Heavy metals trace element analysis by X-Ray fluorescence (XRF) spectrometry in eaf dust

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Abstract—Analysis of heavy metals from dust electrofilter by X-ray fluorescence (XRF) spectrometry is an elemental analysis technique with broad application in science and industry. XRF is based on the principle that individual atoms, when excited by an external energy source, emit X-ray photons of a characteristic energy or wavelength. By counting the number of photons of each energy emitted from a sample, the elements present may be identified and quantitated.
EAF dust represents one of the most hazardous, since it contains heavy metals such as Zn, Fe, Cr, Cd and Pb.
The goal of the present work is to characterise the waste through chemical analysis by X-ray fluorescence spectroscopy (XRF).
Modern XRF instruments are capable of analyzing solid**,** liquid, and thin-film samples for both major and trace (ppm-level) components. The analysis is rapid and usually sample preparation is minimal.
Axios-Metals performs even the most demanding XRF applications; from high-precision metals analysis to accurate trace element determination. Sensitive, reproducible and stable, it provides consistent high quality data across the full elemental range, from fluorine to uranium and from ppm to 100 wt%.
XRF instruments are valuable tools here, from measuring traces for environmental reasons to the analysis of heavy metals in dust electrofilter to ensure environmental control. Elemental analysis using XRF is well established in the metals industry. Now, PANalytical's Axios-Metals wavelength-dispersive XRF spectrometer provides a powerful analytical solution, specifically for the steel and metals sectors.

Keywords— environmental control, heavy metals, dust electrofilter, steel and metals sectors, X- ray fluorescence (XRF) spectrometry

I. Introduction

European Community Directive 2002/95/EC restricts the use of certain hazardous substances in electrical and electronic equipment[1]. In particular, restrictions are placed on lead, mercury, cadmium, hexavalent chromium, and bromine (in polybrominated biphenyls or polybrominated diphenyl ethers). XRF is a convenient method for detecting the presence and measuring the amounts of these elements. Reliably quantifying all of these elements in plastics typically requires a large number of standards that are not yet readily available[2]. Because of the light element matrix, using a "standardless" fundamental parameters method requires some reliance on the primary beam scatter, complicating the analysis algorithm and increasing the uncertainty. We have tested a simplified fundamental parameters method that determines the matrix via difference, requiring only one standard. The method was tested on a series of reference materials containing all of the regulated elements in a variety of plastic resins. One multi-element reference standard was used. It was necessary to include all of the additives in the specimens to achieve good quantitative accuracy. In addition, the scattered primary intensity was used in one set of tests to compensate for variations in specimen thickness. This thickness compensation was necessary to get acceptable results for Cd. Results were very promising, with average relative errors and relative standard deviations of about 10%. 2007 *International Centre for Diffraction Data*

Steel production by electric-arc furnace (EAF) technology has been of increasing importance over the past 20 years, and it is expected that, in the coming years, it will dominate the steel production. During the EAF production of steel, about 15–20 kg of dust is formed per tonne of steel [3].

EAF dust usually has a zinc content of more than 15%, with a range of 5–35%. Other metals present in EAF dust include lead (2–7%), cadmium (generally 0.1–0.2% but can be up to 2.5% where stainless steel cases of nickel-cadmium batteries are melted), chromium (up to 15%), and nickel (up to 4%). Generally, an EAF produces 10 kilograms of dust per metric ton (kg/t) of steel, with a range of 5–30 kg/t, depending on factors such as furnace characteristics and scrap quality.[4]

This dust contains heavy metals and thus is considered as a toxic waste. These metals are found both as free oxides (e.g. PbO, ZnO) as well as in the form of composite structures with iron oxides (e.g. $ZnFe_2O_4$). More specifically, EAF dusts contain iron, zinc, calcium and silicon in the form of simple or mixed oxides, as well as copper, manganese, chromium, cadmium and lead which either originate from the scrap iron raw material or are introduced as additives and [5,6].

II. RESULTS

Analyses were made on a PANalytical AXIOS Advanced sequential X-ray spectrometer.
Data processing is controlled by the SuperQ 4 software

package.
The samples are prepared for measurement as glass disks. Because the surface and homogeneity of the specimen are essential for the accuracy and precision of the determination, we use a fully automated fusion technique, SGE 21, Schoeps. This minimizes potential errors usually associated with manual preparation methods. The glass disks are used for both major and trace element determination are prepared by using mixtures of lithium tetraborate and lithium metaborate, Spectromelt A 12, Merck. For the dilution 4200 mg of this flux and 700 mg of the sample are weighed in platinum-gold crucibles and fused for 15 min at 1100^{o}C. The melt is poured into pre-heated, polished 32 mm-diameter moulds. The Axios spectrometer is equipped with the SuperQ 4 software.
Analyses have been made on five dust samples of electric arc furnace electrofilters (EAFD) during the steel production process.
The dust waste samples are essentially composed of the elements Fe, Zn, Ca, Cr, Mn, K, Si, Mg, Pb, Cd, Sb, Sn, Sr, Ni, Cu, Ti, etc. The XRF has presented **compounds** such as ZnO, Fe_2O_3, MnO, SiO_2, CdO, SrO, Sb_2O_3, PbO, etc.

Weight percent calculations
Quantitative analysis of an element by XRF technique is based on the intensity, counts per unit time, of characteristic x-rays of that element detected by the system. The characteristic x-ray intensity, count rate, is a function of the number of atoms of that element present in the specimen. Therefore, XRF accounts for the absolute amount of atoms present in a measurement area in mg/cm2 unit that is also referred to as *area-density*. The thicker a sample, in a homogeneous matrix, the larger the number of atoms hence, the greater the characteristic count rate for a given atom.
The weight percent calculations (wt%, PPM) from the laboratory techniques provide a relative ratio of a desired element as a function of total weight of the specimen analyzed by the method which is not affected by the materials thickness

Quantitative analysis
1. *Calibration-Standard Methods*. The analyte-line intensity from samples is compared with that from standards having the same form as the samples and, nearly as possible, the same matrix.
2. *Internal Standardisation*. The calibration-standard method is improved by quantitative addition to all samples of an internal standard element having excitation, absorption and enhancement characteristics similar to those of the analyte in the particular matrix. The calibration function involves measuring the intensity ratio of the analyte and internal standard lines.
3. *Matrix-Dilution Methods*. The matrix of all samples is diluted to a composition such that the effect of the matrix is determined by the diluent rather than the matrix.
4. *Thin-Film Methods*. The samples are made so thin that absorption-enhancement effects substantially disappear.
5. *Standard Addition and Dilution Methods*. The analyte concentration is altered quantitatively in the sample itself. The sample is subjected to one or more quantitative incremental concentrations or dilutions of the analyte. The intensity of the analyte lines is measured for effectively the same matrix in each case.
6. *Mathematical Corrections*. Absorption-enhancement effects are corrected mathematically by the use of *influence coefficients* for each element present (these are derived experimentally from reference samples). The basic approach is that the XRF intensity at a particular wavelength will in some way be affected by each element in the sample.

R. M.S	**0.037**
Sum before normalization	**91.8%**
Normalised to	**1100.0 %**
Sample type	**Pressed powder**
Initial sample weight (g)	**10.000**
Weight after pressing (g)	**12.000**
Correction applied for medium	**No**
Correction applied for film	**None**
Used compound list	**OXIDES**
Results database	**Lq+37mm 4kw**
Results database in	**c:\program files\panlytical \superq\userdata**

Sample 1 – Quantification of electrofilter dust sample

Analyte	Calibration status	Compound formula	Conc. %	Calc. method
<I>	**Not free**	**I**	**0.000**	**Fixed**
Na	**Calibrated**	**Na_2O**	**1.793**	**Calculate**
Mg	**Calibrated**	**MgO**	**3.721**	**Calculate**
Al	**Calibrated**	**Al_2O_3**	**0.798**	**Calculate**
Si	**Calibrated**	**SiO_2**	**4.880**	**Calculate**
P	**Calibrated**	**P_2O_5**	**0.363**	**Calculate**
S	**Calibrated**	**SO_3**	**2.048**	**Calculate**
K	**Calibrated**	**K_2O**	**1.573**	**Calculate**
Ca	**Calibrated**	**CaO**	**7.358**	**Calculate**
Ti	**Calibrated**	**TiO_2**	**0.063**	**Calculate**
Mn	**Calibrated**	**MnO**	**4.457**	**Calculate**
Fe	**Calibrated**	**Fe_2O_3**	**58.426**	**Calculate**
Ni	**Calibrated**	**NiO**	**0.011**	**Calculate**
Cu	**Calibrated**	**CuO**	**0.348**	**Calculate**
Zn	**Calibrated**	**ZnO**	**10.450**	**Calculate**
Rb	**Calibrated**	**Rb_2O**	**0.012**	**Calculate**
Sr	**Calibrated**	**SrO**	**0.028**	**Calculate**
Cd	**Calibrate**	**CdO**	**0.040**	**Calcula**

	d			**te**
Sn	**Calibrate d**	**SnO_2**	**0.055**	**Calculate**
Sb	**Calibrate d**	**Sb_2O_3**	**0.010**	**Calculate**
Pb	**Calibrate d**	**PbO**	**1.792**	**Calculate**
F	**Calibrate d**	**F**	**0.717**	**Calculate**
Cl	**Calibrate d**	**Cl**	**1.049**	**Calculate**
Br	**Calibrate d**	**Br**	**0.010**	**Calculate**

Sample 2 – Quantification of electrofilter dust sample

R. M.S	**0.000**
Sum before normalization	**89.0%**
Normalised to	**1100.0 %**
Sample type	**Pressed powder**
Initial sample weight (g)	**10.000**
Weight after pressing (g)	**12.000**
Correction applied for medium	**No**
Correction applied for film	**None**
Used compound list	**OXIDES**
Results database	**Lq+27mm 4kw**
Results database in	**c:\program files\panlytical \superq\userdata**

Analyte	Calibration status	Compound formula	Conc. %	Calc. Method
<C>	**Not Found**	**C**	**3.820**	**Fixed**
Na	**Calibrated**	**Na_2O**	**0.162**	**Calculate**
Mg	**Calibrated**	**MgO**	**3.460**	**Calculate**
Al	**Calibrated**	**Al_2O_3**	**3.077**	**Calculate**
Si	**Calibrated**	**SiO_2**	**9.845**	**Calculate**
P	**Calibrated**	**P_2O_5**	**0.170**	**Calculate**

S	**Calibrated**	**SO_3**	**0.994**	**Calculate**
K	**Calibrated**	**K_2O**	**0.204**	**Calculate**
Ca	**Calibrated**	**CaO**	**20.552**	**Calculate**
Ti	**Calibrated**	**TiO_2**	**0.127**	**Calculate**
Mn	**Calibrated**	**MnO**	**0.925**	**Calculate**
Fe	**Calibrated**	**Fe_2O_3**	**56.457**	**Calculate**
Zn	**Calibrated**	**ZnO**	**0.050**	**Calculate**
Sr	**Calibrated**	**SrO**	**0.016**	**Calculate**
Ba	**Calibrated**	**BaO**	**0.045**	**Calculate**
Pb	**Calibrated**	**PbO**	**0.017**	**Calculate**
Cl	**Calibrated**	**Cl**	**0.079**	**Calculate**

Sample 3 – Quantification of electrofilter dust sample

R. M.S	**0.023**
Sum before normalization	**91,9%**
Normalised to	**1100.0 %**
Sample type	**Pressed powder**
Initial sample weight (g)	**10.000**
Weight after pressing (g)	**12.000**
Correction applied for medium	**No**
Correction applied for film	**None**
Used compound list	**OXIDES**
Results database	**Lq+27mm 4kw**
Results database in	**c:\program files\panlytical \superq\userdata**

Analyte	Calibration	Compound	Conc.	Calc.

	status	formula	%	Method
<C>	**Not Found**	**C**	**4.050**	**Fixed**
Na	**Calibrated**	**Na_2O**	**1.107**	**Calculate**
Mg	**Calibrated**	**MgO**	**1.678**	**Calculate**
Al	**Calibrated**	**Al_2O_3**	**2.484**	**Calculate**
Si	**Calibrated**	**SiO_2**	**5.503**	**Calculate**
P	**Calibrated**	**P_2O_5**	**0.123**	**Calculate**
S	**Calibrated**	**SO_3**	**6.565**	**Calculate**
K	**Calibrated**	**K_2O**	**5.236**	**Calculate**
Ca	**Calibrated**	**CaO**	**13.954**	**Calculate**
Ti	**Calibrated**	**TiO_2**	**0.104**	**Calculate**
Cr	**Calibrated**	**Cr_2O_3**	**0.026**	**Calculate**
Mn	**Calibrated**	**MnO**	**0.508**	**Calculate**
Fe	**Calibrated**	**Fe_2O_3**	**47.390**	**Calculate**
Cu	**Calibrated**	**CuO**	**0.293**	**Calculate**
Zn	**Calibrated**	**ZnO**	**0.144**	**Calculate**
Se	**Calibrated**	**SeO**	**0.011**	**Calculate**
Sr	**Calibrated**	**SrO**	**0.012**	**Calculate**
Cd	**Calibrated**	**CdO**	**0.028**	**Calculate**
Pb	**Calibrated**	**PbO**	**1.106**	**Calculate**
F	**Calibrated**	**F**	**0.210**	**Calculate**
Cl	**Calibrated**	**Cl**	**9.386**	**Calculate**
Br	**Calibrated**	**Br**	**0.082**	**Calculate**

Sample 4 – Quantification of electrofilter dust sample

R. M.S	**0.021**
Sum before normalization	**86.4%**
Normalised to	**1100.0 %**
Sample type	**Pressed powder**
Initial sample weight (g)	**10.000**
Weight after pressing (g)	**12.000**
Correction applied for medium	**No**
Correction applied for film	**None**
Used compound list	**OXIDES**
Results database	**Lq+27mm 4kw**
Results database in	**c:\program files\panlytical \superq\userdata**

Analyte	Calibration status	Compound	Conc. %	Calc. Method

		Formula		
<C>	**Not Found**	**C**	**0.980**	**Fixed**
Na	**Calibrated**	**Na_2O**	**1.115**	**Calculate**
Mg	**Calibrated**	**MgO**	**3.823**	**Calculate**
Al	**Calibrated**	**Al_2O_3**	**0.513**	**Calculate**
Si	**Calibrated**	**SiO_2**	**4.515**	**Calculate**
P	**Calibrated**	**P_2O_5**	**0.393**	**Calculate**
S	**Calibrated**	**SO_3**	**2.002**	**Calculate**
K	**Calibrated**	**K_2O**	**1.566**	**Calculate**
Ca	**Calibrated**	**CaO**	**5.528**	**Calculate**
Ti	**Calibrated**	**TiO_2**	**0.036**	**Calculate**
Mn	**Calibrated**	**MnO**	**4.719**	**Calculate**
Fe	**Calibrated**	**Fe_2O_3**	**58.949**	**Calculate**
Ni	**Calibrated**	**NiO**	**0.012**	**Calculate**
Cu	**Calibrated**	**CuO**	**0.374**	**Calculate**
Zn	**Calibrated**	**ZnO**	**11.803**	**Calculate**
Rb	**Calibrated**	**SeO**	**0.011**	**Calculate**
Cd	**Calibrated**	**CdO**	**0.051**	**Calculate**
Sn	**Calibrated**	**SnO_2**	**0.102**	**Calculate**
Sb	**Calibrated**	**Sb_2O_3**	**0.016**	**Calculate**
Ba	**Calibrated**	**BaO**	**0.081**	**Calculate**
Pb	**Calibrated**	**PbO**	**2.023**	**Calculate**
F	**Calibrated**	**F**	**0.768**	**Calculate**
Cl	**Calibrated**	**Cl**	**0.607**	**Calculate**
Br	**Calibrated**	**Br**	**0.014**	**Calculate**

Sample 5 – Quantification of electrofilter dust sample

R. M.S	**0.027**
Sum before normalization	**87.5%**
Normalised to	**1100.0 %**
Sample type	**Pressed powder**
Initial sample weight (g)	**10.000**
Weight after pressing (g)	**12.000**
Correction applied for medium	**No**
Correction applied for film	**None**
Used compound list	**OXIDES**
Results database	**Lq+27mm 4kw**
Results database in	**c:\program files\panlytical \superq\userdata**

Analyte	Calibration status	Compound Formula	Conc. %	Calc. Method
<C>	**Not Found**	**C**	**3.400**	**Fixed**
Na	**Calibrated**	**Na_2O**	**0.502**	**Calculate**
Mg	**Calibrated**	**MgO**	**2.849**	**Calculate**
Al	**Calibrated**	**Al_2O_3**	**0.270**	**Calculate**
Si	**Calibrated**	**SiO_2**	**2.654**	**Calculate**
P	**Calibrated**	**P_2O_5**	**0.193**	**Calculate**
S	**Calibrated**	**SO_3**	**2.002**	**Calculate**
K	**Calibrated**	**K_2O**	**0.843**	**Calculate**
Ca	**Calibrated**	**CaO**	**5.545**	**Calculate**
Ti	**Calibrated**	**TiO_2**	**0.017**	**Calculate**
V	**Calibrated**	**V2O5**	**0.037**	**Calculate**
Cr	**Calibrated**	**Cr2O3**	**0.225**	**Calculate**
Mn	**Calibrated**	**MnO**	**3.963**	**Calculate**
Fe	**Calibrated**	**Fe_2O_3**	**62.067**	**Calculate**
Ni	**Calibrated**	**NiO**	**0.011**	**Calculate**
Cu	**Calibrated**	**CuO**	**0.226**	**Calculate**
Zn	**Calibrated**	**ZnO**	**13.035**	**Calculate**
Mo	**Calibrated**	**MoO_3**	**0.009**	**Calculate**

Cd	**Calibrated**	**CdO**	**0.050**	**Calculate**
Sn	**Calibrated**	**SnO_2**	**0.202**	**Calculate**
Sb	**Calibrated**	**Sb_2O_3**	**0.025**	**Calculate**
Ba	**Calibrated**	**BaO**	**0.044**	**Calculate**
Pb	**Calibrated**	**PbO**	**1.446**	**Calculate**
Cl	**Calibrated**	**Cl**	**0.464**	**Calculate**

III. DISCUSSIONS

The fastest XRF spectrometer on the market. When there is a need for speed, the Axios-FAST simultaneous XRF spectrometer is the ideal solution. Axios FAST allows simultaneous fixed-channel measurements of up to 28 elements, giving extremely rapid routine analysis for real-time process control.

IV. CONCLUSIONS

Major pollutants present in the air emissions include particulates (1,000 milligrams per normal cubic meter, mg/Nm3), nitrogen oxides from cutting, scarfing, and pickling operations, and acid fumes (3,000 mg/Nm3) from pickling operations. Both nitrogen oxides and acid fumes vary with steel quality.

Successful recycling of the valuable metals (iron, zinc and lead) reduces the disposal problems and results in resource conservation.

While these examples give a clear insight into the use of XRF spectroscopy for the analysis of both heavy–metal contaminants and light elements of environmental interest, the technique has the potential for numerous additional environmentl applications. Advances software programmes and sample preparation requirements combine to make XRF a cost-effective, user-friendly technique suitable for routine use.

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Education -University – Bachelor of Engineering, " The Polytechnic Institute " of Bucharest - Extractive Metallurgy Faculty, Department: Nonferrous Alloys. Courses: *Metallography, Heavy Metals, Light Metals, Rare (earth) Metals, Non-ferrous Alloys and Precious Metals, Radioactive Materials* - 1982 promotion. Thesis: Superplastic non-ferrous Alloys.

Professional experience

!982 – Eng at "Calimani" – Sulphur Mine.

1982 – 1984 – Applications Engineer at "UPET" Targoviste – for "*Heavy Water Plant"* – Drobeta – Turnu Severin.

1984 – 1994 - Applications Engineer at "UPET" Targoviste – for "*Nuclear Power Station*" Cernavoda.

1993 – 1998 – English Language Substitute.

1998 – so far - Materials Science and Engineering, Mechatronics and Robotics at "*Valahia*" University of Targoviste as part of RESEARCH CENTER ACADEMIC SCHOOL OF MATERIALS SCIENCE, Director Prof.dr.doc.eng. OPREA FLOREA.

Addition education

- Master – *Research on atmospheric pollution level in metallurgical areas of Romania. Industrial ecology, Sustainable Development*
- Ph.D. candidate, Research Theme – *Heavy Metals on Environmental and Health Risks*

Publications

- 47 ISI papers, 2 books, - *"Explanatory Technical English Dictionary" (1100 pages), "English Dictionary for Economics" (654 pages).*

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EDUCATION

- 1972 – 1977 Polytechnique Universirty of Bucharest – Metallurgy Faculty.

FIELDS OF EXPERIENCE

- 1977 – 1997 ICEM Bucharest;
- 1997 – 1998 – 2002 "Valahia"University from Targoviste - Chief of Papers,
- 1997 . Ph.D in technical Sciences from Polytechnique Institute of Bucharest – Thesis Research regarding influence of manufacture and processing parameteres on the physico-chemical and technological properties of alloys from platinic materials.
- 1998 – 2002 "Valahia"University from Targoviste, Reader
-Supervisor of doctoral studies – Fundamental field: Engineering sciences; Field: Materials Engineering
- 2002- until now Professor, Ph.D, "Valahia"University from Targoviste.

Job endorsed /Professional field: Didactic, scientific research, academic administration

OTHER SKILLS AND COMPETENCES:

Representative Awards selected

- Attestation CNRS – Vitry – Centre d'Etudes de Chimie Metallurgique, iulie 2002
- Excellence Award for outstanding and new materials in Microtechnologies, November, 2003.
- Handbooks, courses, guidelines – 8 (author)
- Patents – 4 (co authors)
- Composite materials;
- Emergent materials;
- Nano technologies;
- Phyisico-chemical processes in heterogeneous systems;
- Presious metals
- Member of professional associations:
-Member of "Institute of Standards Engineers" India since 1995.
- Member of Romanian Society for Metallurgy since 1990.
- Member of the Society of Chemistry, Romania since 2006.
- Member of the Romanian Society for Biomaterials since 2006.

Professional Skills selected

- Improvement of existing technologies in metallurgy and specific introduction of new advanced materials technologies
- Making and processing special alloys.
- Teaching (holder of disciplines in the last five years):
- Smart materials
- Shape memory alloys
- Procedures for obtaining advanced materials unconventional
- Non-crystalline materials
- Powder metallurgy
- Composite materials
- Emergent materials
- Nanotechnologies
- Physico-chemical proceses in heterogeneous systems
- Scientific activity (syntheses)
- Academy reviews – 1 (co author)
- Profile Society Reviews – 7 (co author)
– University gazettes – 19 (authors)
- International conferences in the country – 4 (co author)
- International conferences abroad 9 (author), 7 (co author)
- Foreign specialized reviews – 1 (author), 5 (co author).
- National Scientific Events – 15 (author), 1 (co author)
- Grants since the last promotion: Academy – 1 project (member); CNCSIS – 1 project (director); MATNANTECH – 1 project (director) and 2 (member); RELANSIN – 2 (member); CEEX – 2 projects (director).

– Research fields approached selected

- Thermodinamics and kinetics of physico - chemical processes from alloys manufacture
- Chemical equilibrium, diffusion phenomena, surface properties of heterogeneous systems at manufacture and processing of special alloys
- **Composite materials**

Publications

- Articles ISI: 110

– Standardisation. Standard Promotion, Report of The Twenty –Eight International Training Programme in Standardisation and Quality Systems for Developing Countries, New Delhi, 11 October to 8 December 1995, India (Bureau of Indian Standards);

Didactic papers for higher education: 10

Elena Valentina Stoian, was born in Targoviste, (Dambovita County, Romania) to July 2 , 1976. She graduated Faculty of Science and Materials Engineering, Specialization Science of Mateials, Valahia University of Târgovişte in 2003. She graduated in Masters Special Alloys in 2004 at University of Valahia Targoviste, and Master specialization Management of Projects, Faculty of Economic Sciences, Valahia University of Târgovişte, in 2006. From October 2003 until now was Assistant Professor at Faculty of Material Science, Mecatronics and Robotics, "Valahia" University from Târgovişte, Elena Valentina Stoian has published in Proceedings of Conferences and Journal about 40 scientific research paper and prepented Poster and oral communications, 8 research project (as collaborator and responsible of project) an 1 research project as a directory of project and 1 book. Member of Academic Research Center School of Materials Science from 2006.

Poinescu Aurora Anca. *Date and place of birth*: May 13th 1973, Galati. ***Education*:**

1992-1997 "DUNAREA DE JOS" University of Galati, Metallurgy and Materials Science Faculty, Specialization: Materials Science
Graduation paper: *Studies and researches regarding the obtaining of Fe-Zn alloys through the heat treatment of a zinc-coated pressed steel.*

1997-1998 Master's degree - "Dunarea de Jos" University, Metallurgy and Materials Science Faculty, specialization: Metallic materials with special properties.
Graduation paper: *Researches regarding recovering offal's from SIDEX S.A.*

1999-2000 Master's degree - Valahia University of Targoviste, Science and Engineering of Materials Faculty, specialization: Special Non-ferrous Alloys.

2000 Course "Oil & Gas Flow Measurement & Control Techniques", Fluid Control Research Institute, Kanjidoke West, Palghat,

Kerala, India., Graduation papers: Effects of cavitation on material properties.
22 Aprilie –
6 May 2007 The traning of the teaching personnel for new metods/techniques of education and instruction in domains of priority and complementary to the European ones – intelligent/IT/equipments/tools, En.A.I.P.Piemonte Torino – Italia, Vocational Trening Certificate.

2007 trainer for PhD degree at "Valahia" University of Targoviste, Materials Engineering field, PhD theme: Research on new hybrid composite materials with biofunctional properties.

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