About EAF and environment

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Abstract. In this paper we present the results of industrial experiments consisted in determination, by specialized measurements, of the dust percentage in the evacuated gases from the EAF and of chemical composition of polluting burnt gases. The electric arc furnaces (EAFs), as powerful energy consumers, are also polluting emissions generators with an important environmental impact. The steel refining in the EAF is based on a complex mechanism of oxidizing chemical processes, due to the introduced oxygen and air. A first step is the diffusion and adsorption on the slag surface of molecular oxygen. The most significant polluting emissions of the EAF are metallic and oxides powders driven by emergent gases.

1. Introduction

From the point of view of reducing the impact over environment, the most important step is the optimization of powder retaining from the process gases both from the furnace and from the work-area. This optimization is necessary for improvement of work conditions and for obeying the limits imposed by the work and environment protection legislation.

A disadvantage of specific power installed growth of electric arc furnace transformers was formed by raising the level of noise in the operation of the furnace and especially from melting. Thus, in the context of the modernization works of the UHP oven steel furnances Campi-Nueva Italsider, was measured over the noise level between 63dB (80 m) and 120 dB (liturgy), [1]. This disadvantage has been removed by an enclosure of insulating panels around the oven electrically sound.

The electric arc furnaces (EAFs), as powerful energy consumers, are also polluting emissions generators with an important environmental impact.

The most significant polluting emissions of the EAF are metallic and oxides powders driven by emergent gases [1-5]. The powders are produced during the following technological operations: raw materials loading, steel melting, refining, alloying and evacuation. Generally, the driven powders contain heavy metals (Cr, Ni, Zn, Cd, Pb, Cu etc) and some metal oxides (iron, manganese, aluminum and silicon oxides) and they can reach values of more than 15 kg/t steel.

The steel refining in the EAF is based on a complex mechanism of oxidizing chemical processes, due to the introduced oxygen and air. A first step is the diffusion and adsorption on the slag surface of molecular oxygen.

Then, the presence of the adsorbed oxygen molecules (written as \{O_2\}_{ads}) leads to the redox chemical reaction with ferrous ions from the slag (symbolized as (Fe^{2+})); this is a reaction with exchange of two electrons resulting oxygen ions and ferric ions, both ionic species dissolved in the slag:
\[
\frac{1}{2} \{O_2\} \text{ads} + 2(Fe^{2+}) = (O_2^{-}) + 2(Fe^{3+})
\] (1)

Next step is the diffusion of O2- and Fe3+ ions (within the slag and penetrating the slag–metallic melt interface).

2. EAF and Environment

From the total EAF polluting emissions, over 90% are generated during the technological operations of melting and refining [6], [7]. The chemical composition of these emissions is extremely variable and directly dependent on multiple factors, as followings:

- the melting managing way;
- type of refining process that is used (with gaseous oxygen or ore);
- desired quality degree of the elaborated steel;
- composition of the raw materials that make up the loading;
- time duration of the melting and refining steps.

Figure 1 presents the main scheme of the environment polluting system through the EAF.

![Figure 1](image.png)

**Figure 1.** The scheme of the environment polluting system through the EAF.
Table 1 presents the variation limits of chemical composition for the powders generated during the steel elaboration in electric arc furnaces in the USA and Germany, from loading that consists of scrap iron, only [1-3].

| No. | Component | Variation limits, % | SUA | GERMANY |
|-----|-----------|---------------------|-----|---------|
|     |           |                     |     | Plain Basic Steel | Alloy Steel |
| 1   | Fe_total  | 16.4 – 38.6         |     | 21.6 – 43.6       | 35.3        |
| 2   | Si        | 0.9 – 4.2           |     | 0.9 – 1.7         | 17.0        |
| 3   | Al        | 0.5 – 6.9           |     | 0.1 – 1.5         | 0.4         |
| 4   | Ca        | 2.6 – 15.7          |     | 6.6 – 14.5        | 0.4         |
| 5   | Mg        | 1.2 – 9.0           |     | 1.0 – 4.5         | 1.2         |
| 6   | Mn        | 2.3 – 9.3           |     | 0.9 – 4.8         | 2.0         |
| 7   | P         | 0 – 1.0             |     | 0.1 – 0.5         | 0.5         |
| 8   | S         | 0 – 1.0             |     | 0.3 – 1.1         | 0.1         |
| 9   | Zn        | 0 – 35.3            |     | 5.8 – 26.2        | 1.4         |
| 10  | Cr        | 0 – 8.2             |     | 0 – 0.1           | 13.4        |
| 11  | Ni        | 0 – 2.4             |     | x)                 | 0.1         |
| 12  | Pb        | 0 – 3.7             |     | 1.3 – 5.0         | 0.4         |

Figure 2. Scheme representation of the mathematical model concept for load calculus in the EAF

1 – Metal load (scrap iron); 2 – Iron ore; 3 - Lime; 4 – Calcium fluoride; 5 - Dolomite; 6 - Coke; 7 - Electrodes; 8 – Blown oxygen; 9 – Exhausted atmospheric air; 10 – Liquid steel; 11 – Slag (liquid); 12 – Burnt gases.
Input materials (MI,i) mainly consist of (Figure 2):
- Metal load (scrap iron)
- Iron ore
- Lime
- Calcium fluoride
- Dolomite
- Coke
- Electrodes
- Blown Oxygen
- Exhausted atmospheric air

Output materials (ME,j) are:
- Liquid steel
- Slag (liquid)
- Burnt gases

3. Conclusions
Optimizing steel making in the EAF has as a starting point the analysis of the chemical mechanisms attached to the specific transformations.

EAF polluting emissions, over 90% are generated during the technological operations of melting and refining.

The blown oxygen quantity was established by means of thermal-technical measurements, and the quantity of exhausted oxygen as a difference between the necessary oxygen for the process and the inspired oxygen. The frequently determined excess oxygen, by means of complex thermal-technical measurements, has emphasized an almost permanent supplementary exhaust of the atmospheric air inside the EAF. This aspect is directly correlated to the lack of isolation of the elaboration machinery.

References
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