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Application of Particle Swarm Optimization Method in Fleet Transportation Systems of Two-Wheeled Automotive Industry

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ABSTRACT

One of the activities in the supply chain system in the motorcycle industry is the process of sending components or spare parts from vendors to motorcycle assembly plants. Delivery of spare parts using the respective vendor's fleet. Along with the increase in market demand, demand for components from vendors has also increased. This has an impact on increasing the number and frequency of fleets entering the factory area, besides that there is also an increase in transportation costs from Vendors. This study aims to make efficiency in the number, frequency and cost of fleet transportation by using the VRP (Vehicle Routing Problem) approach. To get optimal results, the PSO (Particle Swarm Optimization) method was used by utilizing the Matlab 2020 software. This research involved 40 vendors, logistics partners and motorcycle assembly factories. The results of this study showed better results, namely before the research was carried out the number of fleets was 40 units and the delivery frequency were 40 times with a total shipping cost of IDR 2,769,330. Meanwhile, after conducting research using the PSO optimization method, it was obtained that the number of delivery frequency fleets was 8 times with a total shipping cost of IDR 2,679,113.

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1. INTRODUCTION

The activities of the motorcycle industry in Indonesia include the processing of raw materials into finished goods in the form of motorcycles that are ready to be marketed throughout Indonesia and abroad. One of the activities in the motorcycle industry in Indonesia is of course having vendors who supply raw materials [1] . In the delivery process, suppliers or suppliers need transportation facilities in the form of a fleet of trucks with various types and models[2][3]

Transportation in the supply chain system in the motorcycle industry has a very important role, among others, in carrying out the movement of goods, both goods in the form of raw materials, components, semi-finished goods and finished goods.[4]. The economic value of transportation in carrying out this role is moving inventory from the location of origin to a certain destination location in the supply chain management system. Transportation performance will have an impact on the performance of procurement, production and customer relationship management.

Based on the results of observations that the transportation equipment for sending components from vendors to factories uses the supplier's own transportation fleet or rents a fleet. The number of vendors that send components to the factory is 40 companies and the vendor's location is within a radius of 85 km from the factory location. One of the factors that affect the price of parts is the cost of transportation. Transportation costs incurred by 40 Vendors totaled Rp. 2,769,330 per day. In addition, problems related to Vendor fleets are queues or buildup in the Warehouse receiving area. This is due to the ever-increasing production needs causing the frequency of component delivery to also increase [5]. In addition, the problem is also the existence of rules that limit the time of receipt at the warehouse at certain times [6][7]

Based on several phenomena that occur, effective and efficient transportation is an important focus for the company because it has an impact on the company's finances. Thus, the company must carry out the right strategy to reduce all transportation costs. One strategy is the optimization of routes and distances using the Particle Swarm Optomization method through the VRP (Vehicle Routing Problem) approach. [2][8][9][10]. The research objective is

1. Optimizing the frequency of fleet arrivals

2. Efficient fleet transportation costs

This research is expected to provide benefits:

For research companies, this can reduce the number of fleets going in and out of the warehouse area and can reduce transportation costs incurred by vendors. The theoretical research benefits expected from the research results can be used as a reference or basis for further industrial engineering development for other researchers who conduct effective and efficient transportation studies.

A. METHOD

Vehicle Routing Problem (VRP)

The approach used is VRP (Vehicle Routing Problem). VRP is a problem in the distribution system that aims to create an optimal route for a group of vehicles whose capacity is known, expected to meet consumer demand with a known location and number of requests. An optimal route is a route that meets various operational constraints, including having the shortest total distance and travel time to meet

consumer demand and using a limited number of vehicles.[11]. To solve route problems, the fleet capacity factor (Capacitated VRP) must be considered, operational time limitations, pickup delivery parts (Pickup and Delivery) VRP) [9][12], the process of returning the facility from the warehouse to the supplier (VRP with backhaul)[13][14]. To obtain optimal results, this study uses systematic steps to obtain the desired objective function as shown in Figure 2.1

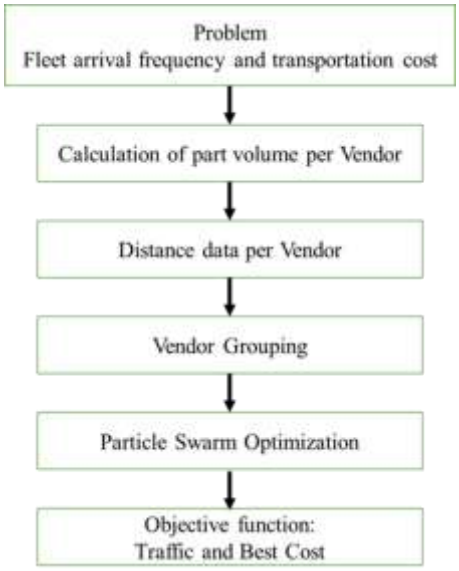

Figure 2.1 Research Framework

Particle Swarm Optimization (PSO)

Particle Swarm Optimization (PSO) is one of the evolutionary computational techniques, in which the population in PSO is based on a search algorithm and starts with a random population called particles. each particle in PSO is also associated with speed [15]. Particles move through space at dynamic speeds that adjust according to their historical behavior. PSO is similar to a genetic algorithm that starts with a random population in the form of a matrix [16].

A. Calculation of Area and Volume of Polybox per Part

$$TP = \sum_{i=1}^{N_t} D_t * OPt * Pr_t \quad (1)$$

$$PQty = \frac{TP * OP_t}{P_c} \quad (2)$$

$$PV = Ps(p) * Ps(l) * Ps(t) \quad (3)$$

$$PQV = PQty * Pv \quad (4)$$

Remark:

N_t : Number of types
D_t : Request Per type
OP_t : Percentage of orders
Pr_t : Product per type
TP : Total parts per type
P_{Qty} : Part Qty
P_C : Packing Content
P_v : Volume Part
P_{QV} : Part Qty Volume
$Ps_{v(p)}$: Long Part
$Ps_{v(l)}$: Wide Parts
$\boldsymbol{Ps_{v(t)}}$: High Part

B. Calculation of Polybox Needs per Day (Amount, Area and Volume) per Supplier

Vs = $\sum_{i=1}^{N_t} \boldsymbol{P_{Qv}}$ ..... (5)

Remark:

Vs : Volume Supplier/Vendors

PQv : Part Qty Volume

C. Fleet Capacity Calculation

Va = $\sum_{k=1}^{N_s}\left(\sum(\boldsymbol{V_s} < \boldsymbol{C_9}) + (\boldsymbol{V_s} < \boldsymbol{C_7})\right)$ k = 1,2, ……Ns …….. (6)

Remark:

Va : Fleet Volumes

C9 : Maximum Vehicle Capacity 9 meters

C7 : Maximum Vehicle Capacity is 7 meters

Ns : Number of Suppliers/Vendors

D. Distance Calculation (Pool1/2, Supplier, Factory)

Ja9 = $\sum\sum \boldsymbol{ecludean}\left(\boldsymbol{Jarak}(\boldsymbol{R_a})\right)$ ..... (7)

Ja7 = $\sum\sum \boldsymbol{ecludean}\left(\boldsymbol{Jarak}(\boldsymbol{R_a})\right)$ ..... (8)

JCa9 = Ja9 * Ca9

JCa7 = Ja7 * Ca7

Remark:

Distance : Distance Matrix (Distance between points using Google Map)

Ja9 : Fleet Distance 9

Ja7 : Fleet Distance 7

Ca9 : 9M Operating Costs

Ca7 : 7M Operating Costs

JCa9 : Fleet Cost 9M

JCa7 : Fleet Cost 7M

Ra : Fleet Route

E. Time Calculation

Wa9 = JCa9/ Fleet speed ..... (9)

Wa7 = JCa7/ Fleet speed ..... (10)

Remark:

Wa9 : Fleet Time 9M

Wa7 : Fleet Time 7M

F. Calculation of Fitness (Objective Function)

Cost = (JCa9 * J9) + (JCa7 * J7) ..... (11)

Minimize f = $\sum Cost$ ..... (12)

Remark:

JCa9 : Fleet Cost 9M

JCa7 : Fleet Cost 7M

J9 : Number of vehicles 9M

J7 : Number of vehicles 7M

Cost: Cost function

f : Fitness function

G. Supplier Grouping

Formula:

$\sum_{k=1}^{Ns} J_{k1} < J_{k2}$, ΣP1, ΣP2 ..... (13)

Remark:

K : Number of Suppliers 1,2,3, ……Ns

Jk1 : Supplier Distance -k to Pool-1

Jk2 : Supplier Distance -k to Pool-2

P1 : Pool-1

P2 : Pool-2\

H. Collect Data

The data collection process involves 40 suppliers, factories, logistics partners. The first part of the analysis phase is to collect some of the data needed for PSO analysis. These data include production requirement data/day, data on the need for parts per type, truck fleet capacity data and distance matrix. The data can be seen in Table 2.1, Table 2.2. Table 2.3 and Table 2.4.

Table 2.1 Production Requirement Data/Day

Engine production (type per day) (A)						
Type A	Type B	Type C	Type D	Type E	Type F	Total
4,100	1,150	1,900	350	250	2,100	9,850

Table 2.2 Data on the Need for Parts Per Type

SUPLIER	PART NAME	Standard using part per tipe (B)						% ORDER (C)	Requirement Part per Tipe A*B*C)						
		A	B	C	D	E	F		A	B	C	D	E	F	Total
ADI	SW ASSY, START IDLE	0	0	1	0	0	0	100 %	-	-	1,900	-	-	-	1,900
ADI	SW ASSY, DIM HORN WINKER	0	0	1	0	0	0	100 %	-	-	1,900	-	-	-	1,900

2.3. Truck Fleet Capacity Data

	Long	Wide	High	Square	Content
Pallet	110	110	12	12,100	145,200
Stack of polyboxes	100	100	100	10,000	1,000,000
Truck 9 meter	940	240	250	225,600	56,400,000
Truck 7 meter	750	240	245	180,000	44,100,000

A.

	Fleet 9 Meter	Fleet 7 Meter
Available capacity (cm3)	56,400,000	44,100,000
Maximum Palet (cm3)	4,320,000	3,360,000
Truck Effective Capacity (cm3)	52,080,000	40,740,000

Calculation of the distance between the Pool as many as 40 Vendors. Factory location determination based on Google Map. The following recapitulation of the distance between the 40 Vendors, pools and Factory can be seen in Table 2.4.

Table 2.4 Distance Matrix

	Pool1	Pool2	AHM	ADI	FNI
Pool1		41.40	14.60	13.50	15.90
Pool2	41.40		37.90	40.90	38.70
AHM	14.6	37.90		3.70	2.70
ADI	13.5	40.90	3.7		2.70
FNI	15.9	38.70	2.7	2.7	

Supplier Grouping is carried out based on the distance between the closest supplier to Pool 1 or Pool 2. This aims to reduce the distance and shipping route from the supplier to the Warehouse which involves 40 sVendors and logistics partners who have 2 different locations (1st Pool & 2nd Pool). As shown in table 2.5.

Table. 2.5 Vendor Grouping

Group	Vendors
Pool-1	1,2,3,4,5,6,7,8,10,12,18,19,20,21,22,23,24,26,28,29,30,31,32,33,34,35,36,37,38,39,40
Pool-2	9,11,13,14,15,16,17,25,27

2. RESULT AND ANALYSIS

Analysis with Particle Swarm Optimization Method (PSO)

Calculations with the Particle Swarm Optimization method with 500 iterations. Each iteration determines the optimal result. Following are the results of analysis with PSO (Table 3.1)

Table 3.1 Result of PSO

		Pool 1	Pool 2	Total
Cost Minimum (Rp)		1,854,823	824,290	2,679,113
Truck fleet requirements	9meter	4	1	5
	7meter	0	0	0
Number of Traffic (Frequency)		7	1	8

Based on the analysis of the Particle Swarm Optimization methods, optimal results are obtained. This analysis yields lower results in cost usage and the number of truck fleets required. The following is a comparison of total fleet traffic and operational costs per day for 40 Vendors can be seen in Table 3.2

Table 3.2 comparison of results before and after the study

	Preliminary data	PSO
Cost Minimum (Rp)	2,769,330	2,679,113
Truck fleet requirements (Unit)	40	5
Number of Traffic (Frequency)	40	8

The results of the PSO analysis show the number of trucks needed, the amount of traffic and transportation costs. The results of the analysis show that PSO is more efficient in producing the required number of truck fleets and transportation costs compared to the data before the study

Discussion

The research implications are

1. There are no transportation costs incurred by the supplier because it has been replaced by a logistics partner who picks up components to the supplier and delivers them to the factory warehouse.

2. The supplier's part price has fallen because the transportation cost component has disappeared.

3. There are savings in transportation costs from the difference in supplier costs minus partner logistics costs

However, this research can still be developed with an IoT approach as was done by [17] to monitor fleet movement communications. The results of this study can also be used as a source of information for saving on fuel consumption[18]

Conclusion

The conclusion obtained in this study is that there is a decrease in:

1. Total Traffic from 40 times to 8 times or down 80%

2. Transportation costs from IDR 2,769,330 per day to IDR 2,679,113 per day or a decrease of 3,25%

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