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[1.]Cristina Daniela PACURAR, [2.]Teodor HEPUŢ

MATHEMATICAL MODELING ON THE LOAD METAL OF THE ELECTRIC ARC FURNACE

[1-2.] University Politehnica Timisoara, Faculty of Engineering Hunedoara, Hunedoara, ROMANIA

Abstract: In research conducted, it was considered analyze the fabric of electric arc furnaces on several dimensions, but especially the removal of liquid steel, one of the main technical and economic indicators in the steel industry.This indicator depends on several factors aids and specifically: structure and the quality of the metal load, the degree of preparation of the content of materials accompanying non-metallic, unit of elaboration, the technology of elaboration, etc. the load has been composed of eight metallic components, in some cases with great differences from the point of view of quality. The data obtained have been processed in the programs of MATLAB calculation using the three types of equations, results obtained being presented both graphically and analytical. Based on results obtained has opted for an optimum structure of the load.
Keywords:steel industry, electric arc furnace, liquid steel, MATLAB calculation

INTRODUCTION

Currently steel industry shows interest in two units for steelmaking, namely: oxygen converter and electric arc furnaces.

The purpose of this paper is to understand the actual working conditions and performance of the EAF, determine the best technical and economic choices in order to achieve the performance targets making a correlation of data obtained by applying mathematical models of experimental design that is currently most modern tool used in optimization problems.

It contributes to the achievement of important clarifications on the relationship between variables, parameter estimation links, testing different ways of practical action, determining the optimal level of controlled variables and model behavior of the variation factors. For optimal management of processes it is necessary to know the characteristics of mathematical models of these processes.

STUDY OF THE PROBLEM

Industrial experiments conducted mainly aimed at determining correlations between structure loads double metal components respectively stake (%) and removal of liquid steel (%). To analyze the fabric of metal were followed a total of 30 batches of steel produced at a steel mill elective equipped with an electric arc furnace type EBT, which have the capacity 100t, a facility type LF and a casting plant continues with 5-wire Bloom is molded preforms (270x240mm).

During the development was monitored carefully load structure, its status in terms of dimensional presentation of the content of slag both bark from inside, mostly on slag heaps, but also commercially. Also appreciated was prepared visual quality scrap E1, E2, E5, E100, scrap derived from internal cassation, in terms of the levels of rust, nonferrous metals, earth. The analysis was conducted for 30 batches of steel and experimental results were processed in Matlab computer programs, using three types of equations.

MATHEMATICAL DATA MODELING

The data processing was made in the computing program MATLAB, using three types of correlation equations. The results are presented both analytical and graphical form, each correlation being analyzed technologically indicating optimal values for the independent parameters. The analysis conducted shows a comparison between the results obtained by three types of equations for each correlation.

» Equation 1:

$$z_1 = a_{(1)}\, x^2 + a_{(2)}\, y^2 + a_{(3)}\, x\, y + a_{(4)}\, x + a_{(5)}\, y + a_{(6)}$$

» Equation 2:

$$z_2 = a_{(1)} + a_{(2)}\, x + a_{(3)}\, x^2 + a_{(4)}\, x^3 + a_{(5)}\, y + a_{(6)}\, y^2 + a_{(7)}\, y^3 + a_{(8)}\, y^4 + a_{(9)}\, y^5$$

» Equation 3:

$$z_3 = a_{(1)} + a_{(2)} \log(x) + a_{(3)} \log(x)^2 + a_{(4)} \log(x)^3 + a_{(5)}/y + a_{(6)}/(y^2) + a_{(7)}/(y^3) + a_{(8)}/(y^4) + a_{(9)}/(y^5)$$

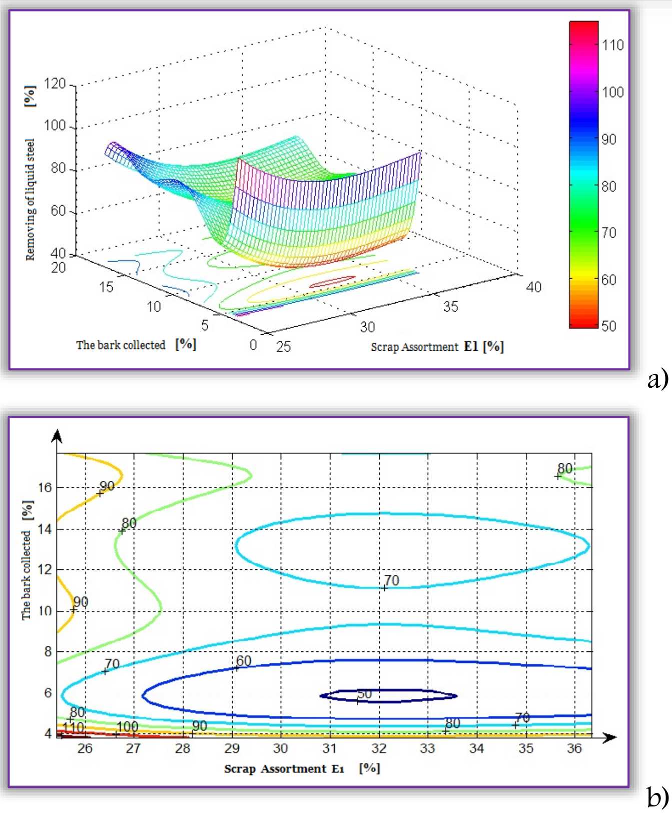


Figure 1.Variation of removal of liquid steel depending on scrap iron assortment E1 and the bark collected a) spatial representation; b) Curved level, projection in the horizontal plane

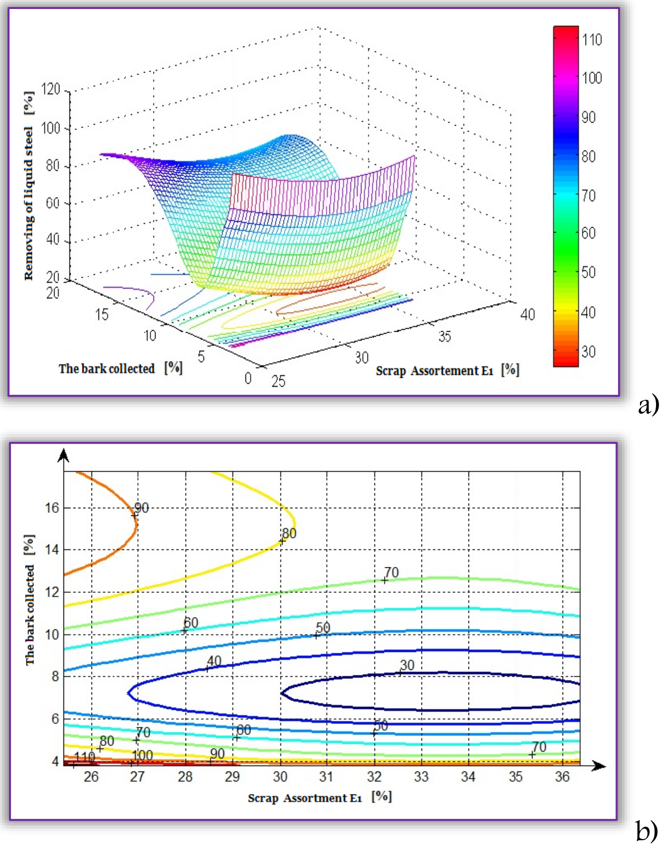


Figure 2.Variation of removal of liquid steel depending on scrap iron assortment E1 and the bark collected a) spatial representation; b) Curved level, projection in the horizontal plane

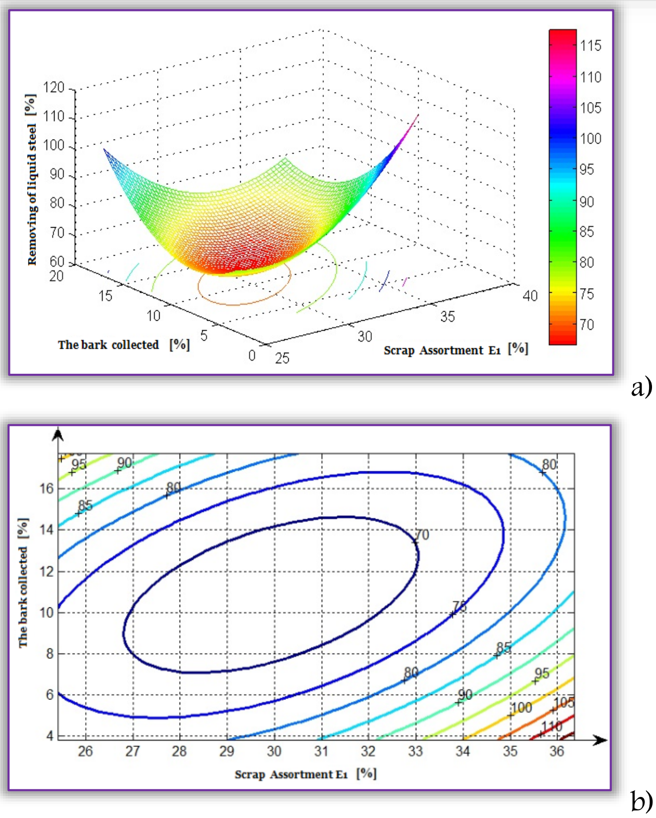


Figure 3. Variation of removal of liquid steel depending on scrap iron assortment E1 and the bark collected. a) spatial representation; b) Curved level, projection in the horizontal plane

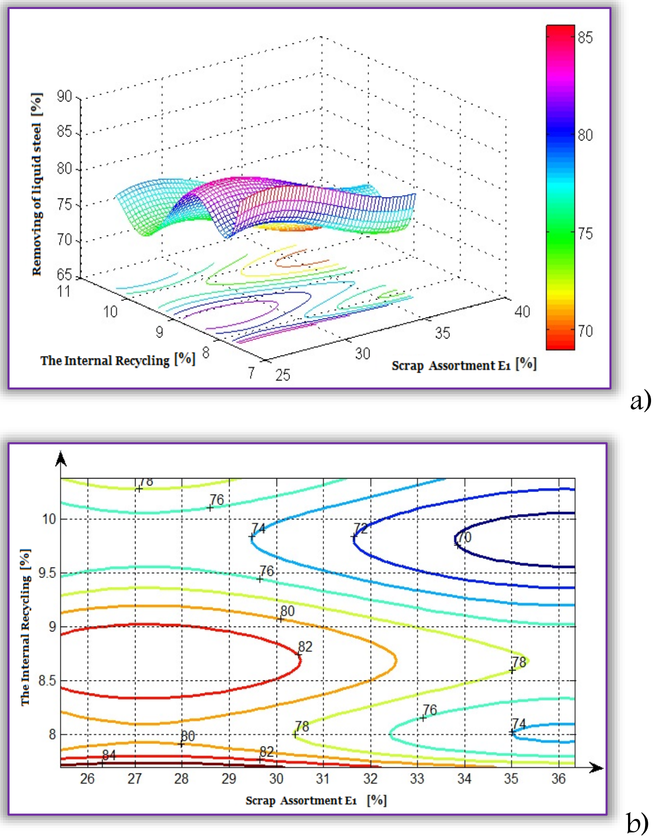
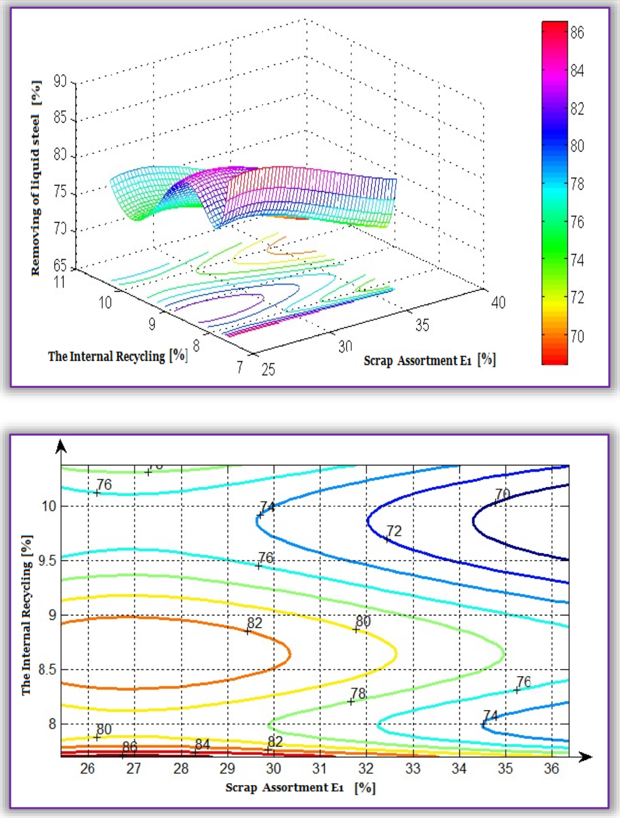


Figure 4. Variation of removal of liquid steel depending on scrap iron assortment E1 and the internal recycling a) spatial representation; b) Curved level, projection in the horizontal plane



a)

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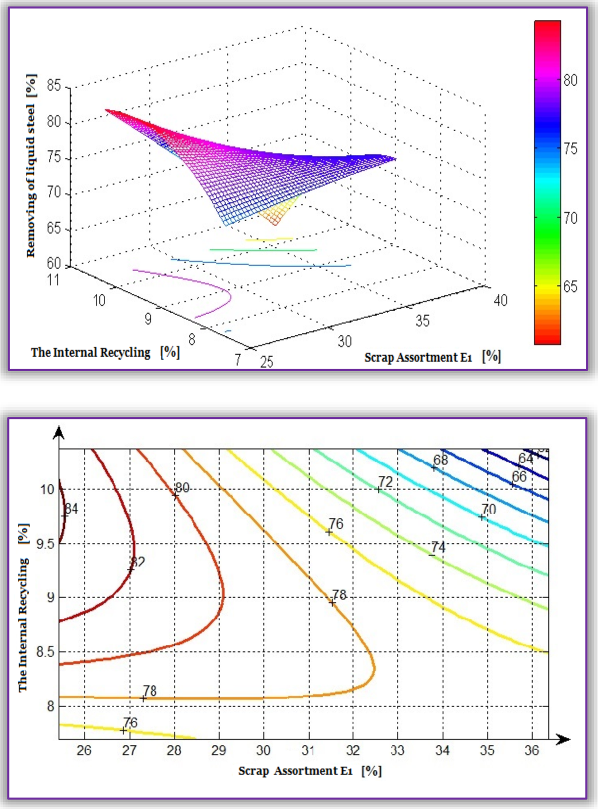
Figure 5. Variation of removal of liquid steel depending on scrap iron assortment E1 and the internal recycling. a) spatial representation; b) Curved level, projection in the horizontal plane



a)

b)

Figure 6. Variation of removal of liquid steel depending on scrap iron assortment E1 and the internal recycling a) spatial representation; b) Curved level, projection in the horizontal plane

$$z_1 = 2055.978 - 96.9298\,x + 2.7087\,x^2 - 0.0249\,x^3 - 464.043\,y + 94.1492\,y^2 - 8.9908\,y^3 + 0.4089\,y^4 - 0.0071\,y^5. \quad R^2 = 0.7901 \tag{1}$$

$$z_2 = -22618.34 + 20449.93\log(x) - 6253.52\log(x)^2 + 634.44\log(x)^3 + 225.83/y - 350566.31/(y)^2 + 2426.70/(y)^3 - 7737.716/(y)^4 + 9333.687/(y)^5 \quad R^2 = 0.7608 \tag{2}$$

$$z_3 = 0.45469\,x^2 + 0.31039\,y^2 - 0.370718\,xy - 23.19604\,x + 4.359415\,y + 390.12349 \quad R^2 = 0.54409 \tag{3}$$

$$z_1 = 334772.217 + 49.527\,x - 1.595\,x^2 + 0.016\,x^3 - 183952.436\,y + 40233.530\,y^2 - 4383.805\,y^3 + 237.957\,y^4 - 5.148\,y^5 \quad R^2 = 0.2290 \tag{4}$$

$$z_2 = -121884.628 + 8276.466\log(x) - 2372.550\log(x)^2 + 225.896\log(x)^3 + 5437.035/y - 1043.316/(y)^2 + 9933.190/(y)^3 - 4691.719/(y)^4 + 8801.122/(y)^5 \quad R^2 = 0.2326 \tag{5}$$

$$z_3 = -0.012\,x^2 - 2.125\,y^2 - 0.8751\,x\,y + 7.757\,x + 63.881\,y - 309.054 \quad R^2 = 0.4078 \tag{6}$$

$$z_1 = 243166.294 - 30.104\,x + 2.690\,x^2 - 0.072\,x^3 - 134334.481\,y + 29605.198\,y^2 - 3251.290\,y^3 + 177.9344\,y + 3.8823\,y^5 \quad R^2 = 0.4540 \tag{7}$$

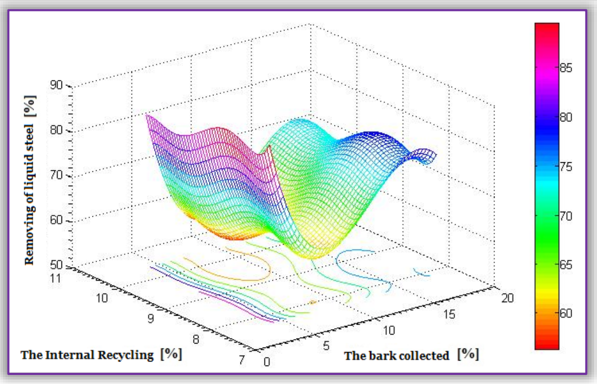
$$z_2 = 113101.143 - 633.699\log(x) + 277.959\log(x)^2 - 39.387\log(x)^3 - 4786.051/y + 8096.734/(y)^2 - 6808.853/(y)^3 + 2846.182/(y)^4 - 4734.095/(y)^5 \quad R^2 = 0.5163 \tag{8}$$

$$z_3 = 0.1104\,x^2 - 1.7666\,y^2 - 0.1475\,x\,y - 1.5058\,x + 30.2430\,y - 36.9735 \quad R^2 = 0.2208 \tag{9}$$

$$z_1 = 7486.588 + 158.4922\,x - 5.32198\,x^2 + 0.05885\,x^3 - 477216.852\,y + 121097.401\,y^2 - 15321.1660\,y^3 + 966.4518\,y^4 - 24.3154\,y^5 \quad R^2 = 0.3822 \tag{10}$$

$$z_2 = -7969.4302 + 52952.9294\log(x) - 15602.9092\log(x)^2 + 1530.9533\log(x)^3 + 2926.0360/y - 4634.981/(y)^2 + 3659.408/(y)^3 - 1440.451/(y)^4 + 2261.2983/(y)^5 \quad R^2 = 0.3620 \tag{11}$$

$$z_3 = 0.0788\,x^2 + 1.2697\,y^2 + 0.3408\,x\,y - 8.317\,x - 26.4914\,y + 304.8916 \quad R^2 = 0.5272 \tag{12}$$



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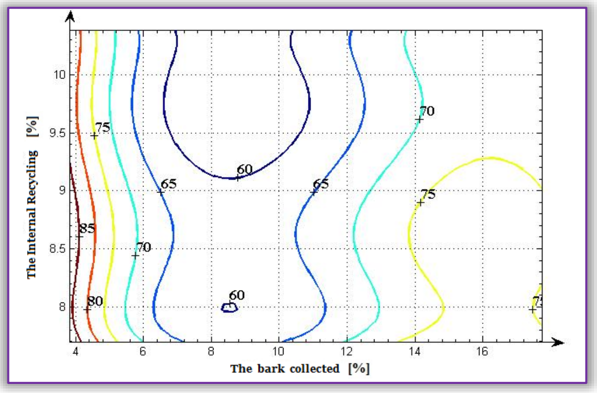
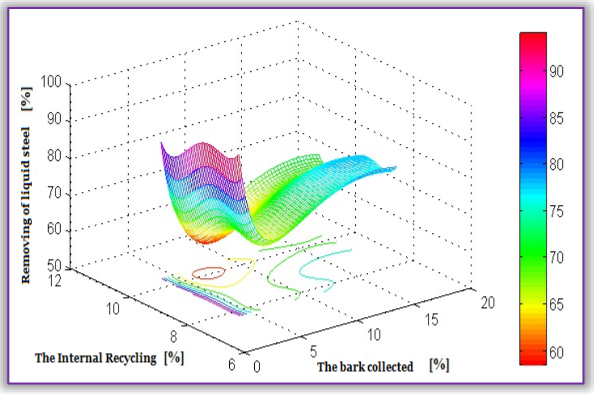


b)

Figure 7. Variation of removal of liquid steel depending on bark collected and the internal recycling
a) spatial representation; b) Curved level, projection in the horizontal plane



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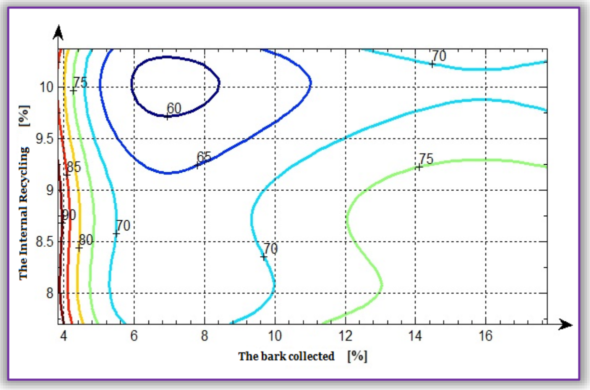

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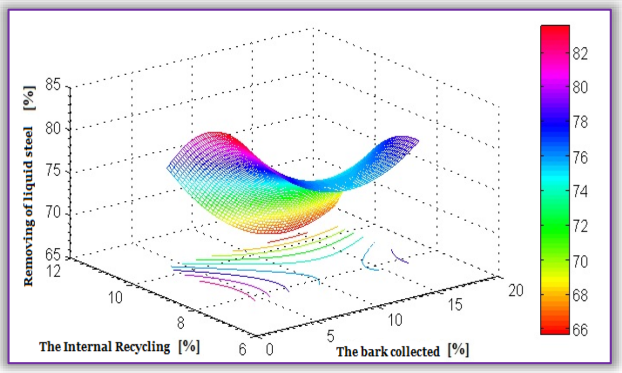
Figure 8. Variation of removal of liquid steel depending on bark collected and the internal recycling
a) spatial representation; b) Curved level, projection in the horizontal plane



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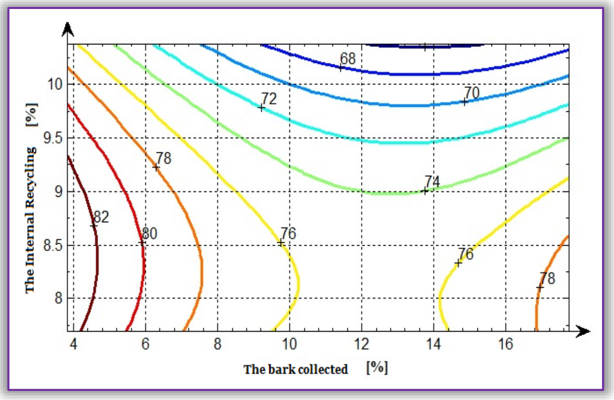
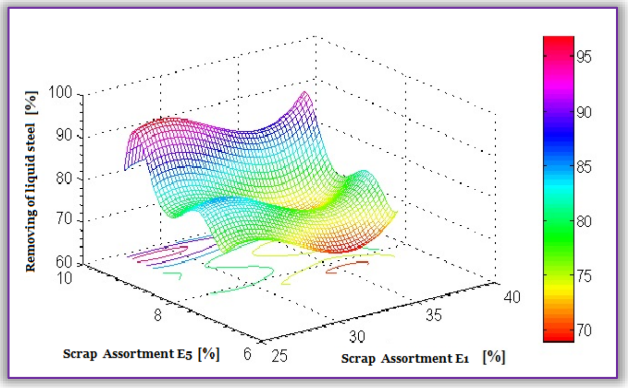


b)

Figure 9. Variation of removal of liquid steel depending on bark collected and the internal recycling
a) spatial representation; b) Curved level, projection in the horizontal plane



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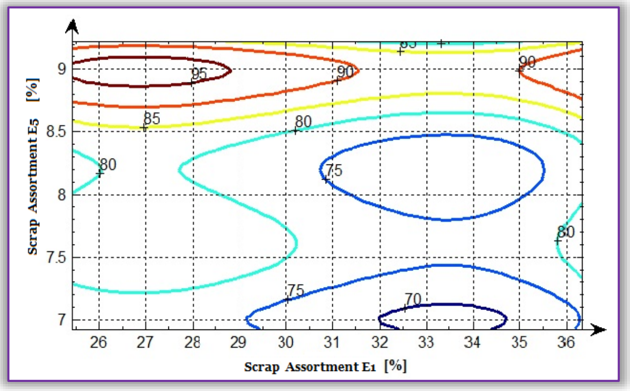

b)

Figure10. Variation of removal of liquid steel depending on scrap iron assortment E1 and E 5 scrap iron assortment. a) spatial representation; b) Curved level, projection in the horizontal plane

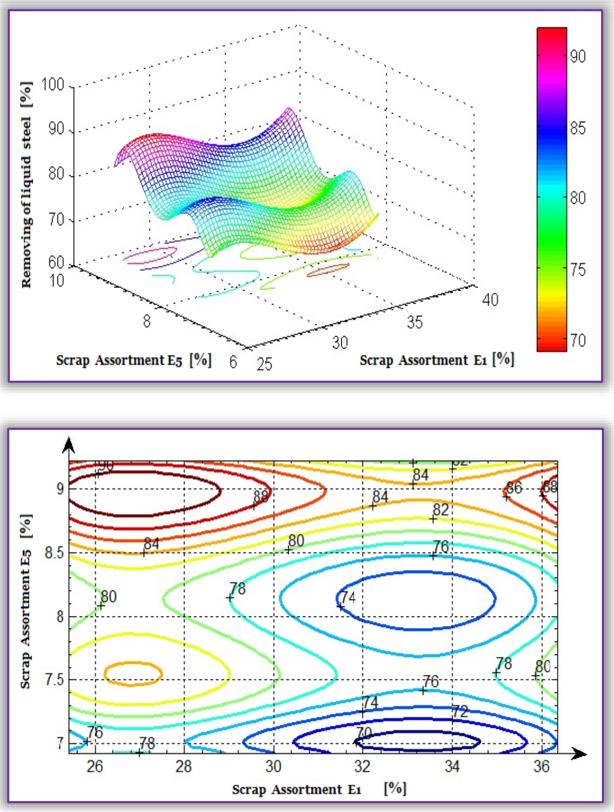

Figure 11. Variation of removal of liquid steel depending on scrap iron assortment E1 and E 5 scrap iron assortment. a) spatial representation; b) Curved level, projection in the horizontal plane

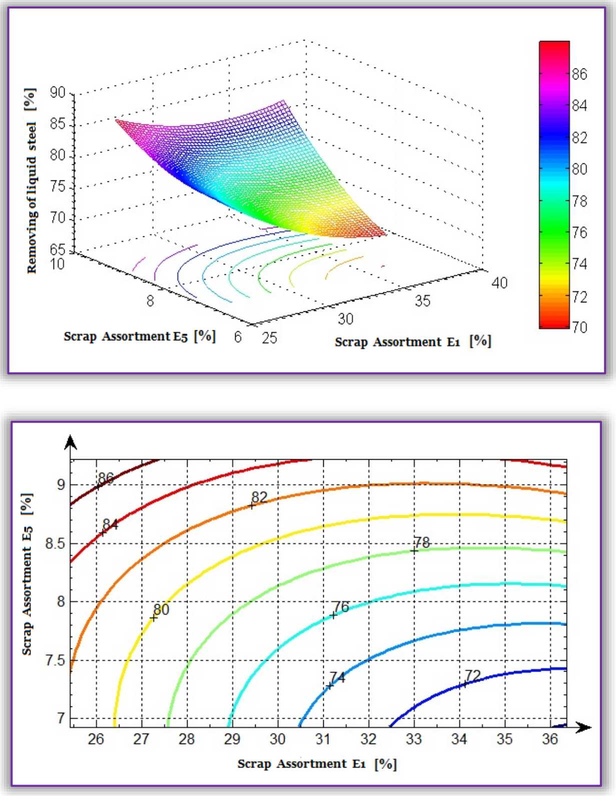

Figure 12. Variation of removal of liquid steel depending on scrap iron assortment E1 and E 5 scrap iron assortment. a) spatial representation; b) Curved level, projection in the horizontal plane

TECHNOLOGICAL ANALYSIS OF THE RESULTS

Regarding the quality of the load on the basis of the representations received for the duration of the session tracking we found that from the point of view of quality load has not been of the highest quality in the sense that prevailed from the point of view of quantitative old iron gently (Baler) and metal rugs from internal and external, fact confirmed also by the values obtained for the removal of liquid steel. In particular, the quality of the barks metal,both under the aspect of the content of iron and granulometrically is less appropriate.

From the graphic representations obtained from the processing of personal data in the MATLAB program can be established the proportions of the components in the load in order to obtain a specific value for removing of liquid steel, respectively choose load component taking into account and the quantity of available varieties concerned the possibilities of supply.

The results obtained after the three types of equations used in the course of correlations are fairly close to the example:

» in Figure 4, Figure 5 and Figure6 to a content of 30 % and 10% values for removing of liquid steel are 74% and 76.2%; a difference of 3,03% compared to the other values (value permissible practically) regardless after which we analyze the technological point of view is significantly;

» in Figure 7,Figure8 and Figure9 to a content of 14 % and 10%. The values for the removal of liquid steel are 70%; 68 % and 69 %, a difference of 1.4 percent as compared to the other (value permissible practically) regardless after which we analyze the technological point of view is significant.

In the same way can be analyzed and the other correlation.

CONCLUSIONS

In the analysis of the results obtained in the research can be concluded the following:

» the quality of the metal load has not been of the highest quality and reflected in the values obtained for the removal of liquid steel;

» from representations of curves by level in the projection surface can choose values for load metal composition, must be considered and the possibilities for supply of raw materials;

» it requires the use of a metal load of top quality, which will lead to a reduction in the specific consumption of energy, which will be found in lower degree of environmental pollution.

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