OPTIMIZATION OF PRODUCTION COSTS WITH SIMPLEX METHOD

Firmansyah¹, Dedy Juliandri Panjaitan¹, Madyunus Salayan¹, Alistraja Dison Silalahi²

¹ Department of Mathematics Education, FKIP, University Muslim Nusantara Alwashliyah, Indonesia
² Accounting Department, Faculty of Economics, University Muslim Nusantara Alwashliyah, Indonesia

Corresponding Author : dedyjuliandri@umnaw.ac.id

Abstract.

One of the problems in the company is my resource limitation, the time of production and the tools used in the production process. Companies in making decisions in production planning in the presence of these limitations, should seek to maximize the profit generated. However, in the production process a production planning reference is required to maximize the results obtained and minimize the production costs used. To solve the problem, needed a problem solving tool that is linear program using simplex method. Simplex method is one of the methods of linear program in solving the problem of more than two variables that can be applied into everyday life and can be used in production process planning. With one of the ultimate goal is the achievement of the optimum value with the constraints of limited resources. The results of the simplex method have decreased costs incurred less than the usual costs incurred every month and the results obtained using the simplex method can be used as a reference in making decisions to get optimal results on production costs in the company.

Keywords: Optimization, Minimization, Simplex Method

1.1 INTRODUCTION

The scope of mathematics is very broad, the application of mathematics in life has spread wide enough because it has positive effect with many benefits. In the production sector, which converts raw materials into new varied products expect maximum profit with minimal production costs.

Linear program is one of the solution problem in determining the optimal solution. "The problem of linear programming is basically concerned with the determination of the optimal allocation of limited resources (limited resources) to meet an objective (objective)" [1]

There are several problem solving methods in the linear program that are graphical method, algebraic method, gauss jordan method, and simplex method.

"Most linear programming problems in the real world have more than two variables that lead to completion with less effective chart methods" [2]. The algebraic method will be more complicated in finding problem solving if more than three variables, as well as the gausss jordan method, must be more thorough in the process to obtain the minimum solution.

"In 1947 a mathematician from the United States named George D. Dantzig devised a way of deciphering and solving linear programming problems with Simplex Methods" [3]. With the simplex method will be in the final result which is the best value in minimizing profit.
Before performing iterative calculations to determine the optimal solution, at the pre-analysis stage, determine the decision variable of the real problem. Then formulate the problem into the standard form of linear programming so that the formation of objective function and constraint function, change the inequality into the form of linear equation by adding slack variable, surplus variable and additional variable. Presents the data into the initial simplex table and determines in advance the initial feasible baseline settlement that provides the zero goal function. Specifies which variables go into the decision variables and that comes out of the base variable, based on key and key row columns. Perform calculations to generate a new split in the simplex table by iterating the simplex method until the optimal value of the destination function is reached. When we have obtained the optimal value of the objective function then we are finished in the process of simplex analysis.

1.2 RESEARCH OBJECTIVES

The purpose of this study is to optimize production costs as a limited resource in this case minimizing costs.

1.3 METHODS

This study uses a study of literature studies followed by case study research. Begin by collecting various sources concerned with linear program material and simplex methods such as journals, books, theses, and the internet. Discusses the material of simplex mathematics, slack variables, surplus variables, additional variables and materials related to this research. The next step collects data from the Business Entity owner and takes samples needed in data processing. The data taken is secondary data.

2. LITERATURE REVIEW

Rumahorbo [4] From the results of his research has concluded that the simplex method can be used as solution in solving linear program problem more than two variables consistently in case of maximization and minimization.

Sunarsih [5] also argues that the most successful technique in solving linear programming problems with the large number of decision and limiting variables can be used the simplex method.

Conclusion of Sukanta [6] in Simplex Method Linear Program In Polyster Material In Indonesia that the simplex method can be taken into consideration for use in minimizing costs with the use of materials to be more optimal.

In Chandra's study [5] also says that the number of iterations is not influenced by the number of variables, but depends on the value of the objective function of the previous iteration.

3. RESULT AND DISCUSSION

3.1 Simplex method algorithm

Simplex method algorithm in analyzing data as follows:

1. Identify decision variables and formulate them into mathematical symbols.

2. Identify the objective function to be achieved and the function of the boundary into the mathematical model.
3. Function objectives and boundary functions are formulated into standard form of simplex method by adding slack variables, surplus variables, and additional variables.

4. Creating initial table of simplex method Initial table

5. Enter the value of each variable into the simplex initial table

6. Specify a key column based on the largest z value.

7. Determine the solution ratio

\[ s = \frac{\text{the key row column value}}{\text{element cell}} \]

8. Determining the lock row based on the smallest ratios (without z row)

9. Specifies the cell element that is the slice of the key column and the lock row

10. Perform a stages (iteration) that begins by specifying a new row of keys

\[ \text{new row of keys} = \text{Key Lock lines} \]

11. transform a line other than the lock line

\[ \text{new row besides row lock} = \text{old row} - [\text{(old column value) x (new row key)}] \]

(if the coefficient on the z row still exists that is positive, then back to the numbers 6 - 11)

12. Testing the optimality, until all the coefficients on the z-row is no longer a positive value, which means the table is optimal.

3.2 Mathematical Model of Simplex Method

Minimize objective function (purpose function)

\[ z - c_1x_1 - c_2x_2 - c_3x_3 + M(r_1 + r_2 + r_3 + r_4 + r_5 + r_6 + r_7 + r_8) = 0 \] (1)

With constraints

\[
\begin{align*}
    a_{11}x_1 + a_{12}x_2 + a_{13}x_3 - s_1 + r_1 &= l_1 \\
    a_{21}x_1 + a_{22}x_2 + a_{23}x_3 - s_2 + r_2 &= l_2 \\
    a_{31}x_1 + a_{32}x_2 + a_{33}x_3 - s_3 + r_3 &= l_3 \\
    a_{41}x_1 + a_{42}x_2 + a_{43}x_3 - s_4 + r_4 &= l_4 \\
    a_{51}x_1 + a_{52}x_2 + a_{53}x_3 + s_5 &= l_5 \\
    a_{61}x_1 + a_{62}x_2 + a_{63}x_3 - s_6 + r_6 &= l_6 \\
    a_{71}x_1 + a_{72}x_2 + a_{73}x_3 - s_7 + r_7 &= l_7 \\
    a_{81}x_1 + a_{82}x_2 + a_{83}x_3 + s_8 &= l_8 \\
    a_{91}x_1 + a_{92}x_2 + a_{93}x_3 - s_9 + r_9 &= l_9
\end{align*}
\] (2)

Description

\[ Z : \text{minimal production costs} \]

\[ x_n : \text{the number of production} \]

\[ c_1, c_2, c_3 : \text{production cost 1 kg of product} \]

\[ a_{11}, a_{12}, a_{13} : \text{Material A for 1 kg of product}. \]

\[ a_{21}, a_{22}, a_{23} : \text{Material B for 1 kg of product}. \]

\[ a_{31}, a_{32}, a_{33} : \text{Material C for 1 kg of product}. \]

\[ a_{41}, a_{42}, a_{43} : \text{Material D for 1 kg of product}. \]

\[ a_{51}, a_{52}, a_{53} : \text{Material E for 1 kg of product}. \]

\[ a_{61}, a_{62}, a_{63} : \text{depreciation material I (Fuel oil) for 1 kg of product}. \]
3.2 Decision Variables

In this study, which became a decision, that is:

\( x_1 \): the number of square opak production
\( x_2 \): the number of animal feed production
\( x_3 \): the number of round opak production

3.3 Function Goals

The objectives to be achieved can be seen in the following table.

| No | Produk          | Production Cost 1 kg (Rp) |
|----|----------------|--------------------------|
| 1  | Square Opak    | 4035                     |
| 2  | Animal Feed    | 1902                     |
| 3  | Round Opak     | 5146                     |

3.4 Function Constraints

With the constraints and limitations of resources owned can be seen in the table below.

| No | Produk          | Object A | Object B | Object C | Object D | Object E |
|----|----------------|----------|----------|----------|----------|----------|
| 1  | Square Opak    | 3        | 3,75     | 0,9      | 0,45     | 0 gr     |
| 2  | Animal Feed    | 3,333333333 | 0        | 0        | 0        | 0 gr     |
| 3  | Round Opak     | 3        | 6        | 2        | 0,45     | 1 gr     |

91500 kg  67500 gr  17600 gr  7425 gr  2500 gr

Table 3. Table Resource Limits

| No | Produk          | fuel oil (ml) | firewood (cm³) | Pay(Rp) | packaging (Rp) |
|----|----------------|---------------|----------------|---------|----------------|
| 1  | Square Opak    | 6,9231        | 0,3            | 7,05    | 9              |
| 2  | Animal Feed    | 16,6667       | 0              | 7,3333  | 6              |
| 3  | Round Opak     | 15,3846       | 1,04           | 15      | 9              |

Subject to
Formulation of objective functions and constraint functions by adding slack variables, surplus variables, and additional variables as follows:

With Constraint

\[
3x_1 + 3,3333x_2 + 3x_3 - s_1 + r_1 = 91500
\]

\[
\Rightarrow r_1 = 91500 - 3x_1 - 3,3333x_2 - 3x_3 + s_1
\]

\[
3,75x_1 + 6x_3 - s_2 + r_2 = 67500
\]

\[
\Rightarrow r_2 = 67500 - 3,75x_1 - 6x_3 + s_2
\]

\[
0,9x_1 + 2x_3 - s_3 + r_3 = 17600
\]

\[
\Rightarrow r_3 = 17600 - 0,9x_1 - 2x_3 + s_3
\]

\[
0,45x_1 + 0,5x_3 - s_4 + r_4 = 7550
\]

\[
\Rightarrow r_4 = 7550 - 0,45x_1 - 0,5x_3 + s_4
\]

\[
x_3 + s_5 = 2500
\]

\[
6,9231x_1 + 16,6667x_2 + 15,3846x_3 - s_6 + r_6 = 345384,6
\]

\[
\Rightarrow r_6 = 345384,6 - 6,9231x_1 - 16,6667x_2 - 15,3846x_3 + s_6
\]

\[
0,3x_1 + 1,04x_3 - s_7 + r_7 = 6800
\]

\[
\Rightarrow r_7 = 6800 - 0,3x_1 - 1,04x_3 + s_7
\]
7.05x_1 + 7.3333x_2 + 15x_3 + s_8 = 233850

9x_1 + 6x_2 + 9x_3 - s_9 + r_9 = 224100

→ r_9 = 224100 - 9x_1 - 6x_2 - 9x_3 + s_9

Minimize

\[ z = 4035x_1 + 1902x_2 + 5146x_3 + Mr_1 + Mr_2 + Mr_3 + Mr_4 + Mr_6 + Mr_7 + Mr_9 \]

\[ z = 4035x_1 + 1902x_2 + 5146x_3 + M(91500 - 3x_1 - 3,3333x_2 - 3x_3 + s_1) \]

\[ + M(67500 - 3,75x_1 - 6x_2 + s_2) + M(17600 - 0,9x_1 - 2x_3 + s_3) \]

\[ + M(7550 - 0,45x_1 - 0,5x_3 + s_4) + M(345384,6 - 6,9231x_1 - 16,6667x_2 - 15,3846x_3 + s_5) + M(6800 - 0,3x_1 - 1,04x_3 + s_7) + M(224100 - 9x_1 - 6x_2 - 9x_3 + s_9) \]

\[ z = 4035x_1 + 1902x_2 + 5146x_3 + 91500 - 3,3333Mx_2 \]

\[ - 3Mx_3 + Ms_1 + 67500 - 3,75Mx_1 - 6Mx_3 + Ms_2 + 17600M \]

\[ - 0,9Mx_1 - 2Mx_3 + Ms_3 + 7550M - 0,45Mx_1 - 0,5Mx_3 + Ms_4 \]

\[ + 345384,6M - 6,9231Mx_1 + 16,6667Mx_2 - 15,3846Mx_3 + Ms_6 \]

\[ + 6800M - 0,3Mx_1 - 1,04Mx_3 + Ms_7 + 224100M - 9Mx_1 - 6Mx_2 \]

\[ - 9Mx_3 + Ms_9 \]

\[ z = (4035 - 24,3231)Mx_1 + (1902 - 26)Mx_2 + (5146 - 36,9246)Mx_3 \]

\[ + 60434,6M + Ms_1 + Ms_2 + Ms_3 + Ms_4 + Ms_6 + Ms_7 + Ms_9 \]

\[ z = (4035 - 24,3231)Mx_1 + (1902 - 26)Mx_2 + (5146 - 36,9246)Mx_3 \]

\[ - Ms_1 - Ms_2 - Ms_3 - Ms_4 - Ms_6 - Ms_7 - Ms_9 = 760434,6M \]

4 COMPLETION WITH SIMPLEX TABLE

The function objectives and function constraints have been formulated into the standard form of the simplex method by adding the slack variable, arranged into the simplex initial table.

### Table 4. initial table minimization

| V0 | Z | X1 | X2 | X3 | r1 | s1 | r2 | s2 | r3 | s3 | r4 | s4 | r5 | s5 | r6 | s6 | r7 | s7 | r8 | s8 | r9 | s9 | rs |
|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 0  | 4035-24,3231 | 1902-26 | 5146-36,9246 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 760434,6M |
| 1  | 0 | 3 | 3,3333 | 3 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 91500 |
| 2  | 0 | 3,75 | 0 | 6 | 0 | 0 | 1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 67500 |
| 3  | 0 | 0,9 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17600 |
| 4  | 0 | 0,45 | 0 | 0,5 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7550 |

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### Table 5. First Iteration

| VD | Z | X1 | X2 | X3 | r1 | s1 | r2 | s2 | r3 | s3 | r4 | s4 | r5 | s5 | r6 | s6 | r7 | s7 | r8 | s8 | r9 | s9 | 5 | Rs |
|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1  | 3 | 16.6667 | 0.3846 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 2500 | 2500 |
| 2  | 3 | 3.333333 | 1.333333 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 84000 | 25200 |
| 3  | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 12600 | 6300 |
| 4  | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 2500 | 30 |
| 5  | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 4200 | 4200 |
| 6  | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 196850 | 26775.1217 |
| 7  | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 201660 | 33600 |

### Table 6. Second Iteration

| VD | Z | X1 | X2 | X3 | r1 | s1 | r2 | s2 | r3 | s3 | r4 | s4 | r5 | s5 | r6 | s6 | r7 | s7 | r8 | s8 | r9 | s9 | 5 | Rs |
|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1  | 3 | 16.6667 | 0.3846 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 84000 | 25200 |
| 2  | 3 | 3.333333 | 1.333333 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 12600 | 6300 |
| 3  | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 2500 | 30 |
| 4  | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 4200 | 4200 |
| 5  | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 196850 | 26775.1217 |
| 6  | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 201660 | 33600 |

### Table 7. Third iteration

| VD | Z | X1 | X2 | X3 | r5 | s5 | r6 | s6 | r7 | s7 | r8 | s8 | r9 | s9 | 5 | Rs |
|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1  | 3 | 16.6667 | 0.3846 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 84000 | 25200 |
| 2  | 3 | 3.333333 | 1.333333 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 12600 | 6300 |
| 3  | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 2500 | 30 |
| 4  | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 4200 | 4200 |
| 5  | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 196850 | 26775.1217 |
| 6  | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | -1 | 0  | 0  | 0  | 0  | 201660 | 33600 |
Table 8. the fourth iteration

| VD | Z | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 | X13 | X14 | X15 | X16 | X17 | X18 | X19 | X20 |
|----|---|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| VD | Z | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 | X13 | X14 | X15 | X16 | X17 | X18 | X19 | X20 |
| Z  | 1  | 0  | 0  | 0  | 0  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| Z  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| Z  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  |
| Z  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  |
| Z  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  |

Table 9. fifth iteration

| VD | Z | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 | X13 | X14 | X15 | X16 | X17 | X18 | X19 | X20 |
|----|---|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| VD | Z | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 | X13 | X14 | X15 | X16 | X17 | X18 | X19 | X20 |
| Z  | 1  | 0  | 0  | 0  | 0  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| Z  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| Z  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  |
| Z  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  |
| Z  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 5  |
### Table 1. iteration sixth

| x1  | x2  | x3  | x4  | x5  | x6  | x7  | x8  | x9  |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1.932132414 | 1.932132414 | 10.525939852 | 10.525939852 | 667.3333895 | 667.3333895 | 93320.01786 | 93320.01786 |

### Table 2. the seventh iteration

| x1  | x2  | x3  | x4  | x5  | x6  | x7  | x8  | x9  |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1.000000000 | 1.000000000 | 0.000000000 | 0.000000000 | 0.000000000 | 0.000000000 | 0.000000000 | 0.000000000 | 0.000000000 |

### Table 3. iteration eighth

| x1  | x2  | x3  | x4  | x5  | x6  | x7  | x8  | x9  |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1.932132414 | 1.932132414 | 10.525939852 | 10.525939852 | 667.3333895 | 667.3333895 | 93320.01786 | 93320.01786 |
From the calculation result of simplex method gives minimum value of \( z = 93320407.1 \) when \( X_1 = 1400, 08915 = X_2 = 1400, X_2 = 12599,91977 = X_2 = 12600, \) and \( s_3 = 2500. \) In the ninth iteration also obtained \( s_8 = 5250,379873 \) which is the excess material (residual material), \( s_2 = 0.334295178, s_3 = 0.080230843, s_4 = 0.040115421, s_7 = 0.026743614 \) and \( s_9 = 0.320930931 \) which is use of material that exceeds the limit.

5. CONCLUSION

From the research result, it can be concluded that the total cost of production per month is the minimum production cost by producing square opak 14000 kg, animal feed 12600 kg and opak bulk 2500 kg, so in the month required production cost equal to Rp 93.320.407.1

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