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OPTIMIZATION OF PERFORMANCE IMPROVEMENT OFCONTAINER CRANE AT CONTAINERS TERMINALUSING GENETIC ALGORITHM

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ABSTRACT

This paper is describe as an effort to answer the performance improvement of container crane (CC) equipment in order to improve the performance of container terminals. One of the most important determinats of container handling efficiency is the productivity of container cranes. Optimization is done with the intention to find solutions to the performance of container crane equipment in container terminal operations. The research location is Surabaya Container Terminal and analysis is performed using Genetic Algorithms (GA).Optimization with randomize patterns is done through crossover and mutation in the GA method gives a value which fluctuates in each iteration. From the results of the analysis carried out, there are three (3) simultaneous suggestions to improve container crane performance so that the device operational service on the wharf can be optimized, namely a long wharf, the number of equipment in operation and coefficient of equipment. The decision to choose one of the options on the optimal iteration process needs to consider the conditions on container terminal today.

Keywords:optimization, performance, container terminal, genetic algorithm.

INTRODUCTION

The main function of port operations or container terminal is to prepare equipment and facilities sufficient to facilitate the activities of loading and unloading [1]. Container terminal is an important infrastructure in the global logistics network of freight packaging [2]. The ability to provide maximum logistics services have become a critical issue for the survival of the port, while creating value-added services and meet customer needs.[3].

As the world's largest archipelagic state, Indonesia sea transportation plays an important role in international and domestic trade. Efficient marine transportation is essential to support economic growth in a fair and balanced between regions.[4]. In fact, the domestic sea transportation contributes to its high price difference between the region and the movement of goods inter islands in the country are often more expensive than the movement of goods to and from overseas. [5]. The high costs of sea transport, causing the price of logistics is much more expensive in areas especially eastern Indonesia. This is due the port performance is not optimal, such as loading and unloading, stacking and transportation should be more efficient but about 60 percent of shipping cost is a cost in port. Meanwhile, according to [6] and [7], a standard container transportation has a direct impact on transportation efficiency and does not cause high cost economy in shipping patterns.

Increasing economic growth contributes to the busyness of the container terminal operations around the world and resulted in an increased interest in optimizing the performance of Container Crane (CC) in research and practice. Container terminal productivity can be measured in terms of productivity are two types of operations, ie. operations on the ship, where the container was loading and unloading from and to the ship. The other is operational at the dock of receiving and transporting of containers using trucks to and from the harbor. [8].Some research has been done to improve the operational performance in the container terminal with efficiency and scheduling equipment crane or container quay cranes and nothing to optimize the productivity, the number of containers transported per unit time. [8] scheduling quay cranes (QCs), most important gear in the port terminals by applying the method of branch and bound (B & B) to obtain the optimal solution of scheduling QC and fusion algorithm heuristic search is called greedy randomized adaptive search procedure (GRASP). [9] to consider the problem of scheduling quay cranes to minimize the turnaround time of vessels and time idle cranes. They proposed algorithm branch-and-cut (B & C) to solve this problem. [10] tried to scheduling quay cranes with restrictions without interruption and they propose a genetic algorithm to obtain near-optimal solutions. To solve the same problem, [11] proposed a Tabu Search algorithm (TS) where the environment is defined by a disjunctive graph. The computing time is reduced significantly at the expense of the quality of the solution slightly weaker compared with the algorithm B and C. There are also efforts made by [12] adds to the model proposed in [13] by inserting a crane-service rates of individual and unidirectional modes QC trip. They use scheme B & B to complete QCSP considered. [14] investigated QCSP while considering the time window on the availability QC, operational range QC and QC movement direction.

This paper attempts to describe genetic algorithm (GA) analysis to improve the productivity of existing container crane (CC) equipment and that a minimum CC productivity standards required in container terminal in Indonesia. As it is known that in Surabaya Container Terminal, where the study was conducted, the standards and minimum requirements of container crane productivity are 25 boxes / CC / hour. [15], in accordance

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with the Decree of Directorate General of Sea Trnasportation No. UM.002 / 38/18 / DJPL.2011

MATERIALS AND METHODS

Container terminal

The Containers to be shipped comes from the manufacturer or factory located on hinterland, so as to move this item can be used trucks or a trains, and then sent to the terminal, before being loaded to the vessel in accordance with its destination, the container is stored while at the container yard or container freight station (CFS), the storage / stacking management in the temporary storage field as arrange in such a way to be easyly in handling management when it is loaded on to the vessel.. It also aims to avoid having the vessel is not too long in the berth or the effectiveness of the vessel is not reduced cause too long a mooring in the port.

Container terminal is a temporary storage area, where a container vessel anchors in the dock area, loading the incoming container and unloading the container out. The terminal includes a warehouse for temporary storage of the incoming containers. Figure-1 shows a schematic representation of the operational and equipment at container terminals, including container cranes for loading and unloading of the ship to the docks, the truck and trailer to carry containers within the terminal area, and rubber gantry cranes (RTGs) to arrange the container in the container yard. [16].

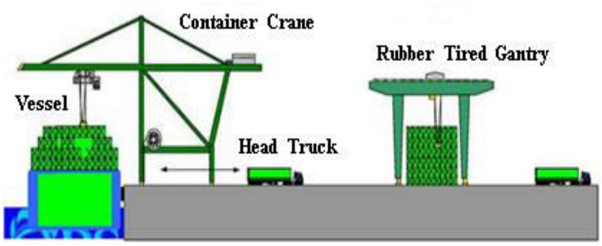

Figure-1. Operational scheme on the container terminal.

Container's flow

The development of logistics transportation flow to Surabaya Container Terminal continues to increase. Total container exports (loading), Import (discharge) and Domestic container activities can be seen in chart on Figure-2.

Figure-2 and Figure-3 shows, that the domestic containers activity is more dominateby unloading activities than loading, or in other words the containers entering the Surabaya Container Terminal area from corner of the country are greater than the containers are transported out from Surabaya Container Terminal to other areas in Indonesian region. While the international container activity, either loading or unloading can be said to be balanced. But in terms of volume, international container is much larger than the domestic container,

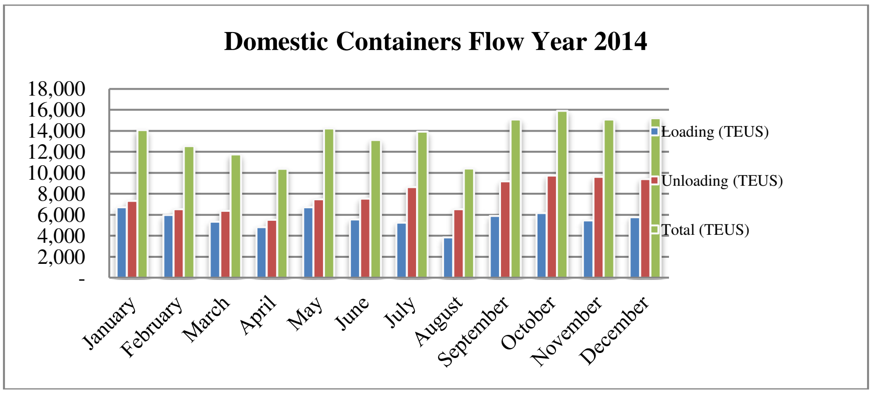

Figure-2. Domestic containers flow.

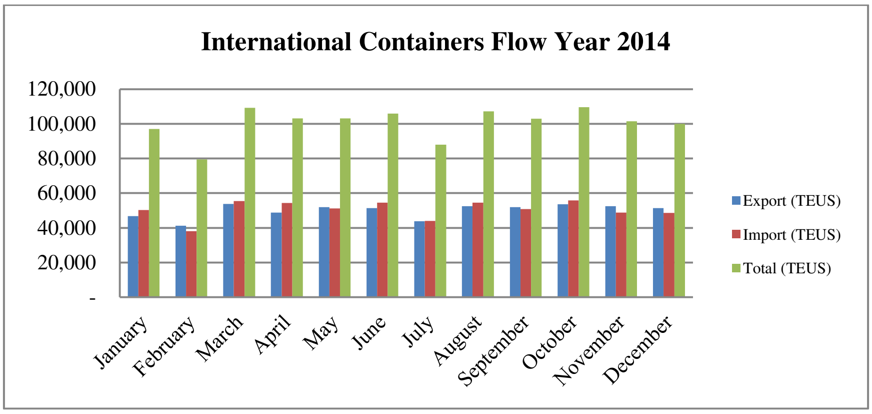

Figure-3. International containers flow.

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Surabaya Container Terminal facilities can be seen in Table-1 below.

Table-1. Surabaya container terminal facilities.

Name of facility	Dimension	
International Wharf	Length	1.000,00 m
	Width	50,00 m
	Depth	10,50 m
Domestic Wharf	Length	450,00 m
Container Yard	Areas	290.000 m^2
	Capacity	34.000 TEUs
	Refrigerated Containers	250 units
Container Freight Station	Areas	10.000,00 m^2
	Dangerous Goods Area	6.500,00 m^2
Rail Sidings (two lanes)	Long Lane	420,00 m.
Equipments		
Container Crane		12 units
Rubber Tyred Gantry		33 units
Reach Stackers		6 units
Side Loader		1 unit
Sky Stacker		3 units
Forklift Diesel		6 units
Forklift Electric		12 units
Head Truck		80 units
Chasis		124 units
Low Bed Chasis		3 units
Cassette		90 units
Trnaslifter		7 units

Source: Surabaya Container Terminal, 2015

Methodology

To analyze the performance improvement of container yard crane with a larger target than a specified target, we use the genetic algorithm methods (GA). One of the hallmarks of genetic algorithm is not too much need the mathematcal requirements in the completion of optimization process. The results of the best genetic algorithm of each generation can be used as an alternative decision support system. The flow chart of optimization completion process with the GA method [17], can be seen in Figure-4 below.

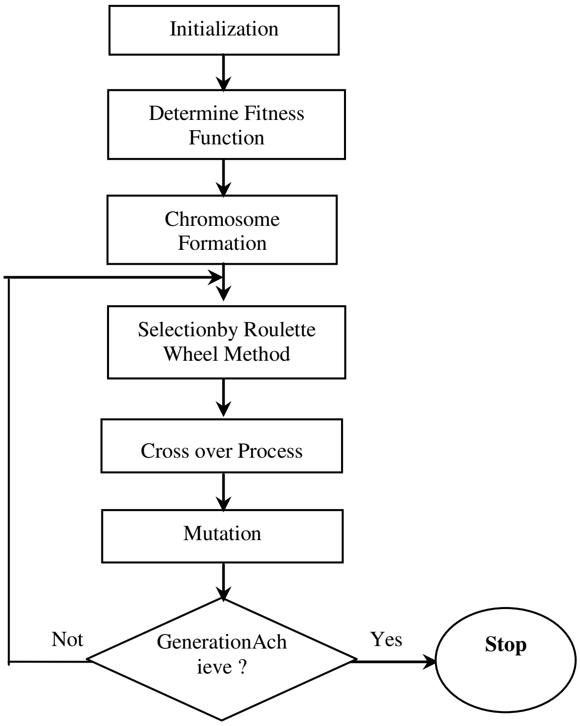

Figure-4. Genetic algorithm process.

RESULTS AND DISCUSSIONS

Objective function

Port operational performance according to standards issued by the government of Indonesian Tranportation Departmet, namely the Decree of Directorate General of Sea Transport No. UM.002 / 38/18 / DJPL.2011 where the required of loading-unloading performance is at least 25 boxes / hour, then the value is considered normal average the equipment's ability in production (β).

$$Total\ Production\left(\frac{boxes}{hour}\right) = \alpha.Q.L.\beta \qquad (1)$$

where :

α : coefficient of equipment (%)
Q : number of equipment (unit / km)
L : Length of wharf (km)
β : normal average the equipment's ability in production (boxes /unit/ hour)

Fitness function

$$Productivity\ average\left(\frac{boxes}{hour}\right) = \frac{Total\ production}{n} \qquad (2)$$

where:

n : number of equipment being operated

Initialization

- coefficient of equipment (Gen-1) = 0,75 – 1 (+0,5 / -0,5)→ multiple of 0,5

- number of equipment (Gen-2) = 4 – 12 (+1 / -1) → multiple of 1,0
- Length of wharf (Gen-3) = 1 – 3 (+0,5 / -0,5) → multiple of 0,5

Stages of Genetic Algorithm (Generation - 1 / Itteration - 1).

a) **Constructing chromosomes randomly:**

The process of randomization the early chromosomal generation is to create a new population according to the number of popsizes that have been determined:

Step 1:

Constructing chromosomes randomly can be performed by random function commands on a software to facilitate randomization of chromosomes.

Step 2:

Calculates the value of the objective function ($f(x)$) on each row or chromosome of the value of the genes, using the formula:

$$\Pr oductivity\ average\ \left(\frac{boxes}{hour}\right) = \frac{Total\ production}{n}$$

So:

$$\Pr oductivity\ average\ per\ unit\ CC_1 = \frac{0{,}75 * 9 * 2 * 25}{9} = 37{,}5 \frac{boxes}{hour}$$

Step 3:

Calculates the fitness value / Evaluation of the objective function ($f\ (x)$) by using the formula:

$$function\ (x) = \frac{1}{f(x)} \tag{3}$$

so;

$$function\ (x) = \frac{1}{37{,}5} = 0{,}02667$$

Table-2. Evaluation of objective function.

chromosome	Gen-1	Gen-2	Gen-3	Fitness $f(x)$	$eval(x) = \frac{1}{f(x)}$
K1	0,75	9	2	37,5	0,02667
K2	0,8	7	2,5	50	0,02
K3	0,8	12	1	20	0,05
K4	0,9	11	1,5	33,75	0,02963
K5	0,85	7	1	21,25	0,04706

b) Selection Process (Roulette Wheel Method)

The selection process is to select the best / most healthy chromosome to cross over:

Step 1:

Calculates total fitness value / evaluation. Eg fitness (pk) where the fitness value of k-individual by using the formula:

$$total\ fitness\ : \sum_{k=1}^{popsize} fitness\ (p_k) \tag{4}$$

Step 2:

Calculate the probability value of the selection of each chromosome / individual by means of the fitness value divided by the total fitness value (sum), using the formula:

$$\Pr ob_k = \frac{fitnesss_{(pk)}}{total\ fitness}, \qquad k: 1,2,3,4 .... popsize \tag{5}$$

so:

$$\Pr ob_1 = \frac{0{,}02667}{0{,}17336} = 0{,}153826819$$

Step 3:

Calculates the cumulative probability value of each chromosome / individual by accumulating the result value of probability, using the formula:

$$\Pr obCum_k = \sum_{j=1}^{k} \Pr ob_k, \qquad k = 1,2,3, ... popsize \tag{6}$$

Step 4:

Constructing the random numbers using software applications random functions with range [0,1] as many popsize numbers.

Step 5:

Conducting the process of selecting a commulative probability by using Roullete Whell method. By choosing a random number compared with the cumulative probability, using the formula:

$$r \le \Pr obCum_k \tag{7}$$

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Table-3. Selection of cumulative probabilities.

chromosome i	$Eval(x_i)$	$\frac{Eval\ (x_i)}{\sum_{j=1}^{5} Eval(x_j)}$	$\sum_{j=1}^{i} Eval(x_j) \frac{Eval\ (x_i)}{\sum_{j=1}^{5} Eval(x_j)}$	r	Selection
K1	0,02667	0,153826819	0,153826819	0,8022	5
K2	0,02	0,115370114	0,269196933	0,538	3
K3	0,05	0,288425286	0,557622219	0,325	3
K4	0,02963	0,170918688	0,728540907	0,1626	2
K5	0,04706	0,271459093	1	0,9075	5

Table-4. Interim results after experiencing selection.

chromosome	Gen-1	Gen-2	Gen-3	Fitness $f(x)$
K1	0,85	7	1	21,25
K2	0,8	12	1	20
K3	0,8	12	1	20
K4	0,8	7	2,5	50
K5	0,85	7	1	21,25

c) Cross over process with crossing probability of 25%

Generate random values as much as the number of chromosomes, then select the parent to be crossover. The way to select of parent to be cross-over is to find the random value smaller than the crossover probability value → r ≤ 0,25

Table-5. Cross-over process.

chromosome	R	Parent chromosome
K1	0,19446	1
K2	0,29257	0
K3	0,94989	0
K4	0,12564	1
K5	0,44041	0

Cross-over steps:

Step 1:

Generating random numbers using software applications with random function (r) with range [0,1] as many as popsize number.

Step 2:

Determine crossover probability value (Pc) with range [0,1].

Step 3:

The process of parent chromosome selection to be cross-over, using the formula: $r \leq Pc$.

The result of the selected chromosomal cross-over is called offspring

Table-6. Interim result of cross-over.

chromosome	Gen-1	Gen-2	Gen-3	Fitness $f(x)$
K1	0,8	7	2,5	50
K2	0,8	12	1	20
K3	0,8	12	1	20
K4	0,85	7	1	21,25
K5	0,85	7	1	21,25

d) The mutation process with a mutation probability of 1%.

Generate random values as many as the number of genes (as much as, 5 x 3 = 15), then select the parent to be mutated. How to select the parent to be mutated is to find the random value is smaller than the value of mutation probability.

$r \leq 0{,}01$

Table-7. Parent selection process is affected by mutation.

Chromosome	r1	r2	r3	Parent selection
K1	0,07232	0,004723	0,937434	r2
K2	0,82334	0,003423	0,30233	r2
K3	0,90232	0,120348	0,7382	
K4	0,00134	0,150001	0,212394	r1
K5	0,01183	0,035435	0,4385486	

For the mutated parent it will randomly change the value of each gene, with the composition as follows:

- Gen-1 = 0,75 – 1 (+0,5 / -0,5) → multiple of0,5
- Gen-2 = 4 – 15 (+1 / -1) → multiple of 1,0
- Gen-3 = 1 – 3 (+0,5 / -0,5) →multiple of 0,5

Table-8. Mutation process.

Chromosome	Gen-1	Gen-2	Gen-3	Fitness $f(x)$
K1	0,8	4	2,5	50
K2	0,8	14	1	20
K3	0,8	12	1	20
K4	0,9	7	1	22,5
K5	0,85	7	1	21,25

Steps for the mutation process:

Step 1:

Generating random numbers using software applications with random function (r) with range [0,1] as much as total number of genes. Where the total number of genes obtained by using the formula:

Total number of genes = popsize x number of genes per chromosome

Step 2:

Determine mutation probability value (Pm) with range [0,1].

Step 3:

Gene selection process to be mutated, using the formula:

$ri \leq Pm$

Step 4:

The selected gene from the process step 3 to changes value by replacing the value of the selected gene with the random gene value.

In the same way, the Iteration process of each Generation is repeated until it finds the best generations that meet the criteria as expected. So the final result obtained from Genetic Algorithm is:

Table-9. Optimization for each iteration.

Iteration	**Coefficient of equipment** (%)	**Number of equipment** (units)	**Lenght of wharf** (km)	**Optimization** (boxes/hour)
1	80	4	2,50	50,000
2	90	7	1,00	22,500
3	75	7	1,50	28,125
4	80	7	1,50	30,000
5	90	8	1,00	22,500
6	90	9	1,50	33,750
7	80	8	2,00	40,000
8	75	9	2,00	37,500
9	85	9	1,50	31,875
10	80	7	2,00	40,000

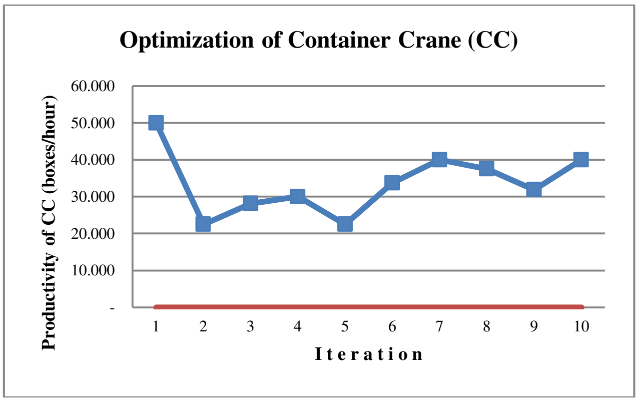

Figure-5. Optimization graph of container crane.

From the results of Table-9 and Figure-5 above can be shown that in some experiments were conducted, some iteration produces a value above the optimum value required. (a). In first iteration, CC productivity reached 50 boxes / hour provided that the lenght of wharf is 2.50 km, the number of equipments of 4 units with 80% of equipment condition. (b). The 3rd iteration CC productivity reached 28 boxes / hour provided that the lenght of wharf is 1.50 km, the number of equipment of 7 units with 75% of the equipment condition. (c). The 4th iteration, productivity CC reached the 30 boxes / hour provided that the lenght of wharf is 1.50 km, the number equipment of 7 units with 80% of equipment condition (d). The 6th Iteration, CC productivity reached 34 boxes / hour provided that the lenght of wharf is 1.50 km, the number of equipment of 9 units with the 90% of equipment condition. (e). The 7th Iteration, CC productivity reached 40 boxes / hour provided that the lenght of wharf is 2.00 km, the number of equipment of 8 units with 80% of equipment condition. (f). The 8th Iteration, CC productivity of up to 38 boxes / hour provided that the lenght of wharf is 2.00 km, the number of equipment of 9 units with 75% of equipment condition. (g). The 9th Iteration, CC productivity reached 32 boxes / hour provided that the lenght of wharf is 1.50 km, the number of equipment of 9 units with 85% of equipment condition (h). The 10th Iteration, CC productivity reached 40 boxes / hour provided that the lenght of wharf is 2.00 km, the number of equipment of 7 units with 80% equipment condition.

Determination of the decision will be a desirable option would need to consider the condition of location and than the minimum risk of use excessive costs.

CONCLUSIONS

Based on the previous description of the optimization of performance improvement the container yard crane, it can be concluded : (a). Genetic algorithm results in each of the best generations can be used as an alternative decision support system in setting policy taken: (b). Selection of the best alternative generation, depending on the most appropriate needs for the object case optimization. (c) In this case, if the length of wharf can not be increased / extended and the number of equipment (CC) also can not be added, then the solution is to maximize / increase the ability of the equipmentl factor in production (β).

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REFERENCES

[1] Prasetyo S. A., Wicaksono Achmad., Anwar M.Ruslin. 2014. Evaluation of Logistics System at Tanjung Perak Port of Surabaya. Journal of Civil Engineering. 8(2): 113-120.

[2] Baird A. 2006. Optimizing the Container Transhipment Hub Location in Northern Europe. Journal of Transport Geography.14(3): 195-214.

[3] Juang Y. and Roe M. 2010. Study on Success Factors of Development Strategies for Intermodal Freight Transport Systems. Journal of the Eastern Asia Society for Transportation Studies, 8.

[4] Adisasmita S.Adji. 2011. Transportation Development Planning, Graha Ilmu, Yogyakarta.

[5] UNCTAD. 2014. Small Island Developing States: Challenges in Transport and Trade Logistics Multi-Year Expert Meeting on Transport, Trade Logistics and Trade Facilitation; Third Session, Geneva.

[6] Raúl Pino, Gómez, A., Parreño, J., De La Fuente and Paolo Priore. 2013. Application of Genetic Algorithms to Container Loading Optimization. International Journal of Trade, Economics and Finance. 4(5): 304-309.

[7] Christopher M. 2005. Logistics and Supply Chain Management - Strategies for Reducing Cost and Improving Service (3rd ed.). Financial Times/ Prentice Hall.

[8] Kim K.H., Park Y.,M. 2004. A crane scheduling method for port container terminals European Journal of Operational Research. 156: 752-768.

[9] Cordeau J. -F., Gaudioso M., Laporte G. & Moccia L. 2005. A branch-and-cut algorithm for the quay crane scheduling problem in a container terminal. In AIRO annual conference. Camerino, Italy, 6-9 September.

[10] Lee D.-H., Wang H. Q. & Miao L. 2008. Quay crane scheduling with noninterference constraints in port

container terminals. Transportation Research - Part E. 44(1): 124-135.

[11] Sammara M., Cordeau J-F., Laporte G.& Moccia L. 2007. A tabu search for the quay crane scheduling problem. Journal of Scheduling. 10: 327-336.

[12] Legato P., Trunfio R. & Meisel F. 2012. Modeling and solving rich quay crane scheduling problems. Computers & Operations Research. 39: 2063-2078.

[13] Bierwirth C. & Meisel F. 2009. A fast heuristic for quay crane scheduling with interference constraints. Journal of Scheduling. 12: 345-360.

[14] Monaco M. F. & Sammara M. 2011. Quay crane scheduling with time windows, one-way and spatial constraints. International Journal of Shipping and Transport Logistics. 3(4): 454-474.

[15] Indonesian Transportation Department.2011. Standard of Port Performance in Indonesia; Decree of Directorate General of Sea Transport No. UM.002 / 38/18 / DJPL.2011.

[16] Güven C., Deniz Türsel Eliiy. 2014. Trip allocation and stacking policies at a container terminal. Transportation Research Procedia. 3: 565-573.

[17] Purnomo Dwi, Hindiyananto. 2014. How to Easily Learn Metaheuristic Optimization Methods using Matlab, Gava Media Publisher, Jogyakarta.