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EVALUATION OF CONTAINER CRANE PERFORMANCE AT TENAU KUPANG PORT

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ABSTRACT

Container Terminal at Tenau Port, Kupang, is logistics services provider for society and as the only port that operates sea transportation exclusive for container that serves domestic purpose in Timor Island. The Demand for containers at Tenau Port has increased in the last 5 years. This study is intended to determine the operational service performance in Container Port of Tenau Kupang nowadays and operational service performance of Container Crane to the Decree of the Director General of Sea Transportation number : HK.1 03/2/1 8/DJPL-16, and get the right recommendation in optimizing the operational service performance in Container Port of Tenau Kupang. The method used is the Genetic Algorithm. The results of this study indicated that number of Berth Working Time (BWT) was 14,19 hours, Berthing Time (BT) was 17,77 hours, Box per Ship Hour in Port (BSHP) was 15,18 box/hour ≈ 16 box/hour, Box per Ship Hour in Berth (BSHB) was 24,39 box/hour ≈ 25 box/hour, and Berth Occupancy Ratio (BOR) was 32,75%. Optimization by using Genetic Algorithm was 24,39 box/CC/hour with the recommended length of pier is 1000 meters, the amount of equipment by 6 units and the current condition of Tenau Port about 92,00%.

KEYWORD: *Evaluation, Container Crane, Genetic Algorithm, Performance.*

1. INTRODUCTION

Bassically, the handling of container in terminal begins when it is unloaded from the ship by using container crane (CC), transported by Head Truck (HT) and stacked in a stacking yard using Rubber Tyred Gantri (RTG) and vise versa. The performance of a port can be measured by establishing a standard, if operational service exceeds a specified standard, operational service quality of the port is properly assessed and vice versa (Triatmodjo, 2010).

As the biggest archipelago country in the world, Indonesia's sea transportation plays an important role in international and domestic transportation. The efficient sea transportation is important to support the equitable and balanced economic growth between regions (Adisasmita, 2011). In facts, domestic sea transportation provide a high contribution for the price differentials between those regions and causes the movement of goods inside the country often more expensive than movement of goods to and from foreign country (UNCTAD, 2014). The high charges of sea transportation causes the logistic price be more expensive in regions especially in East Indonesia. This is caused by sub-optimal performances of port, such as the loading, unloading, stacking and carrying should be able to more efficient but about 60 % of freight charge is a port's charge (Business Economic News, March 28, 2014). While, according to Raul Pino et.al (2013); and Cheon (2007), standard of container transportation facility has a direct impact on transportation efficiency and not causes the high cost economy on the delivery pattern.

A number of research had been already performed to improve the operational performances in container port by made efficient and scheduling equipment of container crane or Quay Crane (QC), but there are very minimal research about optimaze the productivity of number of transportated containers per unit time. Rizal, et el (2017) have evaluated the performances of containers crane in Surabaya Port, increase in productivity of CC into 28 box/hour. Kim and Park (2004), have done a scheduling of Quay Crane, the most important pieces of equipment in Terminal by applying a Branch and Bound Method (B & B) to get solutions for QC scheduling and an algorithm combined of a search heuristic namely greedy randomized adaptive search procedure (GRASP). Cordeau, et al. (2005) was consider the problem of QC scheduling to minimize the completion of the ship and idle crane time. They suggested branch-and-cut (B and C) algorithm to overcome this problem. Lee, et al. (2008) tried to do QC scheduling with limit but no distrubance and suggested a genetic algorithm to get an optimal solution. To fix the similar problem, Sammara et al. (2007) suggested Tabu Search (TS) algorithm which the environment is defined as a disjungtive graphic. The computing time would be significantly reduced by compromising its quality slightly weaker than B and C algorithm. While, the effort made by Legato et al. (2012) to add a model that are offered by Bierwirth & Meisel on 2009 by introducing the service cost of individual-crane and travel mode of parallel QC. They used B & B scheme to finish the QCSP which is considered. Monaco & Sammara (2011) investigated about QCSP while considered time window of the QC available, operational range and undirectional movements.

This paper tries to untangle genetic algorithm (GA) analyses to improve productivity of container crane (CC) tools on productivity standard of required minimum QC in Indonesia's containers terminal. As noted, in container port of Tenau Kupang, minimal standard and requirement of container crane productivity to be 12 box/CC/hour based on Desicion Letter of Directore General of Sea Transportation No. HK.103/2/18/DJPL.2016.

2. MATERIAL AND METHODS

According to Desicion of Indonesia Port's Director No. HK.56/2/25/PI.II-02, container terminal equipped with facilities are as follows; moorings, piers, containers yard (CY) and decent eqiupments to serve container's loading and unloading.

Terminal is a load transfer place between the different transfer system that is from land transport to sea transport and vice versa (Triatmodjo, 2010). The main function of container terminals is to handle container's loading and unloading in order the flows of goods are to conform with the adopted prescripts. By these prescripts, it is expected that all handling of loading and unloading can be performed to create the smooth flow of goods and harmony in the works (Yulianto dan Setiono, 2013).

Containers terminal takes responsibility for the transfer of containers from sea transport to land transport and vise versa (Setiawan et.al, 2016), but the success of container's flow is influenced by numerous factors are as follows

1. The changing weather conditions, damage to the ship's engines and several other factors leading ship to entry to port too late.
2. Accidents, the incomplete documents and several other factors leading ship to entry to port too late.
3. The capacity of stacking yards available.
4. The supporting equipments such as trucks, froklits and others damages.

Containers terminal is temporary storage areas, which is ship anchored in pier area, lifting the container coming and lowering the container coming out. Containers terminal consists of crane of pier to loading and uploading from ship to pier, trucks, trailer to pick container into port and Rubber Tyred Gantry (RTG) to arrange container in yard (Guven, et al, 2014).

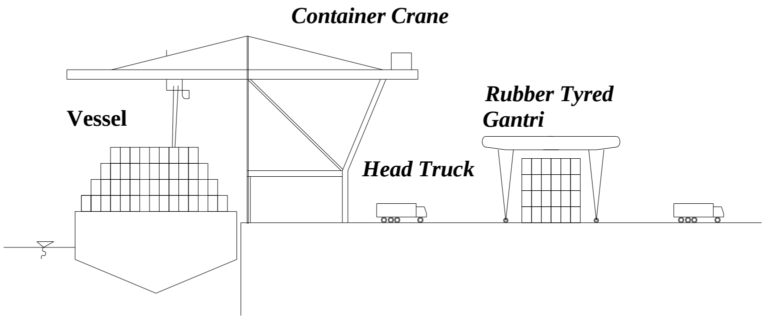

Figure 1: The Operational Scheme of Container Terminal.

Container's loading and unloading

Container's flows was the totally number of container's loading and unloading for the latest five years that is 2015 to 2019. From the obtained data, could be predicted the totally number of containers used to calculate the percentage of Utilitas Container Crane (UCC). Here are presented the data of container's flows from 2015 to 2019 of Container Port in Tenau Kupang in form of Figure 2.

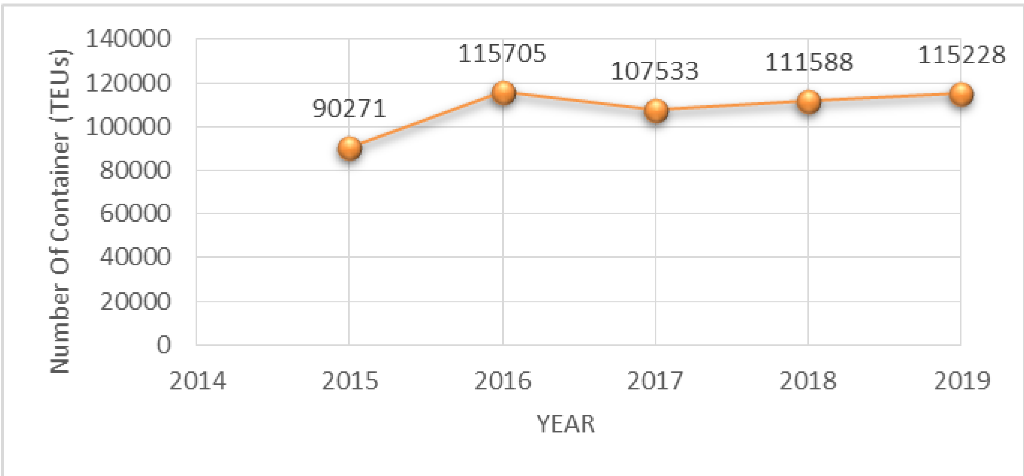

Figure 2: Graphics of Container's Flows In Tenau Kupang Port.

Source; PT. Pelindo III Tenau Kupang Port.

Based on the obtained data on Figure 2, then perfomed the prediction by using Microsoft Excel Program and obtained the equation that is y= 4579,70x–9129189,90. From this equation, then perfomed an estimated number of container in Tenau Kupang Port from 2020 to 2024. Here are presented the table of the estimated number of container's flows from 2020 to 2024.

Table 1: Estimated Number of Container's Flows.

Year	Estimated Number of Container's Flows (TEUs)
	y = 4579,70 x - 9129189,90
2020	121804
2021	126384
2022	130964
2023	135543
2024	140123

This result of estimated data on 2024 used to calculate the utility percentage of container crane.

Facilities of Container Terminal

Facilities and equipments available in Container Terminal of Tenau Kupang Port can be seen in Table 2.

Table 2: Facilities and Equipments in Container Terminal of Tenau Kupang Port.

No	Name of facility	Dimention			
1.	Multi-purpose Pier	length	:	237	Meter
		width	:	20	Meter
		depth	:	-14	MLWS
2.	Nusantara Pier	length	:	223	Meter
		width	:	15	Meter
		depth	:	-12	MLWS
3.	Stacking Yard	area	:	30.000	M^2
		capacity	:	8.075	TEUs
4.	Equipments				
	Container Crane		=	2	Unit
	Reach Stacker		=	4	Unit
	Forklift 5T		=	1	Unit
	Forklift 10T		=	1	Unit
	Mobile Crane 150T		=	1	Unit
	Rubber Tyred Gantry		=	4	Unit
	Head Truck		=	6	Unit

Source: PT, Pelindo III Tenau Kupang Port.

METHODOLOGY

The method used for optimizing the performances of Container Crane with the greater target than established target was Genetic Algorithm Hybrid Method. One of the superiotities of Hybrid Method was to provide the stronger and efficient approach to overcome the complicated problem in the real world. The result of this method on the each greatest generation used as an alternative of desicion support system. The using of heuristic method based in hybrid that was Genetic Algorithm (GA) Method, which is the achievement mechanism toward optimaze has differences with another hybrid method. On the GA Method, each individual as known chromosome shared the informations to others, so that the whole population moved like one group to a optimal area. Broadly, flowchart of optimized the resolution process by using GA (Purnomo, 2014) can be seen in Figure 3.

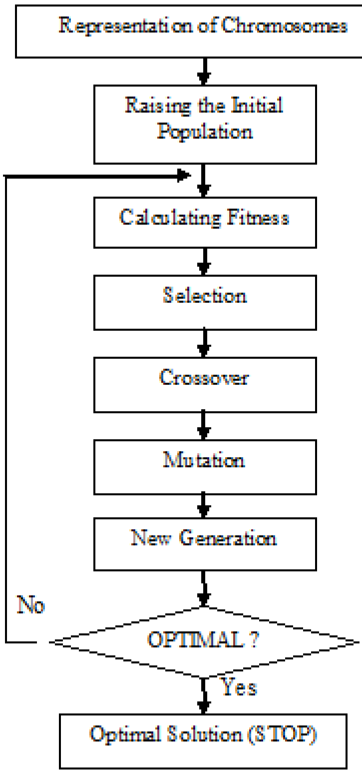

Figure 3: Genetic Algorithm Flow chart.

Table 3: Recapitulation of Container's Flow Handling at Port of Tenau Kupang, June 2020.

No	Name Of Ship	LOA (m)	Ship's Arrival		Initial Handling		Number Of Container's Unloading		Number Of Container's Loading		Total U/L Container's		Final Handling		Ship's Departure		Not Time (NT)	Idle Time (IT)
			Date	Hour (Wita)	Date	Hour (Wita)	BOX	TEUS	BOX	TEUS	BOX	TEUS	Date	Hour (Wita)	Date	Hour (Wita)		
1	Sakura 09	75	3-Jun	16.00	3-Jun	16.05	48	49	50	52	98	101	3-Jun	23.45	4-Jun	0.10	2.17	1.75
2	Jales Mas	115	6-Jun	9.50	6-Jun	10.50	204	209	338	345	542	554	7-Jun	7.09	7-Jun	7.09	27.17	0.27
3	Meratus Kelimutu	129	8-Jun	12.00	8-Jun	13.00	332	366	296	316	628	682	10-Jun	1.00	10-Jun	1.00	3.03	9.07
4	Multi Permai	76	9-Jun	11.00	9-Jun	11.00	109	111	104	106	213	217	10-Jun	2.55	10-Jun	3.00	7.5	1.18
5	Calypso	76	12-Jun	12.00	12-Jun	13.00	87	89	68	68	155	157	12-Jun	22.20	12-Jun	23.20	3.43	0.17
6	Meratus Kalabahi	129	13-Jun	9.00	13-Jun	10.30	359	398	313	345	672	743	14-Jun	16.00	14-Jun	16.00	5.38	0.65
7	Multi Karya I	75	15-Jun	12.00	15-Jun	13.00	112	118	105	110	217	228	16-Jun	2.55	16-Jun	3.30	28.08	0.00
8	Dandelon	72	17-Jun	12.00	17-Jun	13.00	71	73	57	59	128	132	17-Jun	22.00	17-Jun	22.00	1.33	0.48
9	Jales Mas	115	17-Jun	11.00	17-Jun	13.00	168	160	221	222	389	392	18-Jun	6.30	18-Jun	6.30	5.07	0.78
10	Meratus Kelimutu	129	21-Jun	0.00	21-Jun	13.00	379	416	332	357	711	773	22-Jun	23.40	23-Jun	1.00	3.09	1.73
11	Sakura 09	74	21-Jun	9.00	21-Jun	10.00	82	85	57	60	139	145	21-Jun	17.45	21-Jun	18.45	3.27	0.00
12	Multi Permai	76	22-Jun	0.00	22-Jun	8.00	97	102	78	78	175	180	23-Jun	0.05	23-Jun	1.00	6.17	0.87
13	Meratus Kalabahi	130	24-Jun	0.00	24-Jun	13.00	386	431	535	598	921	1,029	26-Jun	3.48	26-Jun	4.00	2.32	2.48
14	Calypso	76	26-Jun	1.00	26-Jun	1.00	91	94	109	111	200	205	26-Jun	14.35	26-Jun	14.36	5.18	0.82
15	Luzon	157	26-Jun	18.30	26-Jun	19.00	150	150	0	0	150	150	27-Jun	5.12	27-Jun	5.54	0.7	0.00
16	Multi Karya I	75	27-Jun	7.00	27-Jun	8.00	110	119	109	113	219	232	28-Jun	0.39	28-Jun	4.00	3.58	1.67
GRAND TOTAL		1,579					2,201	2,970	2,088	2,940	4,289	5,920					107.47	21.92
AVERANGE		98.69															6.72	1.37

3. RESULTS AND DISCUSSION

The measurement of performances

The Measurement of ship service performances

Berth Working Time (BWT) :

ET = $P_{final} - P_{initial}$ – IT – NOT…………………......................……........................(1)

BWT = ET + IT…………………....................………..(2)

= 13.10 +1.09

= 14.19 Hour

Berthing Time (BT): BT = BWT + NOT……………..(3)

= 14.19 + 3.78

= 17.97 Hour

The measurement of container service performances

Box per Ship Hour in Port (BSHP)

BSHP $= \frac{Total\ B/M}{TRT}$……………………..……………………..………….................…..(4)

Total B/M = 5557 box

TRT = 21.91 hour

BSHP $= \frac{347.31}{21.91}$

= 15.85 box/hour

Box per Ship Hour in Berth (BSHB)

$$BSHB = \frac{\text{Total B/M}}{\text{BWT}} \quad \ldots\ldots(5)$$

$$BSHB = \frac{5557}{14.19}$$

= 24, 48 box/hour

Pier Utility

Berth Through Put (BTP)

$$BTP = \frac{\sum(\text{Good/ TEUs one periode})}{\text{length of pier's mooring}} \quad \ldots\ldots(6)$$

$$BTP = \frac{5\ 920}{237}$$

= 24.98 TEUs/m

Berth Occupancy Ratio (BOR)

$$BOR = \frac{\sum(\text{length of ship} + 5)\ x\ \text{mooring time}}{\text{length of pier}\ x\ \text{time available}} \quad \ldots\ldots(7)$$

$$= \frac{(98.69+5)\ x\ 17.97}{237\ x\ 24}$$

= 32.75 %

Utility Container Crane

Utility Container Crane 2024

$$UCC = \frac{X}{Ncc\ x\ Ycc\ x\ BWT\ x\ Wd} x\ 100\% \quad \ldots\ldots(8)$$

$$= \frac{140\ 123}{2\ x\ 16.38\ x\ 14.19\ x\ 365} x\ 100\%$$

= 82, 61 %

Optimization of Container Crane (CC)

The functions of fitness

$$\text{Value of } F(x) = \frac{\text{Total production}}{n} \quad \ldots\ldots(9)$$

$$\text{Total Production}\left(\frac{\text{box}}{\text{hour}}\right) = \alpha.Q.L.\beta \quad \ldots\ldots(10)$$

n = X_2 = number of equipments

Explanation of Notes

Coefficient of equipments (Gen-1) = X1

Total equipments (Gen-2) = X2

Length of pier (Gen-3) = X3

Fitness $=\frac{1}{f(x)}$ ……….........………….......……………………………….....…..(11)

Table 4: Generate Population GA Iteration–1.

Initial Population					
Chromosome	Gen-1 Coefficient of equipment	Gen-2 Total equipment	Gen-3 Pier's length	F(x)	Fitness(x)
1	0.75	9.00	2.00	37.5.00	0.026666667
2	0.80	7.00	2.50	50.00	0.020000000
3	0.80	12.00	1.00	20.00	0.050000000
4	0.90	11.00	1.50	33.75	0.029629630
5	0.85	7.00	1.00	21.25	0.047058824

Selection

a. Calculating the probability of each chromosome

$\text{Prob}_i = \frac{\text{Fitness }(x)_i}{\sum_{i=1}^{n} \text{fitness }(x)_i}$ ………......……………….....………….................(12)

b. Calculating the cumulative probability of each chromosome

$\text{Cum}_i = \text{Cum}_i + \sum_{i=1}^{n} \text{Prob}_i$ ...………..……………………..…...........…….(13)

c. Generating the random number between 0 to 1.

d. Selecting the used master by crossover to gain offspring are as folllows

$\text{Selection}_i = \text{random}_i \geq \text{cumulative}_j$……………….........……….............(14)

$\text{Selection}_{i\,i} = \text{cumulative}_j$…………………..……..…..(15)

Table 5: Temporary Result Post Selection.

Result of changes of population post selection				
Chromosome	Gen 1 Coefficient of equipment	Gen 2 Total equipment	Gen 3 Pier's length	F(x)
1	0.85	7.00	1.00	21.25
2	0.80	12.00	1.00	20.00
3	0.80	12.00	1.00	20.00
4	0.80	7.00	2.50	50.00
5	0.85	7.00	1.00	21.25

From the above table, after the selection process, can be seen the result of changes of population post selection. On the fourth (4) chromosome, F(x) value reaches 50,00. It was show that the CC productivity was able to reach 50 box/CC/hour. But that value was the changes from temporary result post selection. Those value exceeds of normal average value of equipment perfomances.

Crossover

Table 6: Cross-breed Process.

Crossover R ≤ 0,25		
Chromosome	Random	Master Selection
1	0.4704	0
2	0.0998	1
3	0.2102	1
4	0.5525	0
5	0.7072	0

The result of crossover R ≤ 0,25, the best chromosome of cross-breed were second (2) and third (3) chromosome which is the second chromosome was about 0,0998 with master selection value = 1. While, the third chromosome was about 0,2102 with master selection value = 1. The temporary result of cross-breed can be seen in table 6.

Table 7: The Temporary Result of Cross-Breed.

Result of changes post Cross-Breed				
Chromosome	**Gen-1**	**Gen-2**	**Gen-3**	**F(x)**
	Coefficient of equipment	**Total equipment**	**Pier's length**	
1	0.80	7.00	2.50	50.00
2	0.80	12.00	1.00	20.00
3	0.80	12.00	1.00	20.00
4	0.85	7.00	1.00	21.25
5	0.85	7.00	1.00	21.25

The fitnes values have changes if compared with pre process of cross-breed. The highest productivity value on chromosome (1) that is 50 box/CC/hour if compared with another chromosome. This value was the highest value, but that result exceeds of normal average value of equipment perfomances.

Mutation

Table 8: Selection Process of Affected by Mutation.

Mutation R ≤ 0,01				
Chromosome	**R1 Gen 1**	**R2 Gen 2**	**R3 Gen 3**	**Master Selection**
1	0.07232200	***0.0047238***	0.9374344	**R2**
2	0.82334400	***0.0034230***	0.3023300	**R2**
3	0.90232400	0.1203480	0.7382000	
4	***0.00134738***	0.1500010	0.2123940	**R1**
5	0.01183000	0.0354354	0.4385486	

On mutation process, the selected gen was the gen with R value ≤ 0,01, so that the result of selected chromosome were first (1) and second (2) chromosome, with Gen 2 value ≤ 0,01 and fourth (4) chromosome with Gen 1 ≤ 0,01.

Table 9: Mutation Process.

Result of changes of population post Mutation				
Chromosome	**Gen-1 Coefficient of equipment**	**Gen-2 Total equipment**	**Gen-3 Pier's length**	**F(x)**
1	0.80	4.00	2.50	50.00
2	0.80	14.00	1.00	20.00
3	0.80	12.00	1.00	20.00
4	0.90	7.00	1.00	22.50
5	0.85	7.00	1.00	21.50
Optimal	0.90	7.00	1.00	22.50

From the above table, process iteration-1 of Genetic Algorithm (GA) have done with the initial conclusion that the value on chromosome (4) with f(x) 22,50 was selected because it fulfill the criteria of fitness value which is closest to optimum value 30. After the calculation process with 5 iteration by using GA Method on Container Crane (CC), the analyses process with the above same procedure, gained the fitness value on each generation (iteration) as shown in the table below.

Table 10: Summary of GA Iteration Result on CC.

Genetic Algorithm				
Iteration	**Gen-1 Coefficient of equipment**	**Gen-2 Total equipment**	**Gen-3 Pier's length**	**F(x)**
1	0.90	7.00	1.00	22.50
2	0.90	7.00	1.00	22.50
3	0.91	6.30	1.00	22.75
4	0.92	5.60	1.00	23.00
5	0.95	4.82	0..88	21.00

For the optimal value on iteration-4 used fitness value from Genetic Algorithm, so that the used value was 23,00. Based on the summary of GA iteration result of CC above, can be shown in graphic in Figure 4.

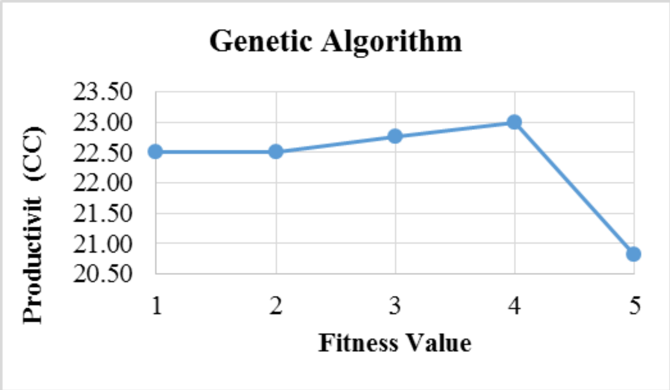

Figure 4: Graphic of CC Optimazed Result by GA Method.

4. CONCLUSION

Based on the result of above discussion, it can be concluded that

1. The operational service performance of Container at Tenau Kupang Port nowadays

a. Ship service performance

The used average time for loading and unloading when the ship is in port, Berth Working Time (BWT) was 14,19 hour and Berthing Time (BT) was 17,77 hour.

b. Container service performance

The average pace during the run of loading and unloading was in port, Box per Ship Hour in Port (BSHP) was 15,18 box/hour ≈ 16 box/hour and the average pace during loading and unloading in mooring Box per Ship Hour in Berth (BSHB) was 24,39 box/hour ≈ 25,00 box/hour.

c. Port utility

Based on the calculation result, the value of used time comparison of port and the number of time available *Berth Occupancy Ratio* (BOR) was 32,75%. This value shown the lower number of ship visits in container port of Tenau Kupang because according to Regulation of Directorate General of Sea Transportation No:HK.103/2/18/DJPL-16., the maximum limits of BOR were 70,00%.

2. The operational service performance of Container Crane based on Regulation of Directorate General of Sea Transportation No: HK.103/2/18/DJPL-16 was 12,00

box/CC/hour, then after doing the optimization using Genetic Algorithm reaches 23,00 box/CC/hour.

3. Based on the optimization result using Genetic Algorithm for the optimal operational service performance that is CC = 23,00 box/CC/hour. The recommended port's length was 1000 m and number of operated equipment was 7 units with good condition about 90%. It shown that the used equipments are in new condition.

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