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# Optimization of the Production Mixture of Selected Raw Material for Plastic Production: A Case Study of Louis Carter Plastic Manufacturing Industry

Okolie Paul Chukwulozie[1]*, Chukwuneke Jeremiah Lekwuwa[1], Okoli Ndubuisi Celestine[2], Azaka Onyemazuwa Andrew[1] and Sinebe Jude Ebieladoh[1]

*Corresponding Author Email:pc.okolie@unizik.edu.ng

[1]*Mechanical Engineering Department, Nnamdi Azikiwe University, Awka*

[2]*Industrial Production Engineering Department, Nnamdi Azikiwe* University,Awka

***Abstract:*** *Statistical experiment design and analysis as tools for production have being developed specifically for the purpose of optimizing mixes, such as plastic products, in which the final product properties depend on the relative proportions of the components rather than their absolute amounts. Although mixture methods have been used in industries to develop products such as gasoline, metal alloys, detergents and foods, they have seen little application in the plastic industry. This paper describes an analysis in which a statistical mixture design tool called response surface design optimization tool was used to optimize the six mixture components of 25mm waste pipe, in order to obtain the optimal mixture ratio and their corresponding product yield. The results obtained show an optimal mixture ratio of PVC (45442.820), Stabilizer (1514.760), Calcium carbonate (0.0), Steric acid (151.480), Titanium (12.120), and Pigment (1.4079) for 25mm waste pipe. The optimal yield and composite desirability for 25mm waste pipe are 51990kg and 0.99990. The objective of the study from the result above was to reduce the wastage of raw materials, so as to increase the profitability of the final products. In addition, the model in use is recommended to the case company for effective utilisation of their various raw material mixes so as to obtain various optimal solutions of their raw materials mix and their various production yields.*

***Keywords-*** *Optimization, production, Raw materials, Surface Response*

## I. INTRODUCTION

For many manufacturers the task of meeting the ever rising demand and customer expectations and lowering production costs in an environment of more products, more complexity, more choice and competition is placing great stress on the effectiveness of the production mixture ratio of the different chemicals used in the production of their different product and the quantity of the products gotten from the mixture. Organizations have already adopted solutions with varying degree of production mixture ratios, operations executive acknowledged that this mixture ratio does not give an optimum yield as a result of wastes encountered during the production.

Loius carter plastic industry limited is one of the impending plastic industries in Nigeria, the work within the market of different plastic product like extrusion product for both domestic and industrial use, sales of their product carry a sturdy seasonality effect; the peak is during the dry season and the raining season is the period of building inventory. Products are customer correlated, so that no production to inventory occurs without an explicit manufacturing authority from customers. Because of this, it is expedient for the company to know how much number of products is expected to be achieved from a given quantity of raw material mix in order to be able to react to customers' needs as at when needed and hence optimization of the raw material mix.

[1] Exemplified how linear programming was applied to determine the feed mix to maintain a balanced ratio that includes calcium, protein, and fibre in the right proportion by the Ozark Poultry Farm. [2] Attempted to show the effectiveness of adopting the linear programming model in maintenance and manpower planning using data from a cocoa processing industry in Akure, Ondo State of Nigeria. Their result shows that only four maintenance crew out of the 19 employees are needed in that section to effectively carry out maintenance jobs in the industry. But in their own contributions, [3] Tried to reveal that risk analysis is necessary in order to

maximize resources allocation efficiency and minimize the effects of risk environment. They used data from a sample of a company's products taking risk into account as the objective function. The result proposed that producing 5 units of $X_1$ generates 36% loss possibility. If decision makers aim risk not to exceed certain limits, then, variances should be used as constraints. The model recommends that producing 3 units of $X_1$ will decrease the objective function from $432 to $287. [4] In their work Optimized Profit with the Linear Programming Model: A Focus on Golden Plastic Industry Limited, Enugu, Nigeria. They determined the product mix of Golden Plastic Industry Limited, Emene. In the process, they established optimal quantities of the various PVC pipes to be produced within the study period in order to maximize profit. Also the status of the resources and the unit worth of each resource to the objective function were known. [5] In his work on Production Scheduling Optimization of a Plastics Compounding Plant with Quality Constraints where the scheduling of parallel production units was considered. A mixed integer program was developed and implemented in GAMS. The model allows that jobs performed on different units may be shifted or resequenced according to the quantity of demand and the product the job performs. [6] In their work Moving Average Analysis of Plastic Production Yield in a Manufacturing Industry states that a close examination of the production pattern and the behavior of the production system based on the data analyses shows that the production industry is organizing production with a clear focus to meet the customers‟ requirements and stiff competitors in the plastic manufacturing industry. However, greater percentages of the customers are not served as and when due leading to queues and waiting before customers are served. However, the tool developed can help the company to remedy this situation.

This study intends to examine Loius Carter Plastic Industry Limited, to analyse the opportunity of adopting response surface design and its optimization tool in determining the quantity of products to have been produced over a given period of time from a given quantity of raw material mix. It is one of the most important industrial sites in Nigeria because of its strategic location with a cluster of industries. The choice of response surface design and its optimization tool is informed by the ability of the technique to solve problems relating to quantity of products that is to be achieved by a given quantity of raw material mix over a given period of time, and it is in a better position to determine waste over that period of time. The aim of the study is to optimize the production extent of products from a given quantity of raw material mixture over a given period of time, determining the accurate mixture ratio of the respective components of the raw material to be mixed in order to give optimum production. The objective function of this project is to determine the optimal number of products that can be gotten from a given quantity of raw material mix. With this value, the case study company can determine whether or not it has been operating within this optimal range and if not, plan for a way to increase their production yield by reducing waste of their raw material.

## II. RESEARCH METHODOLOGY

### 2.1 Data Collection and Regression Model

The production mixture data of Louis carter Plastic Industry Limited were collected. Regression analysis was used to statistically investigate the relationships between variables. Regression analysis is widely used for prediction and forecasting, where its use has substantial overlap with the field of machine learning. Regression analysis is also used to understand which among the independent variables are related to the dependent variable, and to explore the forms of these relationships. In restricted circumstances, regression analysis can be used to infer causal relationships between the independent and dependent variables.
Many techniques for carrying out regression analysis have been developed. Familiar methods such as linear regression and ordinary least squares regression are parametric, in that the regression function is defined in terms of a finite number of unknown parameters that are estimated from the data.

Nonparametric regression refers to techniques that allow the regression function to lie in a specified set of functions, which may be infinite-dimensional. The performance of regression analysis methods in practice depends on the form of the data generating process, and how it relates to the regression approach being used. Since the true form of the data-generating process is generally not known, regression analysis often depends to some extent on making assumptions about this process. These assumptions are sometimes testable if a sufficient quantity of data is available. Regression models for prediction are often useful even when the assumptions are moderately violated, although they may not perform optimally. However, in many applications, especially with small effects or questions of causality based on observational data, regression methods can give misleading results. [7].
Regression models involve the following variables: The unknown parameters, denoted as $\beta$ , which may represent a scalar or a vector .
The independent variables , X .
The dependent variable, Y .

In various fields of application , different terminologies are used in place of dependent and independent variables. A regression model relates Y to a function of X and β .

$$Y \approx f(X,\beta) \quad (1)$$

The approximation is usually formalized as E
( Y | X ) = f( X , β). To carry out regression analysis, the form of the function f must be specified. Sometimes the form of this function is based on knowledge about the relationship between Y and X that does not rely on the data. If no such knowledge is available, a flexible or convenient form for f is chosen.

Assume now that the vector of unknown parameters β is of length k .In order to perform a regression analysis the user must provide information about the dependent variable Y : If N data points of the form ( Y, X ) are observed, where N < k , most classical approaches to regression analysis cannot be performed: since the system of equations defining the regression model is underdetermined, there are not enough data to recover β . If exactly N = k data points are observed, and the function f is linear, the equations Y = f ( X , β ) can be solved exactly rather than approximately. This reduces to solving a set of N equations with N unknowns (the elements of β ), which has a unique solution as long as the X are linearly independent. If f is nonlinear, a solution may not exist, or many solutions may exist. The most common situation is where N > k data points are observed. In this case, there is enough information in the data to estimate a unique value for β that best fits the data in some sense, and the regression model when applied to the data can be viewed as an over determined system in β . In the last case, the regression analysis provides the tools for: (i) Finding a solution for unknown parameters β that will, for example, minimize the distance between the measured and predicted values of the dependent variable Y (also known as method of least squares ), and (ii) Under certain statistical assumptions, the regression analysis uses the surplus of information to provide statistical information about the unknown parameters β and predictors predicted values of the dependent variable Y.

### 2.2 Response Surface Methodology

Response surface methodology is an empirical statistical approach for modeling problems in which several variables influence a response of interest. In RSM, an approximate relation between a single response and multiple variables is modeled as a polynomial equation obtained through regression analysis. The equation is called a response surface and is generally represented graphically on a contour plot for analyzing an optimal solution. Usually, a low-order polynomial in some regions of variables is used [8]. Assume that *y* denotes the response and *xg* denotes the variables, *g* = 1,…, *N*. When a linear function of variables can effectively model a response, then the response surface is a first-order model, as follows.

$$\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x_1 + \hat{\beta}_2 x_2 + \ldots + \hat{\beta}_N x_N \quad (2)$$

where _*g* is the regression coefficients, *g* = 1, …, *N*.
When specifying curvature of a response surface, a polynomial of a high order is appropriate for the response surface. For instance, a second-order model of the response surface is

$$\hat{y} = \hat{\beta}_0 + \sum_{g=1}^{N} \hat{\beta}_g x_g + \sum_{g=1}^{N} \hat{\beta}_{gg} x_g^2 + \sum_{g<f} \sum \hat{\beta}_{gf} x_g x_f \quad (3)$$

The fitted response surface is an adequate approximation of the true response function when an appropriate model is selected. Furthermore, model parameters are estimated effectively when proper experimental designs are used to obtain experimental data. Details of experimental designs for fitting response surfaces are found in [9] and [8].

## III. DATA PRESENTATION AND ANALYSIS

**Table 1: Presentation of 2010-2011 Monthly Data on Production Output**

| *Year* | *Month* | M. Units | 25mm Waste pipe *(units)* |
|---|---|---|---|
| 2010 | Jan | 1 | *0* |
| | Feb | 2 | 47,303.00 |
| | Mar | 3 | 37,413.00 |
| | April | 4 | 33,641.00 |
| | May | 5 | 27,374.00 |
| | June | 6 | 38,750.00 |
| | July | 7 | 50,588.00 |

| | | | |
|---|---|---|---|
| | Aug | 8 | 61,203.00 |
| | Sept | 9 | 70,105.00 |
| | Oct | 10 | 75,209.00 |
| | Nov | 11 | 5,964.00 |
| | Dec | 12 | 93693 |
| 2011 | Jan | 13 | 77,964.00 |
| | Feb | 14 | 65,755.00 |
| | Mar | 15 | 62,349.00 |
| | April | 16 | 8,885.00 |
| | May | 17 | 79,724.00 |
| | June | 18 | 36,343.00 |
| | July | 19 | 55,114.00 |
| | Aug | 20 | 85,009.00 |
| | Sept | 21 | 69,522.00 |
| | Oct | 22 | 29,138.00 |
| | Nov | 23 | 25,063.00 |
| | Dec | 24 | *0* |

Source: Louis Carter grouped data

$X_1$= 32mm Pressure pipe, $X_2$= 25mm Waste pipe

### 3.1 Method of data analysis

Response Surface Design and optimization methods were used to model, design and to optimize the production mixture of Louis Carter manufacturing industry to observe the optimum production output of the raw materials.

**Table 2: Presentation of 2010-2011 Monthly Data on Production Output of 25mm Waste Pipe**

| 25mm Waste Pipe *(units)* | 25mm Waste Pipe(0.9kg) | PVC | Stabilizer | Calcium Carbonate | Steric acid | Titanium dioxide | Pigment |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31535 | 28381.8 | 22942.82 | 764.7607 | 4588.564 | 76.47607 | 6.118086 | 3.059043 |
| 24942 | 22447.8 | 18145.99 | 604.8664 | 3629.198 | 60.48664 | 4.838931 | 2.419465 |
| 22427 | 20184.6 | 16316.5 | 543.8834 | 3263.3 | 54.38834 | 4.351067 | 2.175534 |
| 18249 | 16424.4 | 13276.89 | 442.5631 | 2655.378 | 44.25631 | 3.540504 | 1.770252 |
| 25833 | 23250 | 18794.46 | 626.482 | 3758.892 | 62.6482 | 5.011856 | 2.505928 |
| 33725 | 30352.8 | 24536.11 | 817.8702 | 4907.221 | 81.78702 | 6.542962 | 3.271481 |
| 40802 | 36721.8 | 29684.58 | 989.4859 | 5936.915 | 98.94859 | 7.915887 | 3.957944 |
| 46737 | 42063 | 34002.21 | 1133.407 | 6800.442 | 113.3407 | 9.067256 | 4.533628 |
| 50139 | 45125.4 | 36477.74 | 1215.925 | 7295.549 | 121.5925 | 9.727398 | 4.863699 |
| 3976 | 3578.4 | 2892.649 | 96.42164 | 578.5299 | 9.642164 | 0.771373 | 0.385687 |
| 62462 | 56215.8 | 45442.82 | 1514.761 | 9088.564 | 151.4761 | 12.11809 | 6.059043 |
| 51976 | 46778.4 | 37813.97 | 1260.466 | 7562.794 | 126.0466 | 10.08372 | 5.041862 |
| 43837 | 39453 | 31892.38 | 1063.079 | 6378.476 | 106.3079 | 8.504635 | 4.252317 |
| 41566 | 37409.4 | 30240.41 | 1008.014 | 6048.081 | 100.8014 | 8.064109 | 4.032054 |
| 5923 | 5331 | 4309.388 | 143.6463 | 861.8776 | 14.36463 | 1.14917 | 0.574585 |
| 53149 | 47834.4 | 38667.6 | 1288.92 | 7733.52 | 128.892 | 10.31136 | 5.15568 |
| 24229 | 21805.8 | 17627.02 | 587.5674 | 3525.404 | 58.75674 | 4.700539 | 2.350269 |
| 36743 | 33068.4 | 26731.3 | 891.0433 | 5346.26 | 89.10433 | 7.128347 | 3.564173 |
| 56673 | 51005.4 | 41230.92 | 1374.364 | 8246.185 | 137.4364 | 10.99491 | 5.497456 |
| 46348 | 41713.2 | 33719.44 | 1123.981 | 6743.889 | 112.3981 | 8.991852 | 4.495926 |
| 19425 | 17482.8 | 14132.46 | 471.0821 | 2826.493 | 47.10821 | 3.768657 | 1.884329 |
| 16709 | 15037.8 | 12156.01 | 405.2005 | 2431.203 | 40.52005 | 3.241604 | 1.620802 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Source: Louis Carter grouped data**

## IV. DATA ANALYSIS AND DISCUSSION

### 4.1 Response Surface Regression: 25mm Waste Pipe versus PVC, Stabilizer, ...

Estimated Regression Coefficients for 25mm Waste Pipe(kg)

| Term | Coef | SE Coef | T | P |
|---|---|---|---|---|
| Constant | 28108 | 0 2.13266 | E+07 | 0.000 |
| PVC | 26462 | 757 | 34.961 | 0.000 |
| Stabilizer | -294 | 189 | -1.556 | 0.195 |
| Calcium Carbonate | 1875 | 759 | 2.471 | 0.069 |
| Steric acid | 72 | 24 | 2.956 | 0.042 |
| Titanium dioxide | -4 | 3 | -1.496 | 0.209 |
| Pigment | -2 | 1 | -3.165 | 0.034 |
| PVC*PVC | -421734 | 272759 | -1.546 | 0.197 |
| Stabilizer*Stabilizer | 558404 | 289984 | 1.926 | 0.126 |
| Calcium Carbonate*Calcium Carbonate | 4221 | 872 | 4.839 | 0.008 |
| Steric acid*Steric acid | -159551 | 35662 | -4.474 | 0.011 |
| Titanium dioxide*Titanium dioxide | -11103 | 7518 | -1.477 | 0.214 |
| Pigment*Pigment | -1364 | 853 | -1.599 | 0.185 |
| PVC*Titanium dioxide | 760032 | 459022 | 1.656 | 0.173 |
| PVC*Pigment | 73819 | 183598 | 0.402 | 0.708 |
| Stabilizer*Titanium dioxide | -1004598 | 502670 | -1.999 | 0.116 |
| Stabilizer*Pigment | 111146 | 172388 | -0.645 | 0.554 |
| Steric acid*Titanium dioxide | 272964 | 58484 | 4.667 | 0.010 |
| Steric acid*Pigment | 46242 | 19363 | 2.388 | 0.075 |
| Titanium dioxide*Pigment | -6187 | 3091 | -2.002 | 0.116 |

S = 0.00116064
PRESS = 0.00186542
R-Sq = 100.00%
R-Sq(pred) = 100.00%

R-Sq(adj) = 100.00%

25mm Waste pipe (kg)=$\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 {X_1}^2 + \beta_8 {X_2}^2 + \beta_9 {X_3}^2 + \beta_{10} {X_4}^2 + \beta_{11} {X_5}^2 + \beta_{12} {X_6}^2 + \beta_{13} X_1 X_5 + \beta_{14} X_1 X_6 + \beta_{15} X_2 X_5 + \beta_{16} X_2 X_6 + \beta_{17} X_4 X_5 + \beta_{18} X_4 X_6 + \beta_{19} X_5 X_6$ .. (4)

PVC =$X_1$
Stabilizer =$X_2$
Calcium Carbonate =$X_3$
Steric acid =$X_4$
Titanium dioxide =$X_5$
Pigment =$X_6$
Constant =$\beta_0$
Coefficient = $\beta$

From the data presented in Table 2, the Surface Plots are represented in Fig.(1-16)

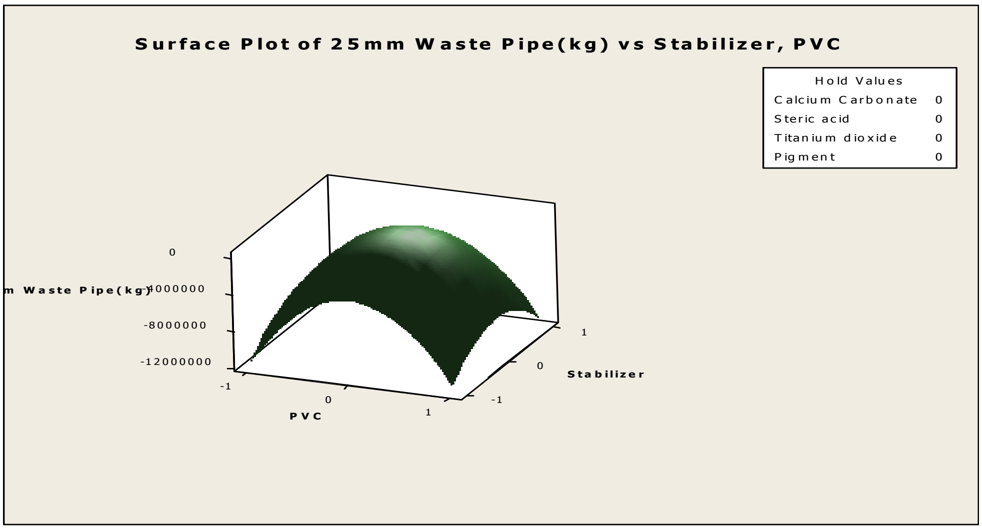


**Fig.1: Surface Plot of 25mm Waste Pipe(kg) vs Stabilizer, PVC**

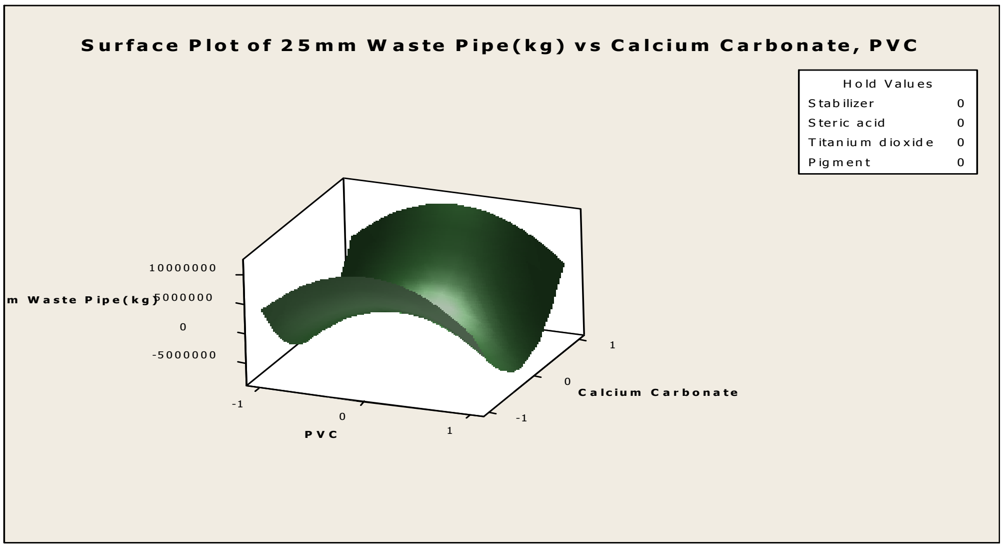


**Fig.2: Surface Plot of 25mm Waste Pipe(kg) vs Calcium Carbonate, PVC**

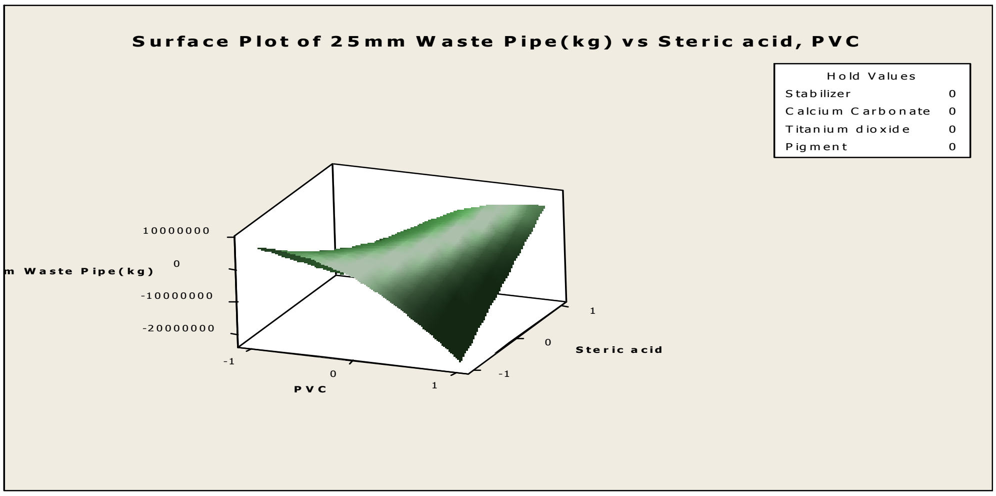


Fig.3: Surface Plot of 25mm Waste Pipe(kg) vs Steric acid, PVC

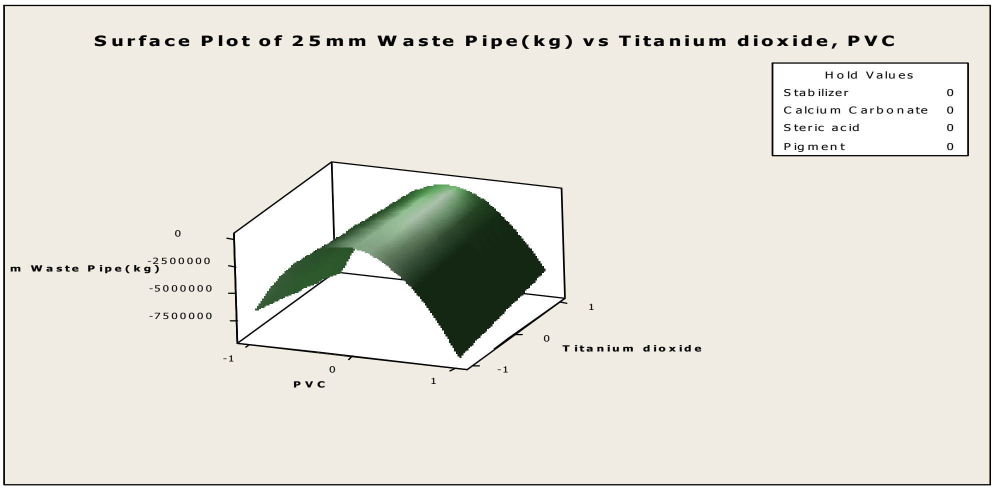


Fig.4: Surface Plot of 25mm Waste Pipe(kg) vs Titanium dioxide, PVC

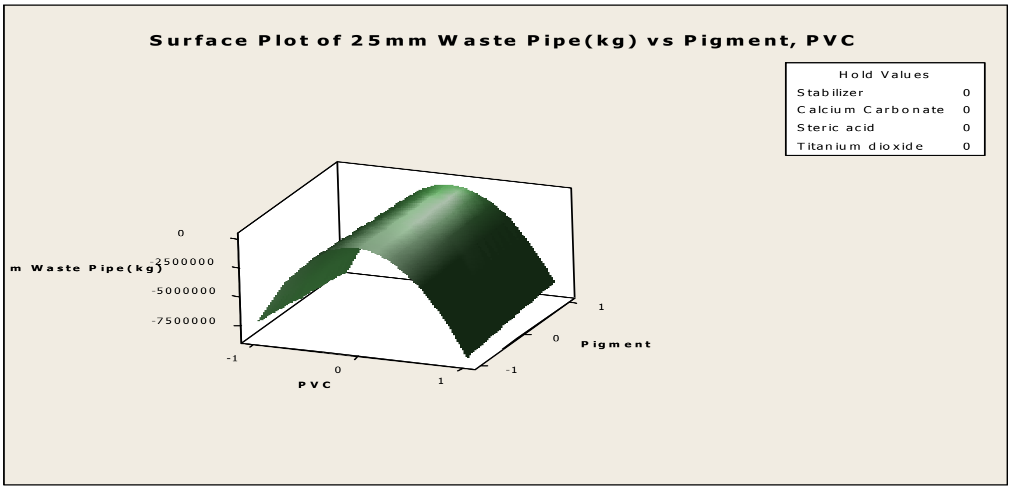


Fig.5: Surface Plot of 25mm Waste Pipe(kg) vs Pigment, PVC

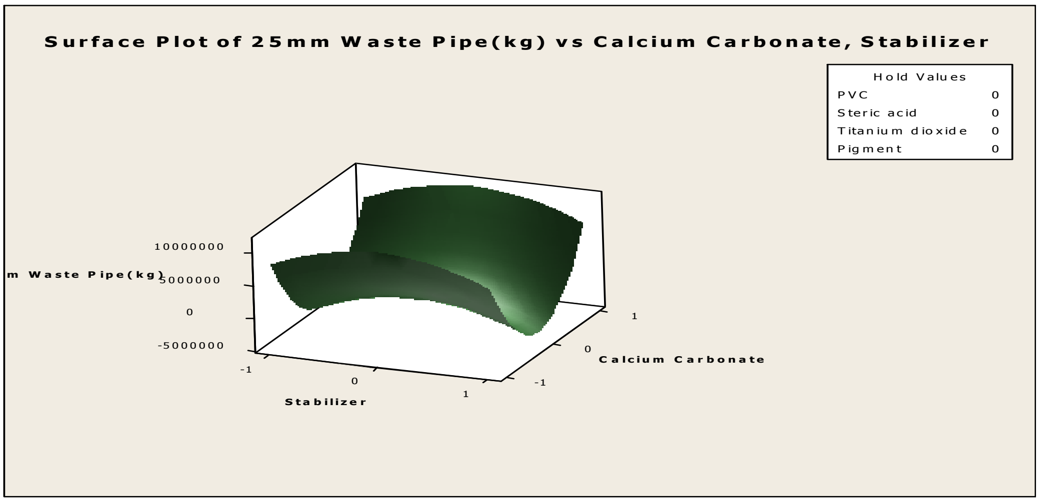


**Fig.6: Surface Plot of 25mm Waste Pipe(kg) vs Calcium Carbonate, Stabilizer**

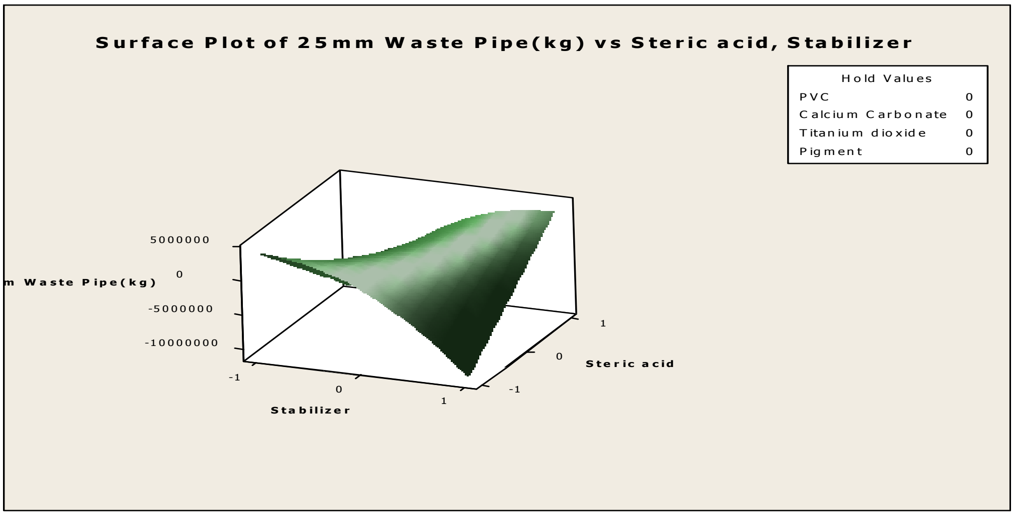


**Fig.7: Surface Plot of 25mm Waste Pipe(kg) vs Steric acid, Stabilizer**

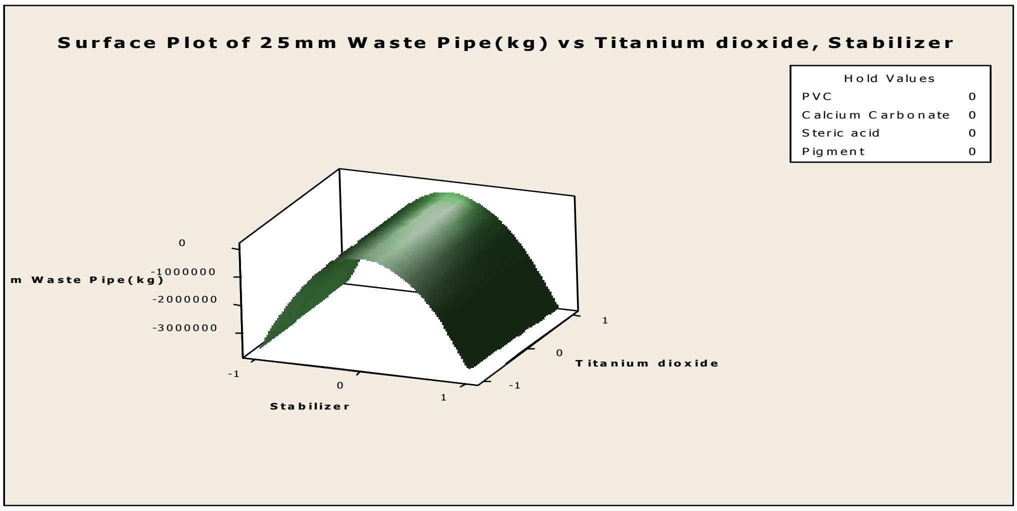


**Fig.8: Surface Plot of 25mm Waste Pipe(kg) vs Titanium dioxide, Stabilizer**

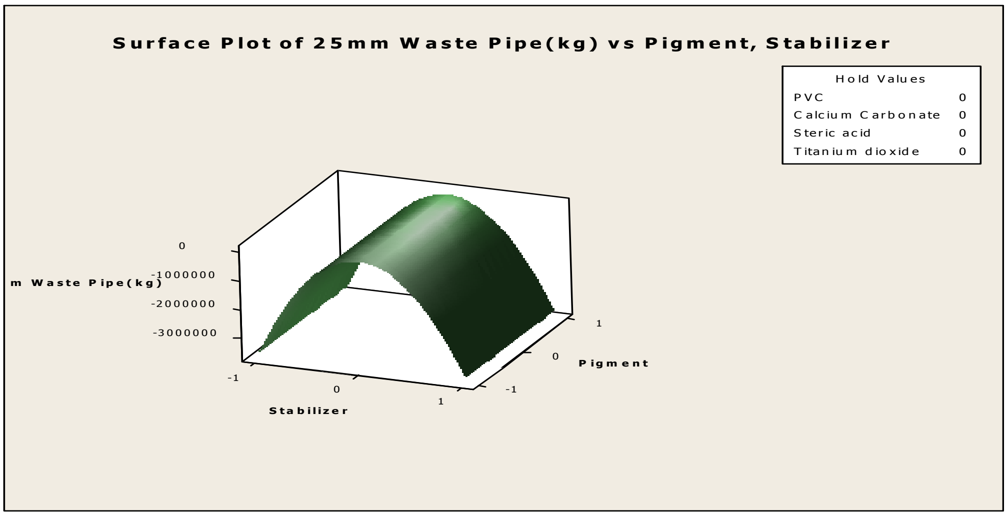


**Fig.9: Surface Plot of 25mm Waste Pipe(kg) vs Pigment, Stabilizer**

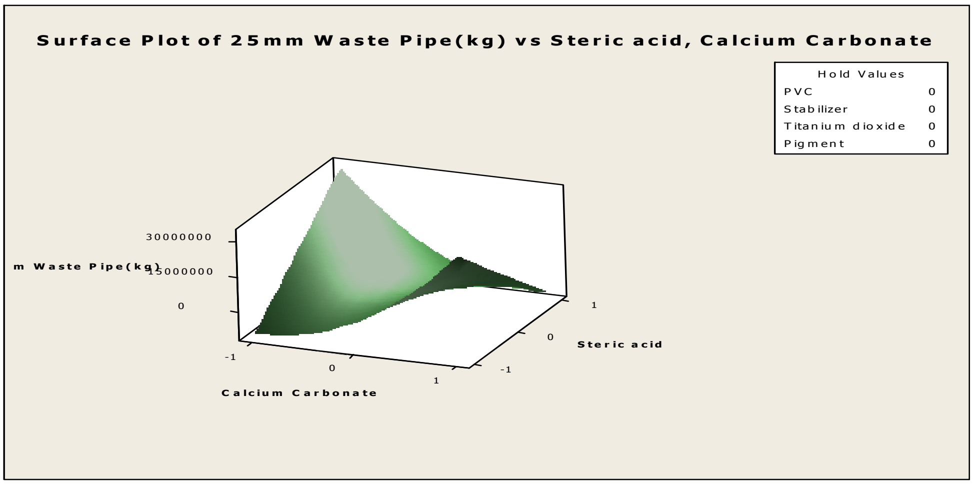


**Fig.10:Surface Plot of 25mm Waste Pipe(kg) vs Steric acid, Calcium Carbonate**

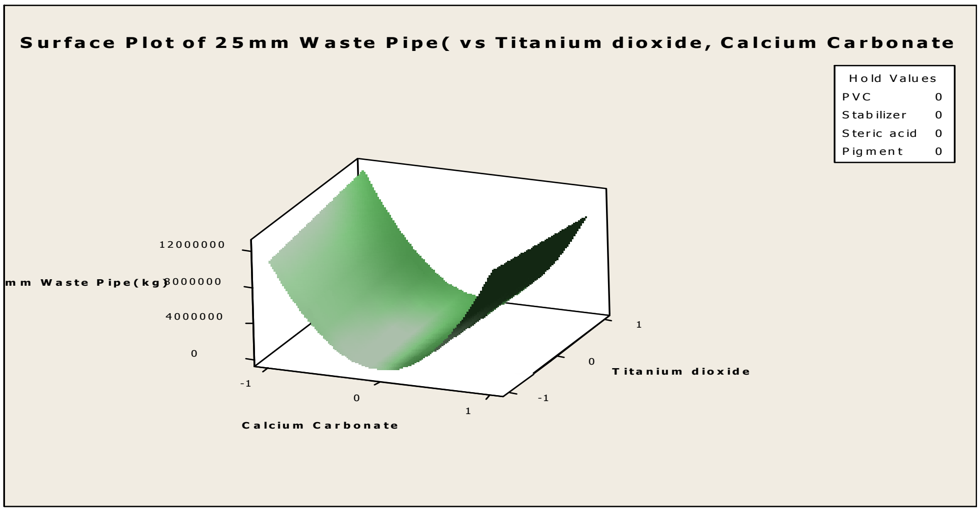


**Fig.11: Surface Plot of 25mm Waste Pipe(kg) vs Titanium dioxide, Calcium Carbonate**

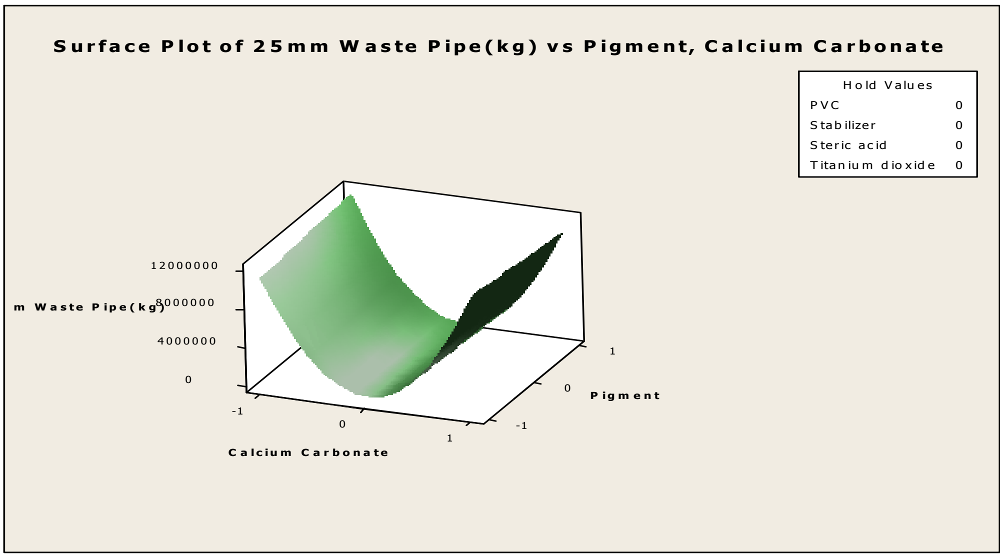


**Fig.12: Surface Plot of 25mm Waste Pipe(kg) vs Pigment, Calcium Carbonate**

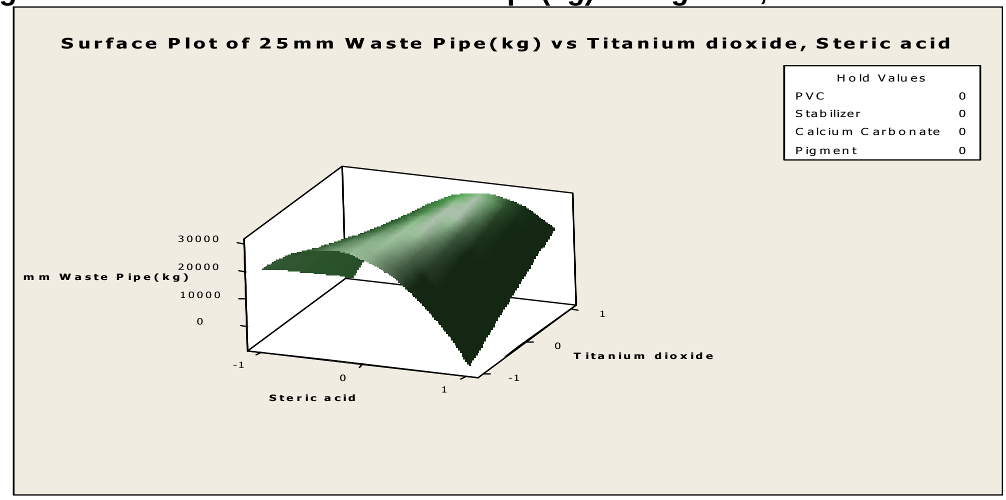


**Fig.13: Surface Plot of 25mm Waste Pipe(kg) vs Titanium dioxide, Steric acid**

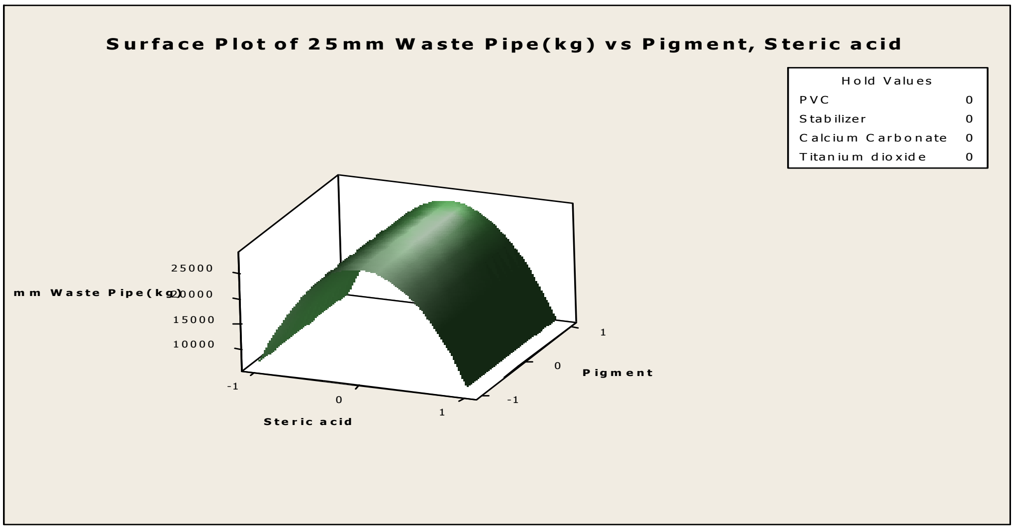


**Fig.14: Surface Plot of 25mm Waste Pipe(kg) vs Pigment, Steric acid**

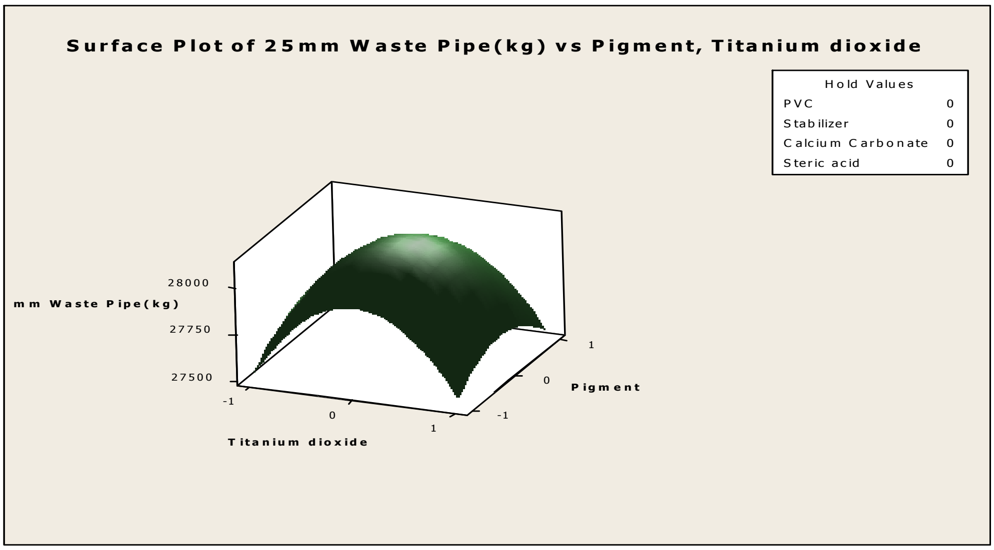


**Fig.15: Surface Plot of 25mm Waste Pipe(kg) vs Pigment, Titanium dioxide**

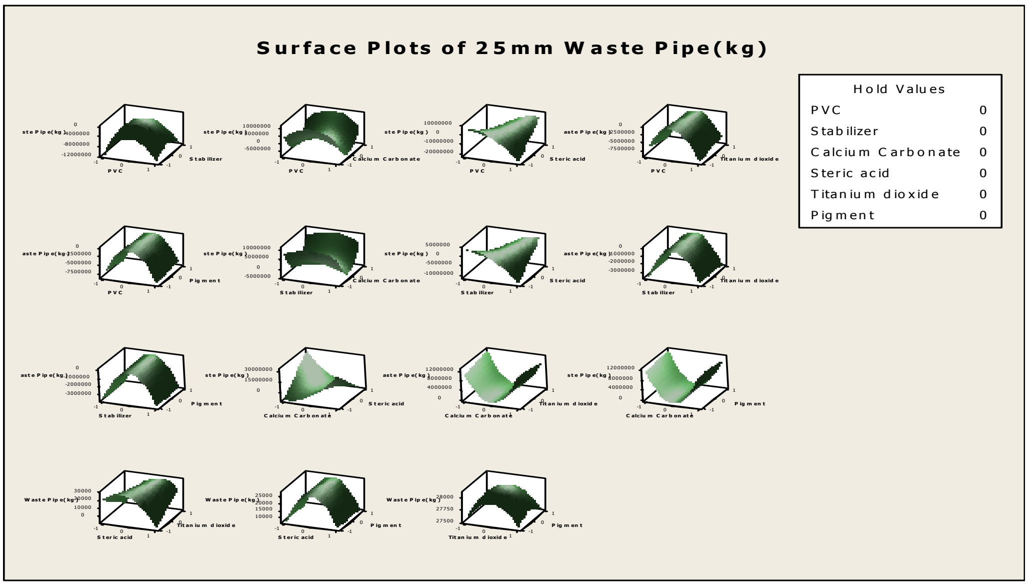


Fig.16: Surface Plots of 25mm Waste Pipe(kg)

### 4.2 Response Optimization

Parameters

| | Goal | Lower | Target | Upper | Weight | Import |
|---|---|---|---|---|---|---|
| 25mm waste Pipe | Target | 1000 | 52000 | 100000 | 1 | 1 |

**Table 3: Local Solutions Table**

| S/N | PVC | STABLIZER | CALCIUM CARBONATE | STERIC ACID | TITANIUM DIOXIDE | PIGMENT |
|---|---|---|---|---|---|---|
| 1 | 45442.8 | 1514.76 | 0 | 151.48 | 12.12 | 1.40788 |
| 2 | 45442.8 | 1514.76 | 9088.55 | 151.097 | 11.6424 | 0 |
| 3 | 45442.8 | 1514.76 | 0.0001670 | 151.480 | 12.1200 | 60.5738 |
| 4 | 45442.8 | 1514.76 | 9088.56 | 151.480 | 12.1200 | 6.05685 |
| 5 | 45442.8 | 0 | 9088.56 | 151.459 | 12.12 | 0.0703254 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6 | 45442.8 | 0 | 0 | 151.457 | 12.12 | 0.0743382 |
| 7 | 45442.8 | 0.0025821 | 0.0004172 | 151.479 | 12.1200 | 6.00280 |
| 8 | 45442.8 | 0.0026424 | 9088.56 | 151.479 | 12.1200 | 5.99895 |
| 9 | 22721.4 | 757.38 | 4544.28 | 75.74 | 6.06 | 3.02937 |
| 10 | 0.0002108 | 1514.76 | 9088.56 | 0 | 0 | 0 |
| 11 | 0.0003063 | 1514.76 | 0 | 0 | 0 | 0 |
| 12 | 0.0070180 | 0.0005276 | 9088.56 | 0.0052626 | 0 | |
| 13 | 1079.88 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 9088.56 | 2.73378 | 0 | 3.31244 |
| 15 | 0 | 0 | 0 | 5.23173 | 2.19678 | 2.81976 |
| 16 | 0 | 1514.76 | 9088.56 | 1.13804 | 0 | 2.30648 |
| 17 | 0 | 1514.76 | 0 | 1.34309 | 0 | 1.63020 |
| 18 | 45442.8 | 0 | 9088.56 | 150.789 | 2.06027 | 6.06 |
| 19 | 45442.8 | 0 | 0 | 150.613 | 2.50444 | 6.06 |
| 20 | 45442.8 | 1514.76 | 9088.56 | 150.482 | 2.88153 | 6.06 |
| 21 | 45442.8 | 1514.76 | 0 | 150.415 | 3.07537 | 6.06 |
| 22 | 45442.8 | 1514.76 | 9088.56 | 150.150 | 3.36754 | 0.485057 |
| 23 | 45442.8 | 1514.76 | 0 | 150.076 | 3.55214 | 0.511846 |
| 24 | 45442.8 | 0 | 9088.56 | 150.053 | 3.61434 | 1.05102 |
| 25 | 45442.8 | 0 | 0 | 149.982 | 3.79266 | 1.10610 |
| 26 | 0 | 1514.76 | 9088.56 | 2.96286 | 3.84594 | 0 |
| 27 | 0 | 1514.76 | 0 | 3.15960 | 3.35380 | 0 |
| 28 | 0 | 0 | 9088.56 | 3.87216 | 1.70613 | 0.0571311 |
| 29 | 0.0009029 | 0 | 0 | 5.88235 | 2.48085 | 2.20986 |
| 30 | 0 | 0 | 9088.56 | 4.49556 | 2.04860 | 4.54440 |
| 31 | 0 | 0 | 0 | 5.00512 | 1.30813 | 4.41359 |
| 32 | 0 | 1514.76 | 9088.56 | 4.19395 | 2.38954 | 2.31145 |
| 33 | 0 | 1514.76 | 0 | 4.50495 | 1.87758 | 1.87799 |
| 34 | 45442.8 | 1514.76 | 0 | 151.48 | 12.12 | 1.40788 |

**Table 4: Table of Predicted Responses**

| S/N | 25mm WASTE PIPE | DESIRABILITY | COMPOSITE DESIRABILITY |
|---|---|---|---|
| 1 | 51994.8 | 0.999898 | 0.999898 |
| 2 | 53235.4 | 0.974263 | 0.974263 |
| 3 | 53744.2 | 0.963662 | 0.963662 |
| 4 | 56215.8 | 0.912171 | 0.912171 |
| 5 | 47033.4 | 0.902615 | 0.902615 |
| 6 | 44575.8 | 0.854428 | 0.854428 |
| 7 | 60728.5 | 0.818157 | 0.818157 |
| 8 | 63191.4 | 0.766846 | 0.766846 |
| 9 | 28107.9 | 0.531527 | 0.531527 |
| 10 | 8931.38 | 0.155517 | 0.155517 |
| 11 | 6459.81 | 0.107055 | 0.107055 |
| 12 | 2471.57 | 0.028854 | 0.028854 |
| 13 | 2000.01 | 0.019608 | 0.019608 |
| 14 | 2883.76 | 0.03637 | 0.036937 |
| 15 | 2458.30 | 0.028594 | 0.028594 |
| 16 | 3728.61 | 0.053502 | 0.053502 |

| | | | |
|---|---|---|---|
| 17 | 2906.71 | 0.037386 | 0.037386 |
| 18 | 2000.01 | 0.019608 | 0.01906 |
| 19 | 5689.19 | 0.091945 | 0.091945 |
| 20 | 5953.29 | 0.097123 | 0.097123 |
| 21 | 5916.80 | 0.096408 | 0.096408 |
| 22 | 5896.38 | 0.096007 | 0.096007 |
| 23 | 5849.03 | 0.095079 | 0.095079 |
| 24 | 5831.77 | 0.094741 | 0.04741 |
| 25 | 5776.23 | 0.093652 | 0.093652 |
| 26 | 4338.62 | 0.065463 | 0.065463 |
| 27 | 3745.99 | 0.053843 | 0.0543843 |
| 28 | 3230.40 | 0.043733 | 0.043733 |
| 29 | 2867.81 | 0.036624 | 0.036624 |
| 30 | 4021.64 | 0.059248 | 0.059248 |
| 31 | 2611.93 | 0.031606 | 0.031606 |
| 32 | 4677.16 | 0.072101 | 0.072101 |
| 33 | 399074 | 0.058642 | 0.058642 |
| 34 | 51994.8 | 0.999898 | 0.999898 |

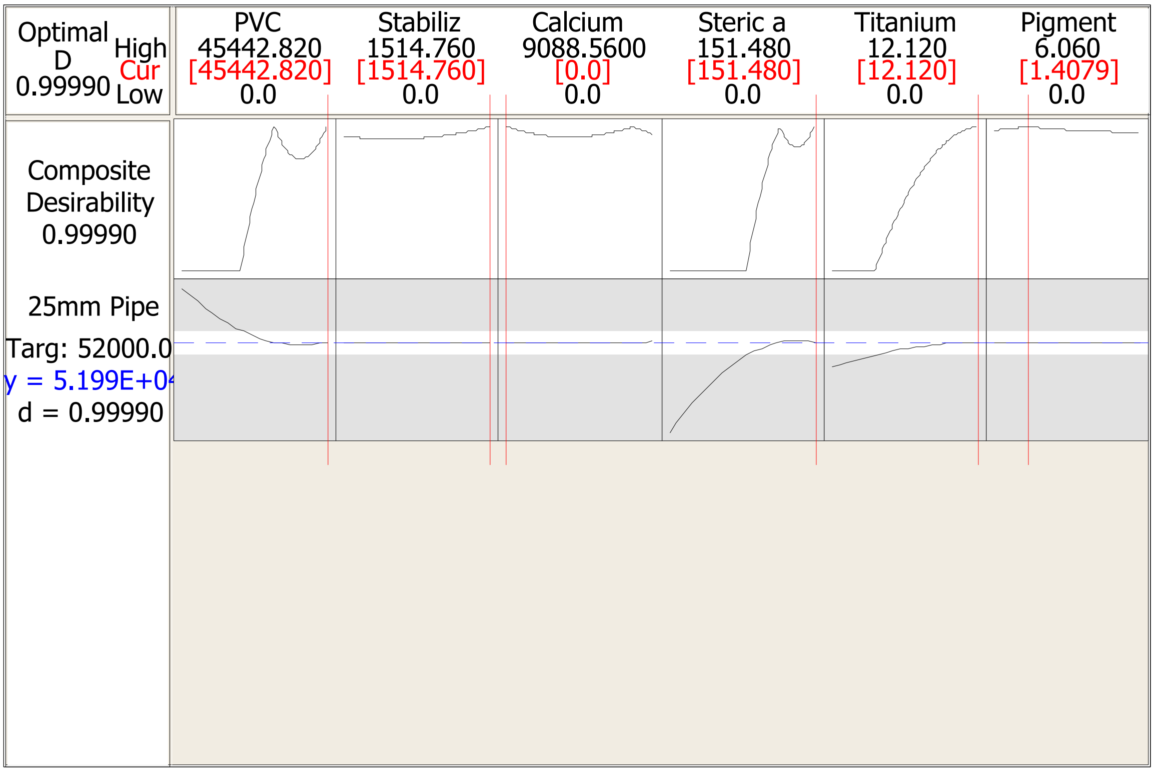


Fig.17: Optimization Plot

### 4.3 Discussion

These results express the optimal production mix of the raw materials in the selected products. The use of response surface model was applied to show the optimal production of the products over the month. The models show that there is a good relationship between the dependent variables and the independent variables and the coefficient of the relationships of the models (R-Sq) is approximately 100%. It also shows from the surface plot, the relationship between the selected products and two different raw materials. The 25mm waste pipe vs Stabilizer, PVC shows increase in the product, then decreases at some point, and increases the Stabilizer, and finally in the 25mm waste pipe vs Steric acid, PVC shows that increase in the product and decreases in the PVC, and an increase in the Steric acid. However, the optimal solution of the 25mm waste pipe above shows an optimal production of 51990kg for the monthly production of the products. The company can achieve the results if the case study will be mindful of their wasted raw materials during production. The model is therefore recommended to the case study company for its applicability for the production of their products in other to achieve its optimal production mixture for the raw materials.

## V. Conclusion

The study has successfully determined the product mix of the raw material of Louis carter Plastic Industry Limited for 25mm waste pipe. This was done using response surface design and its optimization tool. In the process, the optimal quantities of the various PVC raw materials to be mixed within the study period in order to maximize profit were established. This is the advantage of going beyond mere knowledge of existing decision making tools of using wishful mental analysis to actual practical utilization of good engineering powerful tools in decision making of industries. Another issue becomes how the managerial cadre of the case study company could employ this technique in arriving at the objective function of the study. This can go a long way to assisting the management, at least, in the short run. However, in the long run, the case study company would probably gain more from having more permanent employees who can suggest opportunities to utilize these new techniques. There should be people not just one person who can effectively and efficiently interpret the results of mathematical analysis in the company's particular context, as well as possess the necessary competence in the utilization of computers for easy handling of the complex mathematical techniques involved. From the discussion of the study above, it can be seen that response surface model was used to optimize the production mix of the raw materials of selected products and this shows that the case study company wastes some of their raw materials. For this reason, we are recommending this model for the Case Study Company and also advices the company to look into their production system in order to reduce this wastage if they must optimize profit which is the objective function of every enterprise.

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