Environmental Management Elements of The Electric Arc Furnace

The paper presents a theoretical and experimental analysis of the polluting generating mechanisms for steel making in the Electric Arc Furnaces (EAF). The scheme for the environment's polluting system through the EAF is designed and presented in this paper. The ecological experimenting consisted of determining by specialised measures of the dust percentage in the evacuated gases from the EAF and of thereof gas pollutants. From the point of view of reducing the impact on the environment, the main problem of the electric arc furnace (EAF) is the optimisation of the powder collecting from the process gases, both from the furnace and from the work-area. The paper deals with the best dependence between the aggregate's constructive, functional and technological factors, which are necessary for the furnace's ecologisation and for its energetically-technologically performances increasing.

The electric arc furnace (EAF) is an important polluting emissions generator, having a strong impact over the environment [1, 2]. The most important polluting emissions of the EAF [3, 4, 5] are:

- The powders resulted during the technological operations of base material loading and steel melting, refining, alloying and evacuation which contain heavy metals (Cr, Ni, Zn, Pb, etc) and can reach values of 15 kg/t steel [6];
- The gases resulted from the melting and refining proceed ings, which mainly contain CO, CO_2, SO_x and NO_x [7].

From the total polluting emissions, over 90% are generated during the technological oper-ations of melting and refining. These emissions have a high content of iron, manganese, alum-inum and silicium oxides, as well as heavy metals oxides (Ni, Cr, Cd, Pb, Cu). The chemical com-position of these emissions is extremely variable and directly dependent on the following parameters [8]:

- the composition of the base materials that make up the loading;
- the melting managing way;
- the refining process that is used (with gaseous oxygen or ore);
- the period the melting and refining last; the grade of the elaborated steel.

In table 1 there are presented the chemical composition's variation limits for the powder generated during the steel elaboration in electric arc furnaces [9] in the USA and Germany, from loading that consists of scrap iron.

Materials and Methods

From the point of view of reducing the impact over the environment, the most important step is the optimisation of the powder collecting from the process gases [10-13] both from the furnace and from the work-area. This optimisation is both for the work conditions improvement and for the following of the limits imposed by the work and environment protection legislation.

The factors determined by the previous demands, along with the EAF's perform-ances increasing, involve the following: the gases' collecting extension; the increasing of the separation rang or the reducing of the gases' powder content; the reducing of the functioning costs by reducing the energy consumption; the reducing of the maintenance costs and of the investment costs; noise protection; the work conditions improvement.

For the polluting emissions not to get into the work bays' atmosphere and into the environment, the electric arc furnaces had to be equipped with efficient captiv-ation and purification equipment [14,15].

The powder emissions generated during the technological steps of a charge can be divided into primary and secondary emissions depending on their content from the total powder quantity generated during the whole charge duration.

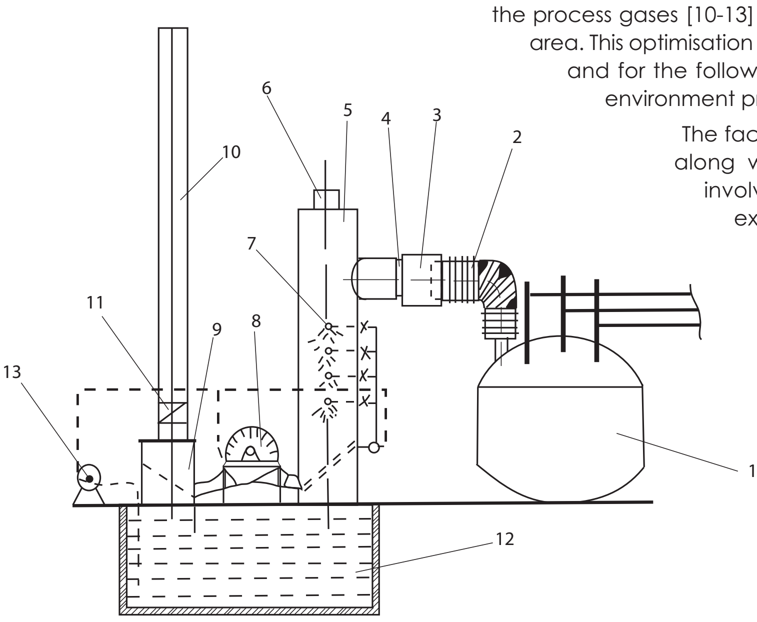

Figure 2. Wet removal plant (10t EAF) ***1*** *- Electric Arc Furnace ;* ***2*** *- Exhausting Pipe;* ***3*** *- Moving Pipe Socket;* ***4*** *- Gap;* ***5*** *- Cooler;* ***6*** *- Safety Piping;* ***7*** *- Nozzles;* ***8*** *- Radial Dezintegrator;* ***9*** *- Separator;* ***10*** *- Chimney;* ***11*** *- Shutter;* ***12*** *- Basin;* ***13*** *- Pump*

No.	Component	Variations Limits %		
		USA	Germany	
			Unalloyed Steel	Alloyed 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	N/A
4.	Ca	2.6-15.7	6.6-14.5	0.4
5.	Mg	1.2-9.0	1.0-14.5	1.2
6.	Mn	2.3-9.3	0.9-4.8	2.0
7.	P	0.0-1.0	0.1-0.5	N/A
8.	S	0.0-1.0	0.3-1.1	0.1
9.	Zn	0.0-35.3	5.8-26.2	1.4
10.	Cr	0.0-8.2	0.0-0.1	13.4
11.	Ni	0.02.4	N/A	0.1
12.	Pb	0.03.7	1.3-5.0	0.4

Table 1 The chemical composition of the powder generated by the electric arc furnace (EAF)

The gaseous phase of the emissions that come out of the EAF mainly consists of the following components: CO, CO_2, NO_x and SO_x, but it also contains other components, very toxic ones, such as volatile organic components resulted from the organic oils burning that decreases the purity of the base material.

The EAF powder emissions classification and content are presented in *table 2.*

In *figure 1* there is presented the main scheme of the environment polluting system through the EAF.

No	Emission Type	Technological phase of the elaboration process	Emission Content(%)
1.	Primary	Melting - Refining	93
2.	Secondary	Loading	2.75
		Evacuation	3.5
		Though lack of tightness (door, arched tank, the space around the electrodes)	0.75
	Total	The charge duration	100

Table 2 EAF powder emissions classification and content

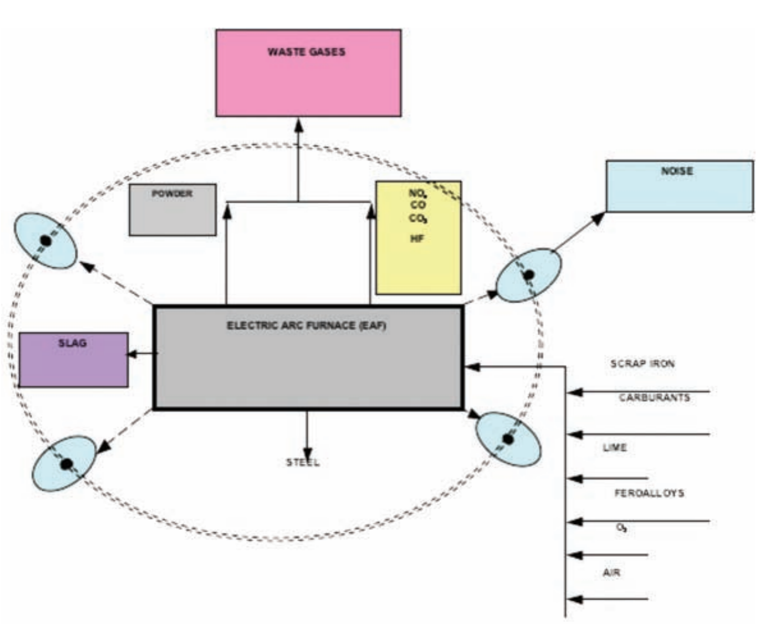

Figure 1. The scheme of the environment polluting system through the EAF.

Ecologisation Possibilities of the Electric Arc Furnace

For the removal of burnt gases that are evacuated from the electric arc furnace the successive realisation of two categories of processes is needed [15-18]:

- the burnt gases captivation;
- the burnt gases removal.

The burnt gases caption can be achieved with one of the following variants:

- hoods;
- exhausting pipe in the arch (through the fourth orifice in the furnace's arch);
- mixed (hood + the fourth orifice in the arch).

The burnt gases removal system can be:

- wet, through the gases' washing;
- centrifugal, with the help of the cyclones;
- filter type with filters with bags (textile materials) or electrofilter.

An example of a wet removing plant used at a 10 t EAF is presented in *figure 2*.

The solution of gases' exhaust through a fourth orifice in the arch was adopted and that proved to be the best way of catching the gases from an electric arc furnace.

The exhausting pipe (2) which has cooling ribs was settled to the metallic construction of the furnace's arch, so that it can follow all its dumping and oscillation movements.

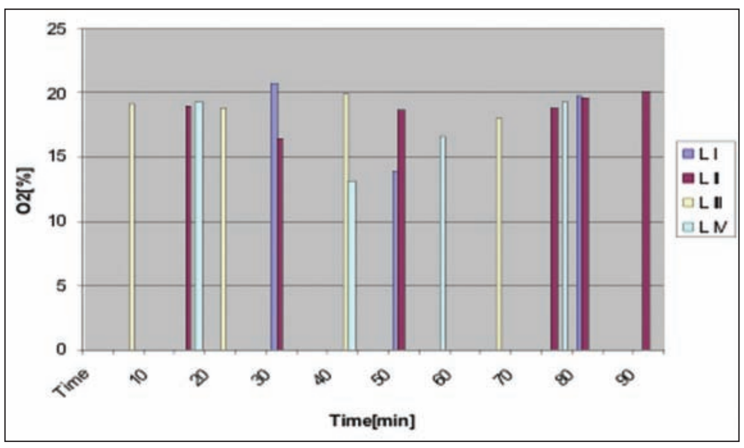

Figure 3. O_2 percentage variation in the waste gases during the melting in the EAF for 4 charges (LI, LII, LIII, LIV)

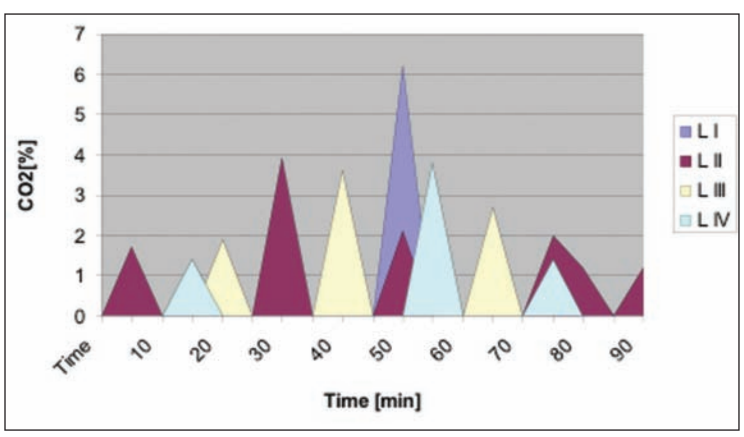

Figure 4. CO_2 percentage variation in the waste gases during the melting in the EAF for 4 charges (LI, LII, LIII, LIV)

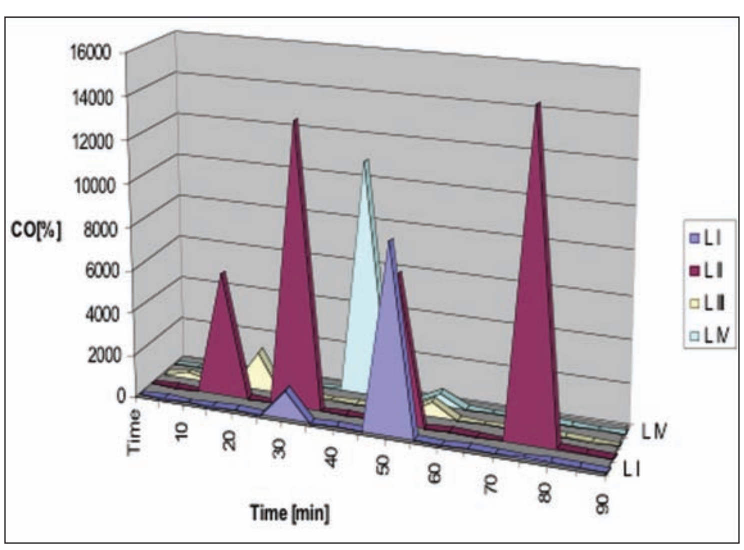

Figure 5. CO percentage variation in the waste gases during the melting in the EAF for 4 charges (LI, LII, LIII, LIV)

The evacuated gases removal proceeding from the electric arc furnaces, expected to be used in siderurgy takes into consideration: the mixed solution of the gaseous phase collecting, both through the fourth orifice of the arch (provided with a cooled linkage) and through a mobile hood electrically operated and placed above the furnace (for the secondary emissions catching); the gases' cooling with air exhausted at the surrounding temperature; filtering element – filter with bags; the necessary draught providing – through a room exhauster (both for the fourth orifice from the arch and for the arch).

Results And Conclusions

In *figures 3, 4* and *5* there are presented the main results of the O_2, CO_2, respectively CO percentage variation in the waste gases during the melting in the EAF.

The decision upon the type of process and plant that are used to remove the evacuated burnt gases from the electric arc furnace takes into consideration the following criteria: not to negatively influence the technological process; the possibility of framing in the available space; the realisation of the environment protection under best circumstances; safety in exploitation; minimum investment volume; minimum exploitation cost; the purified substances' best use.

The using of the removal plant influences the pressure regime in the EAF. Along with the fake exhausted air volume increasing phenomenon (and the increasing of the burnt gases' volume, gases that are evacuated from the EAF) caused by the worn furnace's arch, this aspect imposes the use of cooled arches and walls.

The EAF's thermo regime intensification and its best seal, technological priorities that lead to the EAF's productivity increasing, as well as to the specific energy consumption decreasing, must be done by avoiding the uncontrolled ignition risk of the gaseous phase on the removal plant's route. For this, the introduction of the burning chamber is extremely important.

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