheduling two RMGC with the objective function to minimize the delay time weighted of Automated Guided Vehicle (AGV) and the waiting time weighted truck. Meanwhile, Choe (2011) developed a scheduling algorithm container movement within a block of the Twin ASC to minimize movement of waste - waste from the container when it is done loading and unloading. And in 2014, Gharehgozli et al. developed a mathematical model of scheduling Twin ASC in a block to minimize makespan both ASC. In the study conducted pairwise calculation of travel time for each ASC. The third focus of research to determine the route and scheduling of both ASC assuming locations predetermined container. In addition, researchers only consider the implementation of operating strategies minimum distance between the ASC to avoid any meeting of the ASC. In research - research that discussed above are not related to the use of planning the arrival of the ship and truck transport as one of the criteria in ASC Twin operation.

This study aims to fill the void of the research - the study. Problems developed in the study of how to develop a model and a heuristic algorithm to optimize the operation of Twin ASC synchronize the planning of arrival of the vessel and haul trucks. The analysis will be done is the influence of the planning synchronization arrival of the vessel and haul trucks to the total travel time, total unnecessary movement and energy costs of both ASC.

METHODOLOGY

Conceptual Model

This study observed objects is one block domestic use where the block tesebut Twin ASC serving container delivering and receiving containers in negeri.Objek this research is PT. Terminal Lamong. Where each block is divided into two areas: a landside (landside automatic stacking crane-LASC) and the waterside (waterside automatic stacking crane-WASC). Both ASC move together to manage the arrangement of containers in a block. To avoid the second meeting of the ASC, in use Lamong Bay terminal buffer area as a place to exchange second task ASC. But some studies suggest that it is important to avoid colliding second ASC is to provide a minimum level between the two ASC. ergerakan is because the number of containers that must be handled by CY. That affect the arrival of containers in CY is planning information arrival of the ship and truck transport. This information will be input in a grouping of containers in order to efficiently use the container yard.

CY has dimensions with a bay (length), a row (width) and a number of tier (height). In this study, the dimensions of CY can be seen in Figure 1, Table 1 and Table 2. Whenever makukan removal, an ASC can only carry one container for each carriage. ASC works automatically with the use of power resources. The more displacement and movement of containers in CY, it will be a big boost electrical power source is needed. Besides the more the removal of the container will increase the time of loading and unloading of ships and haul trucks will load the containers. So that the objective function of this problem is to minimize energy costs by optimizing travel time of the ASC

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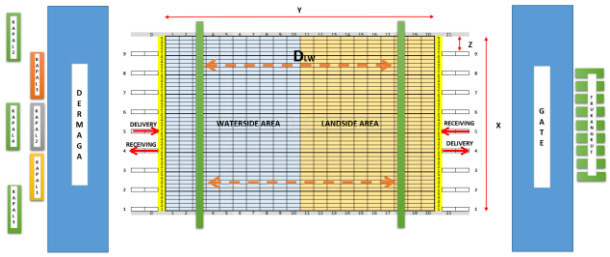

Figure 1 Automated Container Yard dengan Twin ASC Conceptual Model

Table 1 Block Dimensions

	Jumlah Slot
Row (x)	9
Bay (y)	20
Tier (z)	5

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Table 2 Slot Size

Ukuran Slot	Satuan (ft)	Satuan (m)
Panjang	20	6,096
Lebar	8	2,438
Tinggi	8.5	2,591

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To determine the priority of containers services need to consider several categories, including:

1. Delivery containers: arrival time is affected by planning the arrival of the ship.
2. Receiving containers: the arrival time is affected by the arrival of truck transport planning.

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As for the positioning of containers in CY based on the position that most closely ASC or which have a maximum distance between the initial position of the container with a position that allows / available. Containers will be transported by ship / forwarder same will be placed adjacent to one tier and row. ASC long trip can be calculated by pairwise travel time (Gharehgozli, 2014). Pairwise travel time is travel time units of one point i to point j. Here are pairwise travel time formulation used in this study:

$$t_{ij} = max\{|x_i - x_j|, |y_i - y_j|\} + z_i + z_j \qquad (1)$$

Notation

i : the location index i (i=1,2….n);
j : the location index j (j=1,2….m);
tij : ASC travel distance frome node i to node j (unit)
x : unit bay (x = 1,2,…9);
y : unit row (y = 0,1,2,…,21); where y=0 -- *landside* I/O point; y=21 -- *waterside* I/O point;
z : unit tier (y=1,2,…5);
(x_i, y_i, z_i) : coordinate of node i
(x_j, y_j, z_j) : coordinate of node j

Table 3 ASC Speed

	ASC Speed (m/minute)
Full lift	**45**

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	ASC Speed (m/minute)
Empty lift	**90**
Run	**270**

Formulation of pairwise travel time by Gharehgozli (2014) resulted travel time in units (slots). To find out pairwise travel time in meters and minutes it is necessary to develop new formulation. Formulation development pairwise travel time are described in Table 4 and Table 5.

Table 4 Travel Distance (Meter)

Aktivitas ASC	t_{ij} (meter)
ASC displacement to carry containers	$max\{\lvert x_i - x_j\rvert L_s, \lvert y_i - y_j\rvert P_s\} + z_i H_s + z_j H_s$
ASC displacement without carrying containers (*unnecessary movement*)	$max\{\lvert x_i - x_j\rvert L_s, \lvert y_i - y_j\rvert P_s\} + z_i H_s + z_j H_s$

Table 5 Travel Time (Minute)

Aktivitas ASC	t_{ij} (menit)
ASC displacement to carry containers	$max\left\{\frac{\lvert x_i - x_j\rvert L_s}{V_{move}}, \frac{\lvert y_i - y_j\rvert P_s}{V_{move}}\right\} + \frac{z_i H_s}{V_{full}} + \frac{z_j H_s}{V_{full}}$
ASC displacement without carrying containers (*unnecessary movement*)	$max\left\{\frac{\lvert x_i - x_j\rvert L_s}{V_{move}}, \frac{\lvert y_i - y_j\rvert P_s}{V_{move}}\right\} + \frac{z_i H_s}{V_{empty}} + \frac{z_j H_s}{V_{empty}}$

Notation
Ls : width of slot (m)
Ps : length of slot (m)
Hs : high of slot (m)
Vmove : ASC speed (m/minute)
Vfull : ASC full lift rate (m/ minute)
Vempty : ASC empty lift rate (m/ minute)

The purpose of the arrangement of containers in CY and scheduling of both ASC is in order to minimize energy costs pengopesian both ASC to minimize the total travel time and unnecessary movement to obtain a second utility ASC high.

$$Minimize\ Energy\ Total\ Cost = \frac{(Total\ Travel\ Time\ (minute) + Unnecessary\ Movement\ (minute))}{60} x\ 200\ kWh\ x\ Rp.939.85\ /kWh \quad (3)$$

Algorithm

From the problem description and the model, we can develop the new algorthm for solving this problem.

RESULTS AND DISCUSSION

For testing the model and algorithm, we try to make some experiment. First experiment only depend on truck arrival time. Second experiment only depend on vessel arrival time. And the third depend on truck and vessel arrival time. In third experiment from

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six vessel the are three vessel in waiting time. So we make a combination of berthing sequence time to three vessel in quieng like in Table 6.

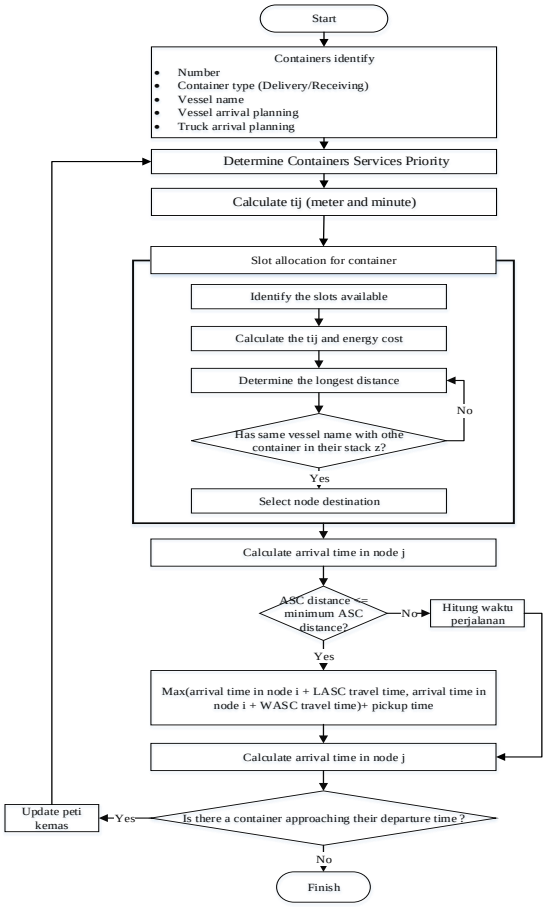

Figure 2 Slot Allocation and Twin ASC Operation Algorithm

Table 6 Vessel Combination

No.	Vessel Berthing Sequence		
	1th	2nd	3rd
3A	LUZON	PAHALA	MARINA STAR 1
3B	LUZON	MARINA STAR 1	PAHALA
3C	PAHALA	LUZON	MARINA STAR 1
3D	PAHALA	MARINA STAR 1	LUZON
3E	MARINA STAR 1	LUZON	PAHALA
F	MARINA STAR 2	PAHALA	LUZON

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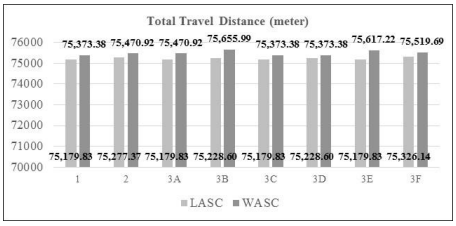

Figure 3 Total Travel Distance

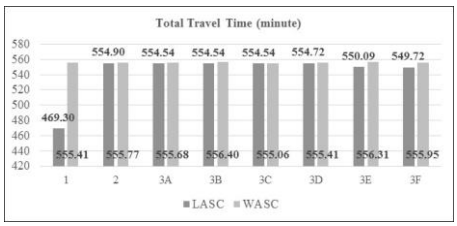

Figure 4 Total Travel Time

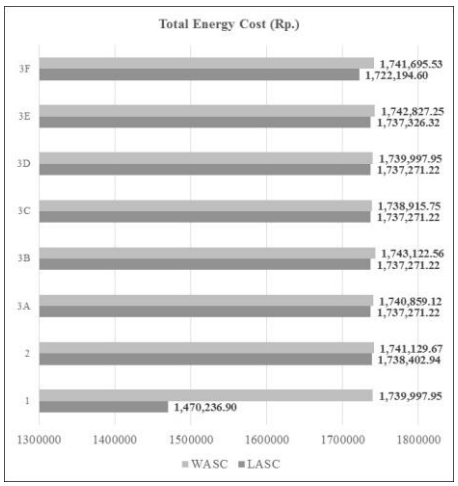

Figure 7 Total Energy Cost (Rp)

From the exeperiment result, we know that vessel and truck arrival time planning has effect to container yard operation. Not only arrival planning, vessel quence combination can improve our performance. Because we used real data, we cant know running the system with extrem data. From the graphic, we can see that in exeperiment 1 has minimum total travel distance, total travel time and energy cost than other aexperiments. With many variation of truck arrival time, experiment 1 has minimum total travel distance and total travel time. If we use truck and vessel arrival time, we need remarshalling and need more total travel distance and total travel time.

CONCLUSIONS AND RECOMMENDATIONS

Based on the result of all research process, this research can show that Twin ASC operation with determine vessel and truck arrival planning can get more effective allocation slotting. Because there are some vessel around the port, we can combination the queing vessel with minimize travel time and energy cost. Vessel combination also can use to operation Twin ASC with minize total energy cost. But it can more minimize total energy cost if only depend on truck arrival time. Because truck arrival time has high variation than vessel arrival time.

ISBN :

REFERENCES

Archetti, C. B. (2012). A Hybrid Heuristic for an Inventory Routing Problem. *NFORMS Journal on Computing*, 101–116.

Bose, J. W. (2011). *Handbook of Terminal Planning Operations Research/Computer Science Vol. 49.* New York: Springer Science+Business Media.

Brinkmann, B. (2005). *Seeh¨afen Planung und Entwurf.* Berlin: Springer.

Choe, R. P. (2011). Generating a Rehandling Free Intra Block Remarshaling Plan for an Automated Container Yard. *Journal of Intelligent Manufacturing*, 201 - 217.

Dekker R, V. P. (2006). Advanced Methods for Container Stacking. *OR Spectrum Vol. 28*, 563–586.

Gendreau, M. P. (2010). *Handbook of Metaheuristics Second Edition.* New York: Springer Science + Business Media.

Gharehgozli, A. H. (2014). Scheduling *Twin* Yard *Crane*s in a Container Block. *Transportation Science*, 1 - 20.

Glover, F. (1990). *Tabu Search : A Tutorial.* Colorado: enter of Applied Artificial Intilligence University of Colorado.

Huang, S.-H. L.-H. (2012). Heuristic Algorithms for Container Pre-Marshalling Problem. *Computers & Industrial Engineering Vol.62*, 13 - 20.

Izquierdo, C. E. (2012). Pre-Marshalling Problem : Heuristic Solution Method and Instances Generator. *Expert Systems with Applications*, 8337 - 8349.

Lee, Y. H.-Y. (2007). An Optimization Model for The Container Pre-marshalling Problem. *Computers & Operations Research Vol. 34*, 3295 - 3313.

Park, T. C. (2010). Real Time Scheduling for *Twin* RMGs in an Automated Container Yard. *OR Spectrum Vol. 32*, 593 - 615.

Park, T. C. (2011). Dynamic Adjustment of Container Stacking Poli*CY* in an Automated Container Terminal. *Int. J. Production Economics Vol. 133*, 385 – 392.

Rei, R. J. (2012). Heuristic Search for The Stacking Problem. *International Transactions in Operational Research Vol. 19*, 379 - 395.

Steenken, D. V. (2006). Container Terminal Operation and Operations Research – A Classification and Literature Review. *OR Spectrum Vol. 26*, 3 - 49.

The World Bank. (2015, Oktober 15). *Container port traffic (TEU: 20 foot equivalent units)* . Retrieved from Data: http://data.worldbank.org

Yu, m. Q. (2013). Storage Space Allocation Models for Inbound Container in an Automatic Container Terminal. *European Journal of Operational Research Vol. 226*, 32 - 45.

ISBN :