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OPTIMIZATION OF INDUSTRIAL PROCESSES USING A SPECIAL SOFTWARE

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Abstract: *The aim of the study is finding the best solution from all the industrial solution and this is a problem that can be solved with the help of the optimization calculation. The paper presents an experimental study regarding the utilization of a special Digital Sky Simplex Software for solving the production optimization of a hypothetical industrial process, using the Phases I problem of the Simplex algorithm. The number of unknowns components of calculation using the classical method is large, difficult, requiring a large volume of work and are insufficiently precise, all work was done whit the optimization by the linear programming, using a personal Digital Sky Simplex Software.*

1. INTRODUCTION

In optimization problems, we have to find solutions which are optimal or near-optimal with respect to some goals. Usually, we are not able to solve problems in one step, but we follow some process which guides us through problem solving. Often, the solution process is separated into different steps which are executed one after the other. Commonly used steps are recognizing and defining problems, constructing and solving models, and evaluating and implementing solutions [1].

In Optimization of Industrial Unit Processes, the term "optimization" means the maximizing of productivity and safety while minimizing operating costs. In a fully optimized plant, efficiency and productivity are continuously maximized while levels, temperatures, pressures, or flows float within their allowable limits [2].

The main optimization criteria are economic, technical and economic nature.

Planning processes to solve planning or optimization problems have been of major interest in operations research [3, 4].

Planning is viewed as a systematic, rational and theory-guided process to analyze and solve planning and optimization problems. The planning process consists of several steps:

1. Recognizing the problem,
2. Defining the problem,
3. Constructing a model for the problem,
4. Solving the model,
5. Validating the obtained solutions, and
6. Implementing one solution.

2. STEPS FOR OPTIMIZATION BY USING A LINEAR PROGRAMMING

A first stage of optimization is to determine the mathematical model and the second step is finding the optimum coordinates in the multifactorial space.

This means determining the extreme values (maximum or minimum) optimized parameters and factors, which receives the optimized parameter values, this step is even calling optimization.
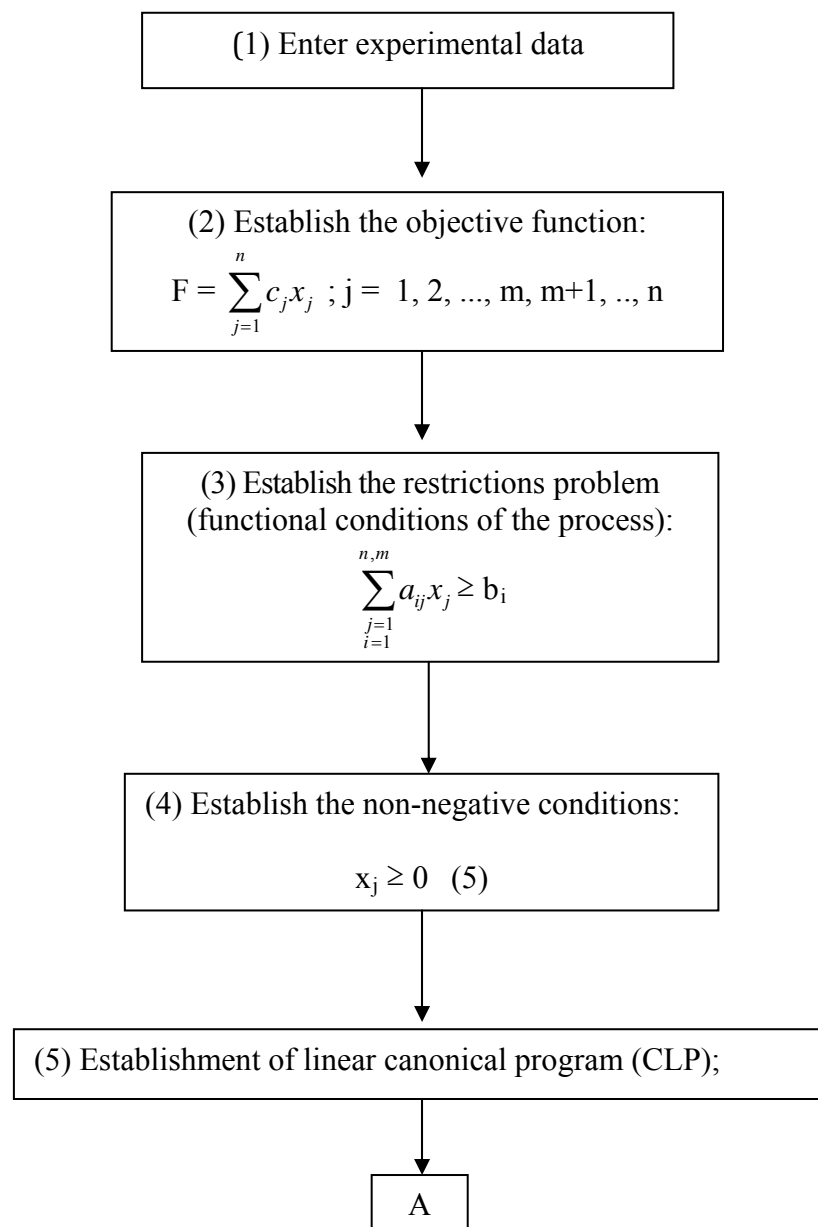
Optimizing a process in terms of technological restriction require the use of a mathematical model which contains the optimized and restrictions of type equality and inequality [5].

If the optimized function and the restrictions are linear, then linear programming is used and when the optimized function and constraints are used nonlinear programming [6, 7].

The most used method to optimize the restriction is the Simplex algorithm method. The method described is a simple total solving linear program and is used frequently when the number of equations (m) and number of variables (n) is small.

Simplex algorithm applies when the number of equations (m) and number of variables (n) is large and full description of the method is cumbersome.

Steps for optimization by using a linear programming are:

$$\boxed{(1) \text{ Enter experimental data}}$$

$$\downarrow$$

$$\boxed{\begin{array}{c} (2) \text{ Establish the objective function:} \\[4pt] F = \sum_{j=1}^{n} c_j x_j \; ; j = \; 1, 2, ..., m, m+1, .., n \end{array}}$$

$$\downarrow$$

$$\boxed{\begin{array}{c} (3) \text{ Establish the restrictions problem} \\ \text{(functional conditions of the process):} \\[4pt] \sum_{\substack{j=1 \\ i=1}}^{n,m} a_{ij} x_j \geq b_i \end{array}}$$

$$\downarrow$$

$$\boxed{\begin{array}{c} (4) \text{ Establish the non-negative conditions:} \\[4pt] x_j \geq 0 \quad (5) \end{array}}$$

$$\downarrow$$

$$\boxed{(5) \text{ Establishment of linear canonical program (CLP);}}$$

$$\downarrow$$

$$\boxed{A}$$

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(6) Perform linear canonical transformation program (CLP) in the standard linear program (SLP) by adding or subtracting (depending on the shape of each inequality: $\geq, \leq, =$) of variable spacing (x_{ie}) or artificial variables (x_{ia})

$$\sum_{j=1}^{n} a_{ij}x_j \leq b_i \text{ turn into } \sum_{j=1}^{n} a_{ij}x_j + x_{ie} = b_i$$

$$\sum_{j=1}^{n} a_{ij}x_j \geq b_i \text{ turn into } \sum_{j=1}^{n} a_{ij}x_j + x_{ia} - x_{ie} = b_i$$

$$\sum_{j=1}^{n} a_{ij}x_j = b_i \text{ turn into } \sum_{j=1}^{n} a_{ij}x_j + x_{ia} = b_i$$

(7) Finding the solution to start, solving equation:
$(n-m)_n = 0$

(8) Determination of the base variables (BV) and the values of base variables (VBV).

(9) Simplex table is built, starting by iteration 0

(10) Calculating basic changes (iteration)

(11) By analyzing differences $z_j - c_j$, determining whether the optimum is reached

(12) If the optimum is determined, *calculation stops*; the values of optimum are displayed:
$F_{max}=z_0=b_i$; $F_{min}= z_0= b_i$; $x_{1_{opt}} =x_1=\widetilde{X}_1$; $x_{2_{opt}} =x_2=\widetilde{X}_2$; $x_{i_{opt}} =x_i=\widetilde{X}_i$
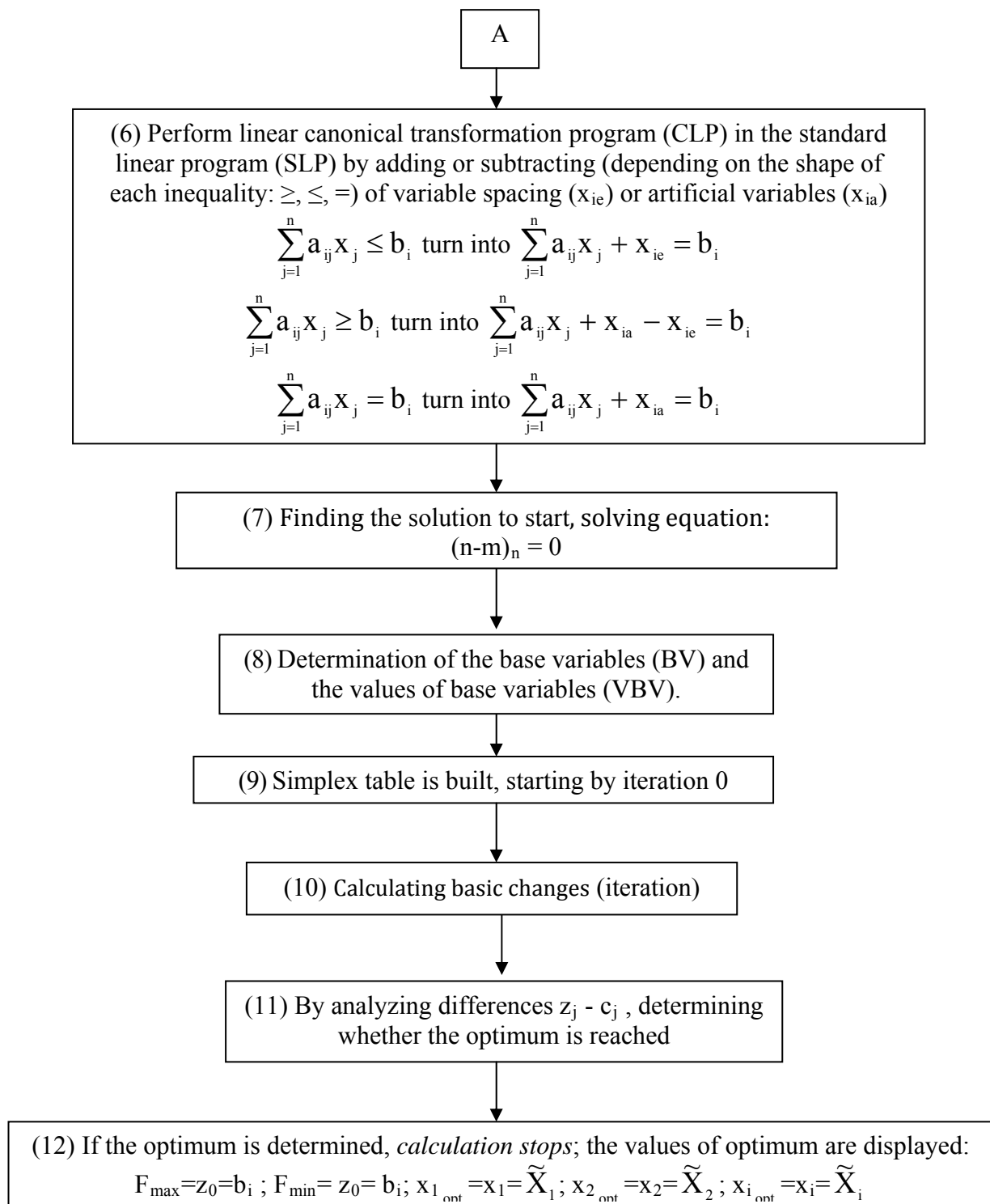
Fig. 1. Steps for optimization by using a linear programming.

where:

x_j (x_1, x_2,......x_n) = system variables- process's parameters;

c_j - connection coefficients;

$j = n$; $i = m$. ($m < n$)

a_{ij} are called coefficients technology and can be each positive, negative or null.

b_i = calculated coefficients;

x_{ie} = variable spacing;

x_{ia} = artificial variables;

n = number of the unknown of the problem

m = number of the equations

BV = the base variables;

VBV = the values of base variables;

z_0 = objective function;

F_{max} = the maximum value of the objective function, F;

F_{min} = the minimum value of the objective function, F;

3. EXPERIMENTAL RESEARCHES

In this experiment it was intended to study the heat treatment of C45 steel grade component parts treated in two heat treatment furnaces [5].

For this process it was calculate the optimization of the specific hourly productivity and the cost of each line in hand, aiming to achieve maximum benefit, using the Simplex algorithm - the One Phases' Method [7].

The optimization of this heat treatment production processes is made in relation to an economic criterion, so the function is an objective indicator of economic efficiency of the process analyzed [4]. The two heat treatment furnaces (F1, F2) for the two specific automotive component (AC_1, AC_2) made by C45 steel grade, are presented in Table 1.

Table 1. The optimized data for the heat treatment of the two specific automotive component (AC_1, AC_2) made by C45 steel grade.

Heat treatment furnaces	Specific hourly productivity for automotive component parts (kg/h)		Maximum production furnace / month, [t]
	AC_1 (x_1)	AC_2 (x_2)	
F 1	2	-	4
F 2	-	1	1
Benefit (million RON)	3	1	-

3.1. Classical calculation steps for optimization by using a linear programming

The steps of the classical calculation are:

1) Establishment of linear canonical program (CLP)

a) The objective function (function to be optimized is the Benefit):

$$F = 3x_1 + x_2 = max$$
(1)

b) The restrictions problem are:

$$2x_1 \leq 4$$
(2)

$$X_2 \leq 1$$
(3)

c) Non negativity conditions:

$$x_1 \geq 0 \; ; x_2 \geq 0$$
(4)

2) Perform linear canonical transformation program (CLP) in the standard linear program (SLP) by adding or subtracting (depending on the shape of each inequality: $\geq$, $\leq$, =) of variable spacing (x_{ie}) variables are added in this care in order to easily get value system (for finding the solution to start).

$$F = 3x_1 + x_2 = max$$

$$2x_1 + x_{1e} = 4$$
(5)

$$x_2 + x_{2e} = 1$$
(6)

$$x_1 \geq 0; x_2 \geq 0; x_{1e} \geq 0 \; ; x_{2e} \geq 0;$$
(7)

3) From the relation presented, it was determine the base variables (BV) and the

values of base variables (VBV), presented in Table 2.

Table 2. Base variables (BV) and values of base variables (VBV).

BV	VBV
x_{1e}	4
x_{2e}	1

The values from VBV are considered to be an admissible basic solution [8];

4) Simplex table is built, starting by iteration 0 (iteration= changing of base), presented in table 3.

Table 3. Simplex Table, Phase I, iteration 0.

c_J / c_i	BV	VBV	0	0	3	1
			x_{1e}	x_{2e}	x_1	x_2
0	x_{1e}	4	1	0	**2**	0
0	x_{2e}	1	0	1	0	1
z_j		0	0	0	0	0
$z_j - c_j$			0	0	- 3	- 1

Because is an maximum program optimization, it was analyzed all differents $z_j - c_j$

- establish a procedure that allows moving from one base to another;

- basic changes are made by decreasing values (problem solved is maximum) optimization function;

- stops the iteration process (moving from one base to another), when it is not possible to increase the value of optimization function, results presented in Table 4.

Table 4. Simplex table, iteration 1.

c_J / c_i	BV	VBV	0	0	3	1
			x_{1e}	x_{2e}	x_1	x_2
3	X_1	2	-	0	1	0
0	x_{2e}	1	-	1	0	**1**
z_j		6	-	0	3	0
$z_j - c_j$			-	0	0	- 1

Stops the iteration process (moving from one base to another) when it is not possible to decrease the value of optimization function, so to reach the optimal solution, F=max, with solution $x_{i\ optimum}$ and all differents $z_j - c_j \geq 0$, so it reached the optimal solution, results presented in Table 5.

Table 5. Simplex table, iteration 2.

c_J / c_i	BV	VBV	0	0	10	20
			x_{1e}	x_{2e}	x_1	x_2
3	x_1	2	-	-	1	0
1	x_2	1	-	-	0	1
z_j		7	-	-	3	1
$z_j - c_j$			-	-	0	0

Because all differents $z_j - c_j \geq 0$, so it reached the optimal (maximum) solution

The mathematical results of the optimal solutions are: $z_0 = F_{max} = 7$, with solutions:
$x_{1\ optimum} = 2; x_{2\ optimum} = 1;$

3.2. Calculation with Digital Sky Simplex Software.

Enter experimental data (figure 2).

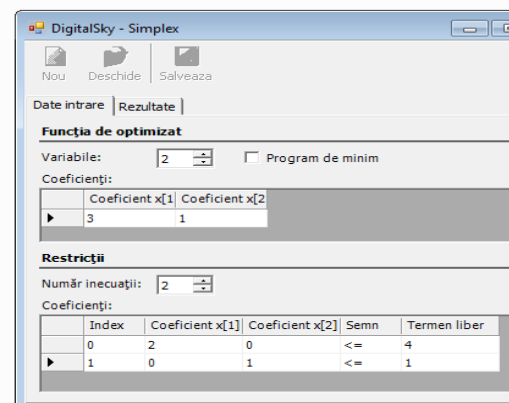Fig. 2. Enter experimental data.

The values of Simplex Table, Phase I, Iteration 0 and Iteration 1 are presented in figure 3.

Fig. 3. The values of Simplex Table, Phase I, Iteration 0 and 1.

The values of Simplex Table, Phase I, Iteration 2, optimal (maximum) solution are presented in figure 4.

Fig. 4. The values of Simplex Table, Phase I, Iteration 2, optimal (maximum) solution.

3. CONCLUSIONS

Analyzing all data taken into account, there can say the following:

- For this process it was calculate the optimization of the specific hourly productivity and the cost of each line in hand, aiming to achieve maximum benefit, using the Simplex algorithm the One Phases' Method.

- In this case, because the number of components is large, the above methods are cumbersome, requiring a large volume of work, using the classical calculation.

- By using this software in place, reduce the computing time to several hours using traditional method to 2-3 minutes, getting an accurate result, respecting both the economic and technical component, without affecting the smooth running of the metallurgical process.

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