International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 11, November-2014

Optimization of Transportation Route for a Milk Dairy

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***Abstract*— A supply chain consists of organizations, people, resources and information involved in moving a product or service from supplier to customer. Transportation is the major function of a supply chain, which provides the movement of products. Finding out the efficient vehicle routes is an important logistics problem. In food supply chain it is observed that the products have very less life span and are easily perishable. Hence transportation is a major issue in food supply chain. In this work the optimization of transportation route for a public sector milk dairy in Kerala is carried out. In this firm, vehicles moves from a central supply depot to a number of customers and returning to the depot. When the firm is able to reduce this length of delivery route, then it will be able to provide better customer service and also the transportation costs can be reduced, as cost reduction is the important objective of every industry. This paper also aims in a comparative study of current transportation route used in this milk dairy and the optimized route suggested by this work considering the distance, cost, quantity, time, number of vehicles.**

Keywords—Vehicle routing problem; ant colony optimization; branch and bound;travelling salesman problem;milk dairy.

I. INTRODUCTION

This study was carried out in a public milk dairy located at Kerala state in India. The firm has a milk handling capacity of 600000 litres/day. This firm has a market share of more than seventy percent of the dairy products. The only method of transportation used in this milk dairy is by road. Dairy comprise number of local area distributers and regional distributers so as to reach the product to any remote corner of the district. In this plant several vehicles runs from a central supply depot to a number of customers and returning to the depot without exceeding the capacity constraints of each of the vehicles. A number of varieties of dairy products other than milk are also produced there.

In the first step of this work, data's of the existing travel route followed by the firm is collected. Then based on this route diagrams, distance matrix etc are prepared and the existing cost of transportation is carried out. The problem is assumed as a travelling salesman problem and based on this optimization of transportation routes is carried out. Different optimization tools such as branch and bound technique, nearest neighbour search algorithm and ant colony optimization tool is used to get the best solution. And at last the comparative study of current transportation route used in this milk dairy and the optimized route suggested by this work is carried out considering the distance, cost, quantity, time, number of vehicles. Also the approximate annual savings in transportation cost to the firm is also estimated.

I. DATA COLLECTION

For this work, information and data from a wide variety of sources has been used, which includes theoretical knowledge of transportation facility, optimization technologies, supply chain parameters, trade-off etc. In this section data's including different delivery locations, different routes of delivery, distances and number of vehicles is collected. To obtain the data needed to form route structure, the project was divided into a number of sections. In the first section details of different distribution locations are collected. This section sought to give information about the different routes active on the current transportation design, as well gather all information about the number of vehicles used in each route and their maximum carrying capacity. The second section deals with the creating a route layout of all the transportation routes. This section was responsible for determining roads, routes and the different locations of the current design on the geographic map and also to find out the distances between the distribution locations covered by each vehicle with in a route and to sketch the transportation network. The third section deals with gathering details about transportation expenses, which includes the vehicle rent, renting methods, and average expenses on each route.

After the relevant information regarding the major supply chain parameters are obtained about each route, it was then summarized in a tabular form so as to complete the comparative study easily. The summary is consist of cost, time, distance and number of vehicles used in each route. The information from expert persons and navigation systems are used to furnish the time and distance summary. The cost summary is completed using the expense calculation method followed by the company. Route summary is shown in the table 2.1

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II. WORK DONE

In this part of the work, the optimization of transportation route is carried out. For this at first, based on the data collected, distance matrix is prepared. Then based on the assumptions used, optimization algorithms are prepared.

3.1 DISTANCE MATRIX

It was really important to find all the affordable and shortest paths connecting all the nodes (delivery location) in the route so as to find the minimum distance path from every single node to all the other nodes within a the routes. Collection of distance and shortest possible connecting roads are identified with the help of GPS navigation system and local area road maps. The shortest distances from nodes to other nodes are then sorted out and a distance matrix is created for each route. The different distance matrix created on each route are as shown in the tables 3.1, 3.2, 3.3, 3.4.

3.2 OPTIMIZED ROUTE

Based on the distance matrix created, optimization is carried out using the optimization tools such as branch and bound algorithm, ant colony optimization algorithm and nearest neighbour search algorithm. Optimized route summary after optimization is shown
in the table 3.5.

3.3 COMPARING THE DESIGNS

After the summary of both the current transportation design and Optimized design is done, it is then subjected to comparative study with all the relevant transportation design parameters namely the distance, time, cost quality and number of vehicles used in each case.

3.3.1 VEHICLES ON EACH ROUTE

As the problem is solved as TSP, the number of vehicle in the optimized design is reduced to just one vehicle which happened to be the same vehicle used by the firm for regional distribution, and the same vehicle is used for local distribution as well, where as in the existing design number of small vehicles are run in parallel, which implies the investment on vehicle is reduced to a huge amount in the optimized design.

3.3.2 DISTANCE

The total distance that is covered by all the vehicles in each route per trip are calculated and are depicted in table 3.6.

Table 3.6 Shows the vehicles on each route

Route	**Current Route**	**Optimized Route**
Ollur	80	58
Chalakudy	158	101
Ayyanthol	118	78
Kodungallur	172	117

3.3.3 EXPENSE OF TRANSPORTATION

The total expenses of transportation of milk from node to node in each route in the current and new design are shown in the table 3.7. Here in the new design it is very clear that the total cost has been reduced enormously per trip.

Table 3.7 Expense of Transportation (in Rs.)

Route	Current Route	Optimized Route
Ollur	2721	1125.78
Chalakudy	3031.56	1960.41
Ayyanthol	2546.31	1513.98
Kodungallur	4219.05	2270.97

3.3.4 TIME OF DELIVERY TO CUSTOMERS

The time of delivery of milk at each node or customers are compared, and it is found that there has been increase in time of delivery at certain nodes, and decrease in certain other nodes. The comparison of current time of delivery of milk at each node or customers in each route and time of delivery at each nodes in the optimized route are shown in tables 3.8, 3.9, 3.10, 3.11.

Table 3.8 Time of delivery - Ollur Route (in Minutes)

Routes	**Current time**	**Optimized time of delivery**
Depot	0	0
Town	13	13
Koorkancherry	20	20
Cherpu	37	37
Puthukkad	50	50
Marathakkara	25	70

Table 3.9 Time of delivery - Chalakkudy Route (in Minutes)

Routes	**Current time**	**Optimized time of delivery**
Depot	0	0
Appollo	40	130
Chalakkudy	50	120
Mala	68	80
Puthur	90	23

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Table 2.1 Shows the Route summary (distance, cost, time and quality)

Route	No.of vehicles	Node – Node	Type of vehicle	Distance from node-node	Total distance (Km)	Cost (Rs)	Total cost (Rs)	Time to delivery (min)	Quality (grade)
Ollur	3	Depot -Town	Tata 407	7	80	388.2	2721	13	A
		Town-Koorkanchery		3				20	A
		koorkanchery-Cherp		10				37	A
		Cherp-Puthukkad	APE	9		1012.8		48	B
		Town-Marathakkara	ACE	11		1320		25	A
Chalakkudy	3	Depot -Appollo	Tata 407	32	158	698.76	3031.56	40	A
		Appollo-Chalakudy		4				50	B
		Chalakkudy-Mala	ACE	14		1320		68	B
		Chalakkudy-puthur	APE	29		1012.8		90	B
Ayyanthol	3	Depot -Round(w)	Tata 407	7	118	213.51	2546.31	12	A
		Round(w)-Ayyanthol		4				21	A
		Milma-Wadakkanchery	ACE	16		1320		24	A
		Milma-chelakkara	APE	32		1012.8		46	A
Kodungallur	4	Depot -Irinjalakkuda	Tata 407	28	172	873.45	4219.05	39	A
		Irinjalakkuda-Kodungallur		17				66	B
		Irinjalakkuda-Cherp	APE	10		1012.8		54	B
		Irinjalakkuda-Aloor	APE	10		1012.8		54	B
		Irinjalakkuda-Triprayar	ACE	21		1320		74	B

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Table 3.1 Distance Matrix – Ollur Route

Locations	Depot	Town	Koorkanchey	Cherp	Pudukkad	Marathakkara
Depot	0	7	10	20	29	13
Town	7	0	3	13	25	11
Koorkanchery	10	3	0	10	14	10
Cherp	20	13	10	0	9	13
Pudukkad	29	25	14	9	0	16
Marathakkara	13	11	10	13	16	0

Table 3.2 Distance Matrix – Chalakudy Route

Locations	Depot	Puthur	Appollo	Chalakudy	Mala
Depot	0	15	32	34	42
Puthur	15	0	28	29	36
Appollo	32	28	0	2	18
Chalakudy	34	29	2	0	14
Mala	42	36	18	14	0

Table 3.3 Distance Matrix – Ayyanthol Route

Locations	Depot	Town(west)	Ayyanthol	Chelakkara	Wadakkanchery
Depot	0	7	9	32	16
Town(west)	7	0	4	36	20
Ayyanthol	9	4	0	35	19
Chelakkara	32	36	35	0	16
Wadakkanchery	16	20	19	16	0

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Table 3.4 Distance Matrix – Kodungallur Route

Locations	Depot	Cherp	Kodungallur	Irinjalakuda	Aloor	Triprayar
Depot	0	20	46	28	30	30
Cherp	20	0	30	10	22	13
Kodungallur	46	30	0	17	24	27
Irinjalakuda	28	10	17	0	10	21
Aloor	30	22	24	10	0	31
Triprayar	30	13	27	21	31	0

Table 3.5 Describes the Optimized route summary

Route	No.of vehicles	Node – Node	Type of vehicle	Distance from node-node	Total distance (Km)	Cost (Rs)	Total cost (Rs)	Time to delivery (min)	Quality (grade)
Ollur	1	Depot-Town	Tata 407	7	58	1125.78	1126	13	A
		Town-Koorkanchery		3				20	A
		koorkanchery-Cherp		10				37	A
		Cherp-Puthukkad		9				50	B
		Puthukkad-Marathakkara		16				70	B
		Marathakkara-Depot		13					
Chalakkudy	1	Depot-Puthur	Tata 407	15	101	1960.41	1960	23	A
		Puthur-Mala		36				80	B
		Mala-Chalakkudy		14				120	C
		Chalakkudy-Appollo		4				130	C
		Appollo- Depot		32					
Ayyanthol	1	Depot -chelakkara	Tata 407	32	78	1513.98	1514	60	B
		Chelakkara-Wadakkanchery		16				86	B
		Wadakkanchery-Ayyanthol		19				128	C
		Ayyanthol-Round(w)		4				136	C
		Round(w)- Depot		7					
Kodungallur	1	Depot -Cherpu	Tata 407	20	117	2270.97	2271	32	A
		Cherpu-Triprayar		13				50	B
		Triprayar-Kodungallur		27				90	B
		Kodungallur-Irinjalakkuda		17				115	C
		Irinjalakkuda-Aloor		10				133	C
		Aloor- Depot		30					

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Table 3.10 Time of delivery- Ayyanthol Route (in Minutes)

Routes	**Current time**	**Optimized delivery time**
Depot	0	0
Round(w)	12	136
Ayyanthol	21	128
Wadakkanchery	24	86
Chelakkara	46	60

Table 3.11 Time of delivery to customers - Kodungallur Route (in Min)

Routes	**Current time**	**Optimized time of delivery**
Depot	0	0
Irinjalakkuda	39	115
Kodungallur	66	90
Cherp	54	32
Aloor	54	133
Triprayar	74	50

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I. RESULTS AND DISCUSSIONS

The various milk delivery route used by the milma dairy thrissur has ben optimized to a minimum disatance transportation using branch and bound algorithm, nearest neighbour algorithm and ant colony optimization technique, with the assumption of running only a single vehicle serially connecting all the nodes, which is being used by milma in the current trnsportation system for their regional distribution. Table 4.1 shows the number of vehicles on each route in the current and optimized designs.

Table 4.1 Shows the Vehicles on each route

Route	Optimized design	Current design
Ollur	1	3
Chalakkudy	1	3
Ayyanthol	1	3
Kodungallur	1	4

Optimized number of vehicles on each route = 1
Total number of vehicles required in the optimized design = 4
The total distance covered in each route is also decreased in the optimizes design. Total distance covered on each route per trip in the optimized design is shown in table 4.2 and figure 4.1.

Table 4.2 Total distance covered on each route (in km)

Route	**Current Route**	**Optimized Route**
Ollur	80	58
Chalakudy	158	101
Ayyanthol	118	78
Kodungallur	172	117

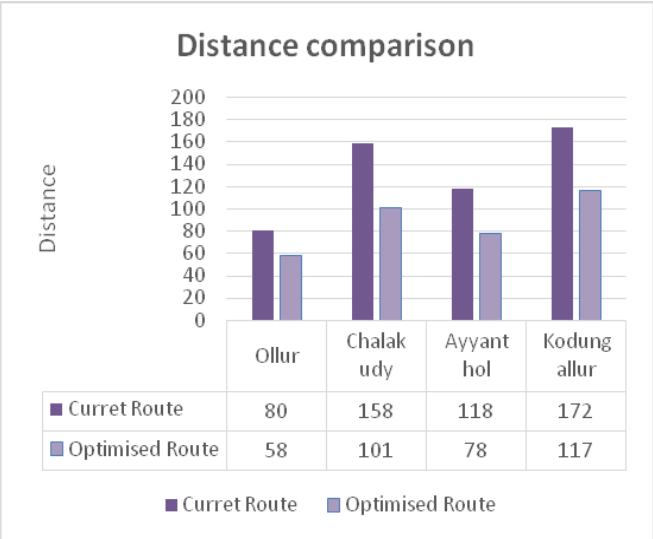

Fig 4.1 Total distance covered on each route (in Km)

As the distance of transportation is reduced, the expense of transportation is also decreased in the optimized design proposed by this project. The expense of transportation on the optimized routes are represented in the table 4.3.

Table 4.3 Portrays the Expense of Transportation (in Rs.)

Route	Current Route	Optimized Route
Ollur	2721	1125.78
Chalakudy	3031.56	1960.41
Ayyanthol	2546.31	1513.98
Kodungallur	4219.05	2270.97

Hence the new design proposed the minimum investments on the vehicle needed for delivering the milk, which is an advantage to the concerned logistics.

In this project four main routes of transportation are considered for optimization. So the total cost of transportation in the four routes using existing design
= Rs.12518
Total cost of transportation in the four routes using optimized design = Rs.6871
Savings = Rs. 5647 per day
Annual Savings of the Dairy = 5647 *36
= **Rs. 2061155**

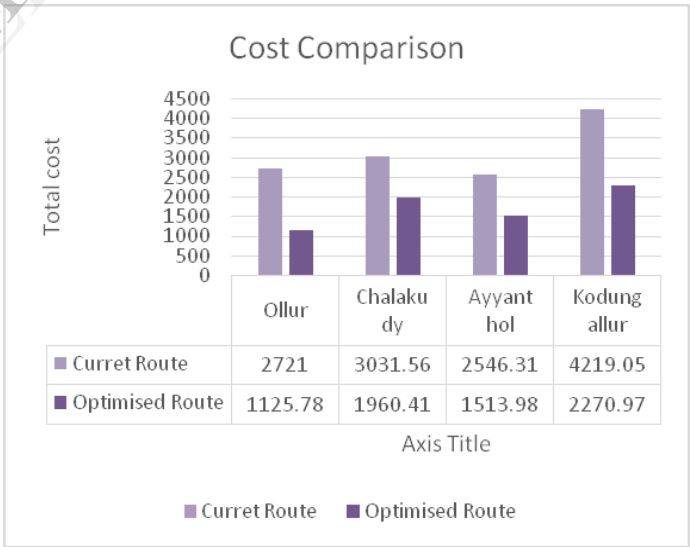

Fig 4.2 Describes the Expense of Transportation (in Rs.)

As this optimization focused on minimizing the total cost of transportation, so the minimization of total distance run by the vehicle while connecting each nodes is given prior importance. Though there is an advantage as far as the total cost is concerned, there is a disadvantage in the time of delivery of milk at certain nodes in the optimized system. Because time has to be compromised to reduce the number of vehicles used and allowing single vehicle to run serially connecting all nodes to avoid multiple vehicles running parallelly in each route. Though there is a slight increase in

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time of delivery of milk at some nodes. This increase in time of delivery is small. As per scientific and experienced opinion pasteurized milk will not get damaged up to 270 min (4.30 hours) at normal room temperature. The maximum time of delivery on each optimized routes are :

Ollur route = 70 min
Chalakkudy route = 130 min
Ayyathol route = 136 min
Kodungallur route = 133 min

So in the optimized design proposed by this project, the time of delivery at each nodes is less than 270 min (4.30 hours) and so it doesn't affect the quality of the product.

I. CONCLUSION

This project was successful in designing a minimum distance transportation for public sector milk dairy in kerala.. This design has proposed new transportation routes for the delivery of milk at all the nodes in each route with minimum distance, minimum transportation cost and minimum investment on the vehicles used for the transportation.

The total distance covered in each route is reduced in the optimized design. As the total distance is reduced, the total expense of transportation in each route is also reduced.

But this design have requested little room for bit of compromise in the time of delivery of product at some nodes, but this could be solved by starting the delivery trips earlier than the usual. Also pasteurized milk will not get damaged up to 4.30 hrs (270 min) at room temperature. And all the delivery time is below this limit, hence it will not affect the quality of the product. This work considered four main travel routes of the firm for optimization. It is also found that, from this four routes considered for optimization, there is an annual savings of more than 20 lakhs per year.

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