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OPTIMIZATION OF DISTRIBUTION COST OF 3KG GAS CYLINDER AT PT. GEMILANG PUTRA SEJATI USING THE NORTH WEST CORNER, LEAST COST, AND VOGEL APPROXIMATION METHOD

Nugroho Dimasuharto, Ade Momon Subagyo
Industrial Engineering Study Program, Faculty of Engineering,
Singaperbangsa University, Karawang
Jl. HS.Ronggo Waluyo, Puseurjaya, Telukjambe Timur District., Karawang Regency, West Java 41361
Email: nugrohodimas5@gmail.com

Abstract : *Gas cylinder 3 Kg is one of the elements that is quite important to meet Indonesia's food needs, especially in the use of gas stoves for cooking. This study aims to solve the problem of the cost of shipping 3 Kg gas cylinders at PT. Gemilang Putra Sejati as a gas cylinder distributor company in the Bekasi Regency area. The gas cylinders are stored in warehouses located in 3 sub-districts, namely West Cikarang, Setu and Cibitung, which will be distributed to 5 main agents. Delivery of gas cylinders uses land transportation in the form of 3-wheeled pick-up motors. Shipping costs are calculated based on the total distance from the warehouse to the agent using 3 transportation models, namely the NWC, Least Cost, and VAM methods. The results of the calculation of distribution costs using the NWC method are Rp. 41,760, Least Cost method of Rp. 34,400, and the VAM method of Rp. 33,990. Furthermore, the VAM method is carried out with the final solution using the Stepping Stone method with the result of Rp. 30,090. Then the VAM method can be applied to the companies.*

Keywords : *Optimization, Distribution, VAM method, Least Cost Method, NWC method.*

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1. Introduction

The increasing competition in the business world in the era of globalization has begun to affect the three main components of gas cylinder suppliers and distributors such as PT. Gemilang Putra Sejati, namely time, cost, and also quality. The need for an increase in service to a company in addition to maintaining the performance that has been achieved. One of the supporting factors is service distribution of products from companies to consumers with distance, time and cost effective. The elements that affect the smoothness of a distribution process include the determination of distribution costs. To achieve this goal, PT. Putra Gemilang Sejati must be able to arrange in various ways so that all costs are used to control between the company's revenue and expenses. Operational costs are one of the costs that are considered by the company. For service companies and manufacturing companies, operating costs are absolute costs.

To minimize transportation and product distribution costs, companies must pay attention to the existing transportation network system. In terms of effectiveness, security, high accessibility, integration, easy to reach, orderly, stable, fast, on time, affordable, comfortable, safe and orderly, low pollution and efficiency, the system transportation network is effective in this practical sense in the system network transportation. Distribution and good transportation are important for the company, so that the product can reach consumers on time at a predetermined location and also, the products are in good condition. The distribution of products from one source to many destinations is of course not an easy problem, due to the presence of several distribution destination points, the product will also lead to more and more distribution channels. Surely this will have a significant impact on transportation costs.

PT. Gemilang Putra Sejati uses its own transportation in the product distribution business. The efficiency of transportation costs with transportation methods is considered appropriate to make optimal cost decisions in an operational delivery of goods. Therefore, if using least cost, NWC (North West Corner Method) and VAM (Vogel Approximation Method) as an initial adjustment, then using the Stepping Stone method as the final adjustment, it can be determined the minimum cost of company expenses. Aim to be able to find out the comparison of total distribution costs for gas cylinder shipments for gas cylinder companies through the above transportation methods. The purpose of the method of transport is to distribute the goods in the original warehouse in a way that meets all the needs of the branch warehouse in the destination area, At the same time, the core purpose of the transportation problem here in order to obtain the lowest cost or maximize profits.

2. Literature Review

Optimization

According to (Sugioko, 2013) optimization is a mathematical discipline whose focus is to systematically obtain minimum or maximum values from functions, opportunities, or the search for other values in various situations and cases. Mathematical optimization is a method for obtaining the limit value, which is the minimum or maximum value of a particular function with a limiting factor. Companies need optimization, to optimize the resources used to produce the expected quantity and quality. The next optimization step, determining the problem and determining the goal, then the next step is to create a mathematical model, the model includes 3 (three) stages, namely determining unknown variables and making it into the mathematical model, thus forming an objective function, which is displayed as a decision variable. The linear relationship of the problem is determined and all problem constraints are expressed in terms of equations or inequalities. This is a linear relationship of the decision variables which reflects the limited source of the problem.

Distribution

Distribution is the process of moving goods from where the goods are produced to various places or areas that need these goods. According to (Kotler, 2012) distribution will include planning, implementing, and monitoring material flow by obtaining profits from the final product from the production site. An important aspect of product distribution is transportation costs, and transportation costs can be affected by transportation. The shorter the marketing and distribution process time is influenced by the distance from the producer to the consumer, which means the longer the distance between the producer and the consumer, the

longer the channel the product goes through. In order to function, in day-to-day operations of assets must implement strategies based on supply chain structures and automation. The process involved is how to deliver the right product to the right outlet and the right customer at the right time. PT. Gemilang Putra Sejati in its distribution has 3 warehouses located in the Bekasi Regency area, including in West Cikarang, Setu, and Cibitung Districts. In the gas cylinder distribution process, the gas cylinder will be distributed from the warehouse to five main agents in five villages, namely, in the villages of Mekarwangi, Lubang Buaya, Cibuntu, Telajung and Lambang Sari.

Transportation Model

Transportation is a means to progress and develop an area. Transportation can improve the ease of accessibility from one area to another. Effective production process, investment continuity and technological development, as well as value creation and market are supported by good transportation system. Transportation issues are related to optimizing distribution from supply centers such as supply centers to receiver centers with strategies that can minimize costs as well as time (Raigar Sarla, 2017). PT. Gemilang Putra Sejati uses transportation owned by the warehouse, namely a three-wheeled pick up motor with a capacity of one transport reaching 80 gas cylinders. The procedure for completing this transportation is carried out in 3. (three) stages, namely compiling a transportation and distribution matrix, determining a feasible initial solution and conducting an optimization test. In this study a matrix was prepared to ensure that the warehouse capacity of PT. Gemilang Putra Sejati which is in the warehouse in balance with the agent's request. Then the initial completion table was determined using the Northwest Corner transportation method, the Least Cost Method, and the Vogel Approximation Method which was then continued with the optimization testing phase. If the above method has been applied, the next step is to compare which method has the minimum distribution cost results for optimization testing using the Stepping Stone method. If the optimization test results show an optimal distribution, then the distribution has reached the minimum value or the best solution.

3. Research Method

This research belongs to the type of applied research. Because it is directly integrated with field studies, then researchers can collect data that will later be used directly in this research in the corporate environment. The type of data to be used is quantitative data, with the data used coming from the original data source. Products that are distributed are 3 Kg gas cylinder. In this study, observations were made in all warehouse areas. The elements of the transport costs that are calculated are the cost of the distance from the warehouse to the main agent, and the cost of fuel used during the expedition. Observation time for one month. Data was collected through observation and interviews with related parties, the main data was collected from the expedition and from the administration department. The research process will be carried out in several stages, namely:

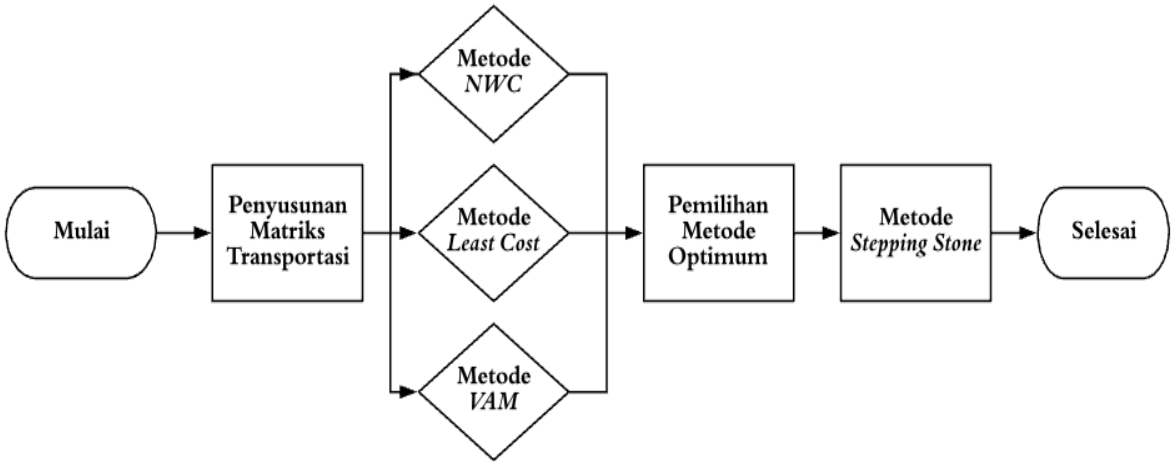

Figure 1. Flowchart Research

4. Result and Discussion

PT. Gemilang Putra Sejati in its distribution has 3 warehouses located in the Bekasi Regency area, including in Cikarang Barat, Setu, and Cibitung Districts. In the gas cylinder distribution process, the gas cylinder will be distributed from the warehouse to the five main agents located in five villages, namely, in the villages of Mekarwangi, Lubang Buaya, Cibuntu, Telajung and Lambang Sari. In its distribution, each warehouse has a different storage stock and also a different demand, here is a table of supply and demand for 3 Kg gas cylinder which is shown in Table 1.

Table 1. Supplies Warehouse Data and Agent Requests

Supplies Warehouse		**Agent Requests**	
Warehouse	Amount (unit)	Agent	Amount (unit)
West Cikarang	240	Mekar wangi	140
Setu	350	Lubang Buaya	200
Cibitung	260	Cibuntu	180
		Telajung	160
		Lambang Sari	170
Total	850	Total	850

In distribution, transportation or vehicles are needed to distribute the product. In the distribution of the gas cylinder, PT. Gemilang Putra Sejati uses warehouse transportation, namely a three-wheeled pick-up motorbike with a one-time capacity of up to 80 gas cylinders, with a total warehouse inventory in the three warehouses of PT. Gemilang Putra Sejati as many as 850 gas cylinders and the total number of requests for the five agents was 850 gas cylinders. The following is the product and vehicle specification data used by PT. Gemilang Putra Sejati in the distribution of 3 Kg gas cylinder in the Bekasi district is shown in table 2.

Table 2. Vehicle and Product Specification Data

Vehicle	**3-wheeled pick up motor**
Fuel	Pertalite
Vehicle Dimensions	1600 x 1250 x 3100 (mm)
Product	Gas cylinder 3kg
Product Dimensions	260 x 260 x 300 (mm)
1x delivery capacity	80
1 liter of gasoline	30 km
Gasoline Price / Km	Rp. 7650 : 30km
	Rp.255

Data on the cost of transporting shipments from warehouses to agents is a cost related to the cost of the gas cylinder itself. Transportation costs incurred is the cost of delivery of every 80 gas cylinders from three warehouses to the agent 1Km / l with a result of Rp. 255. Here is Table 3 which shows transportation cost data:

Table 3. Transportation Cost Data

Source	**Destination**	**Distance (round-trip) /Km**	**Total Cost**
Cikbar Warehouse(G1)	Mekar wangi	8	Rp. 2040
	Lubang Buaya	14	Rp. 3570
	Cibuntu	10	Rp. 2550
	Telajung	16	Rp. 4080
	Lambang Sari	17	Rp. 4500
Setu Warehouse (G2)	Mekar wangi	10	Rp. 2550
	Lubang Buaya	6	Rp. 1530
	Cibuntu	16	Rp. 4080
	Telajung	6	Rp. 1530
	Lambang Sari	16	Rp. 4080
Cibitung Warehouse (G3)	Mekar wangi	18	Rp. 4590
	Lubang Buaya	18	Rp. 4590
	Cibuntu	8	Rp. 2040
	Telajung	20	Rp. 5100
	Lambang Sari	14	Rp. 3570

The data above is the total cost of transportation resulting from the multiplication of the round-trip distance and the cost per 1 km / l, which is Rp. 255. This study performed manual data processing which consisted of several stages. The transportation methods used to process

the data are the North West Corner method, the Least Cost method, and the Vogel Approximation method as initial solutions. After that it is compared to get the smallest transportation costs, which then the method chosen will be proven by the final settlement using the Stepping Stone method. The following is table 4 and table 5 which show the results of the North West Corner method.

Table 4. NWC Transport Table

Destination / **Source**	**A1**	**A2**	**A3**	**A4**	**A5**	**Supply**
G1	2040	3570	2550	4080	4500	**240**
	140	100				
G2	2550	1530	4080	1530	4080	**350**
		100	180	70		
G3	4590	4590	2040	5100	3570	**260**
				90	170	
Demand	**140**	**200**	**180**	**160**	**170**	**850**

Table 5. NWC Cost Result Table

Delivery of 80 gas cylinder / one delivery (1> x <= 80)				**Delivery**	**Total cost**
G1	A1	100	Rp. 2040	2	Rp. 4.080
	A2	100	Rp. 3570	2	Rp. 7.140
G2	A2	100	Rp. 1530	2	Rp. 3.060
	A3	180	Rp. 2080	3	Rp. 6.240
	A4	70	Rp. 1530	1	Rp. 1.530
G3	A4	90	Rp. 4500	2	Rp. 9.000
	A5	170	Rp. 3570	3	Rp. 10.710
Total				**15**	**Rp. 41.760**

Based on the table above, the distribution costs using the NWC method obtained a total cost of Rp. 41,760. The following is table 6 and table 7 which show the results of calculating the transportation cost data using the Least Cost method.

Table 6. Least Cost Transportation Table

Destination / Source	**A1**	**A2**	**A3**	**A4**	**A5**	**Supply**
G1	2040	3570	2550	4080	4500	**240**
	140			10	90	
G2	2550	1530	4080	1530	4080	**350**
		200		150		
G3	4590	4590	2040	5100	3570	**260**
			180		80	
Demand	**140**	**200**	**180**	**160**	**170**	**850**

Table 7. Least Cost Result Table

Delivery of 80 gas cylinder / one delivery (1> x <= 80)				**Delivery**	**Total cost**
G1	A1	140	Rp. 2040	2	Rp. 4080
	A4	10	Rp. 4080	1	Rp. 4080
	A5	90	Rp. 4500	2	Rp. 9000
G2	A2	200	Rp. 1530	3	Rp. 4590
	A4	150	Rp. 1530	2	Rp. 3060
G3	A3	180	Rp. 2040	3	Rp. 6120
	A5	80	Rp. 3470	1	Rp. 3470
Total				**14**	**Rp. 34400**

Based on the table above, the distribution costs with the Least Cost method obtained a total cost of Rp. 34,400. The following is table 8 and table 9 which show the results of calculating the transportation cost data using the Vogel Approximation Method.

Table 8. VAM Transport Tables

Destination / Source	**A1**	**A2**	**A3**	**A4**	**A5**	**Supply**
G1	2040	3570	2550	4080	4500	**240**
	140	10			90	
G2	2550	1530	4080	1530	4080	**350**
		190		160		
G3	4590	4590	2040	5100	3570	**260**
			180		80	
Demand	**140**	**200**	**180**	**160**	**170**	**850**

Table 9. VAM Cost Result Table

Delivery of 80 gas cylinder / one delivery (1> x <= 80)				Delivery	Total Cost
G1	A1	140	Rp. 2040	2	Rp. 4080
	A2	10	Rp. 3570	1	Rp. 3570
	A5	90	Rp. 4500	2	Rp. 9000
G2	A2	190	Rp. 1530	3	Rp. 4590
	A4	160	Rp. 1530	2	Rp. 3060
G3	A3	180	Rp. 2040	3	Rp. 6120
	A5	80	Rp. 3570	1	Rp. 3570
Total				**15**	**Rp. 33.990**

Based on the table above, the distribution costs with the Vogel Approximation Method obtained a total cost of Rp. 33,990. It can be concluded that the VAM method produces the minimum cost compared to the North West Corner method and also the least cost. Hence, the Vogel Approximation Method is the method chosen in the initial settlement method because it gets the smallest cost. The VAM method needs to be proven by final completion using the Stepping Stone method to prove the optimum result or not. The results obtained from the Stepping Stone method have reached the optimum path in table 10 and also get the minimum distribution costs shown in table 11 as follows.

Table 10. *Stepping Stone* Table

Destination / Source	A1	A2	A3	A4	A5	Supply
G1	2040	3570	2550	4080	4500	**240**
	140	10	90			
G2	2550	1530	4080	1530	4080	**350**
		190		160		
G3	4590	4590	2040	5100	3570	**260**
			90		170	
Demand	140	200	180	160	170	**850**

Table 11. Stepping Stone Cost Table

Delivery of 80 gas cylinder / one delivery (1> x <= 80)				**Delivery**	**Total cost**
G1	A1	140	Rp. 2040	2	Rp. 4080
	A2	10	Rp. 3570	1	Rp. 3570
	A3	90	Rp. 2550	2	Rp. 5100
G2	A2	190	Rp. 1530	3	Rp. 4590
	A4	160	Rp. 1530	2	Rp. 3060
G3	A3	90	Rp. 2040	3	Rp. 6120
	A5	170	Rp. 3570	1	Rp. 3570
		Total		**15**	Rp. **30.090**

5. Conclusion

Distribution of 3 Kg gas cylinder at PT. Gemilang Putra Sejati get optimal results. Based on the results of the research and discussion above, it can be concluded that among the three transportation methods of the North West Corner, Least Cost, and Vogel Approximation Method, the Vogel Approximation Method is the most optimal method among the other two methods with the minimum cost of Rp. 33,900. Then the VAM method is chosen to be the method where the final adjustment is made using the Stepping Stone method which gives more optimum results with a final distribution cost of Rp. 30,090.

Suggestion

Based on the results of research on the optimization of gas cylinder distribution costs using transportation methods, there are several constructive suggestions including, PT. Gemilang Putra Sejati is expected to use the Vogel Approximation Method (VAM) to calculate distribution costs. The next researcher is expected to be able to carry out research on transportation methods in both similar businesses and other business fields in the development of a goods distribution system.

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