ANALYSIS OF QUALITY AND ECONOMIC INDICATORS IN STEEL MAKING INVOLVING SECONDARY MATERIALS RECIRCULATION

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În lucrare se abordează problema definirii şi determinării unor indicatori caracteristici pentru elaborarea oţelurilor în CAE cu recircularea materialelor secundare reprezentate de brichete fabricate din praf CAE şi ţunder. Indicatorii analizaţi au fost: carbonul la topire, sulful la topire, fosforul la topire, conţinutul de zinc în oţel, scoaterea de oţel bun şi consumul specific de fier vechi. Sunt definiţi, de asemenea, indicatorii cu ajutorul cărora se pot caracteriza funcţia ecologică şi funcţia de înlocuitor pentru materialele secundare utilizate.

În baza datelor experimentale (prelucrate grafic şi analitic) sunt trase concluzii referitoare la posibilităţile tehnologice de ameliorare a indicatorilor menţionaţi.

The paper tries to define and determine some indicators, which are proper to the EAF steel making using the recirculation of secondary materials represented by brickets made from EAF dust and scale. The analyzed indicators were: carbon, sulphur, phosphorus at the melting point, zinc content of steel, high quality steel output and iron scrap specific consumption.

The defined indicators are used to characterize the ecological function and the substitution function for used secondary materials.

Keywords: secondary materials, brickets containing EAF powder, brickets containing scale.

Introduction

Nowadays it is unanimously accepted, that social and economical performances cannot be attained without the application of the known **sustainable development model (SD).** The real task of engineers is to transpose it into an operational concept for the real condition of each industrial sector. From this point of view, an efficient way to be followed by the steel industry is the *utilization of*

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substituents instead of raw materials, which are actually expensive and scarce, as in the case of iron scrap. In compliance with the recommendations of the sustainable development concept (SD), such a process is based on the capitalization of secondary materials by recycling, e.g. furnace dust, scale or sludge resulting after gas cleaning. Improving the quality and efficiency of such technologies depends in a high extent on the optimization of the quality and the economic characteristics of electric arc furnace (EAF) steel making by the pulverulent secondary **materials exploitation** [1]**.**

1. Experimental

Seven experimental charges have been prepared and investigated according to the following research plan [2]:

a. Charge preparation

The EAF charge consisted mainly in iron scrap. As iron scrap sustitutes pellets were added manufactured using EAF dust or scale, their share ranging between 2 - 14%.

The pellets manufactured on the basis of EAF dust contained:

- EAF dust 70-72%;
- bentonite 6.5-7.0%;
- lime 3.8-4.0%;
- limestone 0.5-1.0%;
- coke 12-17%.

The pellets manufactured on the basis of scale contained following materials:

- scale 59-60%;
- bentonite 6.5-7.0%;
- lime 4.7-5.0%;
- limestone 0.5-1.0%;
- coke 24-26%.

b. The charges were prepared in the 100t EAF (for all seven charges) using technological systems, which are basically not different from the conventional ones.

c. The measurements and calculations concerning the chemical compositions, output and specific consumptions were performed using current methods, wellknown from literature.

d. The graphical and analitical processing of the experimental data were made by methods as prescribed in the literature.

2. Data processing and results

The following experimental data were processed:

- the influence of charge structure on the carbon content at the melting point, $[C]_{melt}$ (Fig.1);
- the variation of sulphur content at the melting point $[S]_{melt}$, (Fig.2);
- the phosphorus content modification at the melting point, $[P]_{melt}$, function the amount of brickets charged into the furnace (Fig.3);
- the influence of brickets addition on the zinc content at the melting point, $[Zn]_{melt}$, (Fig.5);
- the output variation function of the amount of brickets, which substitute the iron scrap (Fig.6).

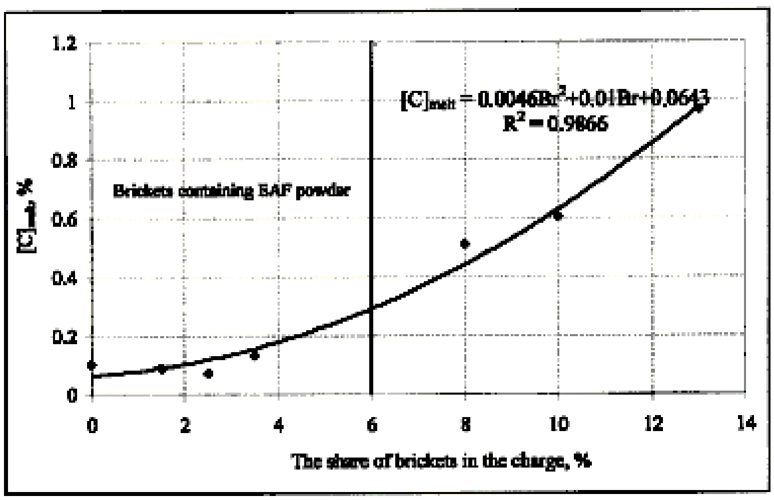

Fig.1 The carbon content versus charge structure at the melting point

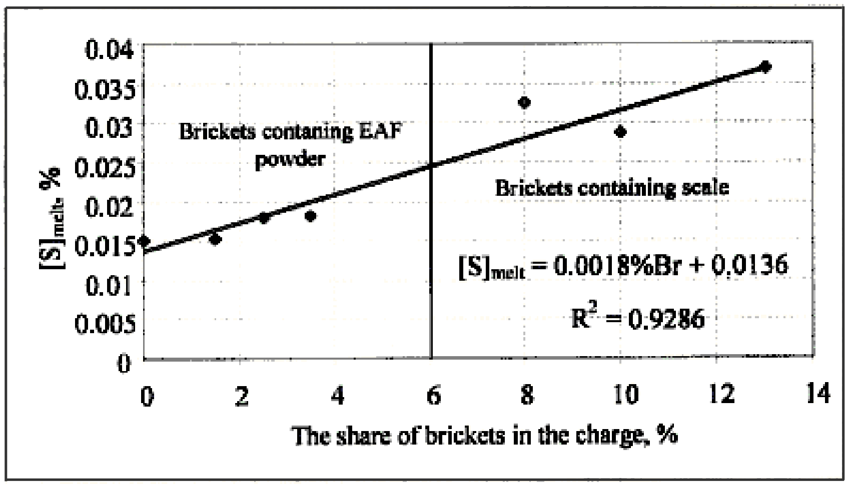

Fig.2 Variation of sulphur versus amount of brickets at the melting point

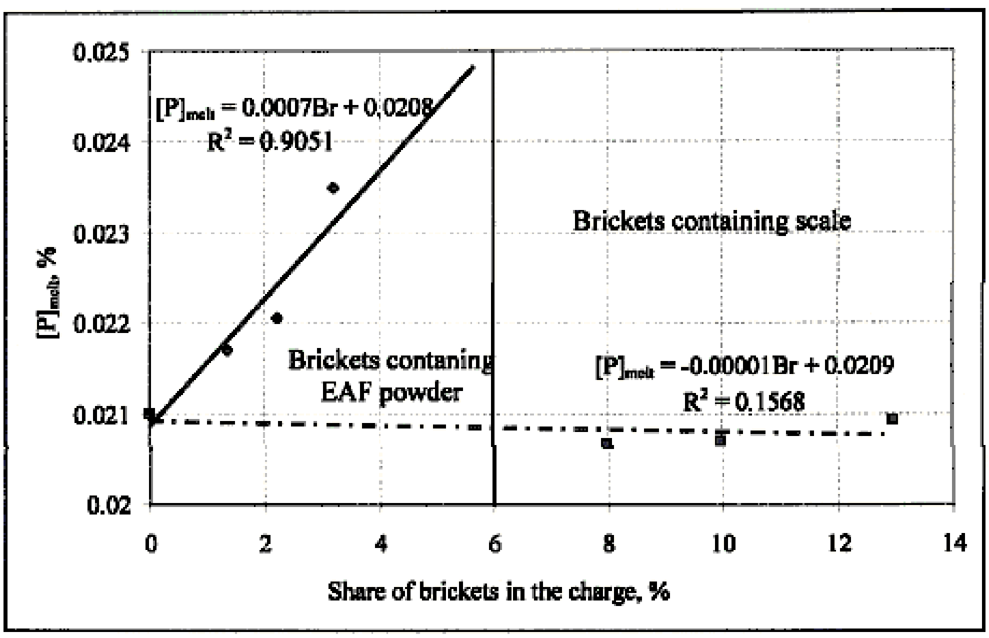

Fig.3 Influence of brickets content on phosphorus at the melting point

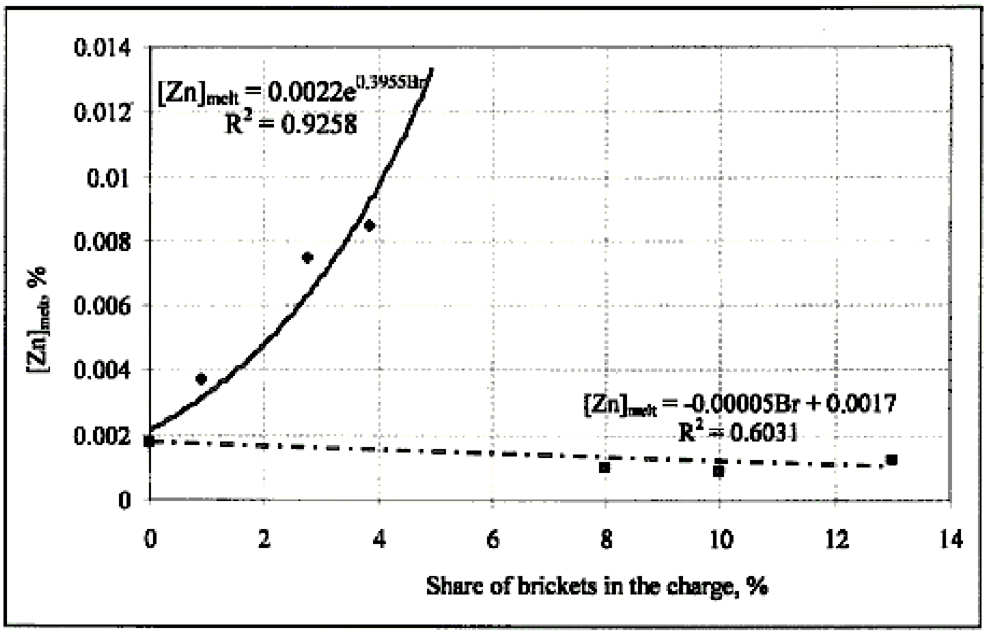

Fig.4 Influence of brickets addition on the zinc of content steel

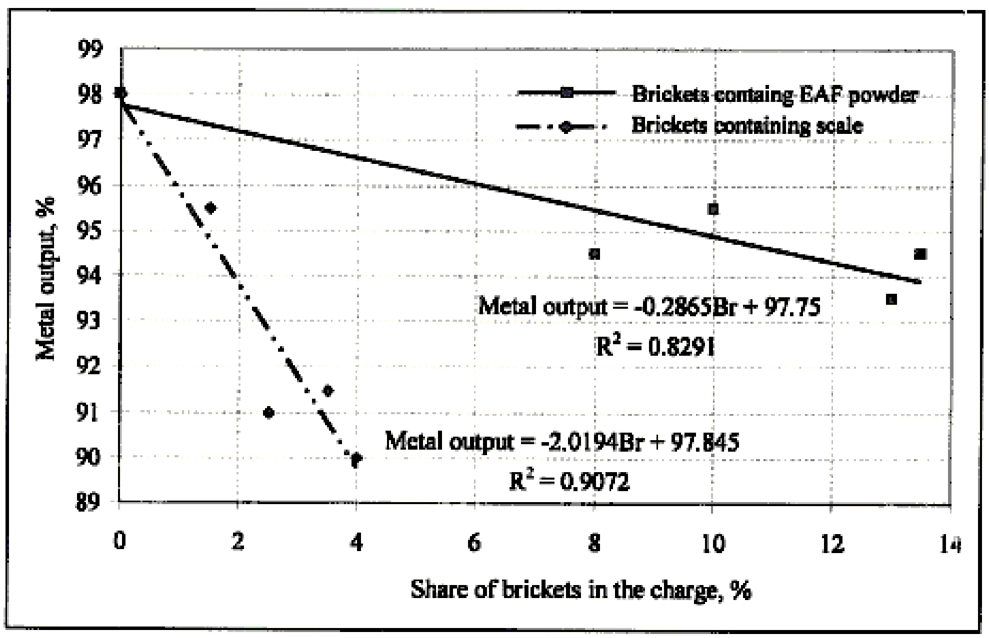

Fig.5 Influence of brickets content in the charge on the steel output

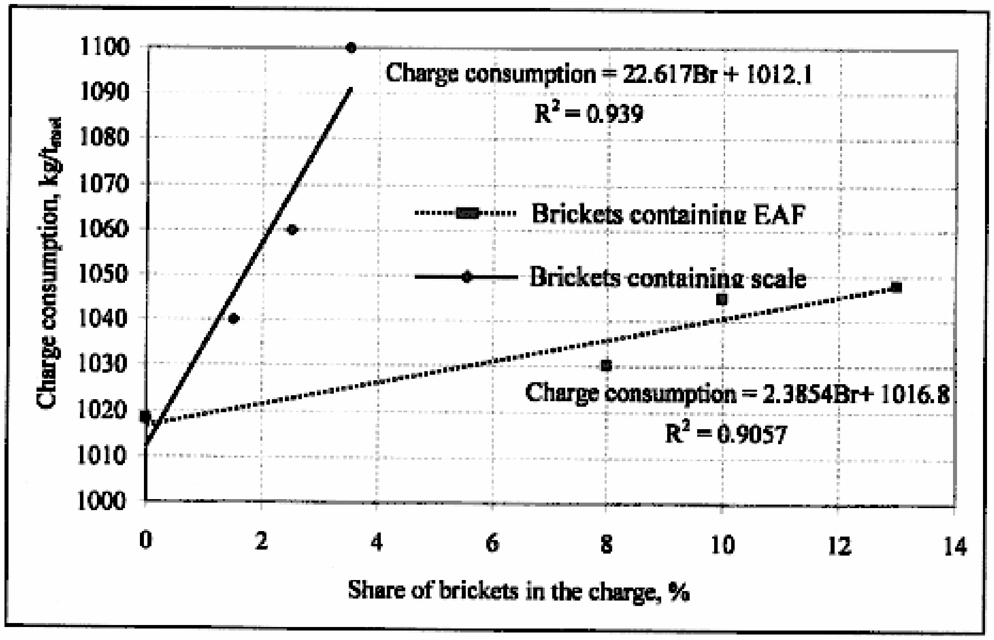

Fig.6 Influence of brickets content in the charge on the iron scrap specific consumption

3. Discussion and conclusions

Examination of the results presented in Fig.1-6 show definite correlations between the amount and nature of the substituents for iron scrap in the steel making process and the the chemical quality of the steel.

A good correlation was put in evidence between the share of bricketts charged into the furnace and the carbon content at the melting point; despite of this, the high carbon concentrations resulted at the melting point in the case of scale bricketts show that it is necessary to decrease the reductant (fuel) in order to provide an optimal carbon content at melting for the foamslag (0.1-0.3%). In the case of bricketts obtained from EAF dust one can consider that this target was reached, thus, the weight of bricketts from dust in the furnace can be increased from this point of view even up to 5-7%.

A good correlation was also observed (Fig.2) between the weight of bricketts charged into the furnace and the sulphur content at the melting point; the higher sulphur concentrations at the melting point for scale bricketts resulted only from a higher share of scale and doesn't generate any troubles when the sulphur content of steel is 0.035% in the case of a treatment performed in a LD ladle installation. From this point of view, the share of brickets made of furnace dust can reach even 5-7% and the weight of scale bricketts must be limited to 12% from the whole charge.

The data from Fig.3 demonstrate a relative good correlation for the furnace dust bricketts, which can be used even in a share of 5-7% of the charge, the phosphorus content of the steel remaining below 0.025%.

Due to the weak correlation for scale bricketts, it is not possible, yet, to draw conclusions as concerns this category.

The zinc content of the sample at the melting point is plotted against the weight of bricketts in the charge, which contain approximately 8% ZnO. No unique correlation for both bricketts types (furnace dust and scale) could be established.

The information from Fig.5 and Fig.6 show individual correlations for every brickett type; the bricketts manufactured from scale provide an output of over 95%, even for a 10% weight in the charge, while the brickets made from EAF dust have to be limited to 2% in order to decrease the output to maximum 94%. However, in both cases one can observe that the output lies below the reference value for iron scrap (output 98%). The results are also similar when performing the analysis of charge consumption (the sum *iron scrap+bricketts* was taken into account).

As concerns the function fulfilled by the pulverulent secondary material during the recycling process, in a first phase, it can be estimated by performing a quantitative analysis of the existent information in the above diagrams as follows:

a. in order to introduce in the charge 1% bricketts manufactured from furnace dust, it is necessary to increase the iron scrap consumption by 11,9 kg/t_{steel}; in this case, the EAF dust is capitalized mostly to avoid the deposition and more restrictvely, as efficient substituent of iron scrap; this means, that the recirculation of EAF dust has to play mainly an ecological function;

b. by introducing in the charge 1% bricketts made from scale, it is possible to reduce the iron scrap consumption by 7.53 kg/t_{steel}; in this case, the iron scrap substituent is also capitalized and the technology used belongs to the group deserving the function of a substituent;

c. in order to provide also the recycling of EAF dust as a substitution component, it is necessary to draw up technologies, which use the mixture: EAF dust + scale.

The ecoefficiency (i.e. the economical and ecological efficiency) can be evaluated in this case by using the indicator C_{ec}, which is defined as the ratio between the costs involved by the environmental friendly technology (C_e) and the costs for the reference technology (C_m):

$$C_{ec}=C_e/C_m.$$

If $C_{ec} < 1$, then the respective technology is able to perform an ecological function under the circumstances of economical efficiency. The ecomical calculations for the present researches show that in:

- the case of steelmaking using the brickets manufactured from EAF dust, C_{ec}= 1.027;
- the case of steelmaking using brickets made from scale, C_{ec}= 0.96.

These calculations demonstrate that it is necessary to combine the bricketts from EAF dust with those manufactured from scale, in order to fullfil the economical function as iron scrap substituent.

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