BEST: International Journal of Humanities, Arts, Medicine and Sciences (BEST: IJHAMS)
ISSN (P): 2348-0521, ISSN (E): 2454-4728
Vol. 5, Issue 12, Dec 2017, 139-144

AN OPTIMIZATION MODEL FOR THE VEHICLE DELIVERING FROZEN FOOD BY RESPONSE SURFACE METHODOLOGY

PARVEEN AYSHA K[1], NISHA JOSE[2] & S. ELIZABETH AMUDHINI STEPHEN[3]

[1 & 2] Food Processing Department, Karunya University. Coimbatore, Tamil Nadu, India

[3] Associate Professor In Mathematics, Karunya University, Coimbatore, Tamil Nadu, India

ABSTRACT

This paper addresses how to deliver a frozen product at a particular temperature with a particular capacity at a particular speed in a day time at lower cost. The optimization of this paper is the cost of delivery. The objective is to find the minimum delivery cost. Frozen temperature, loading weight, time and speed are the parameters used. Response surface methodology (RSM) is used in this paper to find the minimum delivery cost. And it is determined by Central composite design (CCD), statistical analysis and analytical method.

KEYWORDS: Minimum Delivery Cost, Response Surface Methodology & Central Composite Design.

INTRODUCTION

An optimization improves the performance of a product, a process, and a system to obtain the maximum benefit. The frozen food distribution companies tend to serve a large number of customers in dispersed locations, which is crucial for them to design the routes for vehicles in an efficient way so as to minimize the delivery cost by maintaining or even improving food and service quality for the customers.

The most studies in vehicle routing problem (VRP) were focused on expansion of the algorithms and network than for the improvement of the vehicle routing model. The vehicle routing problems in cold chain distribution by using optimization models reduces or minimizes the total cost of delivery, deterioration cost, energy cost and transportation cost.

Vehicle routing problem (VRP) or the vehicle delivering problem is a combinatorial optimization and the integer programming problem. The combinatorial optimization consists of finding an optimal object from a set of objects. It generalizes TSP that is, travelling salesman problem. In 1959, George Dantzig and John Ramser, were first described this, in which the first algorithmic was approach applied to petrol deliveries. The main objective of vehicle routing problem is minimizing the total cost. Clarke and Wright modified the Dantzig and Ramser's approach in 1964, by using an effective approach called savings algorithm.

The VRP have many applications in industry. By the use of a computer optimization program, can give savings of a 5% to a company and makes the transportation sector up to 10% of the EU's Gross Domestic Product (GDP). GDP is the measure of market value of all final goods and services produced in a period (quarterly or yearly).

METHODOLOGY

The most relevant multivariate technique used in this method is the response surface methodology. It is a collection of mathematical and statistical techniques. The objective is to optimize a response (output variable) which is influenced by several independent variables (input variables). An experiment is a series of tests, called runs, in which changes are made in the input variables in order to identify the reasons for changes in the output response. The application of RSM to design optimization is aimed at reducing the cost of expensive analysis methods.

The fixing parameters are frozen temperature, time, loading weight, speed. Fixing response is the cost in this model. Central composite is the design type and design mode is quadratic. There are 30 runs and 2 blocks used in this model.

Steps Involved in Response Surface Methods are:

- The first step of the response surface method is to move from a current operating condition to the optimum response operating conditions. It is done for minimizing and maximizing the response by using a method of steepest descent and steepest ascent respectively.
- Next step is to fit a more complex model between the factors and the response. A special experiment designs, which is referred as RSM designs are used to accomplish or to achieve this. The fitted model has been used to conclude that the most suitable operating conditions those results in either maximum or a minimum response.
- At the same time it is possible to optimize a number various responses. For example, if an experimenter wants to maximize the strength, by minimizing the number of defects. The optimum settings of each response in those cases may leads to the conflicting settings of the factors. Balanced settings have to be found which gives the most suitable values for various responses. In those cases, the desirability functions are useful.

Experimental Design

The experimental design was carried out using optimal mixture of response surface methodology (Design Expert, 10software). The independent variables were frozen temperature (0-2ºF), time (1-24hr), loading weight (3-26 tonnes) and speed (50-60 km/hr). The dependent variable is the cost.

FACTORS	UNITS	LOW LEVEL	HIGH LEVEL
Frozen temperature	ºF	0	2
Time	Hour	1	24
Loading weight	Tones	3	26
Speed	Km/hr	50	60

Statistical Analysis

Statistical analysis is carried out by using Response Surface Methodology, to fit the quadratic polynomial equation which is generated by Design-Expert software version 10. Multiple regressions were used to correlate the response variable to the independent variables and analysis of variance was used for evaluating the quality of fit of the model.

Design Analysis

Table 1 shows the design (actual) of response surface method for vehicle delivering frozen food and table 2 shows the design summary.

Table 1: Design (Actual) of Response Surface Method for Vehicle Delivering Frozen Food

Select	Std	Block	Run	Space Type	Factor 1 A:Frozen te... f	Factor 2 B:Time hr	Factor 3 C:Loading w... tones	Factor 4 D:Speed km/hr	Response 1 cost Rs
	5	Day 1	6	Factorial	0	1	26	50	140
	6	Day 1	15	Factorial	2	1	26	50	115
	7	Day 1	1	Factorial	0	24	26	50	95
	8	Day 1	9	Factorial	2	24	26	50	112
	9	Day 1	3	Factorial	0	1	3	60	147
	10	Day 1	13	Factorial	2	1	3	60	200
	11	Day 1	12	Factorial	0	24	3	60	90
	12	Day 1	7	Factorial	2	24	3	60	255
	13	Day 1	10	Factorial	0	1	26	60	130
	14	Day 1	18	Factorial	2	1	26	60	155
	15	Day 1	14	Factorial	0	24	26	60	175
	16	Day 1	8	Factorial	2	24	26	60	125
	17	Day 1	17	Center	1	12.5	14.5	55	145
	18	Day 1	20	Center	1	12.5	14.5	55	165
	19	Day 1	16	Center	1	12.5	14.5	55	154
	20	Day 1	2	Center	1	12.5	14.5	55	155
	21	Day2	27	Axial	-1	12.5	14.5	55	100
	22	Day2	30	Axial	3	12.5	14.5	55	120
	23	Day2	25	Axial	1	-10.5	14.5	55	210
	24	Day2	24	Axial	1	35.5	14.5	55	175
	25	Day2	22	Axial	1	12.5	-8.5	55	142
	26	Day2	29	Axial	1	12.5	37.5	55	154
	27	Day2	21	Axial	1	12.5	14.5	45	147
	28	Day2	28	Axial	1	12.5	14.5	65	150
	29	Day2	23	Center	1	12.5	14.5	55	230
	30	Day2	26	Center	1	12.5	14.5	55	200

Table 2: Design Summary

File Version	10.0.5.0					
Design Wizar	Optimization > Factorial / RSM > HTC					
Study Type	Response Surface	Subtype	Randomized			
Design Type	Central Composite	Runs	30			
Design Modc	Quadratic	Blocks	2	Build Time (r	62.00	

Factor	Name	Units	Type	Subtype	Minimum	Maximum	Coded	Values	Mean	Std. Dev.
A	Frozen temper	f	Numeric	Continuous	-1	3	-1.000=0	1.000=2	1	0.909718
B	Time	hr	Numeric	Continuous	-10.5	35.5	-1.000=1	1.000=24	12.5	10.4618
C	Loading weigh	tones	Numeric	Continuous	-8.5	37.5	-1.000=3	1.000=26	14.5	10.4618
D	Speed	km/hr	Numeric	Continuous	45	65	-1.000=50	1.000=60	55	4.54859

Response	Name	Units	Obs	Analysis	Minimum	Maximum	Mean	Std. Dev.	Ratio	Trans	Model
R1	cost	Rs	30	Polynomial	90	255	147.367	40.8213	2.83333	None	No model chos

Modeling Equation

$$Y = -1065.55550 - 63.53986 * A - 4.85728 * B + 11.38532 * C + 41.24855 * D + 0.29348 * A * B - 1.44565 * A * C + 2.32506 * A * D - 0.012287 * B * C + 0.071739 * B * D - 0.14565 * C * D - 18.52083 * A^2 + 0.015911 * B^2 - 0.068210 * C^2 - 0.35583 * D^2.$$

Where, Y- Cost

A- Frozen temperature

B- Time

C- Loading weight

D- Speed

The equation in terms of actual factors has been used to make predictions about the response to a given level of each factor. Here, the levels have to be specified in the original units for each factor. This equation should not be used to determine the relative impact of each factor, because the coefficients re scaled to accommodate the units of each factor and the intercept is not at the center of a design space.

RESULT & DISCUSSIONS

For the minimum delivery cost, the level needed for optimized parameters like frozen temperature, time, loading weight and speed are 2ºF, 24hr, 3 tonnes and 60km/hr respectively which show the table3. Fixing response is the cost, the minimum cost obtained for delivering frozen food is Rs 90 and the maximum cost is Rs.255. Figure 1 shows the optimization by numerical representation and figure 2 & 3 shows the contour plot showing the frozen temperature and time.

Table 3: Optimized Parameter

Frozen Temperature	2ºf
Time	24hr
Loading weight	3 tonnes
Speed	60 km/hr

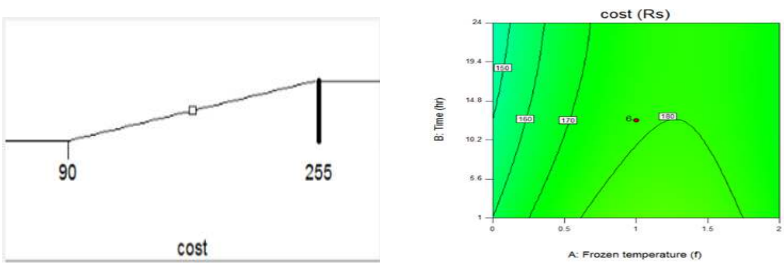

Figure 1(a): Optimization by Numerical Representation
(b). Contour Plot Showing Time & Frozen Temperature

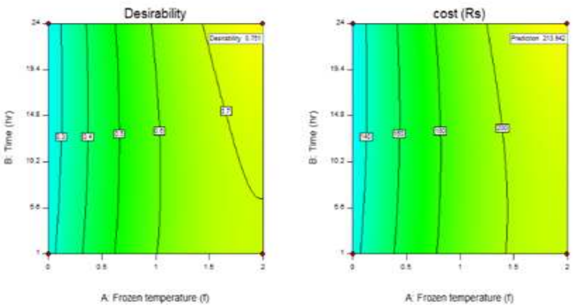

Figure 2: Contour Plot Showing Time & Frozen Temperature where the Desirability is the Cost.

CONCLUSIONS

This paper investigates a unique vehicle delivering problem in the frozen food distribution industry. Formulate the problem into one optimization model with the objective of minimizing the total cost. To solve this problem, response surface methodology is used to solve the vehicle delivering problem which has a very large solution space. To obtain an optimal solution in response surface method, further analysis should be done to determine the parameter value corresponding to each case; the case was designed based on actual information in a frozen food distribution.

The focus of our future studies in this area will be to increase the complexities of assumptions to make them closer to the real world. Response surface method is efficient in improvements of existing studies and products.

REFERENCES

1. C. I. Hsu et al.2013 "Optimal delivery cycles for joint distribution of multi-temperature food," Food Control, vol. 34, no.1, pp. 106-114.
2. Leonardo Junqueira et.al. 2013 "An optimization model for the vehicle routing problem with practical three-dimensional loading constraints." 645-666,
3. Olugbenga Olufemi Awolu. 2017 "Optimization of the functional characteristics, pasting and rheological properties of pearl millet based composite flour". pp. 1-17.
4. Y. Zhang , X. D. Chen. 2014 "An Optimization Model for the Vehicle Routing Problem in Multi-product Frozen Food Delivery". Vol.12, pp. 239-250.