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Effect of water quality on the performance of the galena and blend flotation: case of Draa Sfar complex sulphide ore, Morocco.

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Abstract

To contribute to the process optimization project of MCG (Mining Company of Guemassa-Marrakech, Morocco), a study was carried out on the effect of water quality on the performance of galena and blend flotation of a complex sulfide ore.

The obtained results, in view to reuse tailings dam water in the flotation plant, showed that the mixture between the two types of water (Clear and tailings dam waters) in Pb circuit provides a lead recovery (71 %) with a good quality of the final concentrate and selectivity toward (Cu, Zn and Fe). In the case of Zn circuit, the tailings dam water gives a good Zn recovery compared to those obtained in the case of clear water (70 %), but a low quality of the final Zn concentrate (42%) than in the case of clear water (48%) and the mixture water (45%).

Keywords: *lead flotation, Zinc flotation, process water recycling, complex sulphide ore***.**

1. Introduction

Water is an essential ingredient in mineral processing. Grinding, flotation, gravity concentration and hydrometallurgical processes use large volumes of water (water represents 80% of the volume of the pulp). The main reasons for using water in mineral processing are:

- Water is an efficient and low-cost medium for mineral particles transport through and between different parts of the process, particles mixing and for the addition of reagents into the pulp;
- It allows the transport of chemical reagents and their interaction with the mineral particle surfaces.

Water management in the mining industry is increasingly demanded in view of increasing water use. For economic and supply reasons, and in order to minimize the discharge of waste water in the environment, mineral processing plants reuse more water to reduce fresh water demand [1, 2, 3, 4, 5, 6, 7, 8, 9]. Water recycling is, however, easier for simple flotation than for the differential one of several sulphides. So, it is necessary to make compatible the quality of recycled water with that required by the selective flotation. In froth flotation, the recycled process water can have adverse effects on performance of the mineral separation process and especially at the selective flotation [10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21]. This detrimental impact of the quality of water process on the ore flotation can be attributed to numerous factors [22, 23, 24, 25, 26] as:

- The adsorption and/or precipitation of inorganic and organic species present in the water process on the minerals surface;
- The chemical reactions between the constituents of water process and the chemical species present on the surface mineral;
- The interactions between the chemical and microbiological species present in the water process and the reagents added in solution during the mineral processing;

In the mineral processing plants, the main recycled process waters are: tailings dams, thickener overflows, dewatering and filtration units. The recycled process water contains typical contaminants such as colloids (Silicates, clays, precipitated metal hydroxides, etc.), ions of base metals (Cu^{2+}, Zn^{2+}, Pb^{2+}…etc.), sulfite and sulfate (SO_3^{2-}, SO_4^{2-}), magnesium (Mg^{2+}), calcium (Ca^{2+}), sodium (Na^+) and potassium (K^+), as well as residual reagents such as frothers, collectors and depressants [27, 28]. In Morocco, semi-arid to arid climate makes water as a limited and precious resource. According to data from the Haouz Tensift Basin Agency (HTBA), the region of Marrakech (Morocco) is characterized by low and irregular rainfall (250 mm/year) with a high evaporation rate (2,500 mm/year). The Mining Company of Guemassa (MCG), located 30 km south west of Marrakech, Morocco, using a flotation process, is affected by this issue of water shortage. Flotation process of a complex polymetallic sulphide ore in MCG aims to produce selectively a concentrate of galena (with Aerophine A3418 using NaCN), then a concentrate of chalcopyrite (with Aerophine A3418) and finally a concentrate of sphalerite (with Potassium Amyl Xanthate; PAX). The aim of this study is to determine the effect of the tailings dam waters on the grade and recovery in the lead and zinc flotation, as well as to maximize its use in different process steps.

2. Materials and methods

2.1. Methodology

The methodology we adopted is focused in two key areas:

- Conduct flotation tests of lead and zinc in laboratory scale using fresh water and then the tailings dam water alone for quantifying the effect of the nature of the water on the flotation performance;

- Conduct tests with the mixing of these waters (50 % of fresh water + 50 % of tailing dam water) in view to increase the amount of the recycled one without treatment.

2.2. Materials

The instruments used in the flotation tests are:

- A Outokumpu flotation cell of 5.50 liters capacity (Figure 1);
- A densiometer
- A pH meter.

Figure 1. Flotation cell used.

2.3. Mineral samples

2.3.1. Ore

Flotation tests were carried out on a representative sample of a complex sulphide ore composed of 6.43% sphalerite (Sp: ZnS), 2.22% galena (Gl: PbS), 0.95% chalcopyrite (Cp: $CuFeS_2$), 41.57% pyrrhotite (Po: Fe_9S_{10}), and 48.82% gangue (Gg) consisting mainly of silica, carbonates, and chlorides [10,15, 29].

2.3.2. Sample preparation

Lead rougher

The samples used are taken at the outlet of the ball mill (primary grinding) with a particle size about d80 = 120 microns, then filter to eliminate the water contained in the pulp. The tests are carried out by using of freshwater and tailings dam water.

Lead and Zinc cleaner

In this processing step, representative samples are taken from the feed of each processing step before being filtered and stored in plastic bags to avoid oxidation.

2.4. Water

Water used in flotation tests was the same feed as the processing plant. The clear water was taken from the pelvis that contains the mixture of three types of waters (mine drainage, drilling and dam located few kilometers of the mine site) while the waters of the tailings dam were collected from the conduct that feeds the zinc roughing circuit.

2.5. Process conditions

2.5.1. Lead circuit

Operating conditions used in all tests in the lead circuit are those used in the plant. These conditions are shown in Tables 1 and 2.

2.5.2. Zinc cleaning stages

Operating conditions of the flotation tests of zinc cleaning stages are given in Table 3.

Table 1.Operating conditions of the flotation tests in lead rougher stage.

	Type of used water		
	Clear	Tailings dam	Mixture
Solid mass (g)	3000	3000	3000
V_{water} (ml)	3800	3800	3800
pH	9.48 – 10	9.48 - 10	9.48 - 10
d_{pulp}	1.5	1.5	1.5
Reagents	NaCN = 100 g/t A3418 = 40 g/t Lime + MIBC	NaCN = 100 g/t A3418 = 40 g/t Lime + MIBC	NaCN = 100 g/t A3418 = 40 g/t MIBC
Flotation time (min)	6	6	6

Table 2.Operating conditions of the flotation tests in lead cleaning stages.

	Type of used water		
	Clear	Tailings dam	Mixture
V_{water} (ml)	3800	3800	3800
pH	12 - 12.3	12 - 12.3	12 - 12.3
d_{pulp}	1.4	1.4	1.4
Reagents	NaCN = 180 g/t A3418 = 150 g/t Lime + MIBC	NaCN = 180 g/t A3418 = 150 g/t Lime + MIBC	NaCN = 180 g/t A3418 = 150 g/t MIBC
Flotation time (min)	6	6	6

Table 3.Operating conditions of the flotation tests in the zinc cleaning stages.

	Type of used water		
	Clear	Tailings dam	Mixture
Solid mass (g)	3000	3000	3000
V_{water} (ml)	4000	4000	4000
pH	12.2 - 13.4	12.2 - 13.4	12.2 - 13.4
d_{pulp}	1.35 – 1.45	1.35 – 1.45	1.35 – 1.45
Reagents	AXK = 170 g/t CuSO4 = 360 g/t Lime MIBC	AXK = 170 g/t CuSO4 = 360 g/t Lime MIBC	AXK = 170 g/t CuSO4 = 36 g/t Lime MIBC
Flotation time (min)	7	7	7

3. Results and Discussion

3.1. Lead circuit

3.1.1. Effect of the nature of water on the Lead recovery

After the realization of flotation tests, all concentrates and tails were filtered, dried, and weighed, and then analyzed by atomic adsorption spectroscopy (AAS) for Cu, Pb, Zn, and Fe.

Lead roughers:

In this processing step (Figure 2) shows that the recovery of lead appears to be the same in both cases (73% for the water of the tailing dam and 68% for clear water). The same observation can be made for the recovery of zinc (19% and 18%) and iron (10% and 8%).

Copper has an increase (almost 100%) with the use of the tailing dam water. This is due to the activation of the chalcopyrite which negatively affects the quality of lead concentrate. This effect disappears completely when using the mixture of water (clear and tailing dam) which generates copper recovery yields (15%) similar to those obtained in the case of clear water (17 %).

Finally, we can say that the mixture of the two types of water at the rougher, allows having a lead concentrate with a good yield and good quality (selectivity).

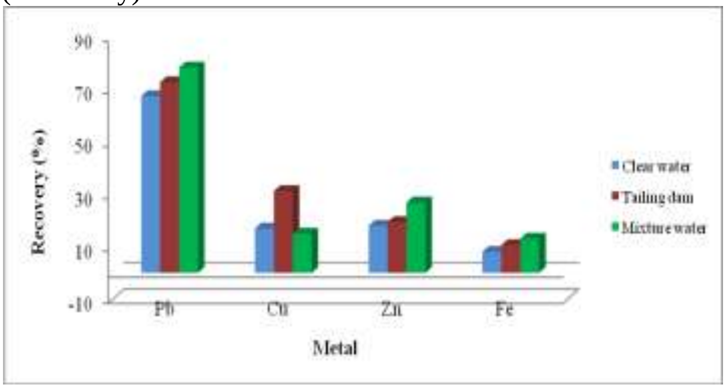

Figure 2. Metal recoveries vs. type of used water in Lead rougher stage.

Lead cleaning stages:

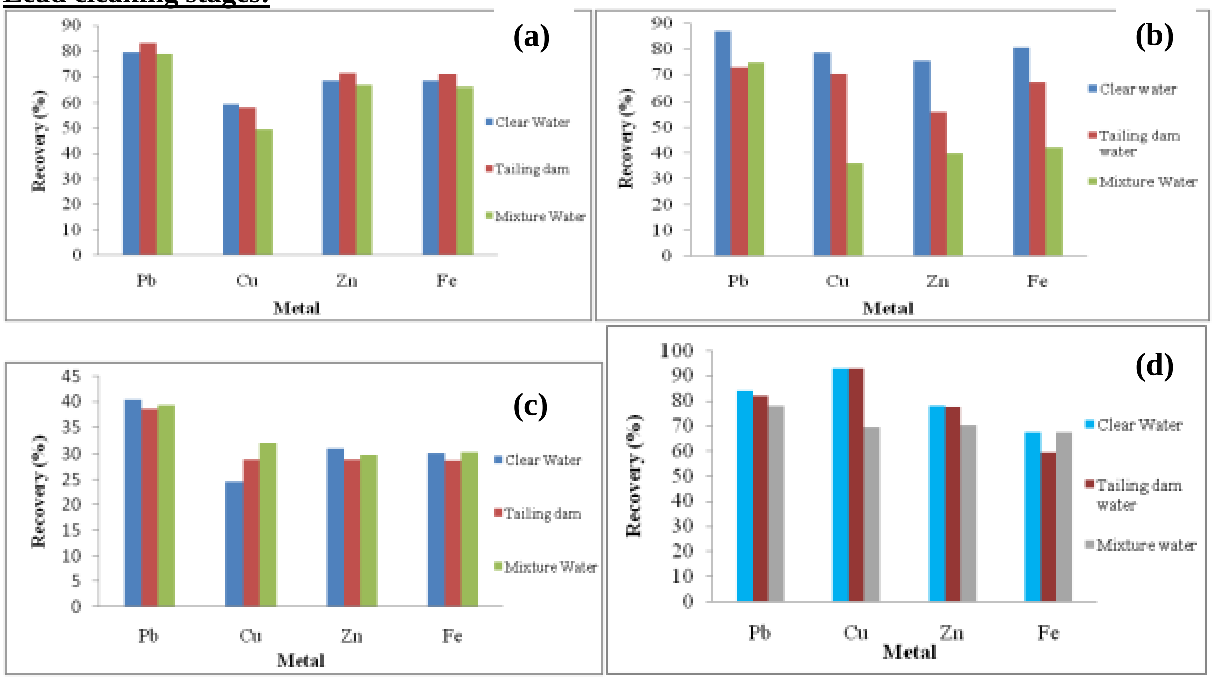

Figure 3. Metal recoveries vs. type of used water in Lead rougher stage: (a) 1rst Cleaner, (b) 2nd Cleaner, (c) 3rd Cleaner and (d) 4th Lead Cleaner.

The results of the flotation tests in the four lead cleaning stages are shown in the graphs below (Figure 3).From these results we see that the use of different types of water (clear, tailing dam or mixture) gave the comparable recoveries of Pb, Cu, Zn and Fe in four lead cleaning stages. The exception is the second cleaner may be due to a change in the nature of the feed ore.

3.1.2. Effect of the nature of water on the froth quality

Analyzed froth quality for all stages of the lead circuit (Figure 4) showed that the three types of water give the comparable concentrates qualities for the first three steps (Rougher, 1^{rst} Cleaner and 2nd Cleaner) whereas in the last two stages (3rd and 4th) the negative effect of tailings dam water is obvious. Indeed, the tailings dam water gives a final concentrate of lower quality (43 %) than clear water (46%) and the mixture (46%). These results show that the use of tailings dam water alone promotes the activation of blend and pyrite because of the presence of elements as Cu^{2+} and Pb^{2+} [18, 30, 31, 32] in high concentrations relative to the mixture water. So one can recommend the use of the mixture (clear water + tailings dam water) in the second cleaner and then use the clear water in the 3rd and 4th cleaner to improve the quality of the final lead concentrate.

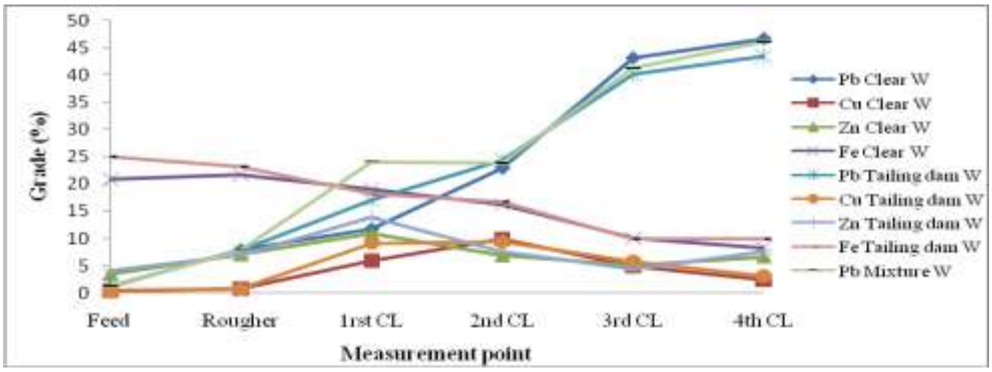

Figure 4. Effect of the type of water on the froth quality.

3.2. Zinc circuit

As in the case of lead circuit were carried the flotation tests in the zinc cleaning circuit using the three types of water. The results are presented in Figure 5. From these results, one can find that the use of the tailings dam waters and the mixture give a comparable zinc recovery to those obtained in the case of clear water within five cleaners.

Regarding the quality of the Zn concentrate, the results obtained (Figure 6) show that the use of tailings dam water gives a final concentrate of lower quality (42%) than in the case of clear water (48%) or the mixture (45%).

Water mixture can so be used especially in the first four cleaners of zinc and thereafter the clear water in the 5th cleaner to improve the quality of the final concentrate.

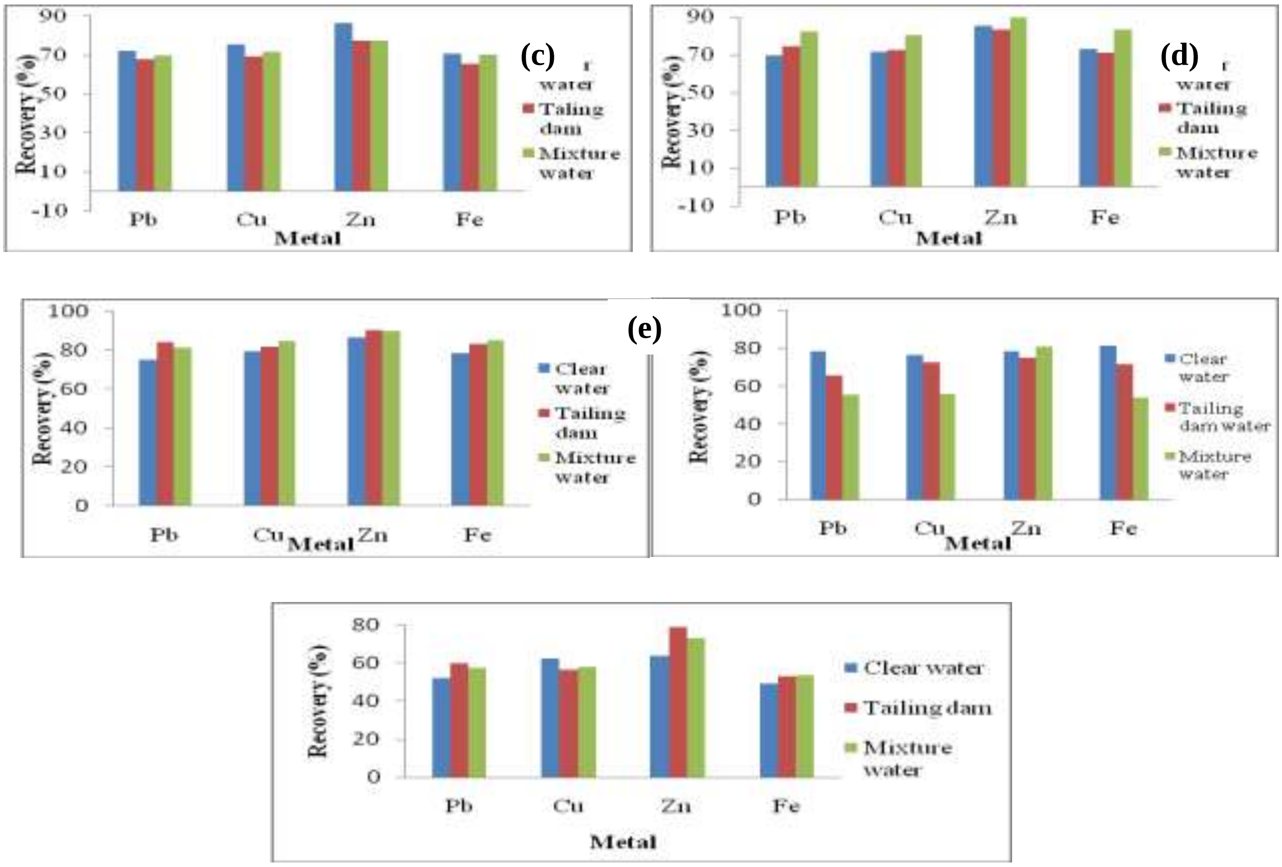

Figure 5. Metal recoveries vs. type of used water in zinc circuit (a) 1st Cleaner, (b) 2nd Cleaner, (c) 3rd Cleaner, (d) 4th Lead Cleaner and (e) 5th cleaner.

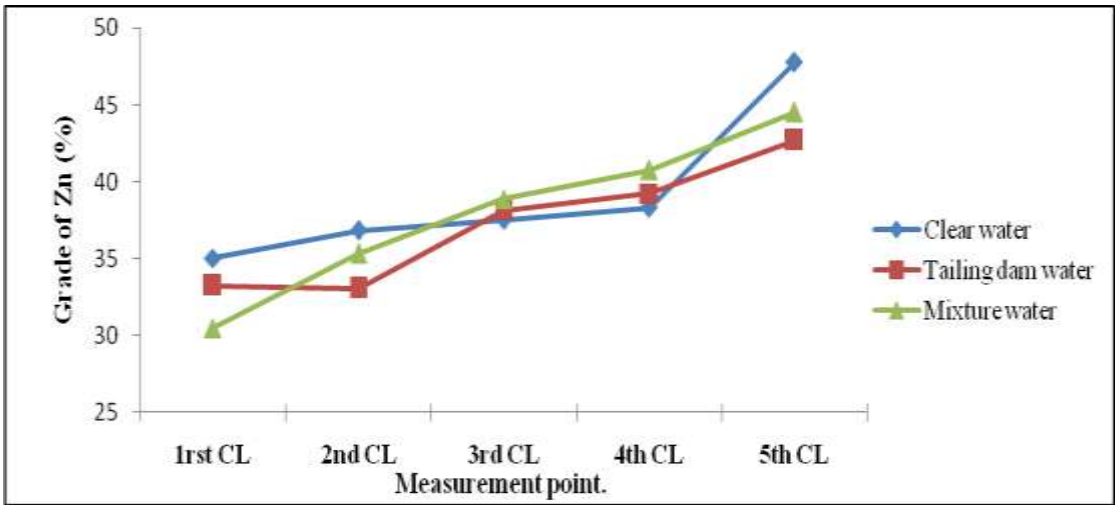

Figure 6. Zinc concentrate grade evolution vs. type of used water.

4. Conclusion

Obtained results of batch scale flotation tests, performed on MCG Pb-Cu-Zn complex sulphide ore to study the influence of water quality on the flotation performance of galena and blend during Pb and Zn flotation step, showed that:

- Mixture water (50 % of tailings water dam + 50% of clear water) at the lead rougher stage gives a good recovery and quality in the concentrate.

- In the four lead cleaning stages, the different types of water (clear, tailings water dam or mixture) gave the comparable recoveries of galena, chalcopyrite, blend and pyrite.
- In Zn circuit, tailings dam water gives a good Zn recovery compared to those obtained in the case of clear water (≈ 70 %), but a low quality of the final Zn concentrate (42 %) than in the case of clear water (48 %) and the mixture water (45%).

So, the economy of the use of fresh water can be reached by its substitution with tailings dam and mixture waters.

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