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ELABORATION OF STEELS IN ELECTRIC ARC FURNACES (EAF) AND ENVIRONMENTAL PROTECTION

Adrian IOANA, Nicolae CONSTANTIN, Dragos Florin MARCU, Vili PASARE, Massimo POLIFRONI, Claudiu NICOLICESCU

Abstract: *This article presents the most important polluting aspects of Electric Arc Furnace (EAF) for elaboration of steels The technological procedures of melting and refining yield more than 90% of overall harmful emissions. These emissions contain high levels of iron, manganese, aluminum, and silicon oxides, as well as heavy metal oxides such as nickel, chromium, cadmium, lead, and copper. In this context, the articles presents: the chemical makeup of the EAF-generated powder; limit values allowed for the powder concentrations; the powder emissions classification and content at the electric furnace; emission Factors for the heavy metals at the EAF elaboration; wet removal plant (10 t electric arc furnace); the removal plant scheme for the gases evacuated from the EAF.*

Key words: *EAF; Steels Elaboration; Environment Protection; Powder Generated.*

1. INTRODUCTION

The electric arc furnace (EAF) has a significant impact on the environment, as it is a major source of polluting emissions.

The most important polluting emissions are [1-3]:

- powder produced by the technological processes of raw material feeding, steel smelting, refining, alloying and vacuum extraction, which can lead to heavy metal concentrations (Cr, Ni, Zn, Pb, etc.) up to 15 kg/t steel.);
- gases from smelting and refining, consisting mainly of CO, CO2, SOx and NOx.

More than 90% of global harmful emissions are generated by technological processes such as smelting and refining. Heavy metal oxides (Ni, Cr, Cd, Pb, Cu) as well as oxides of iron, manganese, aluminum and silicon are strongly present in these emissions.

The type of steel produced is directly related to [4-6]:

- the composition of the base material constituting the load;
- melt management methods;
- the refining technique employed (with oxygen gas or ore);
- the time required for melting and refining.

As [7] “Steelmaking processes generate fume that must be captured and controlled to prevent emissions to atmosphere. This is done with large extraction fans and bag filter cleaning systems. The operation of these systems is critical to ensure good environmental performance of the steelmaking process and optimization is necessary to ensure that the fume extraction systems are run economically. Fume capture also facilitates the recycling of metallic oxides back into the steelmaking process. Owing to the complexity of large extraction systems, it is important to pre-empt plant malfunction so that site engineers are aware of potential problems that may cause system failure or fugitive particulate emissions to atmosphere”.

Table 1 shows the limits for the change in the chemical composition of EAF powders produced for the United States and Germany.

Table 1

The chemical make-up of the powder produced by EAF

No	Component	Variation restrictions, %		
		USA	GERMANY	
			Unalloyed steel	Alloyed steel
1.	Fe_{total}	16.7-37.5	21.3-43.9	35.3
2.	Si	0.7-3.1	0.7-1.5	17.0
3.	Al	0.4-5.7	0.1-1.3	x)
4.	Ca	2.3-15.1	5.3-14.9	0.4
5.	Mg	1.3-9.2	1.2-4.7	1.2
6.	Mn	2.5-9.4	0.7-4.2	2.0
7.	P	0.0-1.3	0.1-0.3	x)
8.	S	0.0-1.2	0.2-1.3	0.1
9.	Zn	0.0-33.1	5.3-25.1	1.4
10.	Cr	0.0-7.1	0.0-0.2	13.4
11.	Ni	0.0-2.1	x)	0.1
12.	Pb	0.0-3.5	1.1-5.2	0.4

x) Missing information

Figure 1 presents variation limits for Germany.

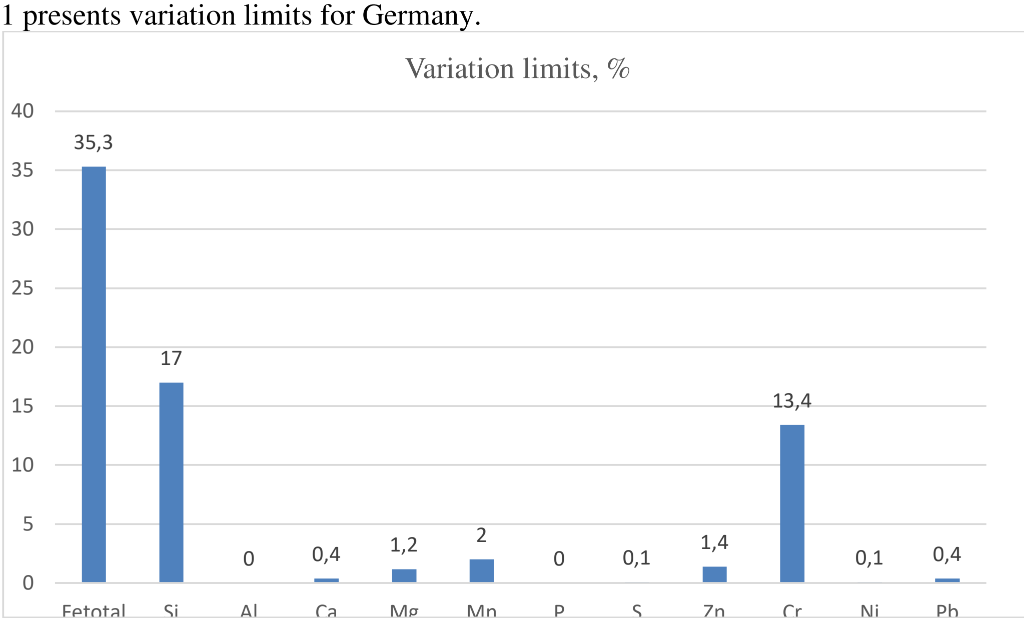

Fig.1. Variantions limits for Germany

2. THE ECOLOGICAL OF EAF

This optimization serves two purposes: improving working conditions and adhering to the restrictions set by laws protecting the environment and the workplace [8,9].

Along with the furnace's performance improving, the factors dictated by the previous demands include the following:

- an increase in the range of separation or a decrease in the amount of powder in the gases;
- a reduction in operating costs by lowering energy consumption;
- a reduction in maintenance and investment costs;
- noise reduction;
- and an improvement in working conditions.

To prevent polluting pollutants from entering the atmosphere of the work bays and the environment, the electric arc furnaces needed to be outfitted with effective collection and purification technology. This thing was also imposed by the severe legislations of many countries, that concern to the limit values of the powder concentrations as it can be seen in table 2.

Table 2

Powder concentration limits are permitted

Country	France	Germany	Norway	Spain	Denmark
The powders' limit values allowed $mg/m^3{}_N$	9	17	21	47	23

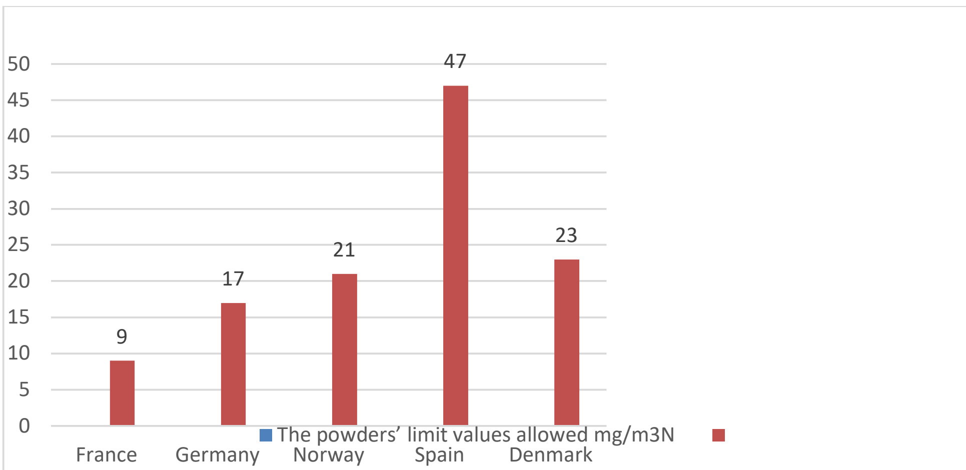

Fig. 2. Limit values allowed for the powder concentrations

Figure 2 presents limit values allowed for the powder concentrations.

According to the amount of powder they contain and the overall amount of emissions produced during the technological phases of a charge, primary and secondary emissions can be distinguished.

The gaseous phase of the furnace's emissions mostly consists of CO, CO2, NOx, and SOx, but it also contains additional pollutants, extremely harmful components including volatile organic components produced by the burning of organic oils, which impure the base material.

Table 3 shows the classification and content of powder emissions from the EAF.

Figure 3 presents emission content.

Table 3

Classification and content of powder emissions from the EAF

Emission type	Technological phase of the elaboration process	Emission content (%)
Primary	Melting – refining	93
Secondary	Loading	2.75
	Evacuation	3.5
	Through untightness (door, arched tank, the space around the electrodes)	0.75
TOTALS	The charge duration	100

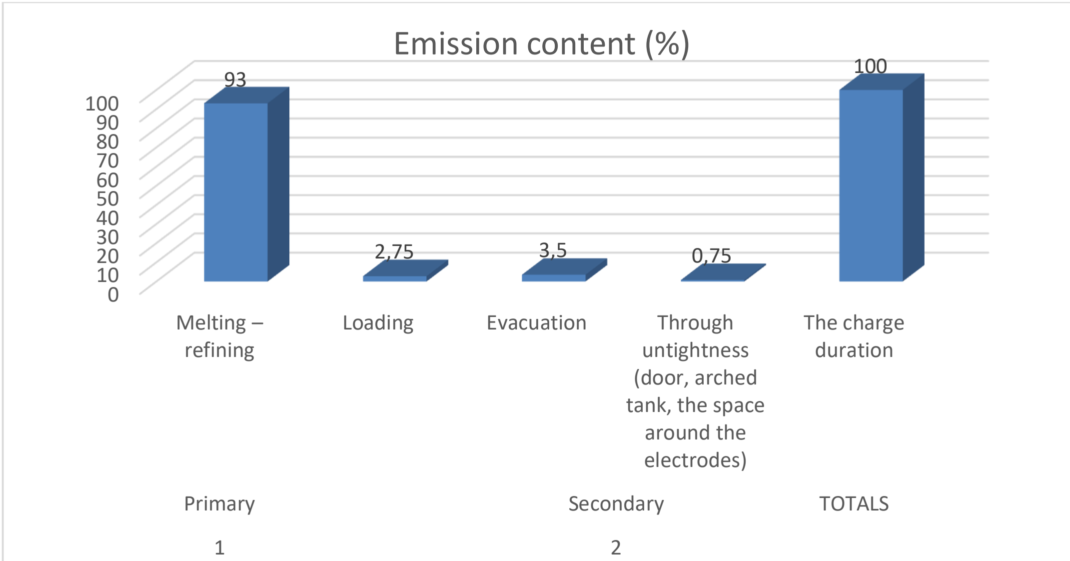

Fig. 3. Emission content

The heavy metals emission factors, for the arc furnace elaboration, oscillate in a large values departure, PARCOM ATMOS recommending for Europe the values presented in table 4.

Table 4

Emission Factors for Heavy Metals During EAF Development

Steel category / Heavy metals	Carbon steel		Non-corrosive steel	
	Departure variation (g/t)	Recommended value (g/t)	Departure variation (g/t)	Recommended value (g/t)
As	0.06-0.14	0.1	0.01-0.02	0.015
Cd	0.05-1.5	0.25	0.05-0.09	0.07
Cr	0.3-2.0	1.0	12-18	15
Cu	0.3-1.0	0.8	0.3-0.7	0.15
Hg	-	0.15	-	0.15
Ni	0.1-0.6	0.25	3-6	5
Pb	5-20	14	1-3	2.5
Be	-	0.05	-	0.05
Zr	20-90	50	4-9	6

3. THE POSSIBILITY OF GREENING THE EAF

To suction the evacuated combustible gases from the electric arc furnace, two different types of procedures must be performed sequentially:
(1) - exhaust gas collection, and
(2) - evacuation of combustible gas.

The exhaust gas treatment method can be one of the following:

- wet, by gas scrubbing;
- centrifugation, using cyclones;
- of the filter type, using a sleeve filter (textile) or an electric filter.

Figure 4 illustrates a wet stripping plant that can be used in a 10 ton electric arc furnace. The use of a fourth hole in the exhaust system was introduced.

Sequential execution of two types of operations, namely combustible gas collection and combustible gas extraction, is required to draw the combustible gas out of the electric arc furnace.

Hoods, hatch exhausts (through the fourth hole in the pit), and combined methods (using both the hood and the fourth hole in the pit) can all be used to capture combustible gases.

Exhaust gas removal methods can be wet, including gas cleaning, centrifugation, cyclone or filter use, bag filter (textile) or electrostatic precipitators.

The best method for capturing gas from an electric arc furnace has been shown to be to discharge the gas through the fourth port in the tunnel.

The exhaust manifold (2) features a cooling fin that is attached to the furnace's metal dome and may follow any fluctuating and exhausting movements of the furnace.

The chimney is provided with a shutter (11) for regulating breathing (draft).

Wash water from the treatment facility is recirculated. From a water tank (12) 18 m.c. provided for different points of use powered by a pump (13).

The IPROMET solution for eliminating emissions from electric arc furnaces for use in the steel industry takes into account:

- the gases are cooled by purge air at ambient temperature
- filter element
- filter covers the bag

Thanks to a preform extractor, the necessary draft is provided both at the tip and at its fourth port. The draft required for gas capture and movement is ensured by the extractor (9) and the evacuation chimney (10), into which the gas is led after the evacuation.

The burned gases are captured by both the fourth hole of the furnace dome and the flue gas

The purification plants can be single (for each furnace) or chained in parallel, which means they are coupled two by two; each of them attend a furnace, as they are presented in figure 6.

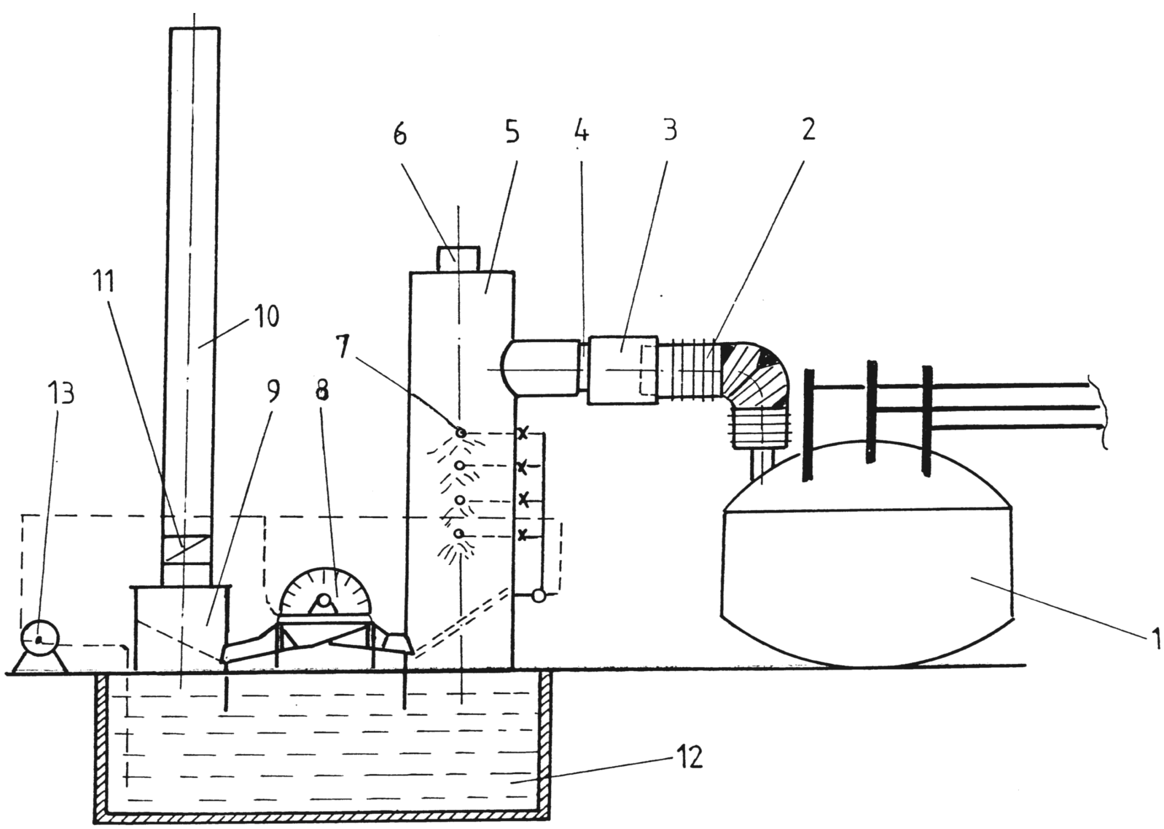

Fig. 4. Wet removal plant (10 t electric arc furnace)
1– is an electric arc furnace; 2 – is an exhausting pipe; 3 – is a moving pipe socket; 4 – is a gap; 5 – is a cooler; 6 – is safety piping; 7 – is a nozzle; 8 – radial dezintegrator; 9 – separator; 10 – chimney; 11 – shutter; 12 – basin; 13 – pump.

Figure 5 presents the removal plant scheme for the gases evacuated from the electric arc furnace.

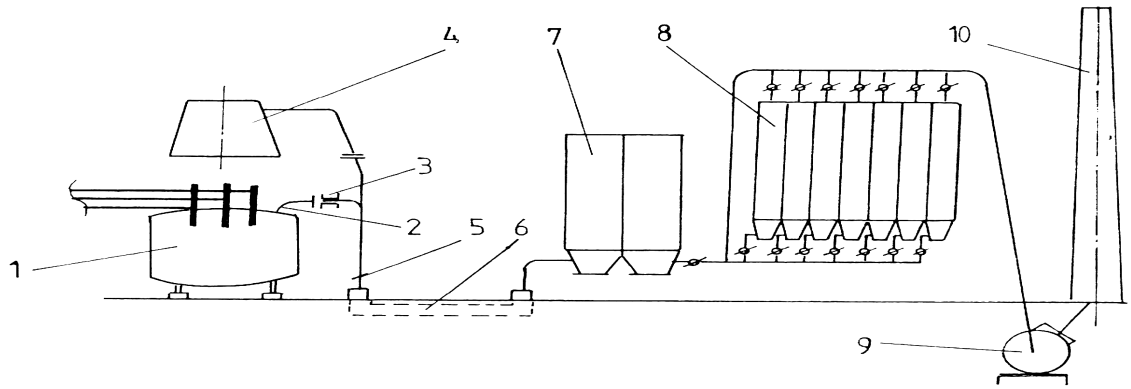

Fig. 5. The removal plant scheme for the gases evacuated from EAF
1- electric arc furnace; 2 – exhausting pipe; 3 – burning chamber; 4 – moving hood; 5 – shutter; 6 – underground channel; 7 – cooler; 8 – filter battery; 9 – exhauster; 10 - chimney

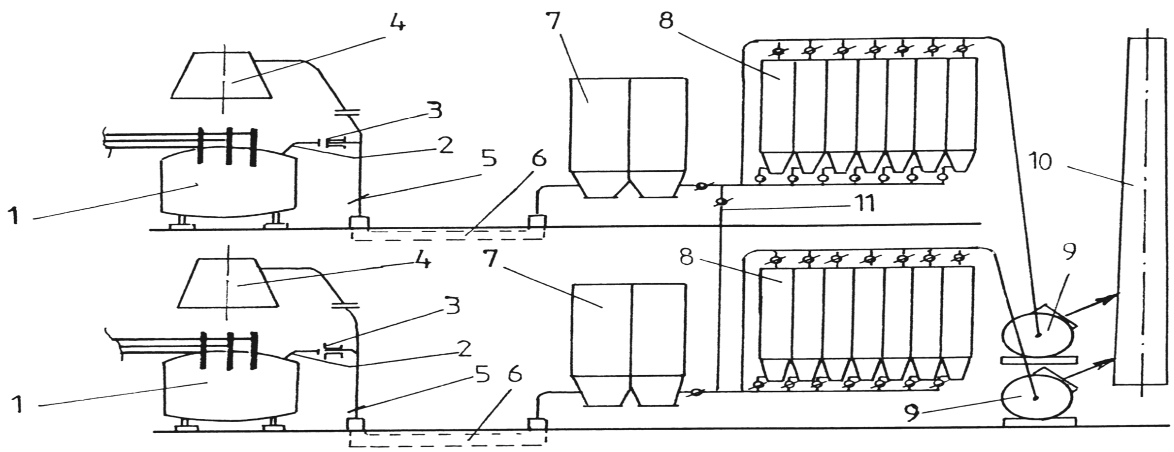

Fig. 6. System of parallel chained purification plants
1- electric arc furnace; 2 – exhausting pipes; 3 – burning chamber; 4 – moving hood; 5 – shutter; 6 – underground channel; 7 – cooler; 8 – filter battery; 9 – exhauster; 10 – chimney; 11 – switching shutter

With the switching shutter (11) the attended furnace can be switched with the removal plant that functions.

The use of the treatment plant affects the pressure regime of the furnace. In addition to the erroneous phenomenon of the increase in the volume of the evacuated air (and the increase in the volume of the combustible gases, the gases escaping from the furnace) due to the wear of the furnace dome, this aspect concerns the use of tunnels and cool the walls.

The enhancement of furnace heat regimes and better sealing, technological priorities leading to increased furnace productivity, as well as reductions in specific energy consumption, must be accomplished.

As in [10-12] "Economic and environmental benefits come from recycling ferrous materials. Increasing the productivity and economic efficiency of electric arc furnaces can be achieved through the implementation of a number of solutions, including:

- increase in installed electrical capacity; the use of oxygen and additional fuel; replace fireproof lining with water
- cooled parts;
- the ability to stir metal heels and treat with foaming slag;
- heat recovery from circulating water in the cooling circuits and from exhaust gases; preheating the waste;
- discharge of slag through a nozzle with an eccentric bottom;

- Optimal management and process control by computer authority.

Although EAF is the most suitable technology synthesis to convert steel waste into high-quality steel, they are the main producers of polluting gases that have a negative impact on the environment."

4. CONCLUSIONS

Electric arc furnaces are an important source of pollutant emissions that have a negative impact on the environment.

More than 90% of global harmful emissions are generated by technological processes such as smelting and refining. Heavy metal oxides (Ni, Cr, Cd, Pb, Cu) as well as oxides of iron, manganese, aluminum and silicon are strongly present in these emissions.

This optimization helps to improve working conditions while respecting the legal constraints imposed by environmental and working environment laws.

In addition to improving furnace performance, historical demand-based criteria include:

- Expanding the gas collection area;
- Extend separation or reduce gas

By ensuring optimal environmental conditions in the processing of steels in electric arc furnaces (gas phase collection), the initial conditions for the recovery and reuse of important resources are implicitly ensured.

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Elaborarea Otelurilor in Cuptoarele cu Arc Electric (CAE) şi Protectia Mediului

Acest articol prezintă cele mai importante aspecte poluante ale cuptorului cu arc electric (CAE) pentru elaborarea oțelurilor. Circa 90% din emisiile poluante aferenta EAF rezulta in timpul operatiilor tehnologice de topire si oxidare. Aceste emisii au un conținut ridicat de oxizi de fier, mangan, aluminiu și siliciu, precum și oxizi de metale grele (Ni, Cr, Cd, Pb, Cu). În acest context, articolul prezintă: compoziția chimică a pulberii generate de EAF; valori limită admise pentru concentrațiile de pulbere; clasificarea și conținutul emisiilor de pulbere la cuptorul electric; factori de emisie pentru metalele grele la elaborarea in CAE; instalație de îndepărtare umedă (cuptor cu arc electric de 10 t); schema instalației de îndepărtare a gazelor evacuate din CAE. Prin asigurarea conditiilor ecologice optime la elaborarea otelurilor in cuptoarele cu arc electric (colectare faza gazoasa) se asigura implicit si conditiile initiale pentru recuperarea si revalorificarea unor importante resurse.

Adrian IOANA, Professor, PhD, Eng., National University of Science and Technology POLITEHNICA Bucharest, România, Spl. Independentei 313, S6, Bucharest, Romania, adyioana@gmail.com

Nicolae CONSTANTIN, Professor, PhD, Eng., National University of Science and Technology POLITEHNICA Bucharest, Spl. Independentei 313, S6, Bucharest, Romania, nctin2014@yahoo.com

Dragos Florin MARCU, Associate Professor, PhD Ec., National University of Science and Technology POLITEHNICA Bucharest, Spl. Independentei 313, S6, Bucharest, Romania, dragos.marcu@yahoo.com

Vili PASARE, PhD, Eng., National University of Science and Technology POLITEHNICA Bucharest, Spl. Independentei 313, S6, Bucharest, Romania, primar_gorj@yahoo.com

Massimo POLIFRONI, Professor, PhD, Ec., Full Professor of business and economics, University of Turin, Italy, massimo.pollifroni@unito.it

Claudiu NICOLICESCU, Associate Professor, PhD, Eng., University of Craiova, Romania, nicolicescu_claudiu@yahoo.com