THE EFFICIENCY OF THE "KIZHNICA" FLOTATION FACILITY AND INTERNATIONAL PRACTICES

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ABSTRACT

Kosovo is endowed with resources of lead and zinc; there are about 60 million tons of proven reserves, within so called Trepça's mineral belt. In the past, in this belt, have been developed six mines with three flotation facilities.
Kizhnica flotation facility is one of the oldest, with old equipment. Increasing of efficiency to this flotation facility is high importance with regards of environment protection and economical aspect.
Different researches worldwide have steadily continued to work with an objective to improve the efficiency and to optimize performance, and to seek innovative modern technology and control systems in their flotation plant and processes.
The aim of this study is to perform investigation, about the innovations in the process of flotation i.e. increasing of efficiency in the process of metals extraction in the process of flotation, as well as reflection of these innovations comparing to performance of Kizhnica flotation facility, with regards of metals extraction in the Kizhnica flotation facility.
The aim of the study is to present opportunities to increase efficiency of the Kizhnica flotation, which hence will have positive impact on environment and mine's profitability.

Key words: flotation, metals, recovery, facility, minerals.

1. INTRODUCTION

Flotation process, patented in the year 1906, was originally developed for mineral industry to recover values from high grade tailings of gravity separation plants. This technology has acclaimed importance as a versatile process for the beneficiation of vast variety of sulphide minerals. Due to

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flexibility of the process and remarkable development taken place in flotation technology and its ancillary systems, it has now become possible to recover fine grained sulphide minerals from complex ore deposits, whose processing was earlier considered uneconomical.

Today, about 400 million tonnes of sulphide ore is treated annually by flotation process worldwide.

The successful industrial practice of flotation involves knowledge and optimization of four important components of flotation process namely:

1. Mineralogical characteristics of the ore (mineral association, liberation size, presence of slime particles and soluble species contributed by the ore).
2. Surface colloid and reagent chemistry which determines selectivity of separation (collectors, frothers, activators, depressant, modifier, dispersants etc.)
3. Process engineering (feed preparation that is size reduction , cell design, control system etc.,
4. Operating parameters such as aeration rate, temperature, Eh / pH (this report present any of a class of diagrams that illustrate the fields of stability of mineral or chemical species in terms of the activity of hydrogen ions (pH) and the activity of electrons (Eh)) , ionic strength and flotation circuit configuration.

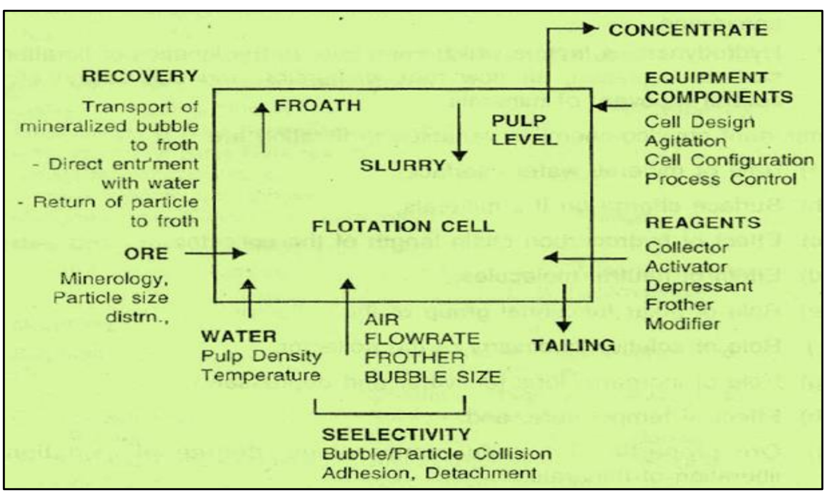

Figure 1. Schematic view of flotation system

Overall separation efficiency in flotation is dependent on

1. Surface chemistry factors such as particle bubble attachment, mineral reagent interactions, reagent chemistry etc. These factors are related to

equilibrium considerations contributing selectivity to separation.
2. Hydrodynamics factors which contribute to the kinetics of flotation such as agitation, air flow rate, dispersion and cell design etc. control recovery of minerals.

Important physico-chemical variables in flotation are: role of mineral/ water interface, surface charge on the minerals, effect of hydrocarbon chain length of the collector, effect of neutral molecules, role of polar functional group of the collector, role of solution chemistry of the collector, role of inorganic ions (activator and depressant), effect of temperature, and ore properties i.e. grade, mineralogy, degree of oxidation, liberation of minerals.

Reagents used in sulphide flotation - Commonly used reagents in industrial flotation plants are Collector, Frother, Activator, Depressants, pH modifier. Amongst above, collectors are the most important reagents which play critical role in sulphide flotation.

Table 1. Industrial collectors used for sulphide flotation

Traditionally Used Collectors	
X anthates	
Dialkyl and Dicresyl Dithiophosphates	
Dialkyl Thionocarbamates	
Mercaptobenzothiazole	
Xanthogen Formates	
Xanthate Ester	
Dodecyl Mercaptan	
Dialkyl Dithiocarbamate	
Diphenyl Thiourea	
Diphenyl Guanidine	
Hydrocarbon oils	
(Several blends comprising above collectors are also used)	
New Collectors (Commercially Used)	
Dialkyl Dithiophosphinates	Cytec/Cyanamid
Alkoxycarbonyl Alkyl thionocarbarmates	
Alkoxycarbonyl Alkyl Thiourea	
Dialkyl Monothiophosphate	
Dicresyl Monothiophosphate	
Monoalkyl and Dialkyl Trithiocarbonates,	Phillips
Nev Collectors (Pipeline)	
F and S series collectors,	Mineral Reagents
	International
Modifiers	
Sulphuric acid,	Sodium sulphide and Hydrosulfide
Lime,	Ammonium sulphide
Soda Ash,	Sodium sulphide and metabisulfide.

Copper Sulphate,	Sulphur dioxide.
Zinc Sulphate,	Nokes reagent, Arsenic Nokes.
Sodium and Zinc Cyanide;	Starch, Guar gum, modified guars.
Sodium Silicate;	CMC, dextrine, organic dyes.
Legnin Sulfonates;	Sodium thioglycolate, Mercaptoethanol and trithiocarbonate deravatives of above.
Discontinued or Very Limited Usage : Chromate, Ferro and Ferri Cyanide, Quebracho, Permanganate	

1.1. Kizhnica flotation facility

Kizhnica flotation facility is located in Kizhnica village, at about eight kilometers to the south-east of capital city Prishtina. Through the Grachanica town, there runs the main Prishtina –Gjilan road. Located in this region are also two mines and two tailings.

Flotation facilities include crushers, ball mills, flotation cells, workers' changing rooms, and assorted buildings for chemical handling, plant maintenance, and plant administration. The infrastructure associated with the mine is generally in a poor condition, with many deteriorating buildings, rusting equipment, and roads in poor condition.

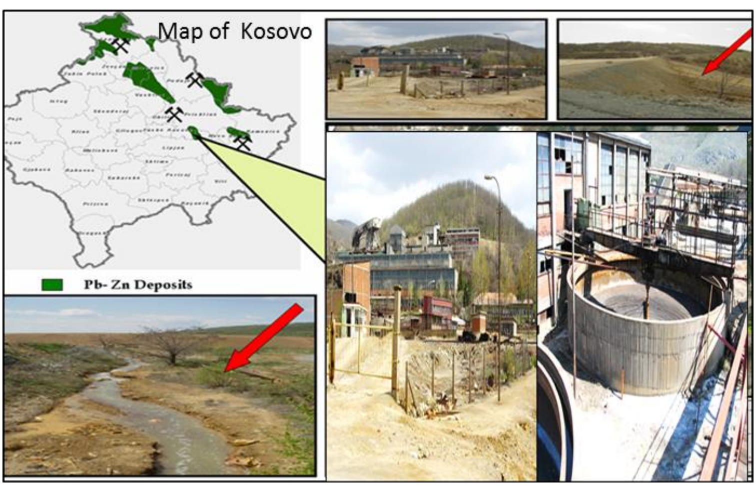

Figure 2. Location of Kizhnica flotation facility

2. INNOVATIONS IN FLOTATION

In view of increasing mineralogical complexity and deplecting grade and general recession in mining industry during seventies and eighties, it became necessary to seek improvement in mineral processing technology. Priority was to reduce operating cost, particularly energy cost and development of new technique to improve metal recovery and plant throughputs. Automation in mineral processing plants becomes essential. Developments taken place in flotation technology are in following major areas:

- Increase in size of flotation cells with better energy efficient design,
- Development of specialty reagents for particular application or specific type of ore,
- Research oriented towards better understanding of surface chemistry and micro processes involved and kinetics of flotation with respect to variables,
- On-line chemical analysis, automatic process control and computer applications. E.g. below is given table of concepts adopted in Hindustan Zinc Ltd., Zawar Mines, Complex copper-lead-zinc ore beneficiation plant.

Table 2.Design parameters of Hindustan Zinc Ltd., Zawar Mines

Product	Grade	Recovery
Feed	1.6 – 2.6 % Pb	100%
	5.4 – 9% Zn	
Lead Concentrate	50 % Pb	74 -80 % Pb
Zinc Concentrate	53 % Zn	82 – 87 % Zn
Note: These parameters are limited due to various problems on metallurgical aspect		

Based on the parameters given on table 2, the lead contents into lead concentrate, respectively zinc contents into zinc concentrate, and has been increased about 25% for lead, respectively 30% for zinc.

Improving of flotation process i.e. increasing of metals recovery from ore, behind of economic benefits has also positive impact on environment, due of reduction of the heavy metals into tailing material.

Another typical example of improving of flotation process, through of performance of control system (PCF) is given for the flotation of a complex lead-silver-zinc sulfide ore from Mengzi Mining and Metallurgy Group, Yunan Province, China (see table, 3).

Table 3. Flotation performance before and after adoption of PCF flotation strategy

Mine	Flotation technology	Time	Raw ore		Concentrate		Recovery/%	
			w(Pb)/%	w(Ag)/(g·t^{-1})	w(Pb)/%	w(Ag)/(g·t^{-1})	Pb	Ag
Nanjing Lead-zinc-silver ore	PCF	1998–1999	2.93	70	58.97	537	89.13	36.68
	Traditional	1997	3.31	82	52.10	743	85.81	51.50

Other practices associated with the efficiency of flotation, are linked with the process of grinding the ore, respectively with granulation of milled ore (fig. 2), higher metal recovery is achieving with granulation between 5-10 microns).

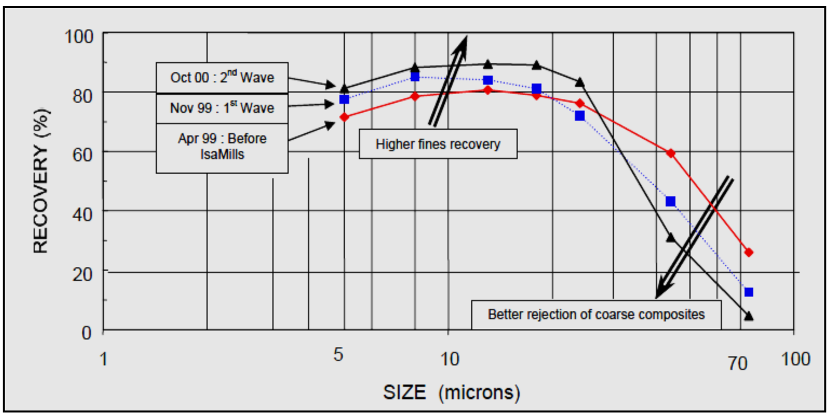

Figure 2. Increased fines recovery after fine grinding in the "IsaMills"

While the flotation process at Kizhnica facility, operates with ore's granulation less than 100 microns, and in the best case achieves size of 70 microns (source: interview with management of the Kizhnica flotation facility - Trepça, 2013).

3. METALS RECOVERY TO THE KIZHNICA FLOTATION FACILITY

The performance of metals recovery to the Kizhnica flotation facility is given in table, 4:

Table 4: Performance of the Kizhnica flotation facility

Product	Grade	Recovery	Lead flow into tailing	Zinc flow into tailing
Lead	2.7 %	-	0.50 %	0.90 %
Zinc	3.6 %	-		
Lead Concentrate	-	60 %		
Zinc Concentrate	-	44%		
Source: Trepça complex – Kizhnica flotation facility, 2014				

Considering the seniority of the flotation facility to Kizhnica and lack of investment for a long time, the author assumes that its performance is even more sits (grade of lead and zinc, recovery) while flow of the lead and zinc into tailing material is even higher.

3.1. Comparison of metals recovery to the Kizhnica flotation facility with international practices

On figure 3, is given performance of the comparability of the Kizhnica flotation facility, with international practices, considering lead and zinc extraction (recovery) from the ore.

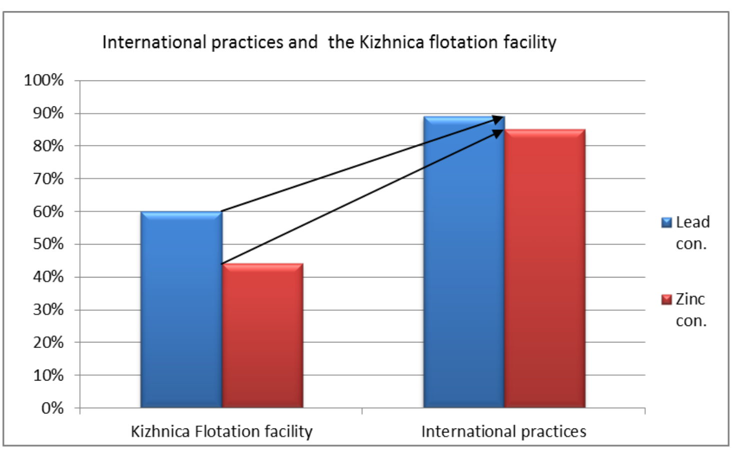

Figure 3. Metals recovery - Kizhnica flotation facility's performance and International practices

As is shown on the figure, 3 the performance of the Kizhnica flotation facility is quite sits, compare with international practices. Indeed, recovery of lead from the ore is less than about 30%; respectively recovery of zinc from ore is less than about 25%.

In subsequent text are given relevant data which describes the lower performance of the Kizhnica flotation facility in relation with international standards and practices:

- Lead concentrate (recovery), 60%; while according to international practices, 74-80%
- Zinc concentrate (recovery), 44%; while according to international practice, 82-87%
- Lead flow into tailing material, 0.50%,
- Zinc flow into tailing material, 0.90%,

3.2. Impact of Kizhnica flotation performance on to environment and economy

The lower performance of the Kizhnica flotation facility, besides of losses of the certain metals (lead and zinc) during the process of the flotation, directly is reflected on the economical aspect of the mine, these losses i.e. lead and zinc flows into tailing material, in such a level have had, and continue to have negative impact also into environment.

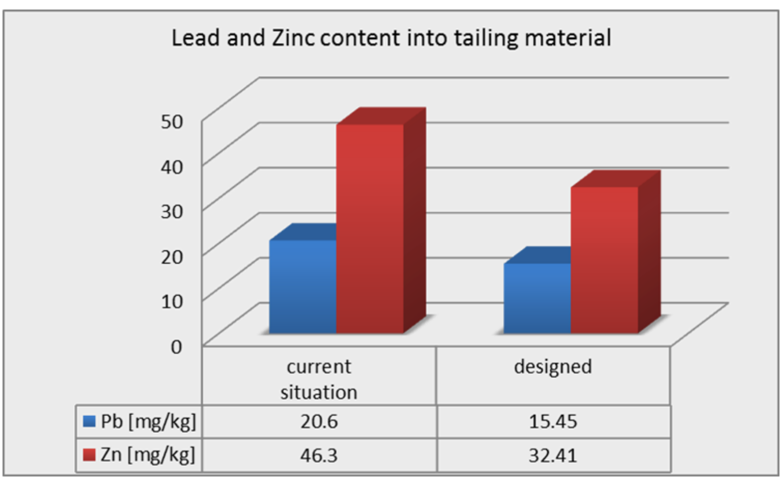

Figure 4. Lead and zinc flows into tailing, and projection based on international practices.

Thus, Kizhnica tailings facility have about 25% more lead and zinc in the tailing, compare to the international practices, while in the environmental aspect means; that society will deal with more than 25% of the heavy metals of Pb and Zn into environment, compare with international practices, while from economic standpoint, the company will have 25% less of Pb and Zn into metallurgical process, i.e. 25% less of Pb and Zn in final products (fig. 4).

4. CONCLUSIONS

There is no doubt that efficiency of the Kizhnica tailing facility is far from the international practices.
According to the international practices (figure, 2) the higher efficiency of metals recovery in the flotation process is under granulation 5 to 10 microns. So, in case of Kizhnica flotation facility, means that investigation should be focused in the milling process, as well as the flotation process must be investigated as a chain process of grinding-milling and froth flotation.
Automatization of the flotation process must be taken into consideration, performance of control system (PCF), on-line chemical analysis, automatic process control and computer application, enable easier intervention in the process of flotation.
Realizing of studies towards of better understanding of chemistry of the ore i.e. granulitic composition of the ore, as well as micro-process and kinetics of flotation, creates condition for development of special reagents to particular application based on specifics of the ore. This way, is likely to mitigate excessive use of reagents, which sometimes may have more negative impact in environment, than heavy metals itself (e.g. cyanide). Otherwise, future designs should consider possibilities of extraction (utilization) of elements already present in the ore, such as: In, Ga, Cu, As, Ni, Co, Tl, Se, Sb, Sn, Bi, etc. this will reflect positively both in economical aspect, as well as in environmental aspect.

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