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OPTIMIZATION OF RUBBER TYRED GANTRY SERVICES AT TENAU KUPANG PORT

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ABSTRACT

The flow of containers at Tenau Kupang Port always increases every period, the January - May period in 2018 was 40.583 TEUs compared to 2017 as many as 38.957 TEUs, the June -October period in 2018 reached 57.224 TEUs compared to 2017 which was 53.229 TEUs. The purpose of this study was to determine the optimization of Rubber Tyred Gantry services on the performance of loading and unloading containers as regulated by the Director General of Sea Transportation number: HK.103/2/18/DJPL-16 regarding port operational service perfomance standards, as well as obtaining recommendations in optimizing service. The method used Genetic Algorithm-Particle Swarm Optimization (GA-PSO). The results of this study indicate that the performance of Tenau Kupang Port, container yard stacking is 34,21 %, so it can be concluded that the performance is good, because the achievement is still below the standard set at 60 %. Optimization of RTG in 2024 obtained a YOR value of 16 % with condition that the RTG operates as many as 7 unit.

KEYWORD: *Optimization, Rubber Tyred Gantry, Containers, Port.*

1. INTRODUCTION

A primary function of port operations or a containers terminal to set up an equipment and adequate facility to enable loading and unloading activities (Prasetyo, et. al, 2014). The container terminal is an important preresiquite to the global logistics network of packing goods (Baird, 2006). The ability to provide maximum logistics service has become an important issue for the survival of ports, while creating added value and meeting of customers needs (Juang & Roe, 2010).

The Port of Tenau Kupang is the largest port in the southern part of Indonesia, which is located on the island of Timor, East Nusa Tenggara Province. There are several docks in Tenau Kupang such as fast boat docks, passenger docks, container docks, cargo docks, and fish docks. The port of Tenau Kupang is the only containers terminal located in the provincial capital of East Nusa Tenggara, and the first to be equipped with the most modern loading and unloading equipment at ports in East Nusa Tenggara to boost the economy and streamline logistics flows in the East Nusa Tenggara Province area.

The flow of containers at the Tenau Kupang port always increases every year, in 2009 there were 49,809 boxes at Tenau Kupang, an increase to 54,751 boxes in 2010, and in 2011 there was an increase to 56,708 boxes. Due to the increase every year, there was an additional 2 units of rubber tyred gantry (RTG) on October 12, 2011 (Bisnis.com, 2012). The flow of containers at the port of Tenau Kupang has increased every period, during the January-May 2018 period, the container flow reached 40,583 TEUs compared to the January-May 2017 period, the container flow was 38,947 TEUs (antaranews.com, 2018). Meanwhile, for the period June-October 2018 the flow of containers increased, including 53,414 boxes or 57,224 TEUs compared to 2017 in the same period of 50,557 boxes or 53,229 TEUs (Bisnis.com, 2018).

Averages of shiping continers that enter each week are about five with the capacity each ship loaded with 400 containers. Improved the flow the containers supported operating 2 containers untis of crane (CC) operating 24 hours, inside one hour this device could unload as many as 26 containers (Bisnis.com, 2018), and there were 4 units of Rubber Tyred Gantry (RTG) and two berth ships were loaded at the same time, because of this its is important that studies be made to know how is the yard perfomance of the buildup (yard occupancy ratio / YOR) and the yard area buildup at present. The objective is to deride operational perfomance in the buildup field (yard occupancy ratio/YOR) and the general field of buildup available at present according to Director General of Sea Transpot number :HK 103/DJPL-16 about the port's operating service perfomance standards, which relate to the level of field use.

2. MATERIAL AND METHODS

Containers Terminal

The terminal facilities are at least equipped with moorings, docks, containers yards and appropriate equipment for loading and unloading of containers (Triatmojo, 2010). The need for package delivery has been abundant and has increased volume over the years and is quite efficient (Nurhadini and Indrayadi, 2018).

The terminal is responsible for moving containers from land to sea transportation or vice versa (Setiawan et.al, 2016), but this activity is a derivative of transportation activities so that the smooth flow of containers at the terminal is more influenced by external factors such as (Supriyono, 2010) :

1) The delay in which the ship comes into the port is due to various factors such as changing the waether conditions of the tides, abrupt diversions of routes, or other damage
2) When a container is late in the terminal, it is also the result of such things as an accident, a traffic jam, or an incomplete document, etc.
3) The area of available containers stacking field,
4) Damage to supporting equipment facilities, such as forklifts, trucks and others,

A container terminal is a temporary stroage area where a container is anchored in the dock area, lifting the container yhat enters and lowering the container that is come out (Rizal and Kumalawati). The terminal includes a warehouse for the temporary storage of the incoming containers. Figure 1 shows a schematic representation of operations and equipment at the container terminal, including container cranes for loading and unloading from ships to quayside, trucks and trailers for carrying containers within the terminal area, and a rubber gantry crane (RTG) for stacking containers at the storage yard. (Guven, 2014).

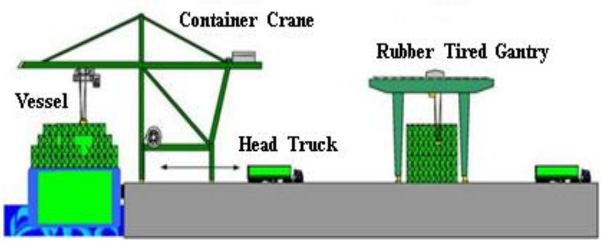

Figure 1: Operational Schematics On the Container Terminal.

Container's Flow

Loading and unloading data container acquired from PT. Pelabuhan Indonesia III (Persero), which is dated 5 (five) of the last year. From 2015 to 2019. The data used calculate of the number of containers going in and out for a year the following data was provided on container loading and unloading charts in the Port of Tenau Kupang.

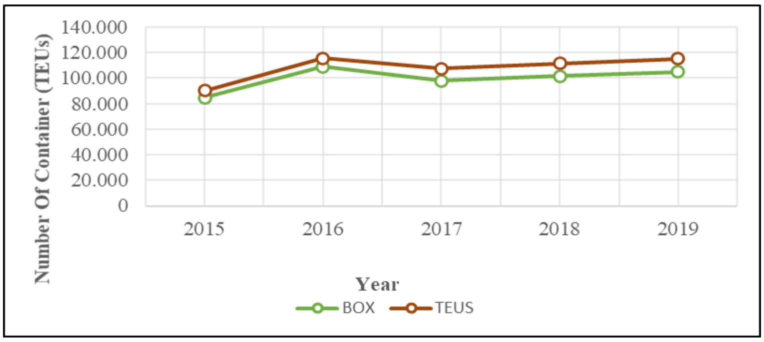

Figure 2: Container Loading Charts in Port of Tenau Kupang.

Based on y= 4.579,70 x – 9.128.189, 90 recovered from the above, it is possible to calculate the current container rate by 2024.

Table 1: Container Streams Estimated At Tenau Kupang Port.

Year	Container Current Estimates (TEUs)
	y = 4.579,70 x – 9.129.189,90
2020	121.804
2021	126.384
2022	130.964
2023	135.543
2024	140.123

Source : *Analysis results*

Containers current data in 2024 that were later used to calcuate the perfomance of Rubber Tyred Gantry (RTG).

Contianer Terminal Facilities

Facilities and equipments of Tenau Kupang containers terminal can be seen at the following table:

Table 2: Container Terminal Facilities at Tenau Kupang Port.

No	Facilty Name	Dimensions			
1.	Multipurpose Pier	Long	:	237	Meter
		Wide	:	20	Meter
		Depth	:	-14	MLWS
2.	Nusantara Pier	Long	:	223	Meter
		Wide	:	15	Meter
		Depth	:	-12	MLWS

3.	The Courtyard buildup	Area	:	30.000	M^2
		Capacity	:	8.075	TEUs
4.	Tools				
	Container Crane		=	2	Units
	Reach Stacker		=	4	Units
	Forklift 5T		=	1	Unit
	Forklift 10T		=	1	Unit
	Mobile Crane 150T		=	1	Unit
	Rubber Tyred Gantry		=	4	Units
	Head Truck		=	6	Units

Source : *Kupang Containers Terminal.2020*

METHODOLOGY

To analyze the increase in perfomance of the Rubber Tyred Gantry (RTG) with larger targets, using Genetic Algorithms Particle Swarm Optimization Method (GA-PSO). One of the Genetic Algorithm advantages is does not require too many mathematical requirements in the completion of the optimization process (Santosa, 2011). The results of the genetic algorithm in each of its best generations can be used as an alternative decision support system. In general, the flow diagram of the optimization completion process with GA-PSO method (Purnomo, 2014), can be seen in Figure 3 below.

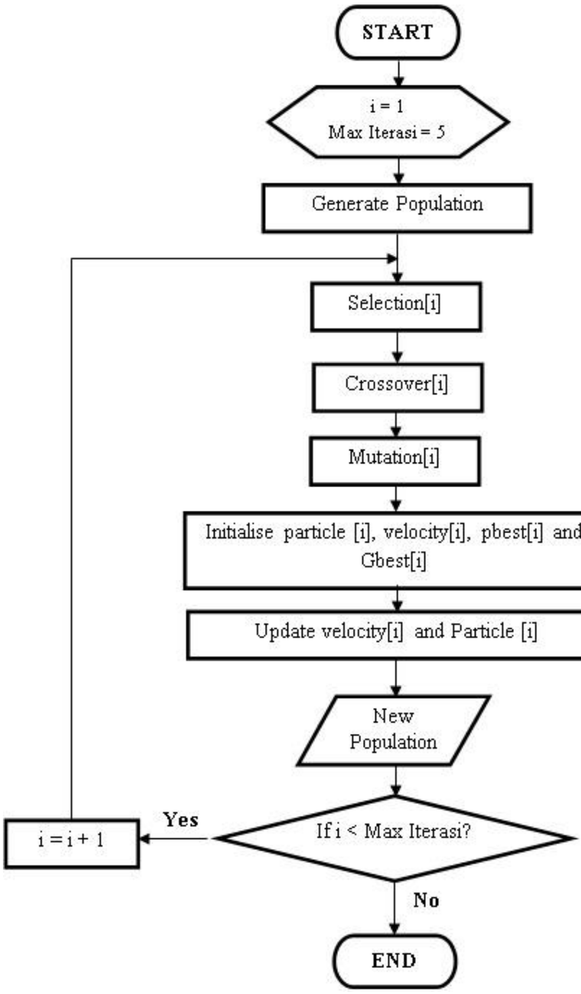

Figure 3: Process of GA-PSO.

3. RESULTS AND DISCUSSIONS

Fitness Function

Value of *f* (x) = YOR (*Yard Occupancy Ratio*)

$$YOR = \frac{(Teus\ x\ Dwelling\ Time)}{Slot\ x\ Tier\ x \frac{Container}{Slot}\ x\ days/Year}\ x\ 100\% \quad ....(1)$$

Explanation:

Slot/RTG = Gen-1 = X1

Tier = Gen-2 = X2

Container/Slot = Gen-3 = X3

$$Fitness(x) = \frac{1}{f(x)} \quad ....(2)$$

Tabel 3: Generate Population GA Iteration -1.

Early Population

Chromosome	Gene-1 (*Slot/RTG*)	Gene-2 (*Stack*)	Gene-3 (*Container*/Slot)	F(x) (%)	Fitness(x) (%)
1	6	3	675	18.95795704	0.0527483
2	7	3	700	15.66933184	0.0638189
3	5	2.5	700	26.3244775	0.0379875
4	5.5	3.5	600	19.94278598	0.0501434
5	6.5	2.5	650	21.80725946	0.0458563

Selection

a. Calculating probability on each chromosome.

$$Prob_i = \frac{Fitness(x)_i}{\sum_{i=1}^{n} fitness(x)_i} \quad \text{.....(3)}$$

b. Calculating the cumulative probability of each chromosome .

$$Kum_i = Kum_i + \sum_{i=1}^{n} Prob_i \quad \text{.....(4)}$$

c. Brings up random numbers 0 to 1.

d. Selecting the parent selection will serve with the crosover to provide the offspring as follows :

$selection_i = random_i \geq cumulative_j$ ……..(5)

$selection_i = cumulative_j$ ....(6)

Table 4: Temporary Results After Selection.

The Results Of Changes To The Population After The Selection				
chromosome	Gene-1 (*Slot/RTG*)	Gene-2 (*Stack*)	Gene-3 (*Container*/Slot)	F(x) (%)
1	5.5	3.5	600	19.94278598
2	6	3	675	18.95795704
3	7	3	700	15.66933184
4	5.5	3.5	600	19.94278598
5	7	3	700	15.66933184

The population changes after the selection look like the table above with a chromosome the *f*(x) value is most optimal on chromosome (3) and (5) on which an f(x) score was obtained by 15,669%≈ 16% on conditions of slot RTG (Gen-1)= 7 units, vertically stack of container/slot (Gen-3)= 700 container.

Crossover

Table 5: The Process Of Crossover.

Crossover R ≤ 0,3

Chromosome	Random	Parent Selection
1	0.030277031	1
2	0.077795719	1
3	0.445135873	0
4	0.304276714	0
5	0.248143571	1

Crossover R≤0,3 value, the chosen chromosome as the best chromosome in the process cross-breeding is a chromosome (1) and (2), where the value of random chromosomes (1) is 0,0303 with a parent 1 selection value, whereas the value of random chromosomes (2) is 0,0778 with a parent selection value 1.

Table 6: The Interim Results Of Crossover.

The Results Of Population Change After Crossover				
Chromosome	Gene-1 (*Slot/RTG*)	Gene-2 (*Stack*)	Gene-3 (*Container*/Slot)	F(x) (%)
1	5.5	3.5	600	19.94278598
2	6	3	675	18.95795704
3	5.5	3.5	600	19.94278598
4	7	3	700	15.66933184
5	7	3	700	15.66933184

The preliminary results of crossover population change, show that the best chromosome with an f(x) is minimam on chromosome (4) and (5) with a condition of slot/RTG (Gen-1)= 7 units, vertical containers (Gen-2) piles an number of containers/slots (Gen-3)=700 containers.

Mutation

Table 7: Parent Selection Process is Affected by Mutation.

Mutation R ≤ 0,1				
Chromosome	R1	R2	R3	Parent Selection
1	0.03266	0.3837	0.75274	
2	0.81019	0.711283	**0.02908**	R3
3	**0.09282**	**0.012388**	0.51222	R1;R2
4	0.682382	0.92374	0.14928	
5	0.7912	0.13867	0.63878	

Value R ≤ 0,1, then chromosome that are selected are chromosome are (2) and (1)

Table 8: A Mutation Process.

The Results Of Population Change After Mutation				
Chromosome	Gen-1 (*Slot/RTG*)	Gen-2 (*Stack*)	Gen-3 (*Container*/Slot)	F(x) (%)
1	5.5	3.5	600	19.94278598
2	6	3	800	15.99577626

3	4	2	600	47.98732877
4	7	3	700	15.66933184
5	7	3	700	15.66933184
Optimal	**7**	**3**	**700**	**15.66933184**

The iteration of the *Genetic Algorthim* (GA) is completed with initial conclusions that the value of chromosome (4) and (5) who have an f(x) 15,6693 was chosen for *fitness* value criteria.

Particle Initialization

Table 9: Generate Population PSO Iteration-1.

Populasi Awal			
Index	**α (X1) (*Slot/RTG*)**	**Q (X2) (*Stack*)**	**L (X3) (*Container*/Slot)**
1	5.5	3.5	600
2	6	3	800
3	4	2	600
4	7	3	700
5	7	3	700

The first generation of PSO, derived from the best mutataed chnages in the 1st. After the early generation were formed, the *fitness* evaluations of each of the particulars appeared on the table.

Table 10: Fitness Evaluation.

Function Evaluation				
Index	**F(X1(0)) (*Slot/RTG*)**	**F(X2(0)) (*Stack*)**	**F(X3(0)) (*Container*/Slot)**	**Result (F) (*%*)**
1	5.5	3.5	600	19.942786
2	6	3	800	15.9957763
3	4	2	600	47.9873288
4	7	3	700	15.6693318
5	7	3	700	15.6693318

The *fitness* selected as the best index with the best grades (F) is 15,6693% ≈ 16% which are index (4) and (5) with an F (X1) slut/RTG= 7 units, whereas F (X2) vertical container piels= 3 stack, and F (X3)= container/slot = 700 container.

Speed Update

Table 11: Particle Speed Update.

Calculate Speed			
Index	**V1(1)**	**V2(1)**	**V3(1)**

1	0.75	-0.25	50
2	0.5	0	-50
3	1.5	0.5	50
4	0	0	0
5	0	0	0

Calculating speed update with valu R1= 0,1 and R2= 0,1 will be selected for best index (4) and (5).

Function Value Evaluation

Table 12: Evaluating The Function Of Each Particle.

Particle count				
Index	**X1(1) (*Slot/RTG*)**	**X2(1) (*Stack*)**	**X3(1) (*Container*/Slot)**	**Fx (*%*)**
1	6.25	3.25	650	17.44580757
2	6.5	3	750	15.74968739
3	5.5	2.5	650	25.77221573
4	7	3	700	15.66933184
5	7	3	700	15.66933184
Optimal	**7**	**3**	**700**	**15.66933184**

After a maximum of 5 iteration count by using hybrids method GA-PSO perfomance approach (YOR) to Rubber Tyred Gnatry (RTG) device, analysis is perfomed in the same way as producing patterns in each generation or inetractions as seen at the table as follows:

Table 13: Recapitulation Of The Iteration Of Results GA-PSO on the RTG.

Genetic Algorithm					Particle Swarm Optimization					
Iteration	**Gen-1** ($\frac{Slot}{RTG}$)	**Gen-2** (*Stack*)	**Gen-3** ($\frac{Container}{Slot}$)	**Fx** (*%*)	**R1**	**R2**	**X1** ($\frac{Slot}{RTG}$)	**X2** (*Stack*)	**X3** ($\frac{Container}{Slot}$)	**Fx** (*%*)
1	7.00	3.00	700.00	**15.6693**	0.3	0.5	7.00	3.00	700.00	**15.6693**
2	7.00	3.50	700.00	**13.4309**	0.3	0.4	8.50	3.70	750.00	**9.76531**
3	8.50	3.70	750.00	**9.76531**	0.2	0.5	10.00	4.40	800.00	**6.54373**
4	8.93	3.28	795.00	**9.91245**	0.2	0.6	10.43	3.98	845.00	**6.57806**
5	10.40	3.60	810.00	**7.5953**	0.2	0.5	11.90	4.30	860.00	**5.23424**
Source : Analysis Results										

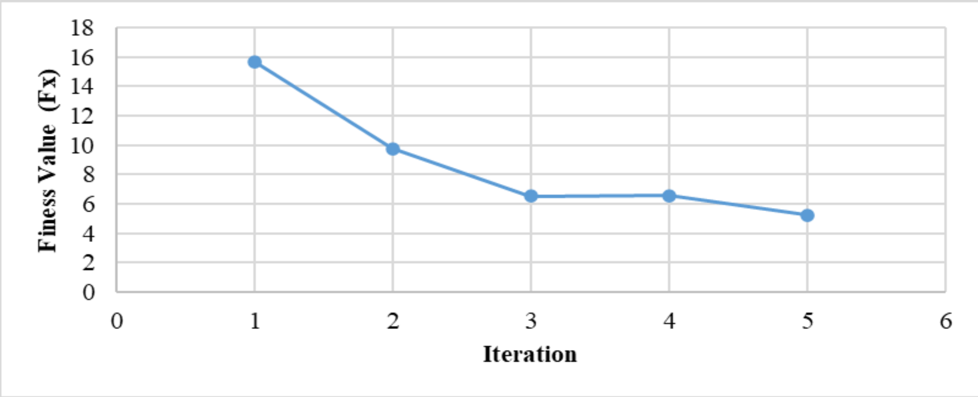

Figure 5: Results of RTG Optimization with GA-PSO Method.

4. CONCLUSION

From the results of the above discussion, it could be summarized as follows :

1) Rubber Tyred Gantry (RTG) optimization acquired by value *yard occupancy ratio* showed that of the 5 iterations perfomed in 2024 qualifyng fitness values from predetermined standards considering both the number of tools and the yardwork area and stacking and the stack method, the fitness value of 15,6693 or fintess value (*f*x) 16%.
2) Based on the optimization results of the rubber tyred gantry (RTG) in 2024, a fitness value (*f*x) of 16% is obtained with the condition that the number of rubber tyred gantry that must be added is 3 units so that the total rubber tyred gantry operating is 7 units, there are 7 slots with the 3 stack method and fill each slot as much as 700 containers/slots and it takes a land capacity of 14.700 boxes or 10.500 TEUs.

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