Załącznik 3

Autoreferat

W języku angielskim

Summary of academicachievements

1. Name and surname: Sylwester Żelazny
2. Diplomas and scientificdegrees:

2007	LCCI International Qualification certificate in English Level B1
2001	Pedagogical study for assistants Cracow University of Technology, Center for Pedagogy and Psychology
1999	PhD in technical sciences, specialization in inorganic technology Doctoral studies at the Faculty of Environmental Engineering Faculty of Chemical Engineering and Technology at Cracow University of Technology Thesis: "Synthesis of new inorganic fibers by recrystallization of gypsum" Promoter: dr hab. Eng. Czesław Ostrowski, prof. PK Thesis defense: 12.1999
1992	Master of Science Cracow University of Technology, Faculty of Chemical Engineering and Technology Field of study: Chemical Technology, Specialization: Inorganic Technology; Subject: "Attempts to purify the extraction phosphoric acid to obtain $CaHPO_4$ with continuous method" Promoter: Adam Kozak, PhD Diploma defense: 06.1992

1. Information on the academicexperience

2003 - now	Research and teaching adjunct Cracow University of Technology, Institute of Chemistry and Inorganic Technology, Department of Chemical Technology and Environmental Biotechnology
2000 - 2003	Scientific and teaching assistant Cracow University of Technology, Institute of Chemistry and Inorganic Technology, Department of Chemical Technology and Environmental Biotechnology
1995 - 1999	Doctoral studies Faculty of Environmental Engineering, Cracow University of Technology
1992 - 1995	Senior technical consultant Cracow University of Technology, Institute of Chemistry and Inorganic Technology

3. Scientific achievements (according to the article 16, paragraph 2 of the Polish legal art. Dated on 14 March 2003, Law on Academic Degrees and Title Degrees and Title in the Arts (Dz. U. 2016 r. poz. 882 ze zm. Dz. U. z 2016 r. poz. 1311):

4.1. Title of scientific achievement:

Management of waste from mining and power industry in order to limit their negative impact on the natural environment

4.2.A series of thematically related articles:

H1. Cz.Ostrowski, **S.Żelazny**, *Methodology of obtaining gypsum fibers*, Patent, PL 185209 B1, granted from 30.04.2003

Punctuation MNiSW$_{2016}$ = 30

H2. Cz.Ostrowski, **S.Żelazny**, W.Natanek, *Attempt at waste management from Bełchatów plant for production of insulating materials,* Polish Journal of Environmental Studies, Vol. 14, Suppl. 4, 2005, pp. 155-157

Punctuation MNiSW$_{2016}$ = 15, IF 2005: 0,352

H3.**S.Żelazny**, A.Jarosiński, *Research on the complex processing of waste deriving from enrichment process of zinc and lead ores,* Polish Journal of Environmental Studies, Vol. 18, No 1B, 2009, pp 278-282

PunctuationMNiSW$_{2016}$ = 15, IF 2009: 0,947

H4. B.Włodarczyk, **S.Żelazny**, *Analiza możliwości zagospodarowania lub zabezpieczenia istniejących składowisk odpadów poflotacyjnych z procesu wzbogacania rud cynku i ołowiu,* Czasopismo Techniczne Wyd. PK, Z. 2-Ch, (2003) s. 41-47

Punctuation MNiSW$_{2016}$ = 13

H5. A.Jarosiński, **S.Żelazny**, A.K.Nowak, *Investigation on backfilling compositions on the basis of the flotation waste of the zinc and lead ores,* Polish Journal of Chemical Technology, 8,(3), 2006, pp. 57-59

Punctuation MNiSW$_{2016}$ = 15, IF 2014: 0,536

H6. K.Chobot, A.Jarosiński, Z.Kowalski, J.Kulczycka, T.Kurek, Z.Mysłek, J.Palarski, P.Pierzyna, F.Plewa, M.Popczyk, B.Włodarczyk, **S.Żelazny**, Patent, PL 207982 B1, *Mieszanka podsadzkowa i sposób otrzymywania mieszaniny podsadzkowej*, grantem 04.12.2006 (implemented)

Punctuation MNiSW$_{2016}$ = 60

H7 A.Jarosiński, A.Kozak, **S.Żelazny**, *Utilization of solutions obtained after magnesium removal from sphalerite concentrates with spent electrolyte derived from winning of cathode zinc,*Gospodarka Surowcami Mineralnymi, t. 29, Z4, 2013, s. 107- 117

Punctuation $MNiSW_{2016}$ = 20, IF 2013: 0,632

H8. Z.Kowalski, **S.Żelazny**, B.Włodarczyk, *Koncepcja wykorzystania roztworów z odmagnezowania blendy w Z.G."Trzebionka" do produkcji siarczanu magnezu,* Gospodarka Surowcami Mineralnymi, vol. 19, (2003), s. 95-102

Punctuation $MNiSW_{2016}$ = 20, IF 2014: 0,54

H9.A.Jarosiński, **S.Żelazny**, B.Włodarczyk, *Analiza możliwości przeróbki niektórych odpadów magnezowych na nawozowy siarczan(VI) magnezu,* EcologicalChemistry and Engineering, t.12, Opole, 2005

Punctuation $MNiSW_{2015}$ = 11

H10. A.Jarosiński, A.Kozak, **S.Żelazny**, P.Radomski, *Removal of magnesium from sphalerite concentrates by means of spent electrolyte deriving from the process of cathode zinc extraction,* GospodarkaSurowcami Mineralnymi,Vol.28 –lssus 3**,** 2012, s. 43-53

Punctuation $MNiSW_{2016}$ = 20, IF 2012: 0,342

H11. K.Pielichowska, S.Żelazny, *Assessment of the usability of the $Mg(OH)_2$ obtained from the solution after sphalerite leaching for the winning of polyethylene composition*, Polish Journal of Chemical Technology, 10, 4, 2008, pp. 37-39

Punctuation$MNiSW_{2016}$ = 15, IF 2008: 0,47

H12. A.Jarosiński, **S.Żelazny**, M.Olek, J.Baron, J.Zabagło, W.Żukowski, M.Fatyga, *Otrzymywanie prażonki cynkowej w procesie konwersji termicznej w piecu fluidyzacyjnym. Część I. Modyfikacja procesu odmagnezowania i flotacji koncentratu sfalerytowego,* Przemysł Chemiczny, 90(5), 2011, s. 809-812

Punctuation$MNiSW_{2016}$ = 15, IF 2014: 0,399

H13. M.Olek, J.Baron, J.Zabagło, W.Żukowski, A.Jarosiński, **S.Żelazny**, M.Fatyga, *Otrzymywanie prażonki cynkowej w procesie konwersji termicznej w piecu fluidyzacyjnym. Część II. Badania kinetyki utleniania ZnS w reaktorze fluidyzacyjnym*, Przemysł Chemiczny, 90(5), 2011, 965-969

Punctuation$MNiSW_{2016}$ = 15, IF 2014: 0,399

H14. **S. Żelazny**, *Zagospodarowanie odpadów z procesów flotacji rud cynkowo-ołowiowych*, Przemysł Chemiczny, t.97, nr 9, 2018, 1569-1574

PunctuationMNiSW$_{2016}$ = 15, IF 2014: 0,399

H15**. S.Żelazny**, V.Čablik, A.Woynarowska, L. Čablíková, Badania popiołu lotnego z biomasy w aspekcie jego zagospodarowania, Przemysł Chemiczny, 93/4, 2014, s. 550–554

PunctuationMNiSW$_{2016}$ = 15, IF 2014: 0,399

H16. **S.Żelazny**, V.Cablik, L.Cablíková, Próby pozyskania potasu i fosforu z popiołu lotnego z biomasy, Przemysł Chemiczny, 94/(6), 2015, s. 956 – 959

Punctuation MNiSW$_{2016}$ = 15, IF 2015: 0,399

H17. **S.Żelazny,** Pat. PL 231753, *Granulowany nawóz potasowy o przedłużonym działaniu na bazie popiołu ze spalania biomasy oraz sposób wytwarzania granulowanego nawozu potasowego o przedłużonym działaniu na bazie popiołu ze spalania biomasy, (2019)*

Punctuation MNiSW$_{2018}$ = 30

H18. **S.Żelazny,** Pat. PL231700, *Granulowany nawóz potasowo-fosforowy o przedłużonym działaniu na bazie popiołu ze spalania biomasy oraz sposób wytwarzania granulowanego nawozu potasowo-fosforowego o przedłużonym działaniu na bazie popiołu ze spalania biomasy, (2019)*

Punctuation MNiSW$_{2018}$ = 30

H19. **S.Żelazny,** Pat. PL 231041, *Granulowany nawóz azotowo-fosforowo-potasowy o przedłużonym działaniu na bazie popiołu ze spalania biomasy oraz sposób wytwarzania granulowanego nawozu azotowo-fosforowo-potasowego o przedłużonym działaniu na bazie popiołu ze spalania biomasy, (2019)*

Punctuation MNiSW$_{2018}$ = 30

H20. **S.Żelazny**, H.Świnder, B.Białecka, A.Jarosiński, *Odzysk pierwiastków ziem rzadkich z popiołów lotnych, cz.* I. Ługowanie, Przemysł Chemiczny, t.96, nr 11, 2017, 2279-2283, s. 956 – 959

Punctuation MNiSW$_{2016}$ = 15, IF 2017: 0,399

H21. **S.Żelazny**, H.Świnder, B.Białecka, A.Jarosiński, *Odzysk pierwiastków ziem rzadkich z popiołów lotnych, cz. II. Wytrącanie z roztworu*, Przemysł Chemiczny, t.96, nr 11, 2017, 2284-2290

Punctuation MNiSW$_{2016}$ = 15, IF 2017: 0,399

H22. **S.Żelazny,** B.Białecka, A.Jarosiński, H.Świnder, Pat. P.423021, *Sposób odzysku metali ziem rzadkich z popiołów lotnych, (2019)*

Punctuation $MNiSW_{2018}$ = 30

IF = 7,011 (the year of publishment),Punctuation$MNiSW_{2016}$ = 463

4.3. Elaboration on the scientific goal of the enlisted articles and achiveved results, along with their potential applications

Introduction

The habilitation achievement has been presented in the form of a series of thematically related publications, which are listed above. The cycle includes 17 articles, 15 published in magazines from the A list of the Ministry of Science and Higher Education, 2 published from list B of of Ministry of Science and Higher Education and 6 patents, including 1 implemented into industry. The total impact factor of the said works in the year of issue is 7,011, and the number of ministerial points is 463. According to the statements of co-authors attached to the application, the average participation of the postdoctoral in the presented works is about 68%.

The scientific goal of the research was to develop methods for managing waste from mining and power generation industries in Poland. The presented series of publications concerns works related to environmental protection in two branches of the economy that are of great importance to Poland. The first determines the possibilities of limiting or managing waste from zinc and lead ore mining. Research on the second part concerned works related to the management of fuel combustion residues (coal and biomass), especially fly ashes. The research results described in the scientific papers and patents in the majority have resulted in a positive effect and contributed to or may contribute to limiting the negative impact of these industries on the condition of the natural environment in Poland.

4.3.1. Waste from flue gas desulphurization

The research area was largely focused on reducing the negative impact of industry on the natural environment. The first stage was closely related to the subject of the dissertation, which concerned the management of waste gypsum from the flue gas desulphurization process from the "Bełchatów" Power Plant. This topic was interesting because in the nineties, wet desulphurisation of exhaust gases from coal combustion processes was increasingly used in Poland. In this process, large amounts of gypsum are formed, which at that time were not economically utilized and were stored in heaps. Gypsum from the landfill from the Heat and Power Plant "Bełchatów" was the raw material used in my research for the production of inorganic fibers.

As a result of gypsum recrystallization in an acidic environment at higher temperature with additions, I managed to obtain crystals of this raw material in the form of fibers over one centimeter [1,2]. The technology of producing gypsum fibers has been patented [H1] and

published [4].
I have also done a lot of research on the properties of the obtained fibers and the possibility of using them as a raw material for the production of building materials. The results of the tests turned out to be very interesting especially in the production of thermal and acoustic insulation boards. The coefficient of thermal conductivity of the composites obtained was at the level of $\lambda = 0.045W / mK$, which is close to that of styrofoam, while their ecological, health and resistance to high temperatures is definitely better [5,6]. The sound absorption coefficient of the boards made on the basis of gypsum fibers is better than the layer of mineral wool with the same thickness [H2,6].

4.3.2. Wastes from zinc-lead ore enrichment processes

At the beginning of the new millennium, as a result of changes in regulations concerning environmental protection and greater social sensitivity regarding this issue, Coalmining plants "Trzebionka" and then mining and metallurgical plants "Bolesław", cooperated with the Cracow University of Technology on solving the most important problems in the field of environmental protection. The subject of this research seemed very interesting to me so I decided to get involved in the work of the team that undertook to implement it.
Areas which are particularly exposed to zinciferous waste are areas of Zn-Pb ore extraction as well as the areas of storage waste, which are generated as a result of obtaining zinc concentrate sand lead. In Poland, there were two basic landfill sites for zinc-lead ore enrichment processes.
ZG "Trzebionka" dealt with the extraction of zinc-lead ore and its enrichment in order to obtain a sphalerite concentrate (ZnS) with a zinc content above 60%, while ZGH "Bolesław" in the Pomorzany mine acquires ore, which in a similar technology receives a concentrate. This concentrate in the combustion process in a fluidized bed furnace is converted into zinc oxide. Zinc oxide is reconstituted in sulfuric acid and zinc is obtained from the zinc sulphate solution by the electrolytic method.SO_2 resulting from the combustion of zinc sulphide serves as a raw material for the production of sulfuric acid.
The first stage of my work in the team appointed to cooperate with ZG "Trzebionka" was the assessment of the environmental condition in the vicinity of the Plant, and especially in the vicinity of the settling pond, on which waste from the zinc-lead ore enrichment process was stored [7].
The research work undertaken related to the settling pond formed as a result of the "Trzebionka" mine. The plant was commissioned in 1962 and liquidated in 2009. During the maximum production period, in the 90's of 20^{th} century and at the beginning of the 21^{st} century, it was one of the largest underground zinc and lead ore mines in the world. The volume of its extraction then exceeded 2.3 million tons of ore per year.
The acquisition of high quality selective concentrate of zinc and lead is associated with many operations and technological processes. In most of them waste is generated, which is deposited on the sedimentary ponds. The scheme of enrichment of Zn-Pb ores of the liquidated mine "Trzebionka" and the operating mine "Pomorzany" is shown on the Figure 1 [8]. The sediment pond of Coalmining plants "Trzebionka" is an object of considerable size, made in the form of an over-storey storage yard with a relative height of about 60m and

covering an area of about 64 hectares. The joint of the pond is mainly made of ground dolomite, which is a waste from the Zn-Pb flotation enrichment process.
The average content of zinc in these wastes is relatively high, from 0.1% to 0.5%, so it can be estimated that in the vicinity of ore processing plants, several thousand tons of these metals are deposited annually on landfills [9].
The final stage of the technological process of Zn-Pb ore processing is hydraulic transport and storage of floatation waste on ponds. The wastes in the form of pulp are pumped by pump. They constitute about 55-62% of the mass of the Zn-Pb mined and processed ore.

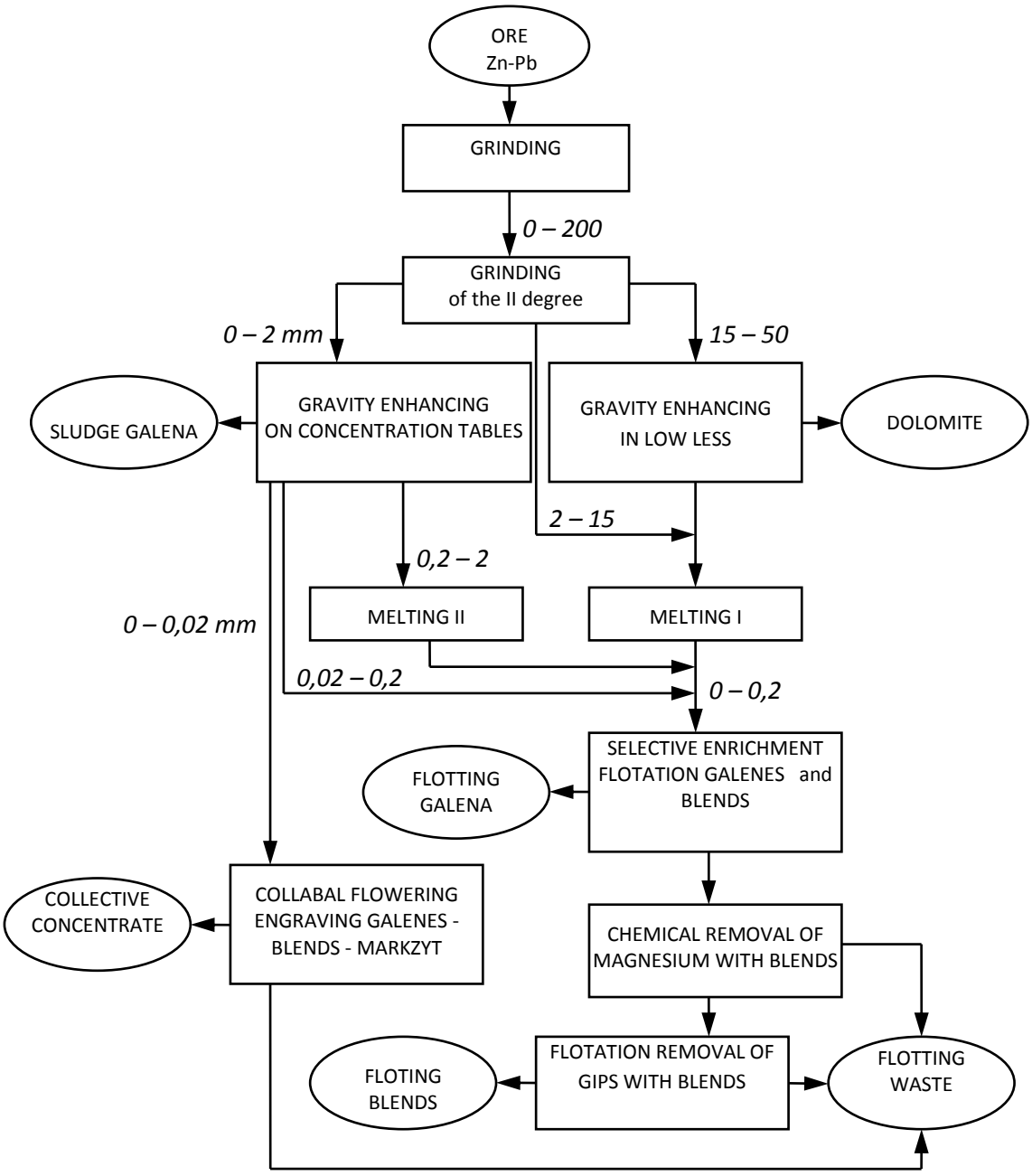


Fig.1. Diagram of enrichment of Zn-Pb ores in Z.G. "Trzebionka" S.A. and ZGH Bolesław [9]

The pulp is directed to the hydrocyclone. Hydrocyclone is separated into two fractions: a coarse fraction consisting of fine sand which is used to strengthen the embankment of the pond, while the dusty fraction is spread on the surface of the pond.
The Fig. 2 below shows the settling pond on which waste was collected from the "Trzebionka" ZG [10], while in Fig. 3 the ZGH "Bolesław" sediment pond was deposited.

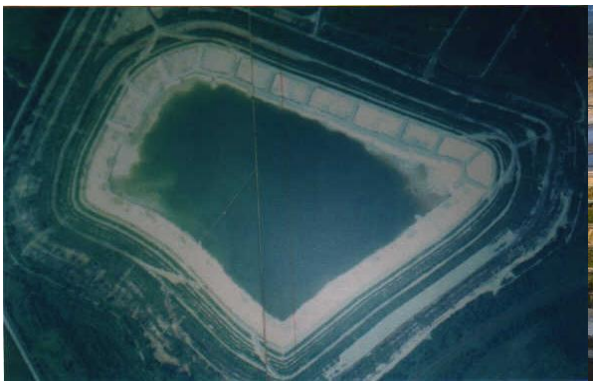
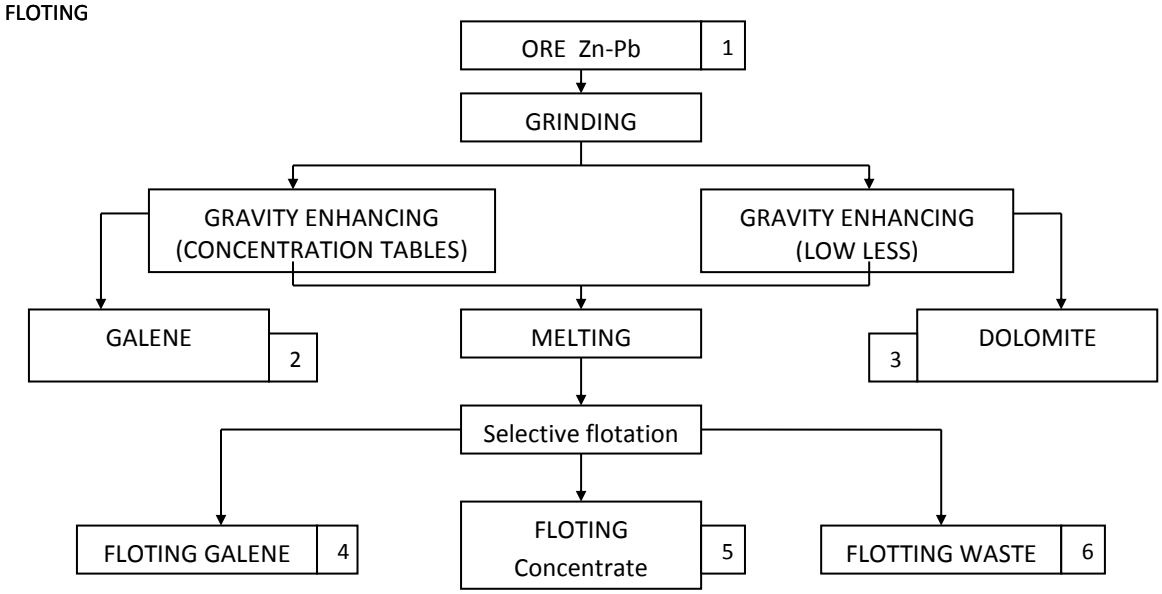


Fig.2. A sedimentary pond in the area of ZG "Trzebionka" S.A. [10]

Fig.3. A sedimentary pond in the area of ZGH "Bolesław"

Figure 4 shows the scheme of enrichment of Zn-Pb ores together with the material balance for ZGH "Bolesław" [11]. A similar scheme was also in force at ZG "Trzebionka".



Lp.	Mass kg	Outlet %	Content %		Obtain %	
			Zn	Pb	Zn	Pb
1	1000	100	3,20	1,50	100	100
2	2,7	0,27	2,50	79,56	0,21	14,32
3	326,3	32,63	0,70	0,16	7,14	3,48
4	13,9	1,39	2,09	67,5	0,91	62,25
5	47,5	4,75	55,08	1,53	81,76	4,84
6	609,6	60,96	0,52	0,37	9,91	15,04

Fig. 4. Diagram of enrichment of Zn-Pb domestic ores along with the material balance [11]

Domestic Zn-Pb ores are hardly enriched, due to their slight mineralization and structural changes of useful minerals.For those ores enrichment, gravitational-flotation methods are used.
The main stream of solid waste arriving at the pond is finely ground postflooding waste. The chemical composition of waste deposited in the landfill in ZG "Trzebionka" is given in Table 1 [H3]. The metal content was converted into oxides.

Table.1. The content of basic constituents in waste from the ZG Trzebionka settling pond [H3]

No.	Component	Content %
1	ZnO	2,36
2	PbO	0,94
3	Fe_2O_3	2,23
4	CaO	30,68
5	MgO	15,75
6	SiO_2	2,11
7	S	1,37
8	CO_2	39,2

The main, vain waste components (about 73%) are carbonates (dolomite, ankerite, calcite), silica and clay minerals. They are characterized by a high content of iron sulphides and a systematically increasing share of clay minerals and silica. The granulometric composition of waste is presented in Table 2 [12].

Table.2. The granulometric composition of post-flotation wastes from ZG Trzebionka [12]

Grainsize mm	Quantity of fraction %
0 - 0,05	44,98
0,05 - 0,1	16,89
0,1 - 0,125	11,98
0,125 - 0,16	6,02
0,16 - 0,2	12,03
0,2 - 0,25	5,26
> 0,25	2,84

Due to the high size of the material, there is a risk of dislodging it from the place of storage into areas adjacent to the pond. The developed surface also facilitates the leaching and penetration of harmful substances into surface and ground waters [13].
In these plants, in order to reduce dusting, coating of the surface of the repository with polymeric substances is introduced. "Latexing", in the periods of drought, wetting of the

surface is also used. The task of these operations is to reduce dust emissions [H4].

4.3.3. Directions of Zn-Pb flotation tailings management

Post-flotation wastes from the Zn-Pb ore enrichment process belong to industrial wastes, created in the process of obtaining zinc and lead concentrates from minerals containing these elements in small amounts. The deposits exploited in Poland in the vicinity of Trzebinia and Olkusz contain about 3.5% of zinc and less than 2% of lead. Low content of useful minerals causes large amounts of waste, which in the vast majority consists of very finely ground gangue, also contain small amounts of useful minerals (ZnS, PbS). It contains as well as other compounds used as additives in the enrichment process and compounds formed in the process of deodorization blends [H4].
The flotation waste management in the mining and metallurgy complex is a significant component of the total cost of zinc production. Flotation waste management is therefore an important factor in the reduction of metal production costs.
Post flotation waste contains large amounts of dolomite, which is widely used in the economy.
My research on this subject was aimed at indicating the possibility of managing flotation waste from Zn-Pb processing. The main ones are:
- filling of mining excavations - solidified fillings,
- production of building materials,
- metal recovery through secondary enrichment,
- use of waste as a material for the production of fertilizers.

4.3.3.1. Filling mining excavations - solidified fillings

The flotation waste resulting from the production of zinc and lead concentrate is mostly under 0.1 mm. The material with high fragmentation does not meet the requirements of the standard specifying the properties of material for hydraulic backfill due to regulations PN-93/G-11010 (Mining - materials for hydraulic backfilling - requirements and tests). Only a fraction above 0.1 mm is suitable for direct application. The finer fractions, which are in superiority in post-flotation wastes.Those fractions require stabilization using cement or other binding agents which cause that these post-flotation wastes with their addition form become a solid proppant [12, 14].
In the arteicles [8,15], it was shown that the admixture of fly ash from the Turów Power Plant allows obtaining material with compressive strength up to 3.9 MPa with 40% ash, but the addition of 25% of ash from this Power Plant already allows to obtain resistance to 2.45 MPa compression, which meets the requirements PN-93 / G-11010 standard, which allows the strength of the self-extinguishing filling to exceed 1.0 MPa.
Values above 1.0 MPa after 28 days were also obtained using a waste additive of 28% fly ash from Kraków Heat and Power Plant and 2% CaO [16].
It was also found that the addition of cement in an amount of at least 6% allows obtaining proppant parameters in accordance with the quoted standard [17]. The addition of the bottom mud also stabilizes the flotation waste [18].

The standard for hydraulic backfill PN-93/G-11010 is general and applies only to proppants as a permanent product. The PN-G-11011 standard is more detailed and also deals with the characterization of underground water (leachate). To assess the suitability of the tested wastes, the regulations contained in both standards are applicable.
Numerous tests of heavy metals leaching from post-flotation tailings with the addition of binding agents were carried out. The performed tests have shown that the leachability of heavy metals from backfill composites is small, and the content of heavy metals in wastewater is allowed by the applicable standards. This is due to the fact that the binding agents added were basic in nature, which resulted in the precipitation of sparingly soluble compounds of these metals. What's more, the addition of cement caused that during its binding some of these metals were immobilized and built into the forming CSH structure of concrete [17]. The research conducted in the team where I was a member of, confirmed the possibility of post-flotation wastes as an ingredient in self-immolative proppants. The results of the research have been published [H5], patented and implemented in Coalmining plants "Trzebionka" [H6]. This allowed to limit the amount of waste deposited on the settling pond, as well as allowed to extend the work of ZG "Trzebionka" by several years.

4.3.3.2. The use of waste for the production of building materials

The flotation waste contains significant amounts of magnesium in the form of dolomite. Studies have shown that in the floatation wastes deposited on the ZG "Trzebionka" sedimentary ponds there are, inter alia, about 17% of magnesium in terms of MgO. This amount is sufficient to obtain a magnesia binder, called Sorel cement. It is obtained by making caustic magnesite (MgO) or caustic dolomite ($CaCO_3 \cdot MgO$) with a solution of divalent salts, the best technical features being obtained by using a magnesium chloride solution as a working liquid.
The strength of chloromagnesium binders is high and ranges from 48-69 MPa. In optimal conditions, the compressive strength of the grout reaches up to 90 MPa. Magnesium cements obtained from semi-filled dolomite do not require additional filler due to the content of undeveloped calcium carbonate. They are characterized by lower in about 40-50% strength values than those obtained analogously from magnesite.Numerous studies with my participation at the Cracow University of Technology have shown that a binder with a strength of more than 20 MPa [19,20] was obtained from flotation waste treated thermally at 800^oC and prepared with the $MgCl_2$ solution.
Such strength allows the use of adhesive for self-leveling floors as well as for sealing rock mass in mines, especially in places where mine waters are strongly saline. The chloromagnesium binder is resistant to chloride, contrary to traditional concrete, which undergoes chloride corrosion under the action of chlorinated solutions.
Another solid waste formed in the blending concentrate enrichment process is gypsum. It arises in the process of de-aging. This process consists in treating the raw blend with sulfuric acid. The process of de-energizing the raw blends concentrate is shown in Figure 5 [21].

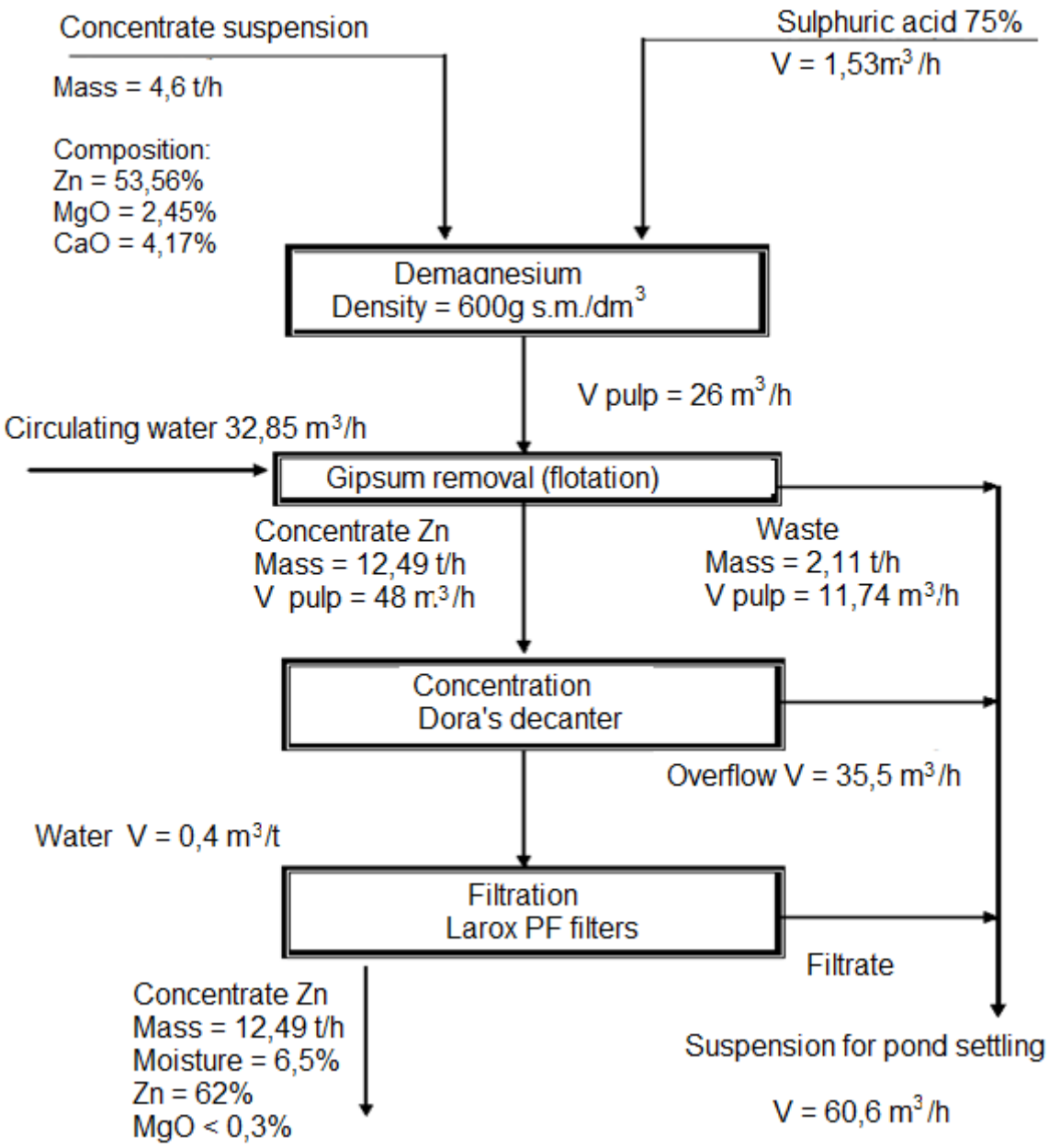


Fig. 5. Simplified scheme of de-magnesization of Zn concentrate in ZG Trzebionka [21]

As a result of the action of sulphuric acid on the residue of CaMg $(CO_3)_2$dolomate contained in the crude concentrate, reactions take place:

$$MgCO_3 + H_2SO_4 = MgSO_4 + CO_2$$
$$CaCO_3 + H_2SO_4 = CaSO_4 \cdot 2H_2O + CO_2$$

The flotation blend flowing from the leach into the buffer mixer is practically completely free of magnesium, which is removed from it in the form of dissolved sulphate in water. In the solid phase of the suspension, however, $CaSO_4 \cdot 2H_2O$ gypsum remains, which is removed from the ZnS concentrate in the flotation process.
After flotation gypsum is deposited on the sludge pond together with the flotation waste.

On my initiative, work was put through on the development of gypsum for the production of gypsum and anhydrite binders.
On the basis of a series of physicochemical tests, it was found that waste gypsum from the process of de-aging can be used on a par with other synthetic plasters in order to replace the natural raw material. On the basis of fractional analysis, the tested gypsum was classified according to PN-B-30041: 1997 standard for intermediate, quick-setting gypsum. According to research [21, 22], the compressive strength of a gypsum binder produced on the basis of waste gypsum in the heat treatment process at a temperature of 160°C is about 10 MPa, which qualifies this material at the upper limit of the values given by PN-B- 30041: 199.This value allows you to include the binder in one of the better building materials made on the basis of construction gypsum.
It is also possible to obtain an anhydrite binder due to the thermal treatment of de-gypsum gypsum at a temperature of 600 to 800^{o}C. Studies held with my participation have shown that waste gypsum from demagnetizing zinc blend after baking at 600 - 800^{o}C and making it with a solution with 1% potassium sulphate in relation to the anhydrite obtained achieves a compressive strength of over 20 MPa [23,24,25].
The mechanical strength of adhesives at this level allows its use in the construction industry.

4.3.3.3. The use of post-flotation waste for the production of mineral fertilizers

The problem of the economic use of wastes from flotation of zinc and lead ores was also tested with my participation in terms of its use as a raw material for the production of mineral fertilizers.
The chemical composition of waste is interesting for agriculture. The total content of calcium and magnesium in terms of oxides is above 46%, and the ratio between these components qualifies the material as calcium-magnesium fertilizer.
Post-flotation tailings processing for calcium-magnesium-nitrogen fertilizer was carried out [26].
In this technology, the waste was treated with nitric acid to obtain calcium-magnesium nitrate. The remaining sludges contained sub-concentrated amounts of zinc and lead sulphides and could be used for their recovery.
Attempts have been made to extract magnesium sulphate from dolomite waste. The dolomite was treated with sulfuric acid.As a result of which the magnesium contained in the treated material as carbonate, passed into the solution in the form of sulphate. The precipitate was separated from the liquid phase by filtration. As a result of concentration, magnesium sulfate heptahydrate $MgSO_4 \cdot 7H_2O$ [H7, H9] crystallized from the solution.
A solution containing magnesium sulfate was formed in the process of de-ionizing the zinc blend with sulphuric acid. I lead research on its recovery in the form of heptahydrate magnesium sulphate [H8, H10,27,28].
This issue was conducted as part of the research project "Research on the removal of magnesium from zinc concentrates and the utilization of by-products" (1 T09B 11930, 2006).
A magnesium oxide hydroxide solution [H11] was also obtained from the waste solution of the blend magnetization.

Further research related to environmental protection, in the majority of applications, was largely the result of cooperation with ZGH "Bolesław".
In the zinc technology by electrolysis, the zinc blend concentrate was burnt in a fluidized bed furnace. The obtained zinc oxide was pulverized in sulfuric acid, purified and directed to the bathtub hall, where zinc was obtained in the electrolysis process.
As a result of the research, I determined the possibility of obtaining products of roasting spheral concentrates characterized by low sulphur content in the sulfide form. The increased sulfur content in the roasted blend negatively affects both the course and the technical and economic indicators of the zinc electrolysis process. The modification proposed by me for the removal of calcium from sphalerite concentrates after chemical treatment consisted in the introduction of calcium sulphate into the magnesia pulp, which caused the calcium sulphate from the demagnetization process to crystallize on their surface without covering the sphalerite grains. After the application of this solution in ZGH Bolesław, the studies confirmed on an industrial scale that when a gypsum graft is used in the process of de-gagging, the effectiveness of the subsequent flotation process is greater and the sphalerite grains are free of gypsum. This results in a material that is better oxidised in a high temperature fluidized bed reactor process (this reduced the amount of ZnS in the lighters from 1.5% to 0.6%).
This idea was implemented in ZGH "Bolesław", and the results were published [H12, H13].
The next step was to hold tests to check the impact of modifying the process of zinc concentrate to the rate of oxidation of the ZnS contained in it. The tests were made under conditions that correspond to the industrial conditions. It was found that this rate was significantly increased due to the changes introduced in the process of zinc diaphragm demagnetization. The result of the optimization of the blend preparation method was almost a two-fold increase in the rate of the oxidation process running under the conditions where its velocity was determined by the diffusion of oxygen from the gas stream, through the boundary layer, inside the grain [H13].
A summary of the experience gained during the implementation of the related topic with the management of waste from the production of zinc and lead concentrates resulted in a review publication [H14].

4.3.4. Fly ash from the power industry

4.3.4.1. Fly ash from biomass burning

Parallel to cooperation with ZGH Bolesław, I undertook research aimed at utilizing fly ash from the power industry.
International commitments forced an increase in the share of renewable sources in the national energy balance. Although in Poland in 2016 the share of renewable energy was around 13.4% and has been steadily growing for several years, it is still lower than in other EU countries such as Austria or Denmark. It was postulated that in Poland this share should amount to 20% in 2020. In line with the EU's demands in recent years, several biomass combustion installations for energy purposes have been launched in Poland, an example of which is "Green Block" in Połaniec, which is the largest thermal boiler in the world fired

at 100% biomass.As a result of biomass burning, waste in the form of fly ash was generated, among others. This ash is interesting due to the high content of potassium compounds.
The ash composition is shown in Table 3 [H15].

Table 3. Composition of fly ash from biomass combustion (Połaniec Power Plant)

Basiccompounds		Heavy metals	
Compounds	Participation, %	Compounds	Participation, mg/kg s.m.
SiO_2	49,6	Cd	5,8
CaO	17,8	Pb	6,2
K_2O	12,8	Co	7,4
MgO	2,1	Cu	36,8
P_2O_5	3,4	Mn	87,8
Na_2O	0,98	Hg	3,7
Al_2O_3	0,72	Cr	66,0
Fe_2O_3	0,61	Zn	241,4
Sulfur	5,53	Ni	9,4
chloride	4,24	Tl	6,6

In pursuing these interests, twice I had three-month internships at the Technical University of Ostrava (Czech Republic), where I conducted research on fly ash from the "Green Block" from the Połaniec Power Plant. The results of these studies were published. The possibility of recovering potassium and phosphorus from this ash has been described. Basic research has identified potassium compounds that can be recovered as a result of leaching with water.
Figure 6 shows a roentgenogram on the basis of which we can determine the composition of salts extracted with fly ash from biomass combustion (Połaniec Power Plant).

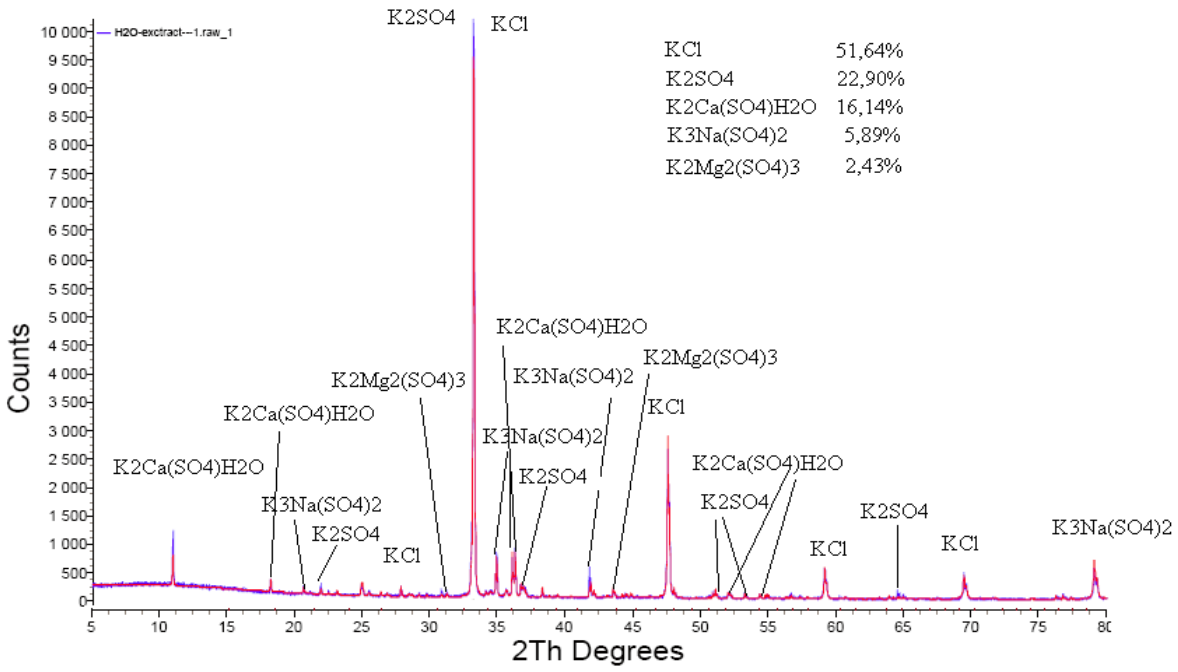


Fig. 6. X-ray of salt extracted with fly ash from biomass combustion (Połaniec Power Plant)

With water, you can obtain clean potassium compounds from the ash, which can be used as a mineral fertilizer [H15].

Due to the fact that over 50% of potassium does not enter the liquid phase as a result of leaching with water, an attempt was made to explain the low level of leaching as described in [H16].

It was found that the phenomenon of agglomeration occurred during the combustion of biomass. This phenomenon is mainly related to biomass characterized by high content of sodium and potassium. Quartz sand is used as the fluidization bed, the main component of which is SiO_2. Its softening temperature is about 1550°C. As a result of the reaction of alkali metal oxides or their salts with SiO_2, an eutectic mixture with a softening temperature of approx. 800^{o}C is created, this is the boiler's operating temperature. Under these conditions, silicate phases were formed, which agglomerate potassium and phosphorus to form aluminum-potassium-calcium silicates.

I also dealt with this topic within the framework of the Eko-Ash research and development project. A fertilizer based on ashes from the combustion of biomass in power plants "(POIG.01.04.00-26-300/13, 2014), in which I was the head of the topic related to previous research.

Research has resulted in the development of three patents, which I am the author. Patents show the methods of managing fly ash from biomass combustion for the production of mineral fertilizers [H17, H18, H19].

In addition, in the scientific article [29] selected aspects and risk analysis for the process of acquiring electricity from biomass were presented. The development of renewable energy in Poland may, however, count on less financial support than in other EU countries, hence the aspect of appropriate risk management in the process is extremely important. The article reviews selected risks associated with each stage of the process of acquiring electricity from

biomass. Internal risks for a company dealing with biomass combustion as well as those related to biomass storage, generation and storage of hazardous waste, or technological risks that could even lead to immobilization of a fluidized boiler are discussed. These risks are also presented, which the company has no direct influence on (external to the company) such as weather risk, logistics risk related to the supply of raw material or risks having a socio-environmental dimension. All risks identified should be the basis for the development of an effective mitigation mechanism, which will allow for more and more effective protection of the process of obtaining electricity from biomass.

4.3.4.2. Fly ash from the hard coal combustion proces

Waste from combustion processes, especially fly ash from conventional energy (combustion of hard coal) was also interested for me due to the fact that they contain rare earth metals.

Rare earth elements are forming a group of 15 lanthanides as well as scandium and yttrium are commonly referred to as the abbreviation REE (Rare Earth Elements). They were classified by the European Union as critical raw materials of strategic importance for the development of modern highly advanced technologies, and are widely used in many industries. Application directions result from their unique properties. For example, their electrical and magnetic properties are used in the production of permanent magnets from Fe-Nd-B alloys, which are characterized by a high density of magnetic energy per unit of mass. The use of neodymium, praseodymium, dysprosium and terbium enabled the miniaturization of electronic equipment.
Research on this topic was held in the international team during the implementation of the RAREASH ERA-MIN / RAREASH / 01/2015 project entitled: "Assessment of possible recycling directions for heavy and rare metals recovered from waste combustion products". In research on obtaining a concentrate of these metals, I used fly ash from hard coal combustion at Łagisza Power Plant. This ash contains small amounts of rare earth elements (454.1 ppm), but fly ash in Poland contains these metals at a similar level.
In the fly ash there is a lot of glassy phase, which "binds" these metals, making them difficult to leach. The preparation of sparingly soluble mineral forms of REE-containing ash into compounds reacting with mineral acids was obtained by sintering ash with soda. This treatment destroys the vitreous structure of the ash and releases REE metal ions into the solution during leaching. Optimal conditions for conducting the process of recovery of rare earth metals from the ash, I determined as the mass ratio of soda: ash 1.2: 1 and temp. 850-950^{o}C. Under these conditions, the degree of leaching of the selected REE at the level of 90% was obtained.

Figure 7 presents an exemplary degree of recovery of some rare earth metals from ash [H20].

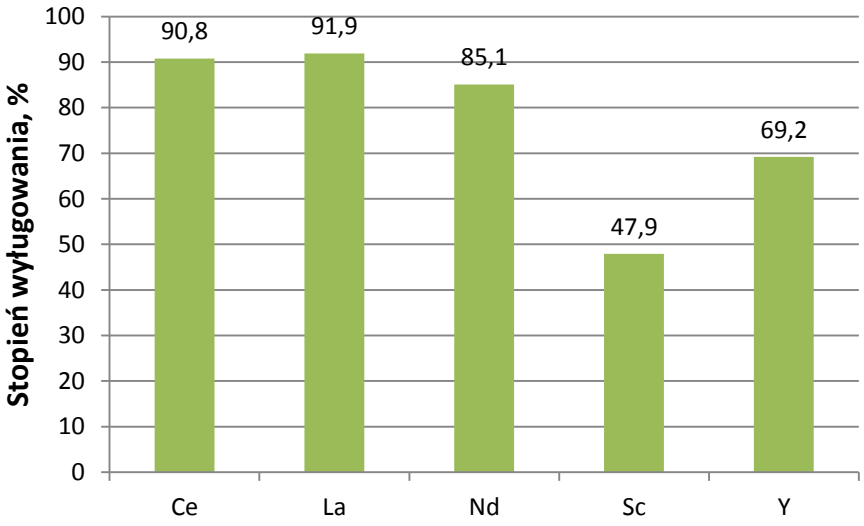


Fig. 7. Degree of leaching REE from sinter obtained in 950°C [H20]

In order to obtain a REE concentrate, I developed the procedure shown on Figure 8 [H21].

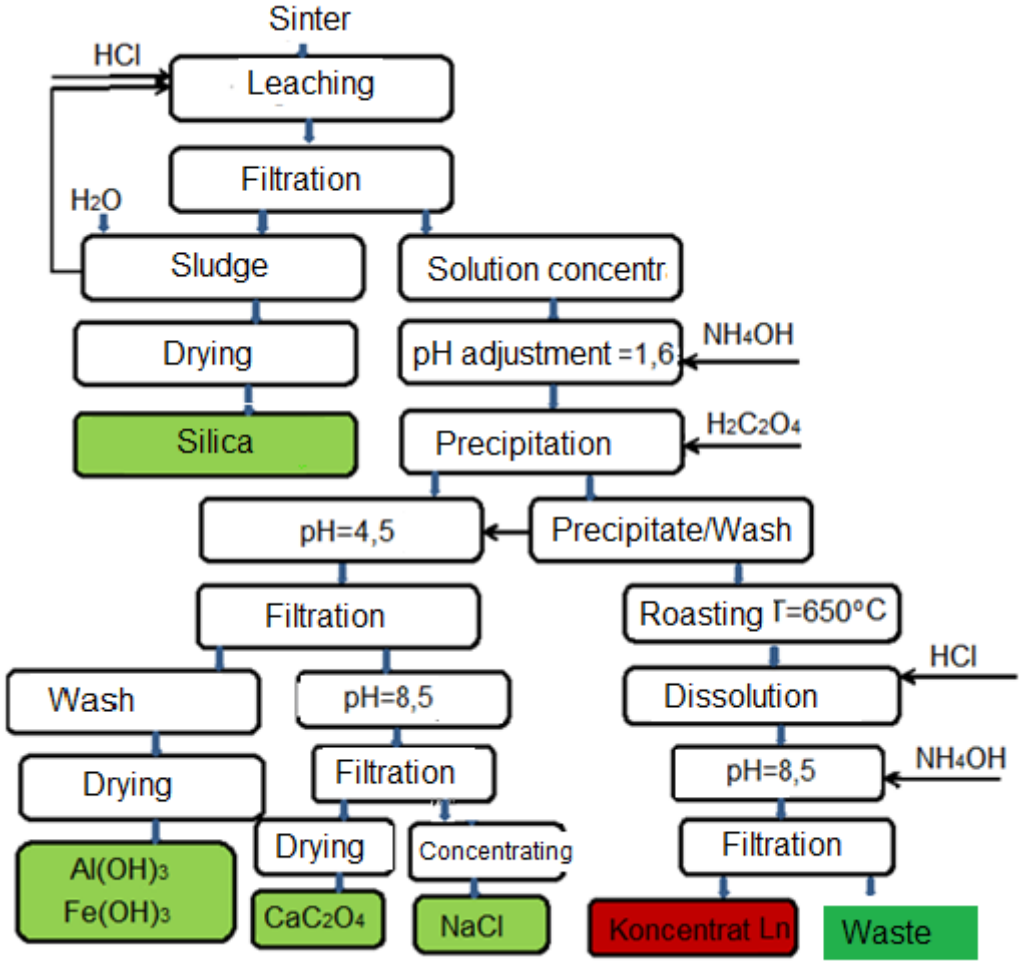


Fig. 8. Schematic diagram of the recovery process of REE from fly ash [H21]

Working according to this scheme I obtained the concentrate product in these metals. The figure below shows the results from the SEM analysis with EDS detector. The results are confirming the higher content of these metals in the tested sample area [H21].

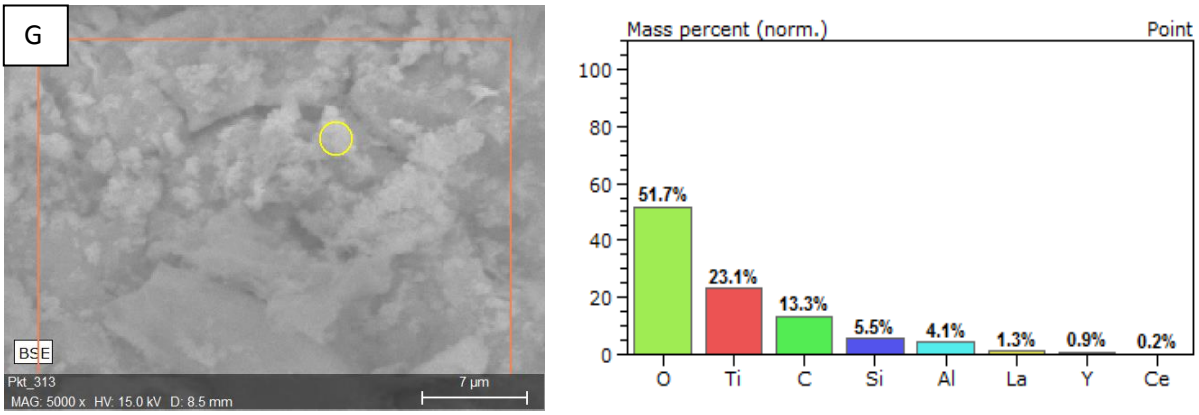


Fig. 9. SEM and EDS testing of a sample concentrated in REE

In the described method, soda was used to release REE from vitreous phase. This process is carried out at high temperature and is therefore energy-consuming. In order to improve the energy balance of the process, I benefited from previous experiences that I acquired by participating in an international project (Polish-Slovak cooperation, SK-PL-0048-09) conducting research on the management of fly ash to obtain a geopolymer bond. Conducting these studies, I found that using sodium hydroxide at a temperature just above 100°C can break the glassy structure of the ash, which will release the rare elements contained in this structure, among others. These tests proved to be so innovative that they were accepted by the Patent Office, which granted the patent, for this solution [H22].

5. Summary

The conducted research has two trends, but both are closely related to environmental protection. By the cooperating with the industry, my research are focused on the application aspects which arehelping toreduce the industry's burdenon the environment.
The second trend is the nature of basic research. Acting with the cooperation with scientific units (Central Mining Institute, AGH University of Science and Technology, Polish Academy of Sciences), we strive to use waste as fly ash to be used as raw material for obtaining REE. In future research, I intend to continue this two trends with emphasis on basic research, in particular I intend to continue research on obtaining REE concentrates from fly ash. As a continuation of this topic, it is planned to build a mobile technical installation, on which it will be possible to test fly ash of various origins.

6. Literature

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5. Other scientific and research achievements do not contributing to the habilitation achievement

a) **5.1. Science achievements**

In addition to the work described in the presented cycle of publications, I dealt with other issues in the majority related to the management of industrial waste. As a result of this work, solutions have been successfully developed that have a positive impact on environmental protection and contribute to innovative modernization in Polish industry. The research concerned the following issues:
a) synthesis of cement clinker at high temperatures,
b) production of binding material based on geopolymers,
c) waste management from electronics,
d) reduction of SO_2 and NOx emissions from industry,
e) acquiring energy from unconventional sources,
f) recognition of the possibility of liquidation of hazardous and harmful waste after the "Górka" plant in Trzebinia,
g) technology for the recovery of potassium sulphate (VI) from waste from biofuel production.

I presented a brief description of these works in the next points of the self-review. Later in the list of works that were not included in the cycle presented in point 4.

a) Synthesis of cement clinker at high temperatures

In cooperation with the Institute of Mineral Building Materials, tests were carried out to obtain a cement binder based on fly ash and calcium oxide. During the technological trials, products with very different properties were obtained. Papers [1,2] describe the clinker production method, the analysis of the product composition and its hydraulic properties. Eight tests were conducted in which the sample composition was variable as well as the temperature (1450-1500^{o}C, 1600-1700^{o}C, and in the torch oxy-acetylene burner about 2000^{o}C). The research allowed to identify the binder phases that were formed and showed large differences in its composition. The hydraulic properties of the obtained material have shown that the binder obtained is an excellent binding material and can be used both as a hydraulic binder as well as an addition to cement improving its strength properties.
The described method shows an alternative route for the management of fly ash from the energy industry from which a high quality product can be obtained.

1. Cz. Ostrowski, S. Żelazny, Badania klinkieru cementowego syntezowanego w wysokich temperaturach na bazie popiołu lotnego i tlenku wapnia, Przemysł Chemiczny, t. 82, Nr 8-9, 2003, s. 1237-1239, **(lista MNISW, A), IF_{2016} = 0,399**
2. Cz. Ostrowski, S. Żelazny, Badania klinkieru cementowego na bazie popiołu lotnego i wapna syntezowanego w wysokiej temperaturze, Materiały Budowlane, nr 2 (378), 2004, 70-73 **(lista MNISW, B)**

b) Production of binding material based on geopolymers

As a result of the implementation of the project within the framework of the Polish-Slovak cooperation (SK-PL-0048-09), the Geotechnical Institute of the Slovak Academy of Sciences (SAS) in Košice (Slovakia) in the team established at WIiTCh took part in the work on obtaining a geopolymer bond. The fly ash used for the research came from the "Łęg" Thermal Power Plant in Kraków. The purpose of the work was to obtain a geopolymer - a binder formed as a result of polymerization taking place with the participation of aluminum silicates and potassium or sodium hydroxides. The influence of the following parameters was investigated: reaction conditions, effect of hydroxide concentration and final product leaching. The polymer has been confirmed by the diffractometric method, and the mechanical strength and leaching of heavy metals has been tested. The test results confirmed that the obtained geopolymer has strength properties comparable with gypsum-anhydrite binders and can be used for the production of building materials.

3. L.Madejska, A.Jarosiński, S.Żelazny, [et al.], Properties of geopolymer binder obtained from fly ash, Czas. Tech., Chem. PK., 2011, z. 1-CH, s. 113-118 **(lista MNISW, B)**

4. A.Jarosiński, L.Madejska, S.Żelazny, Some properties of geopolymers obtained from fly ashes, Waste recycling XV: Recyklaceodpadu: international conference, September 2011, s. 11-5

c) Management of waste from electronics

In the work related to this cycle, together with the team, I proposed a method for the thermal transformation of waste electronic printed circuits, carried out in a reactor with a chemically inert fluid bed. The non-flammable part of the waste remaining after burning the polymer substances was subjected to a two-stage extraction in alkaline medium (30% KOH) and acidic (95% H2SO4). Paper [5] shows the mass shares of selected metals in solid samples after the combustion process and subsequent stages of digestion. A high degree of metal extraction from the starting material was obtained, ranging from 90% (for Ti) to more than 97% for other metals.

The article [6] presents the results of thermal treatment of electric waste in a fluidized bed reactor and digestion of solid products under acidic conditions. During the processes, measurements were made of carbon monoxide, carbon dioxide, volatile organic compounds, nitrogen oxides, sulfur dioxide, hydrogen chloride, hydrogen bromide, hydrogen cyanide, ammonia, phenol, aliphatic hydrocarbonsand aromatic, hydrogen fluoride and phosgene. Several tests were conducted on the etching of solid residue in sulfuric acid at temperatures of 25 ° C and 65 ° C, for 55 minutes to 24 hours. In each case, the dilution method was used, i.e. pre-digestion in concentrated sulfuric acid (VI) (95%) for 40 minutes and then dilution to the expected concentrations (30% - 50%). The most favorable results were obtained using sulphuric acid (VI) at a target concentration of 40% and the temperature 65°C, where the leaching ratio was 76.6% for copper, 71.7% for iron, 91.9% for zinc and 97.4% for tin. The optimal time for efficient digestion was 220 minutes.

5. A.Woynarowska, S.Kandefer, M.Olek, S.Żelazny, W.Żukowski, Termiczna dekompozycja odpadów elektronicznych z wykorzystaniem reaktora fluidyzacyjnego, Przemysł Chemiczny, 90, 7, 2011, s. 1412-1418 **(lista MNISW, A), IF_{2016} = 0,399**
6. A.Woynarowska, W.Żukowski, S.Żelazny, Thermal treatment of electronic waste in a fluidised bed and chemical digestion of solid products, Waste Management & Research, Vol. 34, Iss. 7, 2016, s. 605-618 **(lista MNISW, A), IF_{2016} = 1,803**

d) Reduction of SO_2 and NOx emissions from industry

In paper [7] was described the basis of the results made available from ZGH Bolesław from the change of sulphuric acid production technology from single conversion / single absorption (PK/PA) to double conversion / dual absorption (DK/DA) and literature.
I analyzed the impact of technology modernization on SO_2 emission and mists of sulfuric acid into the atmosphere. The amount of unreacted sulphur dioxide in the PK/PA method is more than 3.7 times higher than in the DA/DA method.
The use of the second conversion stage and the interstage absorption also has additional advantages resulting directly from the thermodynamics and the kinetics of the SO_2 oxidation reaction with oxygen from the air. In the first conversion stage, the catalyst temperature can be kept higher (not exceeding the sintering temperature of the contact mass) than in the PK/PA method. The higher temperature provides a faster reaction speed and allows to use higher process gas flow rates. The higher temperature of the catalyst in the first conversion stage reduces the conversion rate, which results from the thermodynamics of the process, however, unreacted SO_2in the DK/DA method, it is separated from the reaction product (SO_3) in the interstage absorption tower and is then directed to the second conversion stage. In the PK/PA method, it is not possible to convert any unreacted SO_2 later, therefore it is necessary to use a lower process temperature and lower flow rates in order to obtain a high conversion rate at a single gas pass through the contact apparatus. By dividing the process into two stages in the DK/DA method, it is possible to provide conditions favorable to the reaction rate (conditions favorable to the reaction kinetics) in the first stage and conditions conducive to achieving a high degree of transformation in the second stage (thermodynamically favorable conditions). New methods such as multistage conversion and multistage absorption (TK/TA) makes it possible to obtain even higher conversion of SO_2 than the DK/DA method, however high investment costs in the construction of such an installation are a significant disadvantage of this acid production technology. New sulfuric acid production plants should be constructed in the DK/DA standard, or according to the latest TK/TA method in order to obtain the maximum conversion degree of SO_2 and to minimize harmful emissions to the atmosphere.

In [8], based on the knowledge gained in cooperation with the "Azoty Group" plants and literature data, I analyzed and proposed the most effective methods to reduce NOx emissions to the atmosphere.
The presented data shows that the method of nitrogen oxides reduction based on the introduction of a secondary catalyst in the reactor for the catalytic oxidation of ammonia is an effective way to eliminate the emission of nitrogen oxides into the atmosphere. This method makes it possible to keep the concentration of nitrogen oxides below the maximum permissible concentration values.

Further work is underway to modify this method. The research is aimed to obtaining catalysts with high selectivity and minimization of undesired reactions, i.e. the formation of dinitrogen monoxide. Both in the world and in the country, a recipe of secondary catalysts characterized by a high degree of decomposition of nitrogen oxides is also being developed.

7. A.Jarosiński, S.Żelazny, L.Madejska, Ocena pracy układu jedno i dwustopniowej konwersji SO_2 w aspekcie ochrony środowiska, Innowacyjne i przyjazne dla środowiska techniki i technologie przeróbki surowców mineralnych: bezpieczeństwo, jakość, efektywność: monografia : praca zbiorowa / red. nauk. Adam Klich, Antoni Kozieł ; Instytut Techniki Górniczej KOMAG. – Gliwice: Instytut Techniki Górniczej KOMAG, 2013 s. 297-312 (rozdział w monografii)
8. S.Żelazny, A.Jarosiński, L.Stencel, Redukcja emisji azotu na przykładzie wybranego zakładu produkcyjnego związki azotu, *Rozdział w monografii,* 2012, s. 31-36

e) Acquiring energy from unconventional sources

In the paper [9] based on the literature, the concept of the future DEMO fusion power plant based on the AB PPCS model was proposed. A simulation of the operation of the thermal energy change into electrical system based on analysis in CHEMCAD 6.2 has been provided. A comparison of different types of power plant was made by calculating the amount of fuel needed for a 1500 MW power plant during the year.
In the article [10] the possibilities, advantages and disadvantages of hydrogen fuel were analyzed as an alternative to fossil fuels in transport. Methods of obtaining this fuel and positive impact on the environment of its use have been described.

9. D.Bradło, Ś.Żelazny, W.Żukowski, Koncepcja elektrowni termojądrowej, *Czasopismo Techniczne,* **1-Ś, Z. 4,** 2012, s. 31-40
10. A.Jarosiński, S.Żelazny, D.Jarzęcki, Current directions of hydrogen winning, 11th Conference on Environment and Mineral Processing, 31.5.-2.6.2007, VŠB-TU Ostrava, Czech Republic. Pt. 1 s. 223-228 (rozdział w monografii).

f) Identification of the possibility of elimination of hazardous and harmful waste after the "Górka" plant in Trzebinia

Trzebinia Commune guided by responsibility for the state of the natural environment, and in particular the protection of surface and groundwater, has undertaken action to eliminate the environmental threat posed by the landfill of waste after the production of aluminum hydroxide. It is an area consisting of a water reservoir and the accumulation of solid waste. Abandoned limestone quarry in Trzebinia was used as an illegal landfill for the production of special cement and refractories in the years 1960-1984. Waste components were washed away by water accumulated in the excavation. The team appointed at WIiTCh, in which I participated, conducted basic research on the composition of the waste as well as analyzed and proposed the possibility of disposal. For the most part, these were sodium hydroxides and aluminum, and the leaching water formed from the waste was highly alkaline (pH between 11-13). The results of the study were published in the work [11].

11. S. Żelazny, K. Fela, A. Jarosiński, Z. Kowalski, Dump area reclamation withthe use of bottom sludge suspension, Polish Journal of Chemical Technology, 2006, Vol. 8, No. 2, s. 48-53, **(lista MNISW, A), IF_{2016} = 0,725**

g) Technology for the recovery of potassium sulphate (VI) from waste produced from the production of biofuels

Paper [12] describes one of the potential methods of recovery of potassium sulphate(VI)from glycerol residues after biodiesel. I proposed a new method of utilization of glycerol wastes from biodiesel production, consisting of thermal treatment of waste and thermal utilization of organic components as well as recovery of potassium sulphate (VI) as a residue after combustion. The process used a considerable calorific value of waste and its low viscosity at elevated temperature, which facilitated the dosing of material into the combustion chamber.

The research ended with a positive result and on this basis I found that the thermal utilization of glycerol residues along with the recovery of potassium sulphate (VI) as a residue after the combustion process seems to be a good way to manage this waste.In addition to potassium sulphate(VI), a valuable mineral fertilizer, there is a significant amount of energy that can be used. The optimum temperature of the furnace is at 900°C regardless of whether the process was carried out with auxiliary fuel (natural gas) or without it.The technology has been patented [13].

12. S.Żelazny, P.Radomski, Z.Wzorek, W.Żukowski, Technologia odzysku siarczanu(VI) potasu z odpadu pochodzącego z produkcji biopaliw, Przemysł Chemiczny, t. 95, nr 10, 2016, s. 1908-1910 **(lista MNISW, A), IF_{2016} = 0,399**
13. Radomski Piotr, Wzorek Zbigniew, Żelazny Sylwester, *Sposób odzyskiwania siarczanu(VI) potasu z odpadów glicerynowych powstających przy produkcji biodiesli,* PL 231041 B1 (2019)

h) Wastes from ash treatment processes from sewage sludge incineration

The subject of research in this case was the sludge after the recovery of phosphorus from ashes from the combustion of sewage sludge with nitric(V) and phosphoric(V) acid. Industrial ashes from the Polish Thermal Station for Utilization of Sewage Sludge in: Kraków-Płaszów, Kielce, Łódź, Warsaw and Szczecin have been leached. All these installations operate in a fluidized bed combustion system, with the exception of sewage sludge incineratorin Szczecin, where a furnace with a grate furnace is used. The study also examined a solid residue after gasification of sewage sludge from the Institute of Thermal Technology in Gliwice.

Based on the tests, I found that the leaching residue of both nitric acid and phosphoric acid due to the large amount of silica and iron can be used as a raw material additive for the production of cement clinker, which will reduce the consumption of natural materials. An additional advantage of this material is its excellent fineness, which will save energy needed to fragment the natural resources.

I also offered another opportunity to develop this material, using it as an ingredient in cement composites. Most preferably it will be used for the production of artificial aggregate as a concrete filler [14].

14. P.Radomski, K.Gorazda, B.Tarko, S.Żelazny, A.K.Nowak, Z.Wzorek, Charakterystyka pozostałości po procesie odzysku fosforu z popiołów ze spalania osadów ściekowych w aspekcie ich wykorzystania do produkcji materiałów budowlanych, Przemysł Chemiczny, t. 94, nr 6, 2015, s. 967-972, **(lista MNISW, A), IF_{2016} = 0,399**

IF 3,344 (the year of publishment)

5.2. Scientific and research projects, research and development as well as scientific and research works carried out for industrial partners

5.2.1. Scientific and research projects

1. *Research on magnesium removal from zinc concentrates and utilization of by-products, 2006-2009, research grant, 1 T09B 11930*
   My participation consisted in the planning and implementation of the experimental part of the project, the interpretation of results and participation in the editing of the report and the editing of articles for publication.
2. *Proecological technology of utilization of incinerated sewage sludge, as a source of agricultural fertilizers and additives for building materials, 2012-2015, research and development grant, PBS1/A1/3/2012*
   My participation consisted in the planning and implementation of the experimental part in the last point of the project, which provided for the management of waste after the recovery of phosphorus from fly ash from biomass combustion, interpretation of results and participation in editing the report and editing articles for publication.
3. *Eco-Ash. Ash-based fertilizer from biomass combustion in power plants, 2014 - 2015, research and development grant, POIG.01.04.00-26-300/13*
   In this project I was the manager of the topic related to the determination of physicochemical properties of fly ash from biomass combustion. My participation consisted in planning and managing the performance of the experimental part. After interpreting the received results, I wrote a report and presented the results in the form of a paper at a scientific conference.
4. *Assessment of possible recycling directions for heavy and rare metals recovered from waste combustion products, 2015 - 2016, research and development grant, RAREASH ERA-MIN/RAREASH/ 1/2015*
   My participation in this project focused on my own development of the experimental part methodology. On my initiative, a method was developed for obtaining rare earth metals from fly ash from energy, which was patented.
5. *Development of an innovative technology for waste treatment of super alloys based on nickel and titanium alloys*, 2017-2018, research and development grant, POIR.01.02.00-00-0089/17-00

In this project, I proposed and tested substances for removing impurities from the surface of chips of chromium-nickel and titanium alloys, which contributed to the development of technology to return these waste to the process and produce useful materials from them.

5.2.2. Scientific and research works performed for industrial partners (selected)

Scientific expertise

1. Making a scientific opinion on the innovation of a technological line for the production of the car windshield, for Saint-Gobain SekuritHanglas Sp. o.o., ul. SzklanychDomów 2, 42-530 DąbrowaGórnicza, 2010 (work manager)
   Effect: The opinion contributed to the modernization of the technology of windscreens production, which in effect increased the competitiveness of the plant and improved its economy.
2. Performing a scientific opinion on the innovation of the Katex3 windscreen production line, for Saint-Gobain SekuritHanglas Sp. o.o., ul. SzklanychDomów 2, 42-530 DąbrowaGórnicza, 2011 (work manager)
   Effect: The opinion contributed to the modernization of the technology of windscreens production, which in effect increased the competitiveness of the plant and improved its economy.
3. Making a scientific opinion on the product innovation in the form of a set of plaster mortar, renovation, calcium and cement mortars and equipment for the use of calcite, which is the basic raw material for making mortars, for: Zakłady Chemiczne White Stones Sp. z o.o., 04-041 Warsaw, ul. Ostrobramska 101A, 2011 (work manager)
   Effect: The opinion contributed to the preparation of a recipe for new mixtures of plaster mortars used for the renovation of monuments. This allowed adjusting the expansion of the produced binder to changes in the length of mortars found in the monuments (depending on weather conditions), which will cause that the renovation will be more durable.
4. Making a scientific opinion on the applied method of ammonium nitrate production in the Neutralization installation of the Saletrzaku Department at ZAK S.A., for: ZAK Spółka Akcyjna, ul. Mostowa 30 A, direct mail 163, 47-220 Kędzierzyn-Koźle 2012, (work manager),
   Effect: In the opinion, the reason for reducing the strength of fertilizer granules (ammonium nitrate) consisting in the addition of sulfuric acid in the final stage of production was identified. This resulted in inaccurate homogenization of the product, which when the temperature changed resulted in stresses in the interior of the granules caused by different coefficient of expansion. The change in technology proposed by me consisted in the introduction of sulfuric acid at an earlier stage, which helped me to achieve a constant composition of the product and thus increased its mechanical strength.
5. Opinion on innovation concerning the new technological line in the 1.4 mm thick Float glass forming process., for: Saint-Gobain Sekurit Hanglas sp. o.o., ul. Szklanych Domów 2, 42-530 Dąbrowa Górnicza, 2013 (work manager)

Effect: Opinion contributed to the modernization of the technology of producing flat glass in the Float technology. An innovative technology allowing for the production of thinner than 1.4 mm thick glass panes. It allowed for material savings and, consequently, the competitiveness of the plant.

6. Opinion confirming the innovativeness of the implementation solution in the "Orzesze" Glass Branch, for: POL-AM-PACK S.A., ul. Jasnogórska 1, 31-358 Kraków, 2013 (work manager)
Effect: The review included an assessment of technological changes and their impact on the quality of the product and on the efficiency of the manufacturing process. It contributed to obtaining funds for the modernization of the technological line.

7. Opinion on the technological process of aluminum processing of Uniwheels, for: Taxpoint Sp. o.o., ul. Prądnicka 4, 30-002 Kraków, 2014 (work manager)
The opinion presents a suggestion in the modernization of aluminum alloy remelting technology.

8. Making a scientific opinion on the innovation of technological lines producing rear, front and roof automotive windscreens, which will be characterized by high innovation thanks to the introduction of modern technological solutions, for: Saint-Gobain Sekurit Hanglas Sp. o.o., ul. SzklanychDomów 2, 42-530 DąbrowaGórnicza, 2014 (work manager)
Effect: Opinion has contributed to the modernization of the technology for the production of rear, front and roof windows for cars. Modernization consists in the modernization of technology as well as the modernization of the machine park.

9. Determination of phase transformations in saletrosan based on X-ray examinations (50 samples), for: ZakładyAzotowe Tarnów-Mościce, ul. Kwiatkowskiego 8, 33-101 Tarnów, 2014 (work manager)
Effect: On the basis of the conducted tests, additives for the fertilizer improving its mechanical properties were determined.

10. Expertise on the feasibility of implementing new saletrosan with the addition of micronutrients to the existing mechanical granulation plant for: ZakładyAzotowe in Tarnów-Mościce, ul. Kwiatkowskiego 8, 33-101 Tarnów, 2015 (work manager)
The result: The possibility of producing a new product (fertilizers with microelements) that I suggested was included in the opinion, which included market analysis in relation to this type of products. The idea was tested as a result of research conducted at the Agricultural University, and the results confirmed my assumptions. ZakładyAzotowe in Tarnów filed a patent application in which I also participate.

11. Opinion on the possibility of using "Mo-Bruk" cement granulate for the reclamation of post-exploitation soil, for: Commune Head of Grybów, ul. Jakubowskiego 33, 33-330 Grybów, 2015 (work manager)
Effect: The opinion contributed to the possibility of using the "Mo-Bruk" cement granulate for the reclamation of post-exploitation soil.

12. Preparation of scientific opinion / expertise / on chromium emission from the mixing of raw materials and the resulting product with the participation of chromium VI oxide, for: Stalprodukt S.A., ul. Wygoda 69, 32-700 Bochnia, 2017 (work manager)
Effect: On the basis of literature and my own experience, I determined the possibility of chromium compounds emission during homogenization of components involving

chromium (VI) oxide during mechanical mixing at 5-30^{o}C. The second issue discussed in this study is the description of changes in the value of chromium from Cr^{+6} to Cr^{+3} by thermal treatment in the furnace at 750-930^{o}C.

13. Opinion on innovativeness concerning the launch of innovative products in the form of significantly improved luminaires, for Labra Sp. z o.o., 32-061 Rybna, 2018 (head of work)

Result: The opinion concerns investments related to the implementation of a significantly improved product in the form of lighting fixtures in which LEDs will be used. In my opinion, based on the literature, I determined the development directions of LED lighting technology. The opinion contributed to obtaining funds for innovative implementations in the plant.

14. Flammability analysis of classified waste under the code 06 04 03*, for Alventa S.A., ul. Karol Olszewskiego 25, 32-566 Alwernia, 2019 (work manager)

Effect: The opinion based on the study of the combustibility of waste determined the environmentally safe conditions for its storage.

Selected studies for industry affecting the modernization of technology

In the list I have included more important studies for the industry, which had an impact on the modernization of technology in the plant. Cooperation with industrial partners concerned changes in product manufacturing technology as well as technologies reducing the negative impact on the natural environment.

1. Development of the phase composition of the mixture of sodium and potassium nitrates in a weight ratio of 3: 1, Principal: GrupaKęty S.A. ul. TadeuszaKościuszki 111, 32-650 Kęty, 2009 (work manager), Research has contributed to changing technology

   Thanks to the development, the industrial plant could have achieved savings due to a change in technology. This change consists in replacing expensive potassium nitrate with lower-cost sodium nitrate.
2. Analysis of decarbonation deposits and evaluation of their suitability for flue gas desulfurization, Customer: EC Kraków S.A., ul. Ciepłownicza 1, 31-587 Kraków, 2009 (work manager),

   The test results were used to modernize the coal combustion processes in order to reduce the emission of sulfur oxides to the atmosphere. In the combustion process, waste calcium carbonate was used, which was previously subjected to utilization.
3. Modification of the process of reloading and flotation of the sphalerite concentrate, Principal: ZakładyGórniczo-HutniczeBolesław S.A. 32-332 Bukowno, ul. Kolejowa 37, 2010 (team leader),

   The results have been implemented, thanks to the implementation, the quality of the sphalerite concentrate has been improved, which contributed to the reduction of ZnS in lighters from 1.5% to 0.6%. This affects both the protection of the environment by reducing the amount of waste as well as improves the yield of the main product (zinc), which contributes to increasing the profit of the plant.

4. New technology for the preparation of zinc oxide, especially fodder and technical, Customer: Przedsiębiorstwo ARKOP Spółka z o.o., ul. Kolejowa 34 A, 32-332 Bukowno, 2010 (work manager),
   The research results were used to modernize the zinc production technology from waste electrolyte from the electrolytic zinc process.
5. Determination of the content of selected elements and basic chemical compounds in the sample provided, EcotechPolska S.A., ul. Niedziałkowskiego 28, 61-578 Poznań, 2011, (work manager)
6. Quantitative and qualitative determination of the components of the NPK granulated fertilizer produced by Alwernia, for Alventa S.A., KarolaOlszewskiego 25, 32-566 Alwernia, 2011 (work manager)
   The tests confirmed the quality of the product being manufactured.
7. Determination of the amount of hydrogen released during the chemical treatment of aluminum alloys in sodium hydroxide solutions, for: GrupaKęty S.A., ul. Kościuszki 111, 32-650 Kęty, 2012 (research manager),
   The research has contributed to the launch of a new innovative installation for the surface treatment of aluminum components in a solution of sodium hydroxide. On the basis of the tests, the amount of hydrogen evolved during the process was determined. On thisbasis, the rightdimensionshavebeendesigned.
8. Modification of crystalline phases of Saletrosan 26 with additives, Principal: ZakładyAzotowe in Tarnów-Mościce, ul. Kwiatkowskiego 8, 33-101 Tarnów, 2013 (work manager),
   Research has contributed to improving the parameters of the final product, which has a big impact on reducing the complaint, and thus affects the image of the plant as well as saves considerable financial resources.
9. Laboratory tests of samples of the backfilling material, Customer: Dekra Industrial Sp. z o. o., ul. Rzymowskiego 28, 02-697 Warsaw, 2013 (work manager),
   The research allowed to identify the problem of bulging the floor in the large-area store, which contributed to the effective removal of the defect.
10. Analysis of the physical properties of ZnS from ZGH, Gradir, Famakom, Trepca on the basis of bulk density, specific gravity, granulometric composition, dump angle, Principal: Zakłady Górniczo-Hutnicze Bolesław S.A. 32-332 Bukowno, ul. Kolejowa 37, 2014 (work manager)
    The study determined the physicochemical properties of potential raw materials for ZGH Bolesław. Determination of the angle of internal friction allowed to design a landfill with optimal dimensions.
11. Determination of the influence of inorganic salt additions on improving Saletrosan 26 fertilizer parameters, Orderer: Zakłady Azotowe Tarnów-Mościce, ul. Kwiatkowskiego 8, 33-101 Tarnów, 2015 (work manager),
    Research has improved the parameters of the final product. The addition of magnesium sulfate hemihydrate increased the strength of the granules with the simultaneous reduction of dust. The solutionisstillused in industry.

12. Determining the degree of SO_3 absorption in the pre-absorption tower FKS I, Orderer: Zakłady Górniczo-Hutnicze Bolesław S.A. 32-332 Bukowno, ul. Kolejowa 37, 2016 (work manager),
    The research contributed to the determination of the operating parameters of the newly installed absorption tower in sulfuric acid production technology at ZGH Bolesław.
13. Determination of the influence of oxygen concentration in the roasting gas on the quality of the roasting, Principal: Zakłady Górniczo-Hutnicze Bolesław S.A. 32-332 Bukowno, ul. Kolejowa 37, 2017,
    The tests have shown an improvement in the efficiency of the fluidized bed furnace for the combustion of a sphalerite concentrate (they have not been implemented for economic reasons
14. Investigation of sulphate reduction in waste waters "Floating Channel", "Mieczysław" and "Sour sewage from FKS", Orderer: Zakłady Górniczo-Hutnicze Bolesław S.A. 32-332 Bukowno, ul. Kolejowa 37, 2017,
    The research is the basis for the preparation of a grant for co-financing the construction of an industrial installation for the treatment of industrial wastewater from the Plant.
15. Assessment of the possibilities of recycling heavy and rare metals recovered from waste combustion products, Central Mining Institute, PlacGwarków 1, 40-166 Katowice, 2017 (work manager)
    Research has contributed to the development of a new technology for obtaining rare earth metals from fly ash and was the basis for filing a patent application that has been granted.

Patents and patent applications

1. Żelazny Sylwester, Ostrowski Czesław, Method of obtaining inorganic gypsum fibers, PL 185209 B1, 2003
2. Żelazny Sylwester, Kowalski Zygmunt, Jarosiński Andrzej, Włodarczyk Bogusław, Kulczycka Joanna, Filling mixture and the method of preparing a filling mixture, PL 207982 B1(2006) (implemented)
3. Żelazny Sylwester, Granulated potassium fertilizer with a long-term action based on ash from biomass combustion and a method of producing a granulated potassium fertilizer with a long-lasting effect based on ash from biomass combustion,PL 231041 (2019)
4. Żelazny Sylwester, Granulated potassium phosphorus fertilizer with a long-term action based on ash from biomass combustion and a method for the production of granulated potassium phosphorus fertilizer with a long-term action based on ash from biomass combustion, PL 231700 (2019)
5. Żelazny Sylwester, Granulated nitrogen-phosphorus-potassium fertilizer with prolonged action based on ash from biomass combustion and the method of producing granulated nitrogen-phosphorus-potassium fertilizer with prolonged action based on ash from biomass combustion,PL 231701 (2019)
6. Radomski Piotr, WzorZbigniew, ŻelaznySylwester, Method of recovery of potassium sulphate (VI) from glycerine waste produced in the production of biodiesels, PL 231041 B1 (2019)

7. Żelazny Sylwester, Białecka Barbara, Jarosiński Andrzej, Świnder Henry, Method of recovery of rare earth metals from fly ashes, (2017)

Classes

As part of my teaching activity, from 2000 to 2018 I prepared and/or conducted six lectures related to chemical technology and environmental protection. I made most of them available to students on the Moodle platform. These lectures are gradually modernized and due to the high contact with industrial plants I introduce innovative solutions used in industry.
1. Basics of technology – lecture
2. Economy with raw materials and waste – lecture
3. Environmental Protection in Chemical Technology – lecture
4. Proecological Inorganic Technologies – lecture
5. Raw materials and Technological Processes – lecture
6. Technological Project – lecture
7. Technology of binding concrete materials – lecture
8. Technological Project – project
9. Raw materials and Technological Processes – exercises
10. Selected sections of inorganic technology - laboratories (I have launched four new exercise stations by developing instructions for them).

The activity in the scientific club resulted in several lectures at the University Students' Scientific Academic Sessions (international sessions) of students who I was promoted. Using close cooperation with the industry, I organized numerous trips to establishments in order to raise the practical knowledge of students.
As the manager of two grants aimed at increasing the practical knowledge of students, I organized and organized numerous industrial internships within these projects.

Scientific and industrial internships

1. France, University of Pasteur in Strasbourg, Ecoled'Application des Hauts Polymers Scientific internship, December 1, 1993 - February 8, 1994, three months' scientific internship as part of the TEMPUS program.
2. Russia, Iwanow State Chemical and Technological University in Ivanovo, Scientific internship, 1 month, 1999.
3. Poland, Miraculum Cosmetics Factory, Industrial internship, 01/01/2002-12/04/2002 .
4. Czech Republic, VSB, Scientific internship, 29/04/2013 - 29/07/2013, three-month scientific internship, financed within the framework of the 21st century Politechnic project - development program of the Cracow University of Technology of the highest quality didactics for future Polish engineers implemented under the contract No. UDA-POKL. 04.01.01-00-029 / 10-00, NCBIR.
5. Czech Republic, VSB, Scientific internship, 22/04/2014 - 23/07/2014, three-month scientific internship, financed as part of the 21st century Politechnic project - development

program of the Cracow Polytechnic of the highest quality didactics for future Polish engineers implemented under the agreement No. UDA-POKL. 04.01.01-00-029 / 10-00, NCBIR.

Assistant promoter

1. Woynarowska Amelia, PhD thesis: Thermal utilization of electronic waste in a fluidized bed reactor, Krakow 2014

In the years 2000 - 2018: promoter of 39 master's and 30 engineer's theses. Reviewer of about 15 engineering works and about 40 master's theses.

Promoter of 30 engineering works:

1. 2002 - Paweł Malinowski - Metody otrzymywania wapna palonego w Polsce
2. 2006 - Arkadiusz Bernaś - Bilans materiałowy produkcji wapna w wapienniku „Trzuskawica”
3. 2008 - Hanna Witkowska - Procesy pozyskiwania cynku metodą pirometalurgiczną i hydrometalurgiczną w aspekcie BAT
4. 2008 - Lidia Bogdańska - Biomasa jako źródła energii odnawialnej
5. 2008 - Magdalena Tracz - Kierunki rozwoju (BAT) nawozów azotowych w Polsce
6. 2009 - Krzysztof Marczewski - Ocena sekwestracji jako metody walki z nadmiarem CO_2 w atmosferze
7. 2009 - Magdalena Jaśkowiec - Efekt cieplny mit czy zagrożenie?
8. 2009 - Teresa Gibas - Przyczyny i skutki zanieczyszczenia atmosfery
9. 2011 - Karolina Chmielarczyk - Przegląd nowoczesnych metod odsiarczania gazów spalinowych
10. 2011 - Dariusz Bradło - Kontrolowana synteza termojądrowa jako przyszłościowe źródło energii
11. 2011 - Dawid Pandel - Dobór młyna kulowego do rozdrabniania surowców w przemyśle cementowym
12. 2011 - Grzegorz Podleśny - Przegląd metod zapobiegania wybuchom pyłu węglowego w kopalniach węgla
13. 2012 - Marcin Szlęzak - Metody zagospodarowania odpadowego elektrolitu z procesu otrzymywania cynku metodą hydrometalurgiczną
14. 2012 - Joanna Wierzbinka - Porównanie i ocena metod granulacji nawozów azotowych w Zakładach Azotowych w Tarnowie
15. 2012 - Magdalena Wilgucka - Ocena wybranych metod ograniczania emisji tlenków azotu do atmosfery, ze szczególnym uwzględnieniem metod stosowanych w Zakładach Azotowych w Tarnowie
16. 2012 - Klaudia Szatko - Poznanie mechanizmu zbrylania nawozów na bazie azotanu amonu
17. 2013 - Justyna Augustynek - Metody uzdatniania wody do procesu przemysłowego w Elektrociepłowni Energomedia Sp. z o.o. w Trzebini

18. 2013 - Marta Rogacz - Skuteczność wymywania chloru i fluoru z hutniczego tlenku cynku w warunkach ZGH Bolesław S.A.
19. 2013 - Damian Milde - Porównanie układu pojedynczej i podwójnej konwersji SO2 w technologii kwasu siarkowego
20. 2014 - Katarzyna Giemza - Porównanie i ocena metod wytwarzania azotanu amonu
21. 2014 - Weronika Chrobak - Porównanie metod termicznej utylizacji odpadów komunalnych
22. 2014 - Mateusz Kula - Ocena i przegląd nowoczesnych nawozów mikroelementowych
23. 2014 - Jakub Mielcarek - Ocena pracy pieca do wytopu szkła na przykładzie zakładu Owens-Illinois
24. 2015 - Piotr Stępień - Przegląd oraz analiza pozyskiwania alternatywnych źródeł dla przemysłu cynkowego
25. 2016 - Magdalena Więcek - Porównanie technologii wytwarzania wodorotlenku wapnia oraz półwodnego siarczanu wapnia pod względem ekonomicznym oraz ekologicznym
26. 2016 - Jakub Duś - Ocena metod wytwarzania klinkieru cementowego na podstawie bilansu cieplnego
27. 2017 - Joanna Różana - Badania określające wpływ dodatków na szybkość wiązania gipsu otrzymanego ze zużytych form gipsowych z Zakładów Porcelany „Ćmielów”
28. 2017 - Żaneta Dziurrzyńska - Porównanie właściwości mechanicznych spoiwa anhydrytowego ze spoiwem gipsowym otrzymanym z gipsu odpadowego z Zakładów Porcelany "Ćmielów"
29. 2018 - Wojciech Trybus - Próba zagospodarowania popiołów lotnych do produkcji geopolimerów
30. 2018 - Anna Kłeczek - Próba zagospodarowania odpadu poflotacyjnego z ZGH Bolesław do otrzymywania cementu Sorela

Promoter 39 master'sworks

1. 2001 - Dariusz Śledziński - Przemiany fazowe dihydratu siarczanu wapnia w zależności od jego pochodzenia
2. 2001 - Elżbieta Sieczkoś - Kinetyka krystalizacji siarczanu wapnia w układzie CaO-SO_3-HCl-H_2O
3. 2002 - Agnieszka Juszczyk Porównanie wybranych metod usuwania SO2 z gazów spalinowych w elektrowniach i elektrociepłowniach
4. 2004 - Leokadia Cygan - Raport o stanie Środowiska województwa małopolskiego w 2000.
5. 2004 - Dorota Łatka – Koncepcja zagospodarowania gipsu z procesu odmagnezowania koncentratu poflotacyjnego z Z.G. Trzebionka
6. 2004 - Anna Świerczek - Produkcja materiałów podsadzkowych z odpadów poflotacyjnych pochodzących z ZG "Trzebionka" w Trzebini
7. 2004 - Marek Starowicz - Próby odzysku związków magnezu z odpadu po odmagnezowaniu blendy cynkowej
8. 2004 - Zofia Perlikowska - Utylizacja wód zasolonych w kopalni soli "Wieliczka"

9. 2005 - Katarzyna Dudek - Otrzymanie $Mg(OH)_2$ oraz MgO z roztworu odpadowego z procesu odmagnesowania blendy cynkowej.
10. 2005 - Agnieszka Bukała - Badanie rozpuszczalności gipsu w wodnych roztworach chlorku sodu, chlorku amonu i amoniaku
11. 2005 - Maria Morga - Możliwości pozyskiwania magnezu w postaci fosforanów z odpadu poflotacyjnego pochodzącego z przeróbki rud cynkowo ołowiowych z ZG „Trzebionka''S.A.
12. 2005 - Monika Banach Próba aktywacji popiołu lotnego stosowanego do solidyzacji odpadów pogórniczych.
13. 2006 - Piotr Żuradzki - Próba odzysku cynku z pyłów stalowniczych z odpylania gazów odlotowych w procesie wytapiania stali
14. 2006 - Lasek Bartłomiej - Próba otrzymania spoiw magnezjowych na bazie odpadu poflotacyjnego z procesu wzbogacania rud cynku i ołowiu
15. 2006 - Aleksandra Wojcieszczak - Zagospodarowanie odpadów przemysłowych do produkcji paliw alternatywnych
16. 2006 - Robert Mańkowski - Próba ograniczenia przepuszczalności betonów dla gazów celem nierozprzestrzeniania się pożarów w kopalniach węgla kamiennego
17. 2007 - Tomasz Zięba - Próba odzysku cynku z procesu wytapiania stali metodą łukową
18. 2007 - Małgorzata Parzelka - Wpływ uziarnienia na wytrzymałość cementu Sirela otrzymanego z odpadu dolomitowego z procesu wzbogacania rud cynku i ołowiu.
19. 2008 - Małgorzata Kosoń - Badanie odporności kompozytów z cementu Sorela z odpadów dolomitowych na działanie wody z dużą ilością chlorków
20. 2008 - Magdalena Błachut - Opracowanie metody badania stężenia beta glukaniu w słodzie i na poszczególnych etapach produkcji piwa z wykorzystaniem aparatury HPLC
21. 2008 - Iwona Chwierut - Próba optymalizacji czasu wiązania gipsu odpadowego z procesu odmagnezowania koncentratu blendy cynkowej
22. 2008 - Agnieszka Wadowska - Wpływ temperatury wypału oraz uziarnienia na wytrzymałość spoiwa anhydrytowego otrzymanego na bazie gipsu odpadowego z ZG. „Trzebionka”
23. 2009 - Michał K. Smoła - Określenie właściwości fizykochemicznych gipsu odpadowego z form odlewniczych oraz ocena jego przydatności w przemyśle materiałów wiążących
24. 2009 - Amelia Woynarowska - Oczyszczanie ścieków powstających w procesie otrzymywania koncentratów cynku i ołowiu za pomocą wymieniaczy jonowych
25. 2009 - Anna Szawara - Wpływ temperatury oraz ilości MgCl2 na proces wiązania cementu Sorela otrzymanego z odpadu dolomitowego z Z.G. „Trzebionka” S.A.
26. 2010 - Elżbieta Kubiś - Badanie właściwości kompozytów z cementu Sorela otrzymanego z odpadu dolomitowego utwardzonego za pomocą siarczanu magnezu
27. 2011 - Piotr Matysik - Dobór warunków odmagnezowania blendy cynkowej dla zakładu ZGH „Bolesław” w Bukownie
28. 2011 - Łukasz Miodoński - Dobór pieca w procesie spalania blendy cynkowej
29. 2011 - Paulina Tomal - Wpływ dodatków na właściwości fizyczne (plastyczność) pulpy azotanu i siarczanu amonu w granulatorze instalacji mechanicznej granulacji nawozów
30. 2012 - Dariusz Bradło - Rozpoznanie właściwości sorpcyjnych regenerowanych ziem bielących

31. 2012 - Sebastian Jagusiński - Otrzymywanie azotanu wapnia i magnezu z surowca dolomitowego
32. 2013 - Joanna Wierzbinka - Dobór optymalnego składu kąpieli solnej w procesie termicznej obróbki stopów aluminium
33. 2013 - Magdalena Wilgucka - Próba odzysku związków potasu z popiołu ze spalania drewna
34. 2013 - Klaudia Szatko - Wpływ dodatków na układ soli NH4NO3 – (NH4)2SO4 – $Ca(Mg)(CO_3)_2$
35. 2014 - Damian Milde - Rozpoznanie możliwości otrzymania nawozu NPK na bazie azotanu amonu
36. 2014 - Michał Ochman - Spirobiindanowe pochodne bisfenolu A i metody ich otrzymywania
37. 2014 Joanna Jagodzińska - Przetwarzanie termiczne odpadów - bezpieczeństwo czy zagrożenie
38. 2015 Katarzyna Giemza - Badanie możliwości wytwarzania nawozów mineralnych na bazie popiołów lotnych ze spalania biomasy
39. 2017 Jakub Duś - Określenie możliwości odzysku związków potasu z odpadu „by-pass" z cementowni

Organizational activity

1. Dean's Representative, IiTCh Faculty of Practice since 2008. until now
2. Dean's Representative of the Faculty of IiTCh for the Science Festival from 2008. until now
3. Representative of the University's Recruitment Commission (UKR) for full-time and part-time studies of first and second cycle since 2014. until 2018
4. Participation in the Examination Boards of diploma theses at the Faculty of Chemical Engineering and Technology
5. Participation in the Examination Committee of Engineering Works in VSB - TechnickaUniverzitaOstarava, Hornicko-geologickafakulta, Czech Republic, in 2014-2018 and 2018-2022
6. Project leader "Competence starting for an engineering career", contract no. POKL 04.01.01-00-189/14 from the Human Capital Operational Program
7. Member of the Statutory and Statutory Committee of SITPChem for the years 2014-2018
8. Project manager "Time for internship", contract No. POWR.03.01.00-00-S052/17 from the Operational Program Knowledge Education Development
9. I worked in a team that developed guidelines and launched a new faculty at the Faculty of Chemical Engineering and Technology - Building Chemistry

Awards

1. Silver Medal for long-term service from the President of the Republic of Poland, 2012 2nd Prize of the Rector of the Polish Academy of Sciences: 1st level team for organizational achievements, 2012.

Sylwester Żelony