

# Development of Software for Solving Refinery Blending Problems using Visual Studio

Adefami, Olusegun<sup>1</sup>; Ayo, Y. Kuye<sup>1</sup>; Umeda, Uchendu<sup>2</sup>

<sup>1</sup>Department of Chemical Engineering, University of Port Harcourt, Rivers State, Nigeria

<sup>2</sup>Department of Chemical/ Petrochemical Engineering, Rivers State University, Port Harcourt, Nigeria

Email address: Segcyt2 @ yahoo.com, umexil @ yahoo.com

**Abstract**— This work is aimed at developing a software that could be used to solve Refinery blending problem using Visual Studio. The software was developed from visual studio 2020 through visual basic for solving quadratic programming problems which reduced to revised simplex method for linear programming when the objective function is linear. The result shows that the software can perform the same function with Mat lab and Excel Solver, which implied that the software development is consistent with Excel solver applications. It provides the same solution with Mat lab. Also, it is very flexible and easy to operate. The software can optimize 20x20 Matrix while Mat lab solves 15x15 Matrix. Comparison on tested problems indicated that the software is more efficient than Excel Solver and Matlab 7.0.

**Keywords**— Refinery, Revised Simplex, Software and Visual Studio.

## I. INTRODUCTION

Petroleum consists of crude oil, natural gas, and heavy oil components whose components can be separated into fractions in an oil refinery [2]. Crude oil is processed to get intermediate products which are blended together [1, 7]. Different intermediate products are blended to get final refinery products with desired quantity, quality and schedule specifications [4]. The oil products are manufactured by blending two or more different fractions whose quantities and physio-chemical properties depend on the crude oil type, the way and conditions of processing [3]. The quality of the oil products (fuel) for sale has to comply with the current standards for liquid fuels, and the produced quantities have to comply with the market needs [6]. It is in producer's interest to do the blending in an optimal way to satisfy the requirements for the oil products quality and quantity with a maximal usage of the available fractions and, of course, with a maximal profit out of the sold products. The optimization of refinery products blending is accomplished by applying linear programming [5]. This work involved the development of a software using visual studio 2020 through visual basic for solving quadratic programming problems which reduced it to revised simplex method for linear programming when the objective function is linear. The basis matrix which is maintained is symmetric and varies in size from iteration to iteration.

## II. PROGRAM PROCESS DESIGN FLOWCHART

Figure 1 shows the program flow diagram used for revised simplex method. The process starts by effectively developing algorithms for the program. The commercial Visual studio software was used to design software using visual basic application. In the present study, the designing of the program form was first designed before the developing suitable code for the application. Thereafter, the program components used for the revised simplex method (Rsimplex) is sub divided into two window forms called (frm Siimplex and frm Retrieve).

### Algorithm for Linear Programming

**Step 0** Formulate the equation for the linear programming problem.

$$\text{Maximize } Z = C_1X_1 + C_2X_2 + C_3X_3 + \dots + C_nX_n \quad (1)$$

Constraints

$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + \dots + a_{in}x_n \leq b_1$$

$$a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + \dots + a_{2n}x_n \leq b_2$$

(2)

$$a_{n1}x_1 + a_{n2}x_2 + a_{n3}x_3 + \dots + a_{nn}x_n \leq b_n$$

We could also have constraints with  $\geq$

$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + \dots + a_{in}x_n \geq b_1$$

$$a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + \dots + a_{2n}x_n \geq b_2$$

(3)

$$a_{n1}x_1 + a_{n2}x_2 + a_{n3}x_3 + \dots + a_{nn}x_n \geq b_n$$

**Step 1** Converts the linear programming problem to standard form.

$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + \dots + a_{in}x_n + S_1 = b_1$$

$$a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + \dots + a_{2n}x_n + S_2 = b_2$$

(4)

$$a_{n1}x_1 + a_{n2}x_2 + a_{n3}x_3 + \dots + a_{nn}x_n + S_3 = b_3$$

Note: The objective function could be transformed into

$$Z = C_{BV} X_{BV} + C_{NBV} X_{NBV} \quad (5)$$

$$Z + (C_{BV} B^{-1} N - C_{NBV}) X_{NBV} = C_{BV} B^{-1} b \quad (6)$$

**Step 2** Set up matrix for basic variables and non basic variables

$$BV(0) = \{s_1, s_2, s_3, \dots, s_n\} \tag{7}$$

$$NBV(0) = \{x_1, x_2, x_3, \dots, x_n\} \tag{8}$$

And the matrix for coefficient of basic variables and non basic variables

In the objective function.

$$C_{BV} = \{000\} \tag{9}$$

$$C_{NBV} = \{x_1, x_2, x_3\} \tag{10}$$

**Step 3** Find the inverse of the matrix for basic variable

$$B_0 = B_0^{-1} = \begin{pmatrix} 1 & 0 & 0 & \dots & 0 \\ 0 & 1 & 0 & \dots & 0 \\ 0 & 0 & 1 & \dots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \dots & 1 \end{pmatrix} \tag{11}$$

**Step 4** For the current tableau, Compute  $C_{BV} B^{-1}$  (12)

**Step 5** Price out all non basic variables in the current tableau. If each non basic

Variables prices out non negative the current basic is optimal.

If the current basic is not optimal, enter into the basic,

The non basic variable with the most negative coefficient in row 0.

Call this variable  $x_k$

$$\ddot{C}_j = C_{BV} B^{-1} a_j - C_j \tag{13}$$

**Step 6** To determine the row in which  $x_k$  enters the basic compute

$x_k$  column in the current tableau

(i.e.)  $B^{-1} a_k$

compute the right-hand side of the current tableau

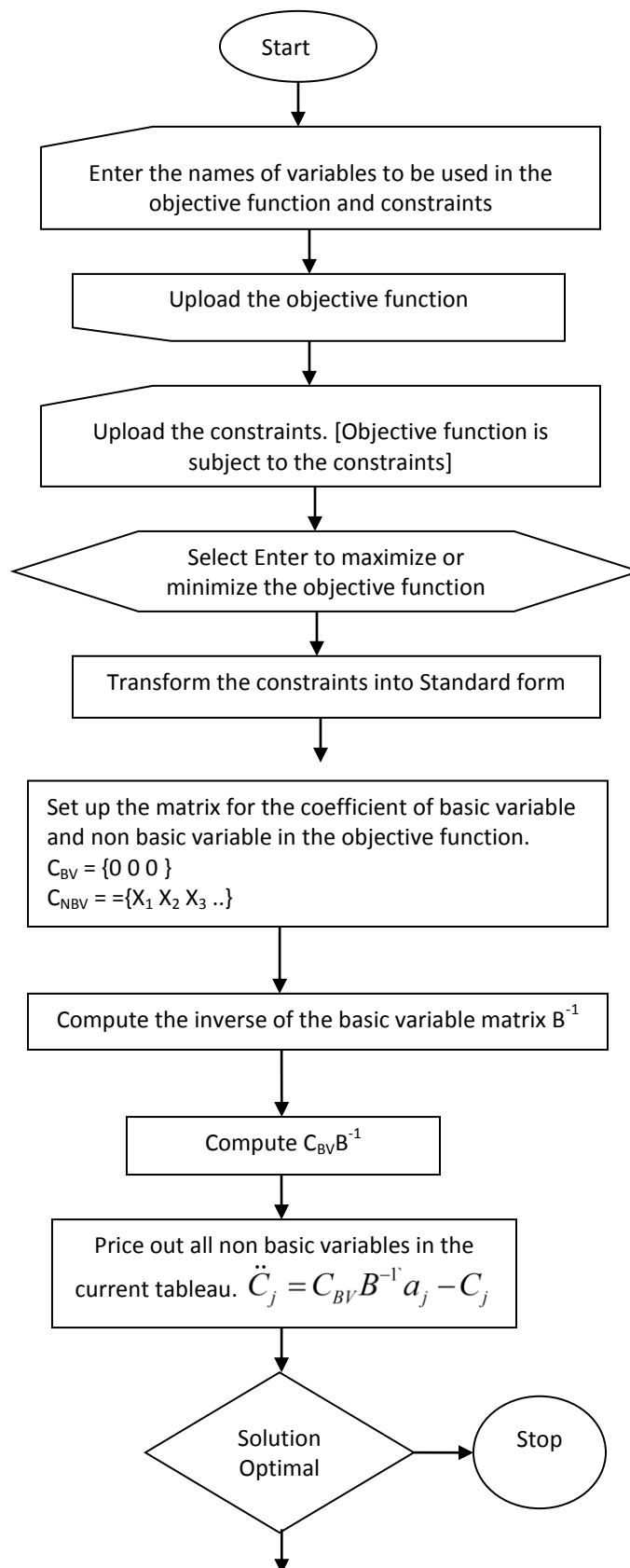
(i.e)  $B^{-1} b$

Then use the ratio test to determine the row in which  $x_k$  should enter the basic. We know the set of basic variable ( $BV$ ) for the new tableau.

**Step 7** Use the column for  $x_k$  in the current tableau to determine

What is needed to get a new?  $B^{-1}$

**Step 8** Return to Step 4.



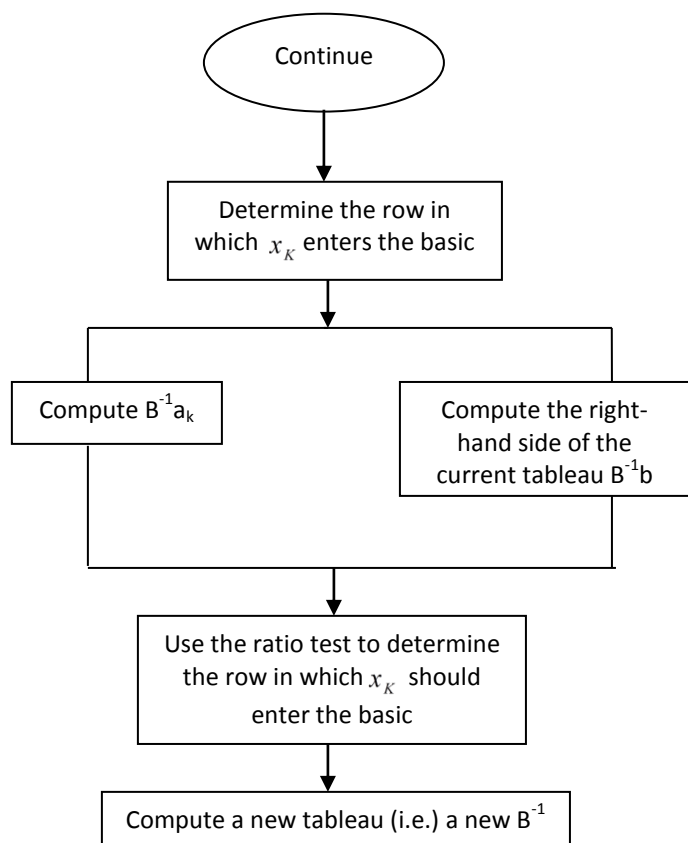


Figure 1. Program Flow chart (Revised simplex Method)

### III. PROGRAM DEVELOPMENT AND OPTIMIZATION PROBLEM

In this section, the program software with coding stage have been established. The software is 99% efficient and it can be applied in different industry for optimization process. The case study of chemical process industries in the 1990’s was examined, the information pertaining to the expected yields of

the fifteen types of crude oils when processed by the refinery is shown below. The product distribution from the refinery is quite different for the fifteen crude oils. The limitations on the established markets for the various products in terms of the allowed maximum daily production are assumed.

The first step required to solve this problem is to formulate the objective function and determined the necessary constraints for the refinery operation and let the variable be:  
 $X_1$  = bbl/day of crude #1;  $X_2$  = bbl/day of crude #2;  $X_3$  = bbl/day of crude #3;  $X_4$  = bbl/day of crude #4  
 $X_5$  = bbl/day of crude #5;  $X_6$  = bbl/day of crude #6;  $X_7$  = bbl/day of crude #7;  $X_8$  = bbl/day of crude #8  
 $X_9$  = bbl/day of crude #9;  $X_{10}$  = bbl/day of crude #10;  $X_{11}$  = bbl/day of crude #11;  $X_{12}$  = bbl/day of crude #12  
 $X_{13}$  = bbl/day of crude #13;  $X_{14}$  = bbl/day of crude #14;  $X_{15}$  = bbl/day of crude #15;  $X_{16}$  = bbl/day of propane  
 $X_{17}$  = bbl/day of butane;  $X_{18}$  = bbl/day of LPG;  $X_{19}$  = bbl/day of Petroleum ether;  $X_{20}$  = bbl/day of ligroin  
 $X_{21}$  = bbl/day of straight-run gasoline;  $X_{22}$  = bbl/day of kerosene;  $X_{23}$  = bbl/day of heating oil  
 $X_{24}$  = bbl/day of gas oil;  $X_{25}$  = bbl/day of diesel fuel;  $X_{26}$  = bbl/day of lubricating oil;  $X_{27}$  = bbl/day of waxes  
 $X_{28}$  = bbl/day of residual oil;  $X_{29}$  = bbl/day of asphalt;  $X_{30}$  = bbl/day of tar

The linear objective function  $Z$  (to be maximized). Other constraints that exist or are implied in this problem are given below. These can be formulated as inequality constraints:  
 Propane:  $X_{16} \leq 48$ ; Butane:  $X_{17} \leq 51$ ; LPG:  $X_{18} \leq 46$ ;  
 Petroleum ether:  $X_{19} \leq 41$ ; Ligroin:  $X_{20} \leq 47$  Straight-run gasoline:  $X_{21} \leq 44$ ; Kerosene:  $X_{22} \leq 43$ ; Heating oil:  $X_{23} \leq 43$ ; Gas oil:  $X_{24} \leq 41$ ; Diesel fuel:  $X_{25} \leq 49$   
 Lubricating oil:  $X_{26} \leq 64$ ; Waxes:  $X_{27} \leq 54$ ; Residual oil:  $X_{28} \leq 56$ ; Asphalt:  $X_{29} \leq 59$ ; Tar:  $X_{30} \leq 45$

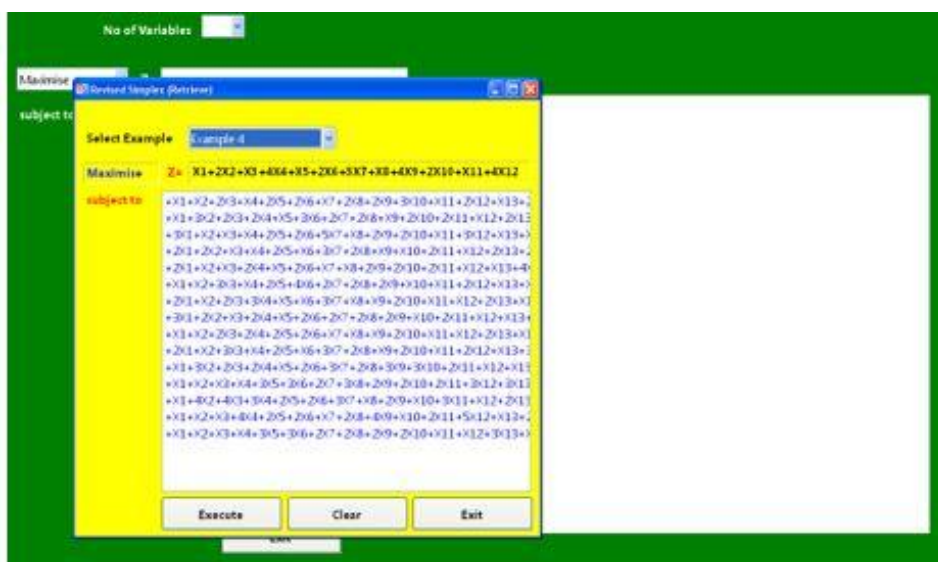


Figure 2 Formulation of Revised Simplex Method

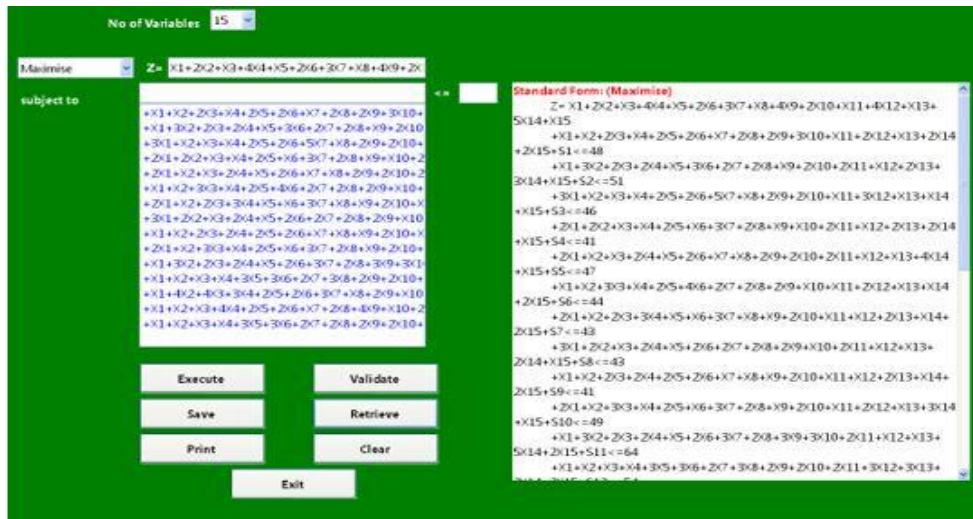


Figure 3: Optimal Solution Revised Simplex Method Using Visual Studio

### Performance Comparison

In this section, Microsoft excel solver was used to compare the software developed from the visual studio. The difference between visual studio software and excel solver is that visual studio shows incorrect inputs and gives directions of what to do at every point in time why excel solver does not show any incorrect input data likewise Matlab is difficult to use for the execution of large problems.

### IV. RESULTS AND DISCUSSION

This work presented a computation method for solving quadratic programming problems which reduces to the revised simplex for linear programming when the objective function is linear. The basis matrix which is maintained is symmetric and may vary in size from iteration to iteration. Comparison on test problems below indicates that the method is more efficient than the other available methods. Using Visual Studio 2021 software in a design of optimization application is equivalent to considering the results of many virtual experiments, each of which is run using different configurations, including geometrical, material or constraints. The design of optimum codes in visual basic is a very difficult task but the application is friendly when compared to Excel Solver and Matlab 7.0 softwares in solving large problems. In the problem formulated and analysed below Excel Solver Software was compared with Visual Studio software which is the aim and objective of this project and we discovered the solutions of both problems were the same. The major difference between ExcelSolver Spreadsheet and Visual basic in Visual Studio 2005 is that Visual Basic shows the incorrect data input while excel solver does not show it. Finally, we can deduce that application of visual studio 2005 in Linear Programming is friendly to the end user and it is useful in refinery blending, Production Planning, Chemical Processing Industry and Financial Distribution.

### V. CONCLUSION

Considering the results obtained in this study, it is important to conclude that the developed software can be used for solving Refinery blending problem using Visual Studio.

### REFERENCES

- [1] Alizadeh, A., Jazayeri, M. R., Gerami, S. & Emadi, M. A. (2015). Foamy oil behavior of an Iranian heavy oil reservoir. *Pet. Sci. Technol.* 33:147–151.
- [2] Ayhan Demirba, Khalid Al –Ghamdi, Nejdett Sen & Walid M. Alalayah(2017). Gasoline and diesel like product from heavy oil via catalytic pyrolysis. *Petroleum science and Technology*, 1-7
- [3] Demirbas, A., Bafail, A. & Nizami, A.-S. (2016). Heavy oil upgrading: Unlocking the future fuel supply. *Petrol. Sci. Technol.* 34, 305–308.
- [4] Hassan M.K., Kandeil A. & Elkhayat A. (2011). Improving oil refinery productivity through enhanced crude blending using linear programming model. *Asian Journal of Science Research*, 2,95 -113.
- [5] Jia Z. & Ierapetritou M. (2003). Mixed-integer linear programming model for gasoline blending and distribution scheduling. *Ind. Eng. Chem. Res.* 42, 825-835.
- [6] Saka, A.H. & Demirbas, A. (2015). The petroleum exploration and production: An overview. *Energy Educ. Sci. Technol.-C.* 7, 171–180.
- [7] Wu, Z., Wu, Y., Xu, S., Guo, J., Zhai, L., & Che, X. (2015). Characteristics and evaluation of extremely shallow oil sand in a heavy oil reservoir. *Pet. Sci. Technol.* 33, 1215–1221.