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# About the Concept of the Environment Recycling— Energy (ERE) in the Romanian Steel Industry

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Additional information is available at the end of the chapter

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## **Abstract**

This paper takes as its starting point an analysis of the ecological functioning of the electric arc furnace (EAF). Thus, we present a classification of emissions generated by EAF, including limits of variation in chemical composition of “dust” issued by EAF in various countries and limit values for permissible concentrations of these emissions. The paper presents and analyzes various abstraction and treatment-related emissions for hipo-polluting operation of EAF. In this chapter, the correlations between macro system represented by metallurgical environment and interacting systems: System-Energy-Recycling Environment (ERE), Ecological system (ECO), and Recycling, Reclamation System (REC-REV) are presented. These correlations are presented in the spirit of sustainable development concepts (DC) and total quality (TQ).

**Keywords:** environment-recycling-energy, metallurgical process technology, ecological system

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## **1. Introduction**

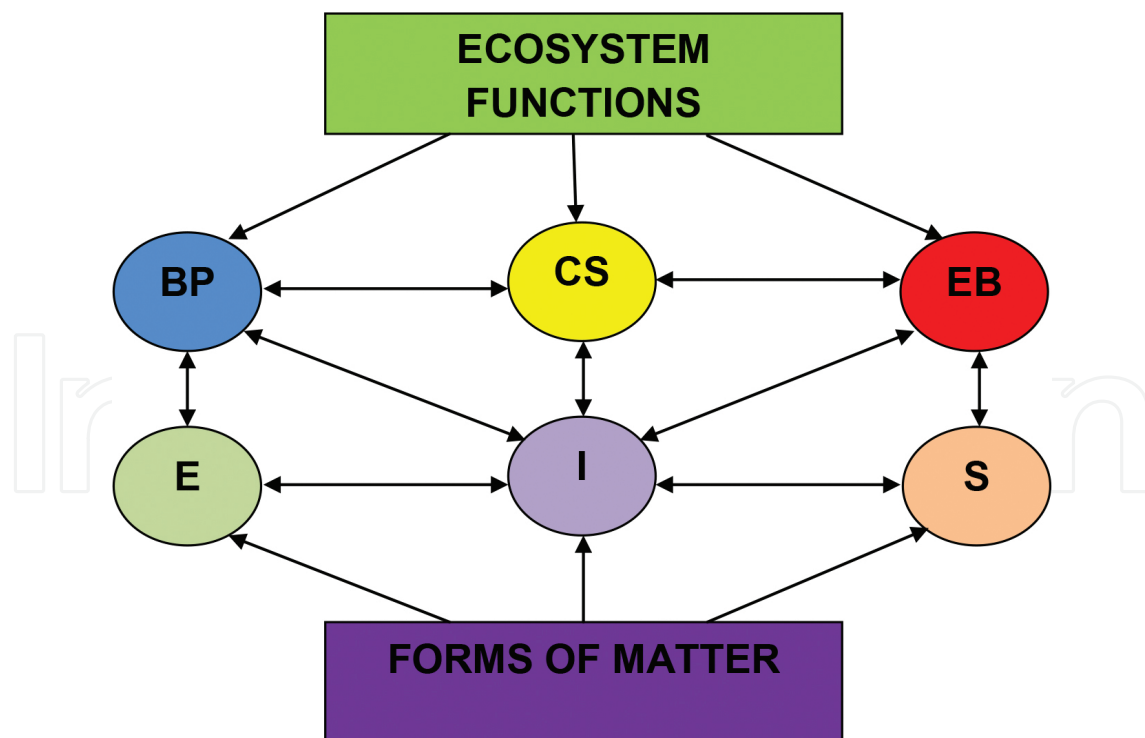
Reducing the amount of emissions and greenhouse gas immissions is an important environmental goal, including specific achievement to ensure the optimal concept of sustainable development.

The Electric Arc Furnace (EAF) for steel development is a powerful polluter. From this point of view, studying and optimizing the functioning of this complex metallurgical aggregate, including the conception of ERE, are of special importance. These activities of study and optimization ensure the optimal conditions for sustainable development.

Metallurgical process is a macroenvironment characterized mainly by the following systems:

- Metallurgical Process Technology system (MPT)—it is analyzed and defined by technological parameters and technological procedures applied.
- The Environment Energy Recycling System (EER)—it defines and characterizes the energy resources necessary for the transformations sources and the metallurgical processes.
- The Ecological System (ECO)—it refers to the organic processing systems pollutant outputs from MPT and EER.
- The Recycling and Revaluation System (REC-REV)—it refers to the energy and material transformations that occur within process flows. This system consists of two subsystems in turn, namely:
  - The recycling subsystem (the capitalization) energy ( $R_E$ ); this subsystem studies and makes more efficient the recycling of energy both within the same ecosystem and within the energetic exchanges between the ecosystems that are interdependent.
  - The recycling subsystem (the capitalization) of materials ( $R_M$ ); this subsystem is directly correlated with energy recycling subsystem, and it represents at the same time a qualitative and quantitative measure of it.

An ecosystem performs three important functions. These functions are as follows:



**Figure 1.** The correlations between an ecosystem functions and forms of matter. Source: own research. BP—the biological productivity; CS—the circulation of substance; EB—the ecological balance; E—energy; I—information; and S—substance.

- The biological productivity (BP)—the biological productivity of an ecosystem is directly dependent both on the quality of the biotope (geographical environment) and on the biocenosis (all living organisms).
- The circulation of substance (CS)—this function of the ecosystem refers to the exchange of materials both within the same ecosystem and between different ecosystems that are interdependent.
- The ecological balance (EB)—is a function of quantification (quantitative determination) of the exchanges of matter and energy within an ecosystem.

The functions of an ecosystem must be analyzed in relation to the transformations through the three forms of matter:

- Energy (E)—energy as a form of matter is a measure of its quality.
- Information (I)—the information is the genetic carrier of the matter; it also characterizes the history and evolution of the respective matter.
- Substance (S)—it is a way of quantifying the matter. **Figure 1** shows the correlations between an ecosystem functions and forms of matter.

A brief explanation is useful to the ecosystem functions:

- The transformation of energy is illustrated by the size and variation in biological productivity.
- The circuit of macroelements reflects the changes of the substance.
- The ecological balance is an expression of the size of information.

## 2. The correlations of MPT-ERE-ECO-REC-REV

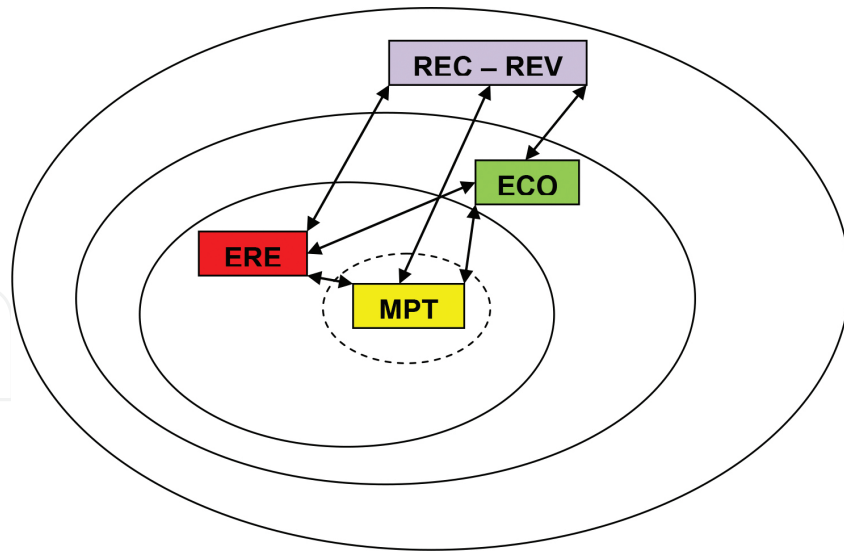
Based on the concepts of sustainable development (SD) and total quality (TQ), the effective analysis of a process and metallurgy must put on the forefront quantify correlations MPT-EER-ECO-REC-REV. In **Figure 2**, we present these correlations scheme.

The ecosystem, by definition, is a group consisting of biotopes, which sets a whole different relationships, both between organisms and between organisms and between abiotic factors.

This first definition of ecosystem requires a specific definition and an explanation of other concepts, such as:

- Biotope
- Biocenosis
- Abiotic

The Biotope is defined as the geographical environment in which there lives a group of living organisms (humans, plants, animals, etc.) in homogeneous conditions.

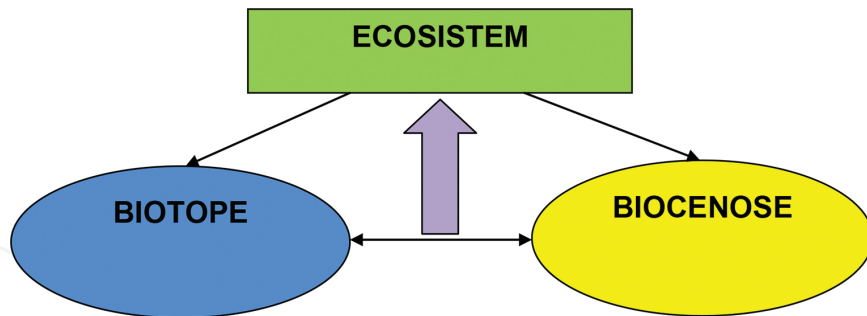


**Figure 2.** The correlations between the systems of MPT, EER, ECO and REC-REV to ensure concepts of DD and CT. Source: own research. MPT—The Metallurgical Process Technology; ERE—The Environment-Recycling Energy System; ECO—The Ecological system; REC-REV—The Recycling and Recovery of the System Recovery; SD—Sustainable Development; TQ—Total Quality.

The Biocenose represents all living organisms that inhabit a particular geographical environment (biotope).

The Abiotic refers to something lifeless, incompatible with life.

It is based on this first definition in **Figure 3**. This is the diagram of the ecosystem.



**Figure 3.** The diagram of the ecosystem. Source: [5].

The following general concepts on which they define in the automatization domeny is the System Ecometalurgic (SE).

The System Ecometalurgic is an ecosystem of custom-specific conditions and technologies in metallurgy (industry metallic materials—ferrous and nonferrous), characterized by a geographic environment and an specific industry (biotope) and by groups of living organisms (people, plants, and animals) that inhabit this environment (biocenosis).

**Figure 4** shows a schematic diagram of the ecometalurgic system.

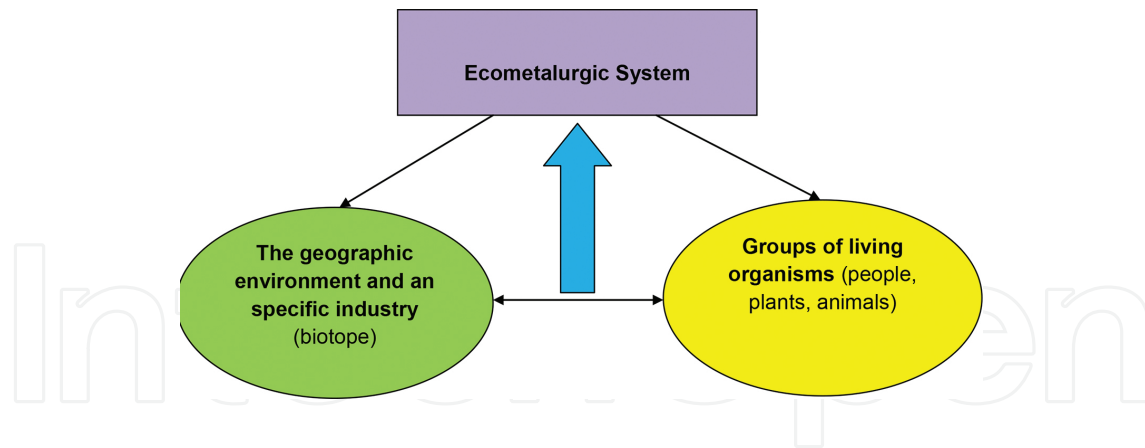


Figure 4. Scheme of ecometallurgic system (ES). Source: own research.

### 3. The Classification and Characterization of the Ecometallurgic Systems (ES)

We define and characterize two types of ecometallurgic systems (ES), namely:

- a. Monovariabile SE (SEMo)
- b. Multivariabile SE (SEMu)

#### 3.1. The characterization

- a. Monovariabile SE (SEMo)—it is characterized by a single magnitude input ( $u(t)$ ;  $m(t)$ ), a single magnitude output ( $y(t)$ ); and a single magnitude of perturbation ( $p(t)$ ).

In Figure 5, we present a schematic diagram of an monovariabile ecometallurgic system (SEMo).

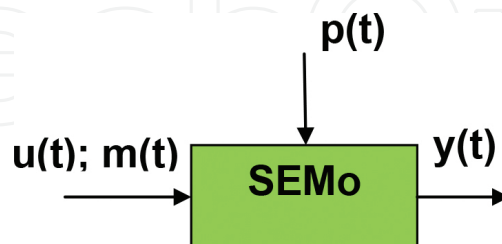


Figure 5. The schematic diagram of an monovariabile ecometallurgic system (SEMo). Source: [5].  $u(t)$ ;  $m(t)$ —magnitude input;  $y(t)$ —magnitude output; and  $p(t)$ —magnitude of perturbation.

SE Monovariabile—it is used to study mathematical modeling and simulation. Given the complexity of the metallurgy, simulation and mathematical modeling can have a great importance.

- a. SE Multivariable (SEMu)—it is characterized by several dataset input quantities ( $\sum u, m_{i(t)}$ ), more outputs—the set of output quantities ( $\sum y_{j(t)}$ ), and several sizes of disturbance—the set of disturbance sizes ( $\sum p_{k(t)}$ ).

Figure 6 shows a schematic diagram of ecometallurgic multivariable system (SEMu).

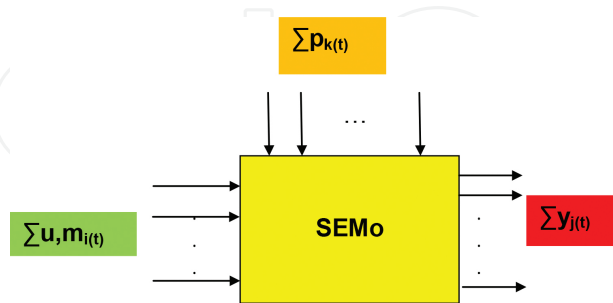


Figure 6. The schematic diagram ecometallurgic multivariable system (SEMu). Source: [5].  $\sum u, m_{i(t)}$ —the set of input quantities;  $\sum y_{j(t)}$ —the set of output quantities; and  $\sum p_{k(t)}$ —the set of disturbance sizes.

#### 4. About the ecological balance

The concept of ecological balance was among the first to go beyond theoretical scientific studies, becoming an emblematic concept of harmony in the environment.

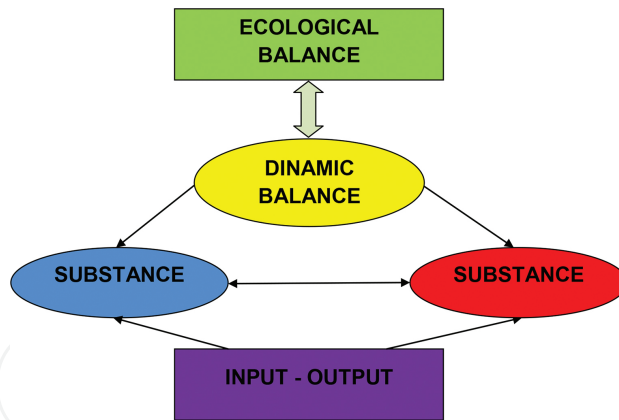


Figure 7. The scheme of the concept of ecological balance. Source: own research.

Ecological balance is a state (an ecosystem) maintained through complex interactions, which aroused particular interest deceleration in terms of theoretical debates and empirical observations.

The study of mechanisms that ensures this status allows the forecast *ecosystem* responses to disturbance anthropic. In terms of exchange of substance and energy, ecological balance expresses *the dynamic balance* ratio between input and output unit.

Figure 7 shows an illustration of the concept of ecological balance.

The maintaining of the ecological balance requires a self as finite nature of resources or space and a virtually unlimited potential of biological breeding populations.

The solutions for maintaining the ecological balance are the recycling and control of the growth which in the ecosystem leads to differentiation of functions for each population, followed by the creation of interdependence and organization of a self-regulating cybernetic system.

## **5. The principles for the environmental legislation applicable to ensure ecological balance**

Among these principles, we consider useful to remember the following:

- The principles of the environmental legislation internally:
- The principle that environmental protection should be an essential element of economic and social policy of the state
- The principle of preventing environmental risks and damage occurrence—this principle has as its main goal to minimize environmental risks, including those from the effect of greenhouse gases.
- The principle of health priority compared with other purposes for use of natural resources—according to this principle greenhouse gases have a major harmful effect upon health.
- The precautionary principle in decision making—any decision, both in technology and in the environmental domain, should rely on this principle of precaution.
- The principle of prevention, reduction, and integrated pollution control—prevention must prevail in any ecological action; in the field of greenhouse gas many decisions of the European Union, which are binding for România as well, predict the slow and gradual decrease in quantity of the emissions and immissions of these gases available before 2030.
- The principle of retention of pollutants at source—the application of this principle is of particular importance to reduce the amount of greenhouse gas emissions.
- The principle of public participation in the environmental protection and improvement.
- The principle of conservation of biodiversity and of ecosystems specific to the natural biogeographical.
- The polluter pays principle—the principle of liability and polluter; this principle, by its punitive character has positive effects including a significant reduction in the quantity of greenhouse gases.
- The principle of state liability and accountability—this principle warns the authorities against possible penalties, including the noncompliance requirements on greenhouse gas emissions.
- The principle of sustainable use of the natural resources—the application of this principle implicitly leads to significant reductions in the quantity of greenhouse gases.



- The principle of cooperation in the context of relationship between state, society, and the environment user.
- The principle of the development of international cooperation for environmental protection – this principle takes into account the fact that greenhouse gases know no borders, so from this point of view, international cooperation in environmental protection becomes crucial.
- The principle of integrating environmental policy into other sectoral policies.
- The principles of external environmental legislation.
- The principles of “sic utere tuo”.
- The principle of good neighborliness—the application of this principle has direct positive effects in default protection of neighboring countries, including in the area of greenhouse gas emissions.
- The principle of protecting the common heritage of mankind—significant reduction in the quantity of greenhouse gases provides the best conditions to accomplish this principle.
- The principle prohibiting pollution—this principle puts in the foreground the significant reduction of greenhouse emissions and imissions gas.
- The principle of protecting natural resources and common areas—greenhouse gases through their effect contradict this principle; consequently, the accomplishment of this principle implies a significant reduction on the amount of these gases.

These principles are particularly important for ensuring ecological balance. Unfortunately, we must recognize that their application is deficient and therefore their effectiveness remains largely theoretical.

## 6. Analysis of ecological electric arc furnace (EAF)

Electric arc furnaces are large generators of emissions, with a strong impact on the environment. The main emissions are as follows:

- Powders (powders) resulted during loading operations of raw materials, smelting, refining, alloying, evacuation steel containing heavy metals (Cr, Ni, Zn, Pb, etc.) that may reach values exceeding 15 kg/t steel.
- Process gases smelting and refining, containing mainly CO, CO<sub>2</sub>, SO<sub>x</sub> and NO<sub>x</sub>.

Of the total dust emissions, 90% are generated during smelting and refining operations. These powders are rich in oxides of iron, manganese, silicon, and aluminum and heavy metals such as nickel, chromium, cadmium, lead, and copper. But their chemical composition is highly variable, being directly influenced by

- composition of raw materials that make up the load EAF;

- melting driving mode;
- refining process used (oxygen gas or ore);
- during smelting and refining processes;
- steel grade that are elaborated.

**Table 1** gives the range of variation of the chemical composition of the dust generated during the production of steel in electric arc furnaces in the United States and Germany, the load entirely made up of scrap.

No.	Component	Variation limits (%)		
		USA	Germany	
			Nonalloy steel	Alloy steel
1.	Fe <sub>total</sub>	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	<sup>a</sup>
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	0.0–1.0	0.1–0.5	<sup>a</sup>
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	0.0–2.4	<sup>a</sup>	0.1
12.	Pb	0.0–3.7	1.3–5.0	0.4

<sup>a</sup>Lack of data. Source: [12]

**Table 1.** Chemical composition of EAF dust emissions.

In terms of the pollution decreasing, the crucial issue in the electric arc furnace is improving the collection of dust from the process gases both in the oven and work area for improved working conditions in those areas and to respect the limits imposed by legislation labor safety and environmental protection.

Determinants of the above requirements along with increased performance CAE, involves the following:

- expanding gas collection;
- increasing the separation or reduction of the dust content in the gas;
- reducing operation costs by reducing specific energy consumption;
- reducing maintenance costs and investment costs;
- protection against noise;

- improving working conditions.

To stop emissions from falling into the halls' working atmosphere and environment, electric arc furnaces had to be equipped with efficient capture and treatment.

This was also imposed by severe laws in many countries, on breakpoints dust, as shown in **Table 2**.

Country	France	Germany	Norway	Spain	Denmark
Allowable dust limit value (mg/m <sup>3</sup> <sub>N</sub> )	10	20	25	50	2–5

Source: [12].

**Table 2.** Limit values for permissible concentrations of dust.

No.	Emission type	Technological phase of the processing	Emission percentage (%)
1.	Primary	Melting	93
2.	Secondary	Loading	2.75
		Evacuation	3.5
		By leaks (door, bowl— vaulted space around the electrodes)	0.75
	Total	Batch duration	100

Source: [12].

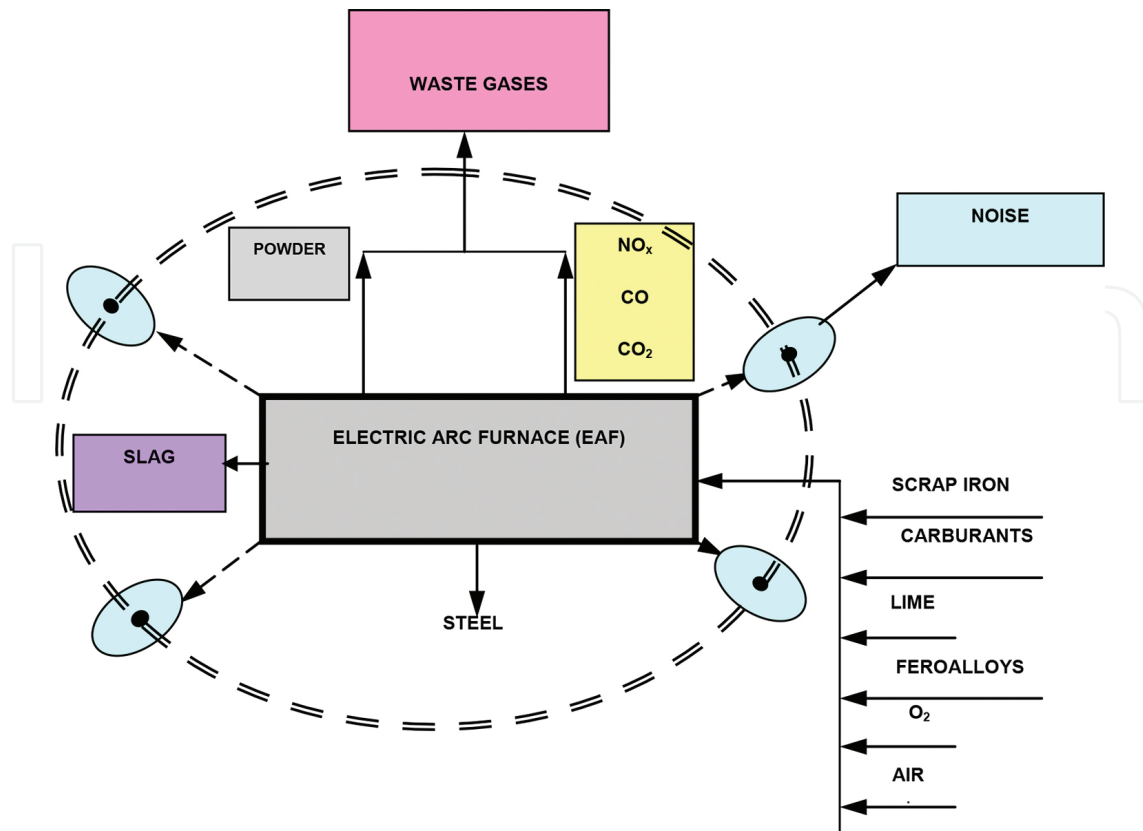
**Table 3.** Weight classification and dust emissions at CAE.

Emission of dust generated during the technological stages of a batch is divided into primary and secondary emissions in the order of their weight in the total amount of dust generated throughout the batch (see **Table 3**).

No.	Heavy metals	Steel type			
		Carbon steel		Inox steel	
		Offset variation (g/t)	Recommended value (g/t)	Offset variation (g/t)	Recommended value (g/t)
1.	As	0.06–0.14	0.1	0.01–0.02	0.015
2.	Cd	0.05–1.5	0.25	0.05–0.09	0.07
3.	Cr	0.3–2.0	1.0	12–18	15
4.	Cu	0.3–1.0	0.8	0.3–0.7	0.15
5.	Hg	—	0.15	—	0.15
6.	Ni	0.1–0.6	0.25	3–6	5
7.	Pb	5–20	14	1–3	2.5
8.	Be	—	0.05	—	0.05
9.	Zr	20–90	50	4–9	6

Source: [12].

**Table 4.** Emission factors for heavy metals in developing the CAE.



**Figure 8.** Scheme system of environmental pollution through EAF. Source: own research.

Gaseous phase of emissions that are emitted from the furnace is not only mainly composed of components: CO, CO<sub>2</sub>, NO<sub>x</sub> and SO<sub>x</sub>, but it also contains other very toxic ones, such as volatile organic compounds (dioxin and derivatives chlorinated benzene and phenol) resulting from burning organic oils that pollute the raw material.

Emission factors in the development of heavy metals in the arc furnace oscillate in a broad difference of values, recommending ATMOS PARCOM work for Europe values shown in **Table 4**.

In **Figure 8**, we present the main scheme of the environmental pollution system through CAE.

For dedusting flue gas discharged from the EAF, it is necessary to perform successively two categories of processes;

- capturing flue gas;
- dedusting flue gas itself.

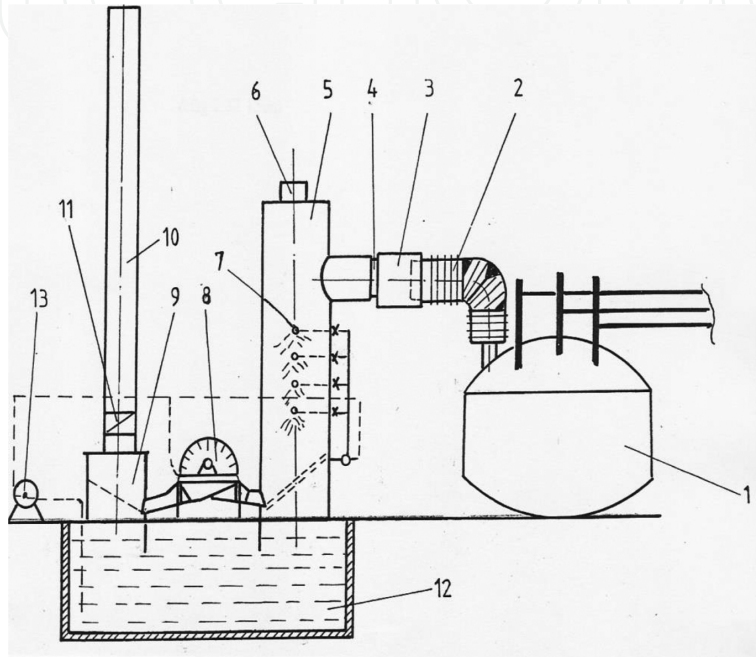
Capturing the flue gas can be achieved mainly by

- Hoods;
- Suction canopy (the fourth hole in the roof of the furnace);

- Mixed (hood + the fourth hole in the ceiling).

Flue gas dust removal system can be:

- Moist by gas scrubbing;
- Centrifugal cyclone;
- Type filters by using filter bags (textile) or electrostatic precipitators.



**Figure 9.** Cyclone wet (electric arc furnace 10 t). Source: [12]. 1—electric arc furnace; 2—suction; 3—mobile sleeve; 4—slot; 5—cooler; 6—tubing safety; 7—spray nozzles; 8—radial disintegrant; 9—separator; 10—cart; 11—throttle; 12—pool; and 13—pump.

The decision on the type of process and the type of facility used for dedusting flue gas discharged from the electric arc furnace is taken mainly based on the following criteria:

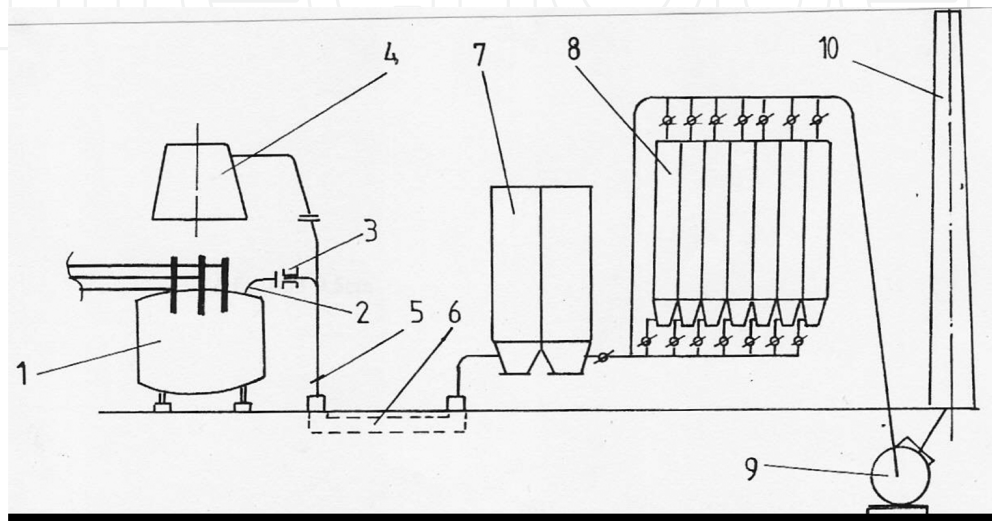
- to not adversely affect the process;
- the possibility of grouping the available space;
- keeping a smooth environment;
- operational safety;
- minimum investment volume;
- minimum operating cost;
- capitalization of substances treated.

An example of a wet cyclone used in an electric arc furnace of 10 t is shown in **Figure 9**.

The solution was gas suction through a fourth hole in the roof, proving to be the best way of capturing an electric arc furnace gas.

The suction pipe [2] provided with cooling fins was fixed by the metal construction of the vault of the oven so as to be able to follow all the movements of the tilting and swinging thereof.

Between suction and fixed air purifying, there is a mobile sleeve [3] and a space (gap) [4] necessary both for taking thermal expansion and for regulating the flow of cold air sucked.



**Figure 10.** Scheme cyclones exhaust gases from the electric arc furnace (EAF). Source: [12]. 1—electric arc furnace; 2—suction; 3—chamber; 4—mobile hood; 5—keyboards; 6—underground channel; 7—cooler; 8—battery filters; 9—turbo-fan (common); and 10—cart.

The burned gases are cooled entirely up to their dew point in the cooler [5] by spraying water through four nozzles [7]. The cover of the cooler is equipped with a safety pipe [6] for additional entry of air.

The Radial disintegrator [8] is arranged downstream of the gas cooler and extracts therefrom, acting as a suction fan, where a fine treatment takes place at the same time. The gases then enter tangentially into a water separator [9] and are discharged into the atmosphere through a stack [10].

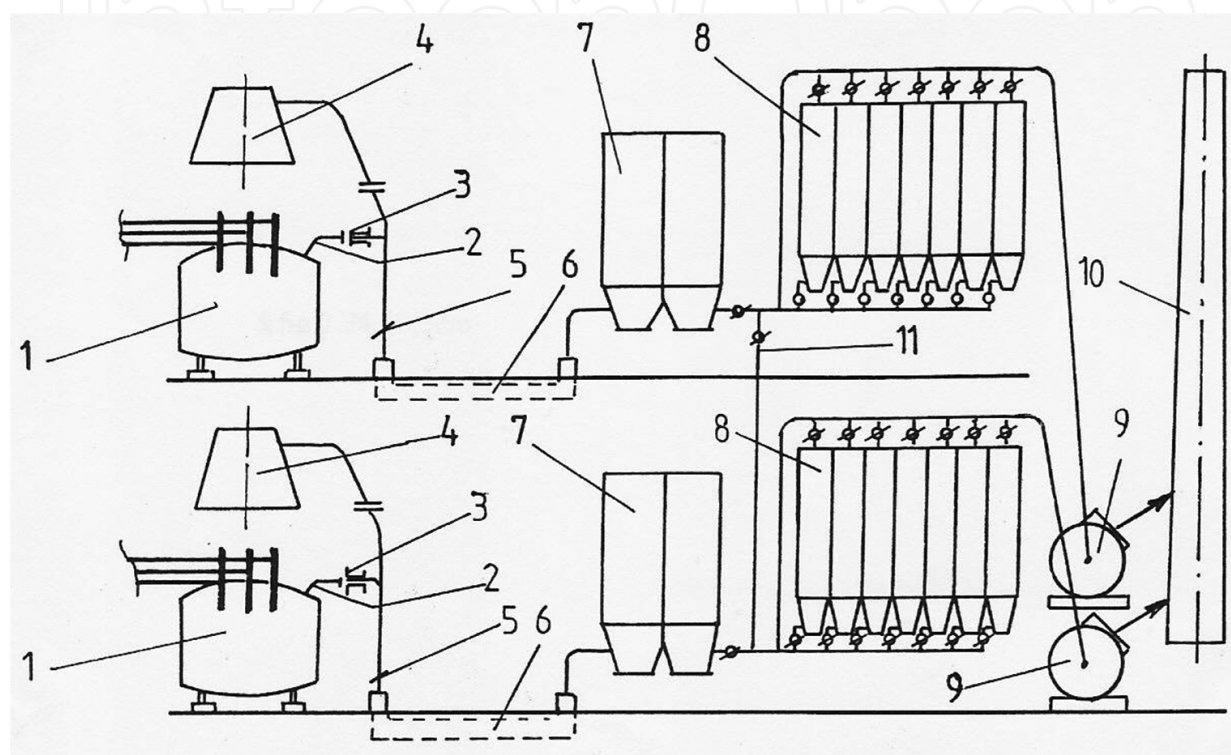
The wash water is recycled to the cyclone reactor. From a pool of water [12] 18 m<sup>3</sup>, various points of use are fed by a pump.

The dedusting process of exhaust gases from electric arc furnaces (IPROMET solution) envisages:

- mixed solution for collecting the gaseous phase, both by the fourth hole in Olt (provided with a fitting cooled) and through a mobile hood over the furnace and electric drive (for secondary emissions capture);
- an air cooling gas at ambient temperature;

- filter element—bag filter;
- depression necessary to ensure—through an exhaust chamber (both for the fourth hole in the vault and the vault).

**Figure 10** presents the scheme of dedusting plant exhaust gases from the electric arc furnace, used in Romanian steelworks.



**Figure 11.** The system of scrubbers in parallel. Source: [12]. 1—electric arc furnace; 2—suction; 3—chamber; 4—mobile hood; 5—flap; 6—underground channel; 7—cooler; 8—battery filters; 9—exhaust; 10—cart; and 11—valve switching.

The flue gases collected through both of the fourth hole in the roof of the oven and the suction pipe (2), gas ceding their heat of reaction in the combustion chamber (3) and through the hood furniture (4). They are directed to an adjustable flap pressure (5) underground channel (6). From this channel, the gases are cooled in cooler (7) and then filtered through the filters battery (8) with bag filters (fabric).

The depression necessary to collect and circulate the gas is ensured by the suction blower (9) and the output bin (10), and the gases are directed after being dedusted.

Aspirations of false air (both by adjustable gap upstream of the combustion chamber and the other leg) directly influence the efficiency of the furnace exhaust gas capture (increased false airflow aspirated gas flow mitigates captured).

Treatment plant may be individual (for each furnace) or in parallel (coupled two by two), each serving one furnace, as shown in **Figure 11**.

Through the throttle switch (11), one can reverse the serviced furnace or that cyclone operation. The coupling system of the plants has the advantage of using a single cyclones for the two furnaces (not simultaneously) so that during repair (revision) of the installation, one of the two furnaces can be operated by the cyclone operation.

Using cyclone influences the regime of the pressure in the oven. Correlated to the increase in false sucked airflow (and implicitly exhaust gas discharged from the oven) caused by the wear dome oven, this requires the use of vaults and cooled walls.

Intensifying the thermal oven and its best possible sealing are goals that lead both to the increase of productivity oven and to reducing specific energy consumption, and they should be made to avoid the risk of uncontrolled ignition of the gas phase route cyclones. To this end, the introduction of the combustion chamber has a decisive role.

In the case of dusting with electrical filters, the gas passes through the electrofilter chamber where deposition electrodes, linked to the ground, and emission electrodes are placed. Due to the difference of voltage of about 75–100 kV between emission electrodes of negative polarity and deposition electrodes, of positive polarity, an electrostatic field is formed.

In the vicinity of the emission electrode, a strong failure of potential is established, which produces the ionization of the gas in this area. Positive ions remain on the emission electrode and the electrons move to the deposition electrodes. on their way The electrons meet gas molecules and dust particles which they ionize negatively. These ionized particles adhere to the deposition electrodes they meet.

The layer of powder deposited can reach a thickness up to 10 mm. It is removed by shaking the deposition electrodes with the aid of a striking hammer device. Dust collection is achieved in a specially arranged bunker at the bottom of the electrostatic precipitator.

In electric filters, continuous current is used so that the ionized particles travel only in one direction (toward the deposition electrodes).

## **7. Pollution prevention through afterburner**

As shown, after thermal metallurgical processes gaseous combustible substances such as CO, H<sub>2</sub>, and CH<sub>4</sub> result. It is proposed that these gases be used, after leaving the contour energy as substitutes for other aggregates of expensive or deficient fuels.

Lately, to increase the efficiency of enthalpy and chemical potential (thermal effect of oxidation reactions—burning) of burnt gas, one need to burn combustible components in the working unit of the aggregate.

This process of modernization, applied, for example, to oxygen converters and electric arc furnace (EAF) is called postcombustion. Since the consumption of CO takes place inside, the method is also considered a way of reducing pollution.



Essentially, the method involves the recovery, even in the technological outline, of the heat of exothermic combustion reaction of CO with oxygen, blown into the workspace via a lance especially designed for this purpose:



The process efficiency is assessed by postcombustion indication rate, defined as the ratio indicator:

$$\eta_{\text{p.c}} = \frac{(\% \text{CO}_2)}{(\% \text{CO} + \% \text{CO}_2)} \quad (2)$$

Detailed analysis of postcombustion process shows that there are still reservations regarding the technical possibilities for improvement and contributions to the development of theoretical knowledge underpinning the process.

Thus, the materials published so far have failed a systematized existing information. For this reason, the authors of this paper, proposes the following classification of postcombustion processes.

a) Natural postcombustion, in which extra energy is built on the combustion components (CO and H<sub>2</sub>), naturally eliminated from the process; combustion occurs upon contact with the jet of oxygen blown into the furnace. This process has two options:

(a.1) Natural free postcombustion based on the furnace burning combustible gases from process gases in the presence of oxygen jet blew right through the walls of the unit, and depending on the placing of the jet, we identify two technologies:

- Natural free postcombustion with nonimmersed jet or, in short, postcombustion nonimmersed jet where the postcombustion is produced in the white space of the melt-existing fireplace.
- Natural free postcombustion with immersed jet or, in short, postcombustion immersed jet, in which case the oxygen jet pierces the layer of slag, producing foaming slag, which is why the process is also found under the postcombustion foamed slag.

(a.2) Forced natural postcombustion performed when the fireplace blows a jet of supplemental oxygen crossing metal melt and slag;

b) Artificial postcombustion that involves blowing of a coal jet and a jet of oxygen at the same time. In this case, postcombustion also involves burning coal and related processes.

c) Combined postcombustion, which involves a combination of the above.

In specific literature, postcombustion is analyzed as the process that occurs in conjunction with other measures (oxy-combustion, foamed slag, etc.). Therefore the authors consider it necessary to distinguish between:

- pure postcombustion, which means postcombustion in a classic oven without other measures;
- pseudo-postcombustion, where postcombustion relates to other modernizing processes.

Since in the case of CAE, there may be hydrogen gas,  $H_2$  coming from the combustion of hydrocarbons added in the combustion process or waste scrap, and it is possible to have a postcombustion reaction:



In these circumstances, we propose that for the calculation of efficiency of postcombustion to use a new relationship that will characterize the complete process:

$$\eta_{p.c.c} = \frac{(\%CO_2 + H_2O)}{(\%CO_2 + \%H_2O + \%H_2 + \%CO)} \quad (4)$$

Based on the general theory of thermo metallurgical installations, CAE part of, we know that when combustible substances (such as  $CO$ ,  $H_2$ , and  $CH_4$ ) are burnt with flame, a process of dissociation of products of combustion simultaneously occurs, according to the reactions :



This phenomenon makes a distinction between combustion calorimetry temperature given by the equation:

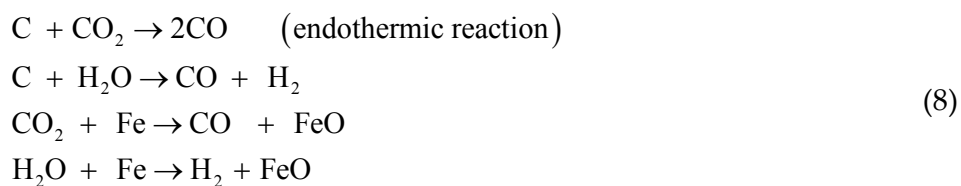
$$t_k = \frac{H_i}{v_{g.a} \cdot c_{p_{g.a}}} \quad (6)$$

where  $H_i$  is the calorific value of the fuel [ $J/kg$ ;  $J/m^3_N$ ];  $v_{g.a}$ —the amount of gas flared [ $m^3_N g.a/m^3_N$ ;  $kg$ ] and —specific heat of flue gas [ $J/m^3_N$ ] and theoretical combustion temperature:

$$t_t = \frac{H_i - Q_{dis}}{v_{g.a} \cdot c_{p_{g.a}}} \quad (7)$$

where  $Q_{dis}$  is the amount of heat consumed for the dissociation of  $CO_2$  and  $H_2O$  [ $J/kg$ ;  $J/m^3_N$ ]. Theoretical calculations, confirmed by the experiment, show that this lost heat can have values  $Q_{dis} = (2...4 \%)H_i$ .

At the same time, postcombustion products  $CO_2$  and  $H_2O$  can react with carbon and iron in molten metal or through oxidation with the iron in the charge:



The last two observations lead to the conclusion that at the same time with the postcombustion processes there occur processes of endothermic consumption of the products  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . Based on this affirmation, in this paper, we propose that we generally call such a phenomena anticombustion.

Theoretical and experimental study in postcombustion shows that so far not enough consideration has been given to intensify postcombustion processes. One of the theoretical and practical possibilities of intensifying launched by the authors in the research is the postcombustion in ultrasonic field called postcombustion ultrasonic (PCU). This new method assumes that the jets of fluids (e.g., oxygen) blown into postcombustion zones be ultrasonic energy carriers, based on which the processes of mass and heat transfer in the mentioned area to be enhanced.

## 8. Conclusion

The metallurgical environmental complexity and therefore the Metallurgical Process Technology (MPT) is grounded and by which it interacts systems: The system-Energy-Recycling The Environment (ERE), Ecological system (ECO), Recycling, Reclamation the system (REC-REV).

The concepts of sustainable development (SD) and the total quality (TC) are of particular importance in analyzing correlations between the System Technology Process Metallurgy (MTP) and the other systems.

The Metallurgical Ecosystem analysis has as a starting point ecometallurgic monovariable system (SEMo). This system applies only theoretically, and it is very important for modeling and simulation environment related to metallurgical processes.

The ecological balance is a concept very complex and very difficult.

The especially self-regulating mechanisms and applying to the concept of sustainable development is very important for ensuring ecological balance.

The principles of environmental legislation were also of particular importance for achieving ecological balance. Among these principles we mention: the principle of preventing environmental risk and damage, the principle of priority health compared with other purposes for use of natural resources, the principle of prevention, reduction, and integrated pollution control, the principle of retention of pollutants at source, the principle of public participation in the protection and improving the environment.

Dedusting the flue gas discharged from the electric arc furnace (EAF) has a special significance for its hipopolluting functioning. The main categories of processes to achieve this are flue gas capture and dedusting actual flue gas.

From a wide range of machinery and equipment specific to this field, having as starting point the scheme of system environmental pollution through EAF, in this first part of our article, we presented the cyclone of wet and dry dedusting plant.

The technological development of steel in electric arc furnaces (EAF) is one that is ecologically impaired. The emissions and immissions resulting from this technological process are many and in significant amounts. In conclusion, special care is required from production managers (and not only) to ensure hipopolluting operation conditions of EAF. This concern should begin in the early stages of research both in technology development and designing this complex aggregate.

Achievements in greening the operation of the electric arc furnace (EAF) to develop steels, are relatively modest on a national level.

The costs for installation and commissioning of the capture and treatment of this complex aggregate emissions are significant. Even so, the restrictive environmental regulations in the field constantly force the user to take technological measures to ensure the functioning of hipopolluting EAF.

From this point of view, the specialists in the field should pay far greater attention and importance of scientific research and design.

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