Analysis Of 3 Kg LPG Determination Route Decision Using Nearest Neighbor Algorithm And Local Search Method

Mitha Istia Mulyadewi, Handriyono, Fiona Niska Dinda Nadia

Abstract: These the problem of product distribution has to be overcome by concerning on economic value in it. The determination of 3 kg LPG (Liquified Petroleum Gas) distribution route which is only based on the experience of driver and kernet of delivery vehicle will give impact improper route determination. Thus, it causes waste of time, energy and costs. The determination strategy of distribution route plays an important role to achieve the aim of time effectiveness and cost efficiency. The methods of nearest neighbor and local search can become the alternative to solve the problem of 3 kg LPG route determination. This mehod used the approach of distribution location determination which has the nearest distance. Distribution route based on analysis result showed in 1 week period, there was minimization of mileage of 146.04 Km. The completon time was 230.31 minutes faster and cost savings of IDR 118.657,-. The application of nearest neighbor and local search methods are good alternative from economic aspect in determining the determination strategy of 3 Kg LPG route.

Index Terms: Vehicle Routing Problem, Nearest Neighbor, Local search.

1 Introduction

COMPETITIVE advantage can be assessed through internal and external source owned by a company [1]. there are five main dimensions affecting competitive advantage of a company, such as the reliability in delivering the product [2]. Supply Chain Management is set of activities including raw material distribution process from supplier until it is conducted transformation process of finished goods then it is delivered to customer [3]. The reliability of company in shipping/delivering these products is included in the Downstream Supply Chain Management concept. It is the activity of storing, distributing and marketing products to consumers [15]. The success of the distribution process will be achieved if it is carried out in a timely manner and using economic costs. Transportation performance in the shipping process contains 5 interrelated elements, including the charge, vehicle, route, destination, and management used [20]. The distribution process of 3 kg LPG carried out in several distributor companies is conducted on the basis of the personal experience of the delivery vehicle driver. It is not conducted the measurement to determine the distribution route which can be assessed for its effectiveness. Therefore, it can be possible during the process of distributing shipping vehicles to travel too far, using too long time, and spending too much money. The problem in this research is how to determine the distribution route of 3 kg LPG gas in an effort to minimize the mileage, completion time, and fuel costs of the vehicles used. Alternative solutions to the problem of determining the distribution route will be overcome by the Nearest Neighbor and Local Search methods.

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The Nearest Neighbor method will generate a distribution route based on the destination location that has the nearest distance, then proceed by optimizing the process with the Local Search method.

2 Literature Review

2.1 Supply Chain Management

Supply chain management is about integration of procurement activities, processing, storage of raw materials into finished goods which are finally distributed to consumers [11]. This activity covers various types from the upstream and downstream processes in the distribution process [19], some of the processes in which include planning, sourcing, production, distribution logistics [7]. The concept in supply chain management is to have the goal of increasing the company's total productivity [3].

2.2 Logistic Management

Logistic management consists of a set strategy process from product distribution activity [6]. Logistic is a structured processes which regulates the flow of materials in the production process to the distribution process [16]. In the logistics system, there are 2 parts such as inbound logistics (raw material flow from suppliers to production processes) and logistics outbound (flow of goods from the production process to delivery to consumers [21]. There are 5 components incorporated in the system logistics such as the location, facilities, transportation, procurement, communication, the structure of storage [8].

2.3 Logistic Distribution

Logistic distribution channel is used by the company to distributing product to customer [17]. Product distribution activities play an important role in the company. Without any pattern of appropriate distribution, it will generate waste in terms of time, distance, energy, and costs [9]. The logistics distribution activities basically function to segment, determine the mode of transportation, scheduling, route determination, storage of inventory, service with value-added [10].

2.4 Vehicle Routing Problem

The problem of distribution routing determination has aim to minimize the cost during product delivering/shipping to the customer [4]. To solve this problem, it can be conducted by determining the number of vehicles and routes that must be taken [18]. There are several characteristics which arise from this problem, among others, the trip begins and ends at the starting point of distribution. There are many places that must be visited. The refilling process needs to be done if the carrying capacity has been exhausted. The main goal is to minimize the total distance [14]. There are several classifications in the Vehicle Routing Problem [10] as follow : Periodic Vehicle Routing Problem; Vehicle Routing Problem with Time Window; Vehicle Routing Problem Split Delivery; Vehicle Routing Problem with Multiple Trips; Vehicle Routing Problem Pick-up and Delivery; Vehicle Routing Problem Multiple Depots; Vehicle Routing Problem Simultaneous Pick-up and Delivery; Vehicle Routing Problem Multiple Product; Stochastic Vehicle Routing Problem; Dynamic Vehicle Routing Problem. There are some components in vehicle routing problem [10] as follow : Depot, the first place for the beginning and the last route; Planning Horizon, it is the maximum limit time to finish the distribution; The completion time, It is the time needed to visit customer to re-process to the first depot; Route, it is the sequence of delivering locations; Tour, it is the combination of some delivering routes.

2.5 Nearest Neighbor

Nearest neighbor method is one of the most natural methods in overcoming vehicle routing problem [18]. The process of nearest neighbor performance is by adding a location which has the nearest distance to the location visited last time. The process is conducted continuously until the distribution process ends and returns to the initial/first distribution point [13].

2.6 Local Search

Local search is a good method in the effort of calculating good quality solution to finish vehicle routing problem in a short time [5]. Implementation of the improvement process is conducted by moving one point to another customer point in the same distribution route [13]. The process of moving consumers with other consumers in sequence is carried out in order to minimize the distance and time of distribution. The exchange process will be done until the best solution is obtained by comparing the measurement results before exchanging.

3 METHODOLOGY

This research was an action research. the main aim was to conduct the performance enhancement of research object [12]. 4 cycles of action research included plan, acting, observing, reflecting were conducted in this research. The process of observation was used to obtain some data. The required data included historical data on the delivery of 3 kg LPG (cylinders) to one of the distributor agents, data on measurements of delivery distance, distribution time to customer, data on vehicle speed used, and vehicle capacity. Data analysis process was conducted using nearest neighbor and local search methods. Before carrying out the route determination process, it was necessary to observe the distribution on the initial/first route that had been historically done. The observation process was to find out how much distance traveled, completion time and costs during the distribution process.

3.1 Routing Determination with Nearest Neighbor

Logistic distribution channel is used by the company to distributing product to customer [17]. Product distribution activities play an important role in the company. Without any pattern of appropriate distribution, it will generate waste in terms of time, distance, energy, and costs [9]. The logistics distribution activities basically function to segment, determine the mode of transportation, scheduling, route determination, storage of inventory, service with value-added [10]. Data analysis process was carried out by determining distribution route using nearest neighbor. There were some steps which had to be conducted as follow: Step 1. conducting demand data input with customer, Planning horizon (H), Loading Time (LT) and Unloading time (UT), then it was continued to step two; Step 2. conducting routing (r = 1), and tour (t = 1). then it was continued to step three; Step 3. determining initial location of depot. then it was continued to step four; Step 4. Determining the customers who had nearest distance of the last location. then it was continued to step five; Step 5. Calculating delivering time between delivery locations (WT). then it was continued to step six; Step 6. Calculating Unloading time (UT) or the time the product declined to each store or customer. then it was continued to step seven; Step 7. Calculating administration time (Wadm). then it was continued to step eight; Step 8. Calculating the completion time (CT), by performing the following calculation: CTi = CTi-1 + WT + UT + LT +Wadm. If the completion time (CTi) ≤ working hours, then go to step ten. If the completion time (CTi) ≤ Working Hours then return to the finished product distribution depot; Step 9. If all customers were already served, then the distribution was complete. If there were still unfinished customers and vehicle capacity > 0, it was proceed to step ten. If the vehicle capacity was <0, it was proceed to step eleven; Step 10. The customer's last point became the starting point for distribution, and looked for the closest distance. Continued to step twelve; Step 11. Return to the initial depot by calculating the travel time during the distribution trip. Continued to step four; Step 12. If the completion time (CTi) ≤ Working hours then it was proceed to step four. If the completion time (CTi) ≥ Working hours then it returned to the initial depot, distribution was complete; Step 13. Perform the process until all customers were served. Input overall data using tables.

3.2 Routing Determination with Local Search

Data analysis process using local search method wa conducted to evaluate and improve the initial distribution routing that had been determined by the Nearest Neighbor method. There were several steps that must be used, as follow: Step 1. conducted from touring 1, it meant i=1, continued to step three; Step 2. Starting from tour 1, it meant i = 1. proceed to step three.; Step 3. conducting the Intra-routing Insertion process (1-0), by doing exchange the order of service for each customer point in the same vehicle for each fleet of vehicles, proceed to four steps if all routes had been completed; Step 4. If the new route had a total smaller distance than the previous one, then choose that route to replace the previous route. Do it until the exchange was complete and proceed to step two. If all tours had been completed or exchanged, proceed to step 5; Step 5. The procedure was complete. After analysis process using both methods, the solution was chosen to determine the most

effective distribution routing with the closest mileage, and the fastest turnaround time.

4 Result and Discussions

4.1 Collecting The Data

Data needed to process routing determination analysis were as follow: 1) Data of distance. Data of distance needed consisted the distance from depot to each customer of 3 Kg LPG and the distance between each customer of LPG 3 kg. Distance measurement was conducted with the assistance of Google Maps. 2) Data of time. Time data is the time needed during the distribution process. This data included the time of distribution from the depot to each customer of LPG 3 kg and between each customer of LPG 3 kg. 3) Data of delivering vehicles. The number of vehicles used in the distribution process were 4 pick-up vehicles. The maximum capacity of each vehicle used were 250 LPG 3 kg. The average vehicle speed used in the distribution process was 40 Km/hour. Costs incurred for the distribution process, each vehicle spends 1 liter of gasoline of the premium type for a distance of 8 km. 4) Travel time. Travel time is time needed during the distribution process from the depot to each customer of LPG 3 kg (tube) and between each customer LPG 3 kg. Calculation of travel time was obtained from the distance divided by the speed of the next vehicle multiplied by 60 or in minutes per hour. 5) Loading and Unloading Time. The loading time is the time needed to take the 3kg LPG (tube into the pick-up vehicle, then the distribution process will be conducted. Loading time is 3 seconds for each 3kg LPG gas (tube). Unloading time is the time needed to process the full gas drop and the process of taking empty LPJ in the pick-up. The unloading time is 6.6 seconds for 3 kg LPG (tube). 6) Working Hours of delivery vehicle driver. The working hours performed by the driver of the vehicle were 8 working hours. 7) Administration time. The administrative service time is the time required while conducting the process of checking the number of sent 3 kg LPG. The time needed for administrative services were 2 minutes.

4.2 Initial Routing Company Used Historically

The company had 23 customers of 3 kg LPG as regular consumers whose number of requests were known. There were 16 customers making order with a daily period, 2 customers making order with a period of once a week, 5 customers making order with periods of twice a week, and 1 customer making order with periods of 3 times a week. Therefore, the company could fulfill all customer demand/order in a period once a week. In once a week period, the company had 6 distribution routing tours in which each tour consisted of 4 distribution routes. the total distance in the 1 week distribution period was 3288.8 Km with Completion Time or the completion time of 8328.45 minutes, it was equivalent to 138.8075 hours.

4.3 Distribution Routing Determination Using Nearest Neighbor

Distribution routing determination using nearest neighbor method was conducted with some steps as follow: Step 1. Conducting demand data input of each customer (Di) = 0, distance between depot and customer, and distance between customer and customer, planning horizon (H) = 480 minutes, vehicle capacity (Q) = 250 units. Loading time (LT) = 3 seconds/unit and Unloading time (UT) = 6.6 seconds/unit. Continued to step two; Step 2. Conducting initial initialization, routing (r = 1), and tour (t = 1). Continued to step three; Step 3. Determining the initial location of the depot. loading process (LT) = 12.5 minutes by filling 250 units into the delivery vehicle. Continued to step four; Step 4. Customers who had the nearest distance from the last location on tour 1 (daily period) was P3, a customer named Mutaki located in Krajan Village with a distance of 7.1 km. Continued to step five; Step 5. Travel time from depot to P3 was 10.65 minutes. Continued to step six; Step 6. Unloading time required was 16.5 minutes. Continued to step seven; Step 7. Administration time (Wadm) = 2 minutes. Continued to step eight; Step 8. Calculating the completion time (CT), completion time (CTi) ≤ working hours or 41.65 ≤ 480. Then continued to the next step; Step 9. Vehicle capacity > 0, or Q currently was 100 units, then proceed to step 10; Step 10. The last point was P3, then the customer who had the nearest distance from P3 was P12 of 0.13 km. continued step 12; Step 12. The completion time (CTi) of the delivering process from P3 to P12 was 54,845 minutes. 54,845 ≤ 480 then it was proceed to step four. The repetitive process was conducted until the completion time (CTi) ≥ Working hours then it returned to the initial depot, the distribution was complete.

4.4 Routing Evaluation Using Local Search

Step 1. conducted the he tour data input and the route generated from the Nearest Neighbor method, continued to step two; Step 2. Starting from tour 1, means i = 1; Step 3. Conducting the Intra-route Insertion process (1-0), by exchanging the order of services for each customer point in the same route for each vehicle. The resulting exchange process did not provide a solution to minimize the total mileage. The results were the same when compared with the route that had not been conducted by the exchange process. continued to step 5; Step 5. The procedure was complete.

4.5 Result Analysis of Routing Establishment

Initial routing historically was used by company for distribution process in for a period of 1 week to form 6 tours. There were 4 routes on each tour. The total distance traveled from the initial route applied was 3,288.8 Km with a completion time of 8,328.45 minutes. The results of the route formation with the nearest neighbor and local search methods, in the period of 1 week to form 6 tours, there were 4 routes on each tour. The total distance traveled was 3,142.76 Km with a completion time of 8,098.14 minutes.

4.6 Analysis of Delivering Vehicle Fuel Costs

The calculation of fuel cost was conducted based on distance traveled by each delivering vehicle. Application of the initial route used by the company in the period of once a week, the distribution process used fuel costs of IDR 2,672,150. Whereas the application of routes formed by the nearest neighbor and local search methods, the 1-month distribution process used fuel costs of IDR 2,553,493, -

5 Conclusion

Distribution routing establishment using nearest neighbor and local search methods result in number of routes which is the same as initial route generated by the company. There are 6 tours 4 routes for each distribution tour. The total distance from the company initial route is 3,288.8 km. Whereas the total

distance from the route with the nearest neighbor and local search methods is 3,142.76 km. Therefore, applying the distribution route with the nearest neighbor and local search methods has a minimum distance of 146.04 Km. The time for completing the distribution from the company initial route is 8,288.45 minutes. Where as the distribution completion time from the nearest neighbor method and local search is 8,098.14 minutes. Thus, applying the distribution route with the nearest neighbor and local search methods, the distribution process can be finished 230.31 minutes faster. The application of the company initial route requires fuel costs for delivering vehicles with a total of IDR. 2,672,150. While in the application of routes with the nearest neighbor and local search methods requires IDR 2,553,493. Cost savings is IDR 118,657 while using routes with the nearest neighbor and local search methods in the distribution process.

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