IMPACT STUDY OF TECHNOLOGICAL PARAMETERS USED IN LF PLANTS IN THE EFFICIENCY OF HYDROGEN REMOVAL

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ABSTRACT:

This paper aims, based on experimental data to determine the equation of correlation between treatment parameters LF steel plant type and yield of hydrogen removal. Experiments were conducted in a steel mill type electric furnace equipped with an EBT, installation LF and continuous casting plant. Treatment facility as parameters LF those of argon bubbling were considered next: bubbling duration, flow and pressure of argon, they were considered as independent parameters and as an independent parameter were considered hydrogen removal efficiency. Independent parameters were determined by measuring and control devices and the degree of hydrogen removal based on hydrogen content determined from samples of steel, taken before and after treatment with argon. The data were processed in Excel and MATLAB programs, which allowed obtaining simple and multiple correlation equations between the parameters chosen in the investigations. Based on the technological analysis of correlation equations, the optimum parameters change of bubbling was established. Results have practical applicability in developing steels.

Keywords:
Treatment parameters, LF steel plant, experimental data, hydrogen removal

1. THEORETICAL CONSIDERATIONS

During the process of making steel in electric ovens EBT There are different sources of hydrogen which, under certain conditions of pressure and temperature, make possible absorption of hydrogen in metal bath. From the experience accumulated from the operation of such furnaces and research conducted on a large number of batches produced, we mention that the main sources of hydrogen in all steel as follows:

- metal load humidity, as there is no technical possibility of drying the tippers loaded with scrap metal.
- the necessary additions to primary slag formation and slag from refining in the study because of the way supply (with 22 tons trucks) of lime and dolomitic lime, which during transport and storage whilst in the bunker, absorbing atmospheric humidity.
- the furnace atmosphere, because of the construction methods (panels, vault and other water-cooled elements) may appear accidental cases of breaking these elements and thus for short periods of time, but working with high pressure, cooling water enters the atmosphere to develop the aggregate.

The hydrogen dissolved in metal bath can be removed by secondary treatment of steel (or by bubbling with inert gas or by vacuum treatment of steel plants) [1,2]

Metal inert gas injection in the refining of steel melts for agitation and also refining, is a simple, widely applied method, by which gases are introduced, either on the bottom of the casting-treatment ladles – through a refractory porous plug or on the top of the pot with a spear or also by submerged porous plug as deep into liquid steel, a process found in literature as the bubbling of the steels. Hydrodynamic action of the gas injected into the melt and formation during metal refining treatments other gases such as CO, CO2, N2 gas high expansion trend contributes to the vigorous mixing of melt. Specific mixing power and thus efficiency of metallurgical processes is dependent on specific parameters of the bubbling process. [3,4]

When inert gas is injected into liquid steel, hydrodynamic processes have as an essential feature the fact that the metal bath is in constant turbulent recirculatory motion. Qualitative and quantitative description of the areas formed in the molten metal at the injection of the gas, of the speed fields and the turbulence fields is a prerequisite condition for understanding the processes of mixing, dispersion and mass transfer and energy in these systems. [2]

2. INDUSTRIAL EXPERIMENTS

In the research program developed, there has been a detailed study of making the steel for the manufacture of pipes in industrial flow electric steel plant (furnace EBT) - secondary treatment facilities, continuous casting LF TC, the main directions followed being:

- determining and recording the level of hydrogen in liquid steel and on the finished product, steel bars for the manufacture of pipes;
- identifying the most important elements of hydrogen generators in liquid steel;
- industrial monitoring and recording all parameters that can influence the absorption or elimination of hydrogen in metal bath;
- modifying one technological parameter on the flow of industrial production, and study its influence on the hydrogen content of steel bath;
- Experiments were performed on a total of 25 batches at which were determined through successive measurements and recorded the following parameters:
- the quantity of the treated steel;
- the quantity of materials needed in LF slag formation and the quantities of ferroalloys;
- lime moisture;
- the chemical composition of the slag formed in L.F.;
- the hydrogen values at the beginning, during, and at the end of the treatment in LF plant;
- the bubbling gas parameters (flow and pressure);
- the total time of secondary treatment and the time of steel standing in the casting ladle;

The data were analyzed in technological terms and eliminated those where different technological deviations were found (measurement errors, human factor interventions).

3. EXPERIMENTAL RESULTS

Data processing was done in MATLAB and Excel programs, results are presented both graphically and analytically.

The graphs below are presented the influence of bubbling parameters on the efficiency of removal of hydrogen during secondary treatment.

In Figure 1 there can be observed a significant dependence (with a correlation coefficient R2 = 0.8879) between the variation of argon pressure and increasing the efficiency of hydrogen removal during secondary treatment. Correlation curve shows a maximum pressure of 4.31 bar, point situated in the technological limits of variation of argon pressure.

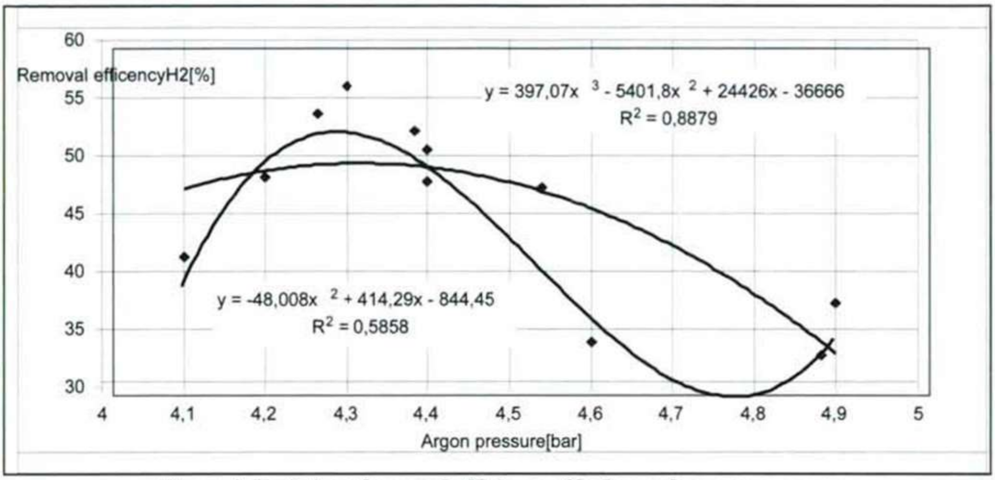

Figure 1. Variation of removal efficiency of hydrogen by argon pressure

Analyzing the graph, shown in the figure above we consider suitable for bubbling pressures lie within 4.1 to 4.5 bars. At lower pressures the bubbles have a lower speed, so a lower quantity of hydrogen will be removed. At higher pressures, the steel in the ladle can remain uncovered (without slag), which would allow an increase through absorption of hydrogen dissolved in steel.

In Figure 2 it is underlined the argon flow influence on yield variation of removal of hydrogen during secondary treatment.

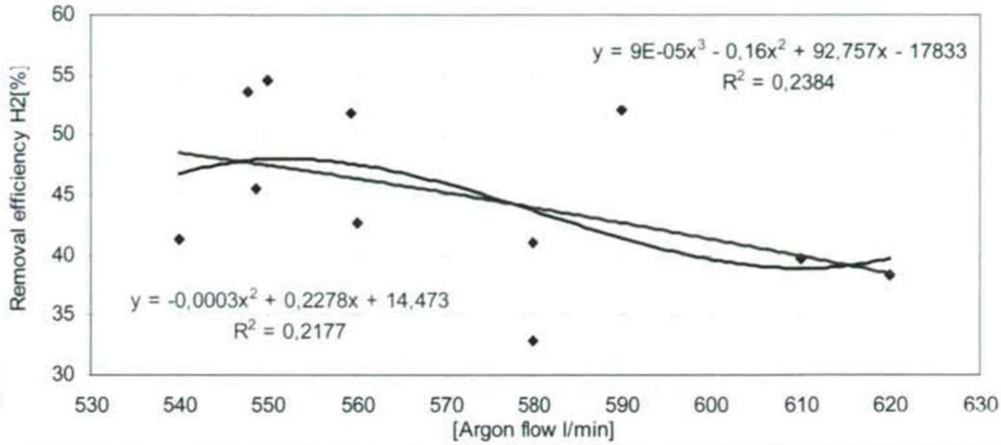

Figure 2. Variation of removal efficiency of hydrogen by argon flow

From the figure above it appears that, if the argon flow values between 540 and 570 l / min, hydrogen removal efficiency varies between 45 -50%. An increased flow of oxygen as a result of increasing pressure leads to a slight decrease in the efficiency of hydrogen removal, a phenomenon caused by hydrogen absorption in steel bath due to the fact that it remains uncovered by slag.
Another influential parameter is the length of the bubbling - fig.3.

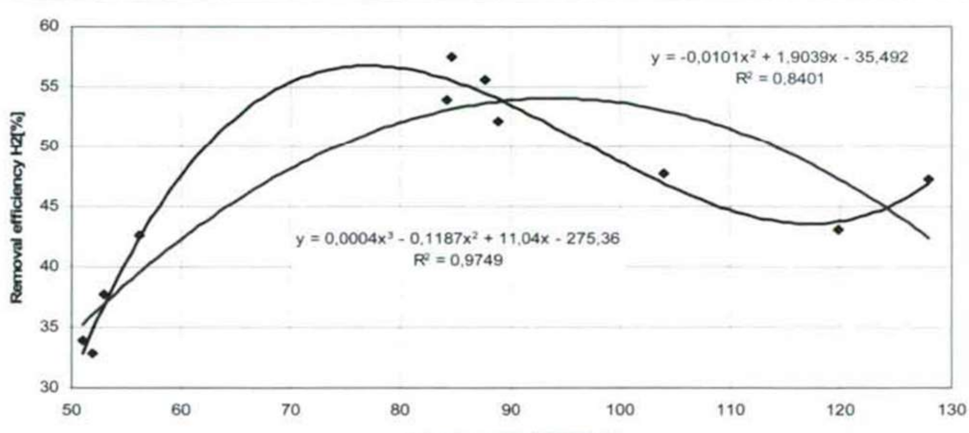

Figure 3. Variation of hydrogen removal efficiency depending on the length of argon bubbling

As it results from the chart shown in Figure 3, the secondary treatment duration has a decisive influence on the efficiency of removal of hydrogen, the ideal duration of treatment is between 85 and 105 minutes.
Next the results obtained in the case of multiple correlation $\eta H = f$ (Tb, Db, Pb) are shown. Since we can not graphically represent (in the space of four dimensions) such correlation, the

equation with three independent parameters, through permutations we assigned to a parameter the medium value so we got equations with two independent parameters, the equation can be graphically represented in the space with three dimensions. Obviously we can get directly from the processing of the data the equation with two independent parameters, but we wanted to obtain an equation with three independent parameters.
The correlation equation with three independent parameters is of the form:

$$\eta_{H2}= 5{,}503\cdot10^{-3}\cdot D_b^2 + 21{,}1831\cdot P_b^2 -2{,}846\cdot10^{-3}\cdot T_b^2 +1{,}7275\cdot10^{-3}\cdot D_b\cdot P_b$$
$$-3{,}3\cdot10^{-2}\cdot P_b\cdot T_b - 2{,}444\cdot10^{-4}\cdot T_b\cdot D_b -6{,}2556\cdot D_b -188\cdot P_b + 1{,}014\cdot T_b + 2{,}195\cdot10^3 \quad (1)$$

The correlation coefficient R= 0,7147. The saddle point coordinates: Db = 570,5209; P_b = 4,5198; T_b = 127,4225; η_{H2} = 49,7965
Substituting into equation (1) for Pb = Pbmed it results an equation (2) of the form:

$$\eta_{H2}= 5{,}503\cdot10^{-3}\cdot D_b^2 -2{,}846\cdot10^{-3}\cdot T_b^2 -2{,}444\cdot10^{-4}\cdot T_b\cdot D_b -6{,}248\cdot D_b +0{,}868\cdot T_b +1776{,}86 \quad (2)$$

Figure 4 show that the correlation surface presents a saddle point in the technological field. For the hydrogen removal yield, the medium value is ηmed = 46.8215.

To obtain higher values for a value near the saddle point, for example over 48%,the values for two independent TB parameters Db must vary so that ηH2 values are always located in the area hatched.

It has been found that the highest values for ηH2 are obtained to the upper limits of TB and DB. For db = Dmed equation (1) has the form:

$$\eta_{H2}= 21{,}1831\cdot P_b^2-2{,}846\cdot10^{-3}\cdot T_b^2-3{,}3\cdot10^{-2}\cdot P_b\cdot T_b - 87{,}28\cdot P_b + 0{,}874\cdot T_b +4{,}174\cdot10^2 \quad (3)$$

Correlation surface is shown in Figure 5, from the surface analysis it results that higher values of ηH2 are obtained as in the previous case for values of Tb to the upper limit. Regarding Pb, higher values for ηH2 are obtained for extreme values of this parameter. For the supreme value of ηH2, we must be situated in the field hatched.

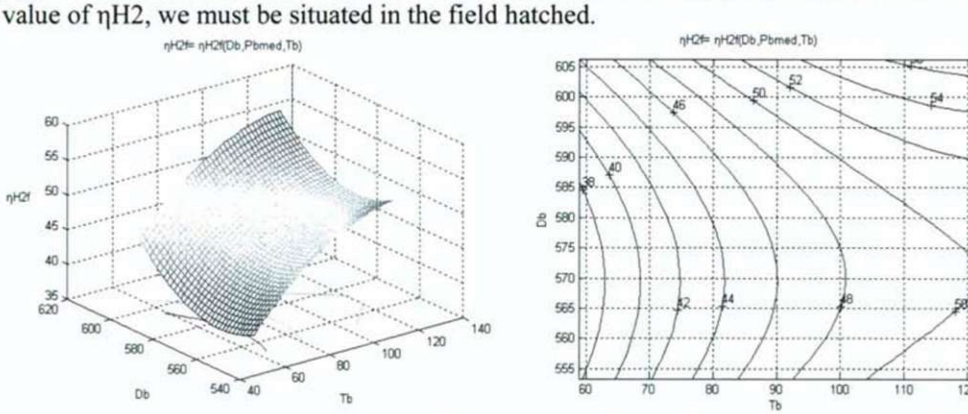

Fig.4.The Influence of argon flow and duration of bubbling in the removal of hydrogen yield

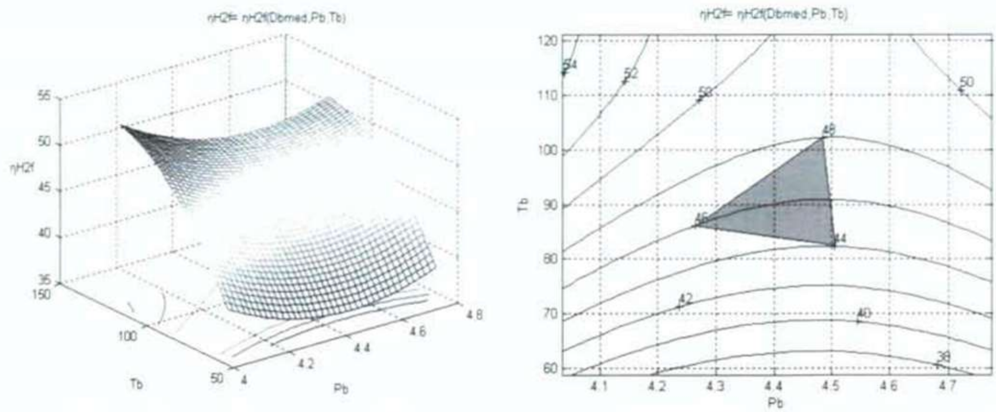

Figure 5. The influence of duration and bubbling pressure on the yield of dehydrogenation at an average flow of inert gas

From Figure 6 it results that at a flow of 560-580 N m 3 / h and a pressure of 4.35 to 4.65 bar of the bubbling gas, metal bath is found favoring the absorption of hydrogen in the atmosphere. Under pressure of 4.5 bar and at a higher rate because the metal bath remains discovered and the contact between the steel and gas bubbling is more intense, that hydrogen diffusion in steel argon bubbles occurs at much higher parameters, a high dehydrogenation level of steel occurs.

For the average duration of bubbling Tb = Tb med. equation (1) becomes:

$$\eta_{H2}=5,503\cdot 10^{-3}\cdot D_b^2 + 21,1831\cdot P_b^2 + 1,7275\cdot 10^{-3}\cdot D_b\cdot P_b - 6,275\cdot D_b - 190,93\cdot P_b + 2,258\cdot 10^3 \quad (4)$$

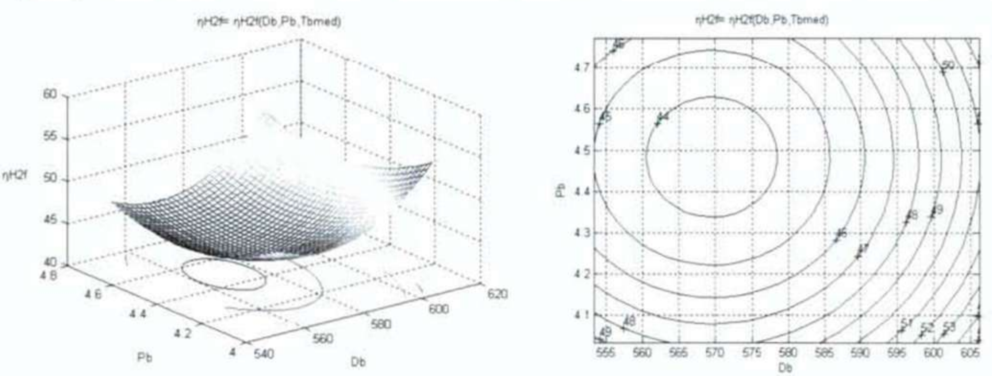

Figure 6. The influence of flow and bubbling pressure on the yield of dehydrogenation at an average duration of bubbling

4. CONCLUSIONS

The quality of finished steel products may be influenced by hydrogen content of liquid steel. Therefore, in the literature are presented many methods and processes of dehydrogenation of steel, but the selection of optimal variant must be made in correlation with specific technological characteristics of the technological flow, as well as in conditions of maximum economic efficiency.

The investigations carried out have resulted in a number of conclusions with practical application, namely:

- between the parameters of the steel bubbling with argon and hydrogen yield there can be established significant correlation equations both mathematically and technologically;
- the equations obtained in Excel program allow the determination for the independent parameters of some the limits of variation for these values;
- the multiple correlation equations, determining the variation fields of the bubbling parameters, given their complex influence;
- by getting the range of variation of the bubbling parameters there can be obtained improved values for the degree of removal of hydrogen.

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