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OPTIMIZATION OF SPECIFIC FACTORS TO PRODUCE SPECIAL ALLOYS

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Abstract: *Finding the best solution from all the industrial solution is an optimization problem. The paper presents an experimantal study regarding the casting of 5 special alloys parts using. 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 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 C-Soft.*
Keywords: *optimization, linear programming, objective function, C-Soft, special alloys*

1. NTRODUCTION

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 an optimization problem, the types of mathematical relationships between the objective and constraints and the decision variables determine how hard it is to solve, the solution methods or algorithms that can be used for optimization, and the confidence you can have that the solution is truly optimal.
The optimization of production processes outside materials must be made in relation to an economic criterion, so the function should be an objective indicator of economic efficiency of the process analyzed [1].
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 [1-5]. 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. STANDARD FORM

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 [1].

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 [3, 4].
The most used method to optimize the restriction is the Simplex algorithm method [4, 5].
Simplex algorithm applies when the number of equations (m) and number of variables (n) is large and full description of the method is cumbersome.
To optimize an industrial process using linear programming, the mathematical model consists of three parts [1]: objective function, limitations and non negative restrictions problem:
a) The objective function:

$$F = \sum_{j=1}^{n} c_j x_j \ ; j = 1, 2, ..., m, m+1, .., n \qquad (1)$$

where: x_j (x_1 , x_2 ,......x_n) = system variables-process's parameters;
c_j - connection coefficients<

b) The inequality constrants problem (functional conditions of the process):

$$\sum_{\substack{j=1 \\ i=1}}^{n,m} a_{ij} x_j \geq b_i \qquad (2)$$

where: j = n; i = m. (m < n)

$$\sum_{\substack{j=1 \\ i=1}}^{n,m} a_{ij} x_j \leq b_i \qquad (3)$$

$$\sum_{\substack{j=1 \\ i=1}}^{n,m} a_{ij} x_j = b_i \qquad (4)$$

where: a_{ij} are called coefficients technology and can be each positive, negative or null.
c) the nonnegative terms:

$$x_j \geq 0 \qquad (5)$$

Relations (1) - (5) form a Canonical Linear program (CLP)
Optimization of such problems it made through the following steps [1]:
1. Establishment of Canonical Linear Program (CLP);
2. Perform linear Canonical Linear Program (CLP) in the Standard Linear Program (SLP) by adding or subtracting (depending on the shape of each inequality: ≥, ≤, =) of variable spacing (x_{ie}) or artificial variables (x_{ia}) variables are added in order to easily get value system (for finding the solution to start).
3. Next step in the resolving this optimization problem is to finding initial starting solution, by equating to 0 the next equation:

$$(n-m)_n = 0 \qquad (6)$$

where: n = number of the unknown of the problem and m = number of the equations
From the relation presented, it was determine the base variables (BV) and the values of base variables (VBV).
4. Simplex table is built, starting by iteration 0 (iteration= changing of base) presented in table 1

Table 1: Simplex Tableau, iteration 0

c_j	**VB**	**VVB**	c_1	c_2	...	c_r	...	c_m	c_{m+1}	...	c_k	...	c_n
c_i			x_1	x_2	...	x_r	...	x_m	x_{m+1}	...	x_k	...	x_n
c_1	x_1	x_1	1	0	...	0	...	0	$a_{1, m+1}$	...	a_{1k}	...	a_{1n}
c_2	x_2	x_2	0	1	...	0	...	0	$a_{2, m+1}$	...	a_{2k}	...	a_{2n}
.	.	.	.	.	...	.	...	.	.	...	.	...	.
.	.	.	.	.	...	.	...	.	.	...	.	...	.
c_r	x_r	x_r	0	0	...	1	...	0	$a_{r, m+1}$	...	a_{rk}	...	a_{rn}
.	.	.	.	.	...	.	...	.	.	...	.	...	
.	.	.	.	.	...	.	...	.	.	...	.	...	
c_m	x_m	x_m	0	0	...	0	...	1	$a_{m, m+1}$	...	a_{mk}	...	a_{mn}
	z_j	z_0	z_1	z_2		z_r	...	z_m	z_{m+1}	...	z_k	...	z_n
		$z_j - c_j$	z_1-c_1	z_2-c_2	...	z_r-c_r	...	z_m-c_m	$z_{m+1}-c_{m+1}$	...	z_k-c_k	...	z_n-c_n

where:
BV - the base variables

VBV - the values of base variables
x_j and x_i = system variables-process's parameters;
x_j (x_1 , x_2 , x_m,......x_n) and x_i (x_1 , x_2 , x_m); j = n; i = m. (m < n)
After the iteration, considering differences zj - cj, analysis is accomplished according to the shape of the program (maximum or minimum) in resolving the case [1].
This results on this study optimization by linear programming, it was verified using software in C-SOFT for rapid optimization of operating plants with limited representative sample utilization .To solve, the one-phase approach is applied [1].

3. EXPERIMENTHAL RESEARCHES

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.
In this experiment it was intended to study the obtaining of 5 cast iron landmarks (R1-R5) using molybdenum, nichel and copper as a alloying elements of cast iron.
For this process were used in the following specifications: specific consumption for each milestone achieved daily, quantity available of alloying cast iron elements, aiming to achieve maximum benefit, using the Simplex algorithm - the Phases I problem [1, 2].
The optimization of the obtaining of 5 cast iron parts is made in relation to an economic criterion, so the function is an objective indicator of economic efficiency of the process analyzed [6, 7].
The presentation of the input data is presented in table 2.

Table 2: The presentation of the input data

Alloys	Specific consumption for each milestone achieved daily, [kg]					Quantity available, [kg]
	R1	R2	R3	R4	R5	
Mo Cast iron	10	20	40	-	20	20000
Ni Cast iron	20	-	20	10	20	5000
Cu Cast iron	20	-	20	20	10	10000
Benefit [Euro]	10	20	20	40	10	-

Analyzing Table 2 mentions the following:
- specific daily consumption to achieve a specific type pieces R1, consuming 10 kg of Mo Cast iron , 20 kg of Ni Cast iron and 20 kg of Cu Cast iron, brings a benefit of 10 Euro;
- specific daily consumption to achieve a specific type pieces R2, consuming 20 kg of Mo Cast iron, brings a benefit of 20 Euro;
- specific daily consumption to achieve a specific type pieces R3, consuming 40 kg of Mo Cast iron, 20 kg of Ni Cast iron and 20 kg of Cu Cast iron, brings a benefit of 20 Euro;
- specific daily consumption to achieve a specific type pieces R4, consuming 10 kg of Ni Cast iron and 20 kg of Cu Cast iron, brings a benefit of 40 Euro;
- specific daily consumption to achieve a specific type pieces R5, consuming 20 kg of Mo Cast iron, 20 kg of Ni Cast iron and 10 kg of Cu Cast iron, brings a benefit of 10 Euro;
1) Establishment of linear canonical program (CLP)
a) The objective function (function to be optimized is the beneficial):

$$F= 10x_1 + 20x_2 + 20x_3 + 40x_4 +10x_5 = \max \quad (7)$$

b) The restrictions problem is:

$$10x_1 + 20x_2 + 40x_3 +20x_5 \le 20000 \quad (8)$$

$$20x_1 + 20x_3 + 10x_4 +20x_5 \le 5000 \quad (9)$$

$$20x_1 + 20x_3 + 20x_4 +10x_5 \le 10000 \quad (10)$$

c) The non negativity conditions:

$$x_1 \geq 0 ;\ x_2 \geq 0;\ x_3 \geq 0;\ x_4 \geq 0;\ x_5 \geq 0 \quad (11)$$

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

$$F = F = 10x_1 + 20x_2 + 20x_3 + 40x_4 + 10x_5 = max \qquad (12)$$

b) The restrictions problem is:

$$10x_1 + 20x_2 + 40x_3 + 20x_5 + x_{1e} = 20000 \qquad (13)$$
$$20x_1 + 20x_3 + 10x_4 + 20x_5 + x_{2e} = 5000 \qquad (14)$$
$$20x_1 + 20x_3 + 20x_4 + 10x_5 + x_{3e} = 10000 \qquad (15)$$

c) The non negativity conditions:

$x_1 \geq 0$; $x_2 \geq 0$; $x_3 \geq 0$; $x_4 \geq 0$; $x_5 \geq 0$; $x_{1e} \geq 0$; $x_{2e} \geq 0$; $x_{3e} \geq 0$; (16)

3) From the relation presented, it was determine the base variables (BV) and the values of base variables (VBV), presented in table 3.

Table 3. Base variables (BV) and values of base variables (VBV)

BV	VBV
x_{1e}	20000
x_{2e}	5000
x_{3e}	10000

The values from VBV are considered to be an admissible basic solution [1];

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

Table 4. Simplex Tableau, Phase I, iteration 0

c_J / c_i	BV	VBV	0	0	0	10	20	20	40	10
			x_{1e}	x_{2e}	x_{3e}	x_1	x_2	x_3	x_4	x_5
0	x_{1e}	20000	1	0	0	10	20	40	0	20
0	x_{2e}	5000	0	1	0	20	0	20	10	20
0	x_{3e}	10000	0	0	1	10	20	0	**20**	10
z_j		0	0	0	0	0	0	0	0	0
		$z_j - c_j$	0	0	0	- 50	- 100	- 100	- 200	- 50

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.
- enter the base, the x_4 is the entering variable in the base and x_{2e} is the leaving variable of the base;
- value of **20** from the column of x_4 are called the pivot operation. The simplex algorithm proceeds by performing successive pivot operations which each give an improved basic feasible solution; the choice of pivot element at each step is largely determined by the requirement that this pivot improve the solution.

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 Tableau, iteration 1

c_J / c_i	BV	VBV	0	0	0	10	20	20	40	10
			x_{1e}	x_{2e}	x_{3e}	x_1	x_2	x_3	x_4	x_5
0	x_{1e}	20000	1	0	-	10	**20**	40	0	0
0	x_{2e}	4500	0	1	-	10	0	10	0	10
40	x_4	50	0	0	-	1	0	1	1	1/2
z_j		2000	0	0	-	40	0	40	40	20
		$z_j - c_j$	0	0	-	30	- 20	20	0	10

- enter the base, the x_2 is the entering variable in the base and x_{1e} is the leaving variable of the base;
- value of **20** from the column of x_2 are called the pivot operation.

In table 6 are presented Simplex table, iteration 2.

Table 6. Simplex Tableau, iteration 2

c_J / c_i	BV	VBV	0	0	0	10	20	20	40	10
			x_{1e}	x_{2e}	x_{3e}	x_1	x_2	x_3	x_4	x_5
20	x_2	1000	-	0	-	1/2	1	2	0	0

0	x_{2e}	4500	-	1	-	10	0	10	0	10
40	x_4	50	-	0	-	1	0	1	1	1/2
z_j		22000	-	-	0	50	20	80	40	20
		$z_j - c_j$	-	-	0	40	0	60	0	1-

Because all differents $z_j - c_j \geq 0$, so it reached the optimal (maximum) solution
The mathematical results of the optimal solutins are:
$z_0 = F_{max} = 22000$ (benefit in Euro), with solutions:
$x_{2\ optimum} = 1000$ (the daily specific consumption of landmark R_2 , in kg);
$x_{4\ optimum} = 50$ (the daily specific consumption of landmark R_4 , in kg);

5. 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 Phases I 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.
- The mathematical results of the optimal solutins of this application are: the benefit is 22000 Euro, producing landmak 2 and 4, consuming the quantities of 1000 and 50 kg respectively.

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