GOSPODARKA SUROWCAMI MINERALNYMI

Tom 17 2001 Zeszyt 4

PETER FECKO*, DANA KRISTOFOVA*, VLADIMIR CABLIK*, ADRIANA FARKASOVA*

Application of bacterial leaching by recovery of heavy metals from metallurgy wastes

Key words

Bacterial leaching, metallurgy wastes, heavy metals

Abstract

The Vitkovice plant belongs to the biggest metallurgical company and produces large amounts of the wastes that are mainly recycled, but the additives of the Cd, Zn and Pb are undesirable in these wastes. Two types of wastes (oxyvite sludge and dust from electric-arc furnace) were tested and bacterial leaching with *Thiobacillus ferrooxidans* was applied. The better results were achieved at leaching of oxyvite sludge, where these yields of Zn — 73%, Al — 70%, Pb — 30%, Cd — 90% were attained. The results from leaching of dust show lower yields of mentioned metals with comparison of oxyvite sludge.

Introduction

Enterprise Vitkovice presents important metallurgical complex that produces large amount of wastes that are partly recycled and big part is due to ineligible admixtures mainly Cd, Zn, Pb landfilled. The aim of this work is to verify the application of bacterial leaching on 2 types of wastes: oxyvite sludge and dust from electric-arc furnace (EAF).

* VSB-Technical University of Ostrava, Faculty of Mining and Geology, Institute of Environmental Engineering, Ostrava-Poruba, Czech Republic.

Reviewed by Ph.D. Eng. Barbara Tora

1. Characterization of waste

1.1. Oxyvite sludge

A predominant part of production from the wet gas-cleaning of converter gases (cca 99%) is composed only by separate oxyvite sludges from oxygen converters K1 and K2 of Steelworks 1. In this study the oxyvite sludge is firm's name of sludge. The oxyvite sludge is chemically formed firstly by Fe oxides and alkali metal oxides. These properties are important for utilization of this waste as secondary raw material — Fe^{3+} correction in cement industry. The only handicap of waste chemism, from the point of view of possibility of its utility in metallurgical recycling, is content of low-fusing metals Zn, Pb, Cd. This content causes problems at an assertion of sludge in agglomeration and subsequently in blast furnace, where condensated vapours of Zn in cooled part of furnace are cumulated in the form of fouling in lining. Subsequently the condensated vapours can be released into the space of casting platform what is undesirable in the recycling process.

1.2. Dust from Electric Arc Furnace

Cleaning of outgoing gases and trapping of light ashes are performed at dry gas cleaning plants. Fouling originating under cover of EAF is drawn off with 4st inlet in the furnace cover and by steel pipelines. Fouling that escapes from furnace to hall is exhausted through monitor created above furnace, further after mixing with fouling from furnace it goes by steel pipelines to gas cleaning plants. Dust from exhausted fouling is trapped in tube filters, by screw conveyer is pneumatically transported to container. From the container is dust drained to pelletization disc where is pelletized.

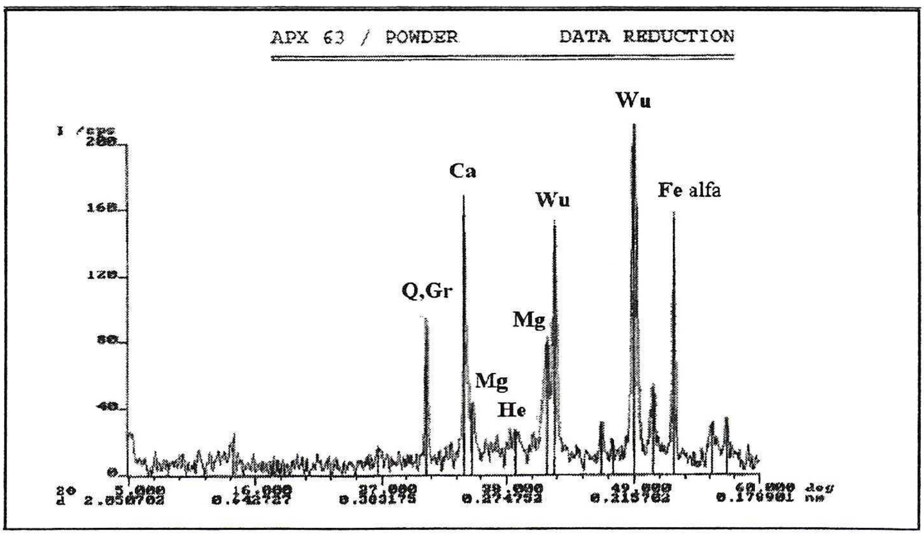

Fig. 1. Diagram of X-RAY diffraction: fine oxyvite sludge — input

Rys. 1. Wykres dyfrakcji promieniowania rentgenowskiego: drobny szlam

This dust is in the form of pellets recycled in two electric arc fiurnaces. Samples of the trapped dust are collected continuously for determination of Zn, Pb, Cd contents.

1.3. Mineralogical analysis

From X-RAY analysis performed in laboratory of Institute of geological engineering follows that sample of oxyvite sludge is formed by: wustite (Wu), metallic iron (Fe alpha), magnesite (Mg), hematite (He), quartz (Q), graphite (Gr) what is presented in Fig. 1. The sample of dust from EAF contains: magnetite (M), franclinite (F), graphite (Gr), wustite (Wu), fluorite and hematite (He) — it is shown in Fig. 2.

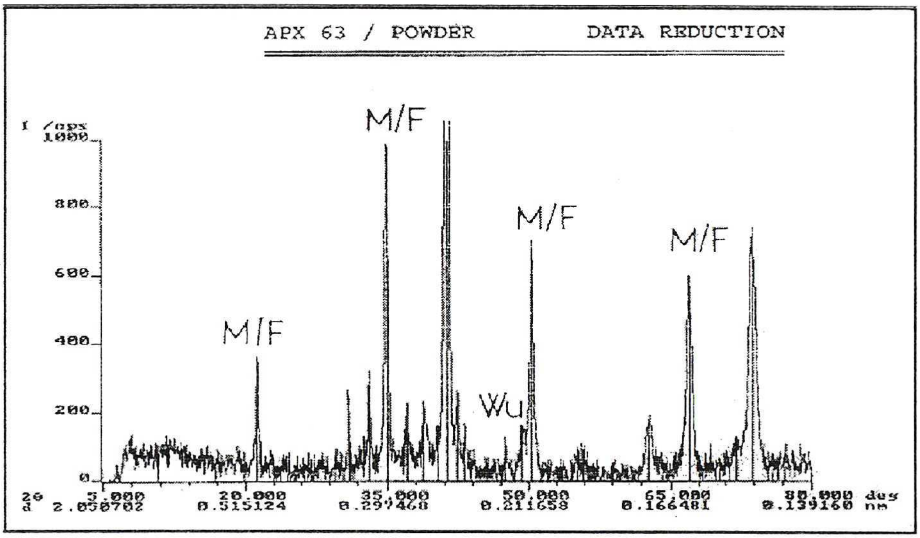

Fig. 2. Diagram of X-RAY diffraction: dust from EAF — input

Rys. 2. Wykres dyfrakcji promieniowania rentgenowskiego: pył z pieca łukowego

2. Bacterial leaching

For bacterial leaching special glass reactors with volume 2.5 l were used. After sterilization fine oxyvite sludge and dust from EAF about 150 g were brought into the reactors. The other components 250 ml of bacterial solution and 2.25 l of medium 9K without $FeSO_4$ were added. Clean cultures of *Thiobacillus ferrooxidans* were used for bacterial leaching. Aeration of leaching area was provided by the pump with a continuous air inlet. The value of pH in leaching area was measured by laboratory pH-meter. The value of pH was kept constant at 1.8—2.2 by solution of 10N H_2SO_4 during the whole process of bacterial leaching. Pneumatic agitation of mash was maintained continuously by air jet. During bacterial test also temperature was kept in the interval 30—32°C.

A bacterial leaching took 5 weeks. Analyses were carried out on specimens which were taken of a suspension weekly once. There was measured number of bacteria in 1 ml of the suspension and the rest was filtered through a Buchner funnel whereby we obtained a filtrate and a filtrate cake. There was determined Fe^{2+} in the filtrate by titration and in the filtrate cake was determined a content of Zn, Pb, Al, Cd metals.

3. Discussion of results of bacterial leaching

The input concentration of metals in the samples are given in Table 1. The results of bacterial leaching of fine oxyvite sludge and dust are given in Tables 2 and 3. From the results of the bacterial leaching of fine oxyvite sludge given in the Table 2 follows that the bacteria are adaptable well for sludge what is indicated by a drop of the Fe^{2+} concetration in the solution.

TABLE 1

The input concentration of metals in the samples

TABELA 1

Wejściowa zawartość metali w próbkach

Sample	Metal concentration [%]			
	Zn	Cd	Al	Pb
Fine oxyvite sludge	4.94	0.10	0.16	1.08
Dust from EAF	3.92	0.01	0.49	1.08

TABLE 2

Results of bacterial leaching: fine oxivite sludge

TABELA 2

Wyniki ługowania bakteryjnego: drobny szlam

Duration of leaching (weeks)	Metal concentration [%]				Recovery of metal [%]				Fe^{2+} [mg·l^{-1}]	Number of bacteria in 1 ml
	Zn	Cd	Al	Pb	Zn	Cd	Al	Pb		
1	3.55	0.06	0.12	1.02	28.14	40.00	25.00	5.56	42.71	$30 \cdot 10^3$
2	3.16	0.05	0.11	0.96	36.03	50.00	31.25	11.11	38.11	$90 \cdot 10^5$
2	3.16	0.05	0.11	0.96	36.03	50.00	31.25	11.11	38.11	$90 \cdot 10^5$
3	2.04	0.03	0.10	0.92	58.70	70.00	37.50	14.81	21.77	$30 \cdot 10^7$
4	1.47	0.01	0.05	0.84	70.24	90.00	68.75	22.22	18.43	$90 \cdot 10^8$
5	1.31	0.01	0.04	0.72	73.48	90.00	75.00	33.33	0.0	$90 \cdot 10^9$

TABLE 3

Results of bacterial leaching: dust from EAF

TABELA 3

Wyniki ługowania bakteryjnego: pył z pieca łukowego

Duration of leaching (weeks)	Metal concentration [%]				Recovery of metal [%]				Fe^{2+} $[mg \cdot l^{-1}]$	Number of bacteria in 1 ml
	Zn	Cd	Al	Pb	Zn	Cd	Al	Pb		
1	2.51	0.004	0.39	1.04	35.97	60.00	20.41	3.70	4.69	$90 \cdot 10^3$
2	2.51	0.003	0.24	1.03	35.97	70.00	51.02	4.63	4.69	$60 \cdot 10^5$
3	2.49	0.003	0.20	0.96	36.48	70.00	59.18	11.11	3.35	$120 \cdot 10^7$
4	2.42	0.002	0.20	0.94	38.27	80.00	59.18	12.96	2.76	$120 \cdot 10^8$
5	2.29	0.002	0.20	0.86	41.58	80.00	59.18	20.37	0.0	$90 \cdot 10^9$

That concentration amounts zero in the last week of leaching as well as there is increased the number of bacteria in 1 ml suspension continuously, what in the last week of leaching amounts maximum values 10^9. The best leached metal among following was Cd, where the recovery after 4 weeks of leaching is 90% and the same is after 5 weeks of leaching. Approximately equally is leached Al and Zn where by extension of a leaching time increases the recovery of metals into the solution. The obtained recovery of both elements after 5 weeks of leaching is about 75%. Extremely slowly is leached Pb. After 5 weeks of leaching the recovery of Pb into the solution is only 33%.

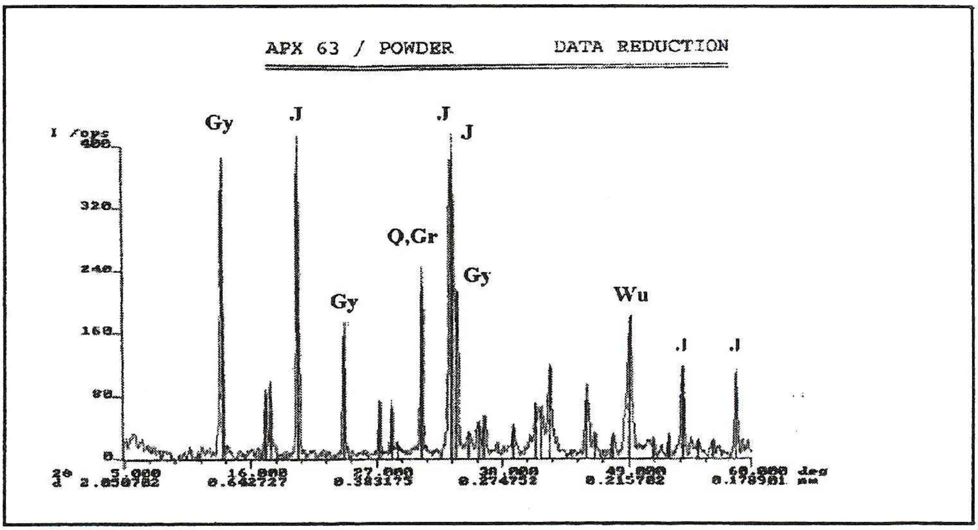

Fig. 3. Diagram of X-RAY diffraction: fine oxyvite sludge after bacterial leaching

Rys. 3. Wykres dyfrakcji promieniowania rentgenowskiego: drobny szlam po ługowaniu bakteryjnym

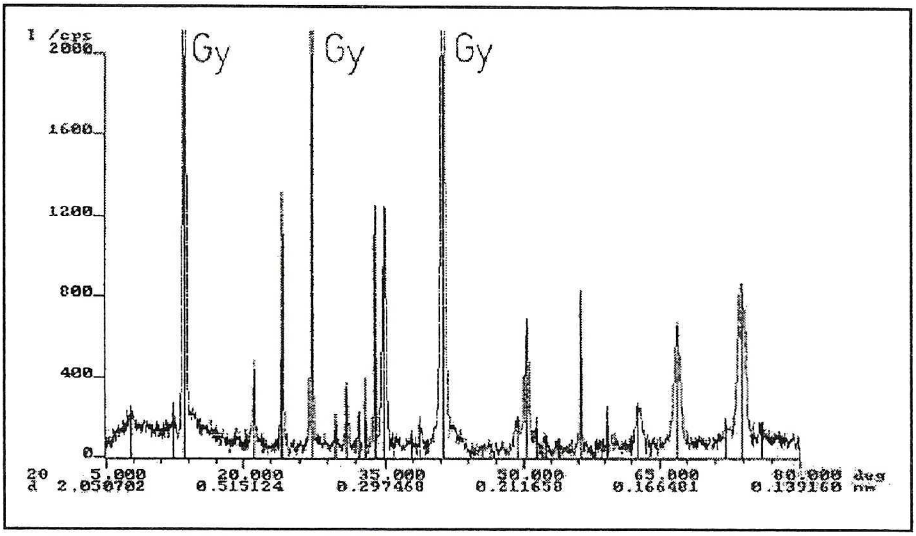

Fig. 4. Diagram of X-RAY diffraction: dust from EAF after bacterial leaching

Rys. 4. Wykres dyfrakcji promieniowania rentgenowskiego: pył z pieca łukowego po ługowaniu bakteryjnym

Regarding the specimen of dust from an electric — arc furnace, similar results were obtained from the point of view of the bacteria *Thiobacillus ferrooxidans* adaptability. It means that after 5 weeks of leaching the concentration of Fe^{2+} is equal zero and the number of the bacteria in 1 ml of the solution is 10^9. There were observed interesting results from the point of the recovery of the separate metals into the solution. The recovery of Zn into a leachate after 1 week of leaching was 36% and after 5 weeks of leaching was 45%. The recovery of Cd into the leachate after 1 week of leaching was 60% and after 5 weeks of leaching was 80% and the same value was received already after 4 weeks of leaching. The recovery of Al increases till 3rd week of leaching which amounts 60% and the same is after 5 weeks of leaching. The leaching of Pb is very low, after 5 weeks of leaching was the recovery of Pb in the leachate only 20%.

From the mineralogical analyses that were performed in the samples after bacterial leaching followed that both samples clearly contain minerals originated by bacteria action as gypsum (Gy) and jarosite (J) and there is decrease of Fe-minerals, magnetite (M), franklinite (F) in both samples. In the Fig. 3 and 4 are presented X-RAY diffractions of oxyvite sludge and dust from EAF after bacterial leaching.

Conclusions

The goal of this work was to verify suitability of the application of bacterial leaching at rem,oval of undesirable metals from wastes of enterprise Vitkovice.

The application of the bacteria in these types of specimens have not been tested in Czech republic yet. From the results of the bacterial leaching followed that the particularly suitable sample for the application of the *Thiobacillus ferrooxidans* bacteria is the oxyvite sludge, where the recoveries of undesirable metals into the leachate were observed as follows: Al, Zn about 75% and Cd about 90%. Very low recovery of Pb was reached.

The significant leaching of these metals into the leachate allow recycling of the oxyvite sludge after the bacterial leaching in the production of Fe in plant Vitkovice. The results of the bacterial leaching of the dust sample are rather worse, after 5 weeks of leaching the recovery of tested metals into the solution is markedly lower.

The better results could be achieved by application of adapted cultures *Thiobacillus ferrooxidans* or using mixed culture of *Thiobacillus ferrooxidans* with *Thiobacillus thiooxidans*.

REFERENCES

Kristofova D., Fecko P., Karnik T., Cablik V., — Bio-metallurgical recycling of metal-bearing waste. Proceedings "New Trends in Mineral Processing III", Volume II, VSB-TU Ostrava, p. 571—576.

Kristofova D., Fecko P., Karnik T., Cablik V., 1999 — Prispevek k biometalurgicke recyklaci kovonosnych odpadu. Sbornik "Odpady 99", Spisska Nova Ves, 4—5 listopadu 1999, p. 228—232.

Fečko P., 1997 — Bacterial desulphuirization of coal from Sokolov lignite basin.Proceedings of the XX International Mineral processing Congress, Volume IV, Aachen, p. 573—583.

Fečko P., Sedláčková V., 2000 — Application of *Thiobacillus ferrooxidans* by bacterial desulphurization of coal. Proceedings of the XXI International Mineral Processing Congress, Rome, Volume C6, p. 43—49.

Bierley J.A., 1999 — Present and future commercial applications of biohydrometallurgy. Proceedings Biohydrometallurgy and The Environment toward the Mining of 21th Century, Volume B, Madrid, Spain, p. 81—98.

Tora B., Fecko P., 2000 — Oczyszczanie osadu z oczyszczalni ścieków "Glimar" Materiały Konferencji: Recyclace Odpadu IV, Ostrava r.

PETER FECKO, DANA KRISTOFOVA, VLADIMIR CABLIK, ADRIANA FARKASOVA

ZASTOSOWANIE ŁUGOWANIA BAKTERYJNEGO DO ODZYSKU METALI CIĘŻKICH Z ODPADÓW METALURGICZNYCH

Słowa kluczowe

Ługowanie bakteryjne, odpady metalurgiczne, metale ciężkie

Streszczenie

Należący do największej spółki metalurgicznej Zakład Vitkovice produkuje duże ilości odpadów, które są w większości przetwarzane, jednakże zawartość Cd, Zn i Pb w odpadach jest niepożądana. Badaniom poddano dwa typy odpadów (szlamy tlenkowe z mokrego oczyszczania gazów z konwertorów tlenowych oraz pyły z pieca łukowego) z zastosowaniem ługowania bakteryjnego przy pomocy Thiobacillus ferrooxidans. Lepsze rezultaty otrzymano w przypadku szlamów, gdzie osiągnięto uzyski dla Zn — 73%, Al — 70%, Pb — 30% i Cd — 90%. W porównaniu ze szlamami, dla pyłów osiągnięto mniejsze uzyski wymienionych metali.