Control of Sulfide Oxidation and its Effect in Galena Flotation

Alireza Javadi*

Mining group, Engineering Department, University of Kashan, Kashan, Iran

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Abstract

Pyrite (FeS_2), chalcopyrite (CuFeS_2), sphalerite (ZnS) and galena (PbS) generate hydrogen peroxide (H_2O_2) when placed in water, that pyrite the most amount of H_2O_2 . The order of these minerals for generate of H_2O_2 in presence water is pyrite > chalcopyrite > sphalerite > galena. In the previous research, the methods of generation of H_2O_2 in the grinding mill have been studied but its effect on the oxidation of pulp components and hence in deteriorating the concentrate grade and recovery in flotation has not been explored yet. In this study, some parameters investigated to control the deleterious effects of H_2O_2 in flotation. The data from experimental have been attached by using MODDE 9 software for 6 parameters consist of composition of water, grinding media, particle size, pH, adding collector among the grinding, adding depressant. Finally, the optimize condition has been achieved: particle size 75μ , process water, adding all collector, without depressant and pH 10. These changes in flotation response of sulphides have been discussed and explained with the formation of H_2O_2 quantitatively and the results are presented and discussed in terms of H_2O_2 generation vis-à-vis concentrate grade and recovery in flotation.

1. Introduction

Recently, most researchers have concentrated on oxidation products and levels of sulfide minerals. It was reported that oxidation products of sulfide minerals were affected by pulp potential and pH as well as time. Presence of oxygen in pulp in the initial stages of flotation is harmful. Gaudin (1932) is thought to produce oxidation of the sulfide surface of the sulfur-oxygen species, which is further transformed with collector ion to form a metal salt [1]. Plaksin et al. (1957) found that the oxygen content was consumed of free electrons at the galena surface, and the surface of the galena will be changed from type n to type p, which led to the absorption of Xanthogen at ions due to the vacancy on the galena semiconductor type p [2]. Most importantly, Keetchener and Tolun [3] and Majima [4] found that the presence of oxygen is as an essential cathode component for electrochemical reactions at the surface of sulfide in electrochemical theory. Our recent studies have illustrated the formation of hydrogen peroxide (H_2O_2), an oxidizing agent stronger than oxygen, by metal-sulphides [5-8]. It was found that pyrite (FeS_2), chalcopyrite (CuFeS_2), sphalerite ($(\text{Zn}, \text{Fe})\text{S}$), and galena (PbS), which are the most abundant sulphide minerals on Earth, generated H_2O_2 in pulp liquid during wet grinding in the presence or absence of dissolved oxygen in water and also when the freshly ground solids are placed in water immediately after dry grinding. Pyrite generated more H_2O_2 than other sulphide minerals and the order of H_2O_2 production by the minerals found to be pyrite > chalcopyrite > sphalerite > galena.

1.1. Formation of hydrogen peroxide

The formation of hydrogen peroxide occurred when the freshly dry grounded and were mixed in water. The effect of water pH on the formation of hydrogen peroxide is shown in Figure 1. It shows that the concentration of H_2O_2 decreases with pH up to 8, in presence of pyrite, chalcopyrite and sphalerite, but in the case of galena, H_2O_2 was only produced at a pH less than 4.5. Also, pyrite produces the most H_2O_2 than other minerals.

Figure 1. Hydrogen peroxide formation by sulfide minerals

1.2. Effect of hydrogen peroxide on galena flotation

Figures 3 and 4 show the effect of pulp potential and hydrogen peroxide concentration on galena and chalcopyrite flotation. It appears that Figure 3 shows that high-flotation capture chalcopyrite has 0.4-0.7 Volt potential range that is tuned to hydrogen peroxide and reduces the ability to float the galena by increasing potentials. Figure 4 shows that galena is completely arrested and chalcopyrite is floating if the concentration of hydrogen peroxide is above 3-10 mol/l. It is suggested that the conditions for the separation of chalcopyrite flotation from galena at pulp potentials greater than 0.65 V at pH greater than 7 with hydrogen peroxide.

Figure 3. Recovery of chalcopyrite and galena flotation due to the hydrogen peroxide adjusted potential pH 9.5 [9].

Figure 4. Recovery of chalcopyrite and galena flotation due to hydrogen peroxide concentration [9]

The depressant activity of the hydrogen peroxide on the galena may be attributed to its oxidizing activity on lead xanthogen at the galena surface, which increases the oxidation and decomposes lead mites.

Therefore, at the critical pH and the concentration of hydrogen peroxide, the complete decomposition of the lead on the galena increases the hydrophilic of the galena surface and captures the galena, while the dioxanthogenate prefix remains stable in chalcopyrite, causing the surface to be chalcopyrite and it is fluttered, which is proved by the method of the voltammogram.

2. Material and methods

The sulphide ore was from Tapeh-Sorkh mine from Bama Mining Company (Bama Co.) that located in 20 kilometers southwest of the city of Isfahan in Central Iran. A bulk ore sample was received in a drum in wet condition and it was dried and crushed in three stages to < 3 mm size and divided into 1 Kg sub-samples using a rotary splitter. A total of 96 samples per kilogram were prepared.

2.1. Design of Experiments

The design of the experiments was done with the MODDE 9.1 software, and the factors affecting the formation of hydrogen peroxide (Table 1) were used in this design. The test was selected to make the model the best, and the software designed 44 tests.

3. Results and discussion

Table 3 shows the results of the flotation test. Analyses showed that the results were excellent, which increased the factory recovery. Figure 5 shows that which parameter has a positive or negative effect on lead recovery. The graph shows that the grinding media have the greatest effect, and the grinding media have a positive effect, and steel grinding media have a negative effect. It was also shown that the addition of choke in the grinding medium has a positive effect on lead, but the addition of the detainer has a negative effect. The particle size of 75 microns has a positive effect, but the particle size of 150 microns has a negative effect due to galena particles are heavy and particles larger than 75 microns do not float well by bubbles. Process Water and pH have positive effect, but distilled water has negative effect.

Table 1. Factors affecting the formation of hydrogen peroxide

Name	Abbr.	Units	Type	Settings
grinding media	gri		Qualitative	SS, MS
pH	pH		Quantitative	8 to 10
collector in mill	coll	%	Quantitative	0 to 100
depressant in mill	de	%	Quantitative	0 to 100
d ₈₀	d80		Qualitative	-45 μm, -75 μm, -150 μm
water type	H2O		Qualitative	Deionised, tap, process

Figure 6 shows the effect of grinding media on lead recovery. The graph shows that stainless steel grinding media have the most recovery in lead, iron in lead concentrate and zinc in lead concentrate. Peng observed that the oxidation reduction environment during grinding is strongly linked to the presence of dissolved iron species from the grinding media [10].

Figure 5. Effective parameters on lead recovery

Table 2. Designing experiments

Exp Name	Run Order	grinding media	pH	collector in mill	depressant in mill	d ₈₀ (μm)	water type
N1	27	SS	8	0	0	-45	Deionised
N2	43	SS	10	100	100	-45	Deionised
N3	35	MS	10	100	0	-45	Deionised
N4	11	MS	10	0	100	-45	Deionised
N5	30	MS	8	100	100	-45	Deionised
N6	37	SS	10	0	0	-75	Deionised
N7	14	SS	8	100	0	-75	Deionised
N8	34	SS	8	0	100	-75	Deionised
N9	5	MS	8	0	0	-75	Deionised
N10	31	MS	10	100	100	-75	Deionised
N11	18	SS	8	100	0	-150	Deionised
N12	1	SS	8	0	100	-150	Deionised
N13	23	MS	10	0	0	-150	Deionised
N14	21	MS	10	100	100	-150	Deionised
N15	6	SS	10	100	0	-45	tap
N16	32	SS	8	0	100	-45	tap
N17	3	MS	8	0	0	-45	tap
N18	38	MS	10	100	100	-45	tap
N19	15	SS	10	0	100	-75	tap
N20	7	SS	8	100	100	-75	tap
N21	33	MS	10	100	0	-75	tap
N22	2	MS	8	0	100	-75	tap
N23	40	SS	8	0	0	-150	tap
N24	24	SS	10	100	100	-150	tap
N25	22	MS	10	0	0	-150	tap
N26	19	MS	8	100	0	-150	tap
N27	4	MS	8	0	100	-150	tap
N28	29	SS	10	0	0	-45	process
N29	26	SS	8	100	0	-45	process
N30	39	MS	8	0	100	-45	process
N31	41	MS	10	100	100	-45	process
N32	9	SS	8	0	0	-75	process
N33	42	SS	10	100	100	-75	process
N34	10	MS	10	0	0	-75	process
N35	44	MS	8	100	0	-75	process
N36	16	MS	8	100	100	-75	process
N37	12	SS	10	100	0	-150	process
N38	17	SS	10	0	100	-150	process
N39	36	SS	8	100	100	-150	process
N40	20	MS	8	0	0	-150	process
N41	25	MS	10	0	100	-150	process
N42	13	MS	9	50	50	-150	process
N43	8	MS	9	50	50	-150	process
N44	28	MS	9	50	50	-150	process

Table 3. The results of the flotation test

Exp Name	Pb %	FePb %	ZnPb %	Eh Flotation
N1	85.84	31.31	79.18	242
N2	89.39	30.26	78	214
N3	88.41	39.34	60.84	210
N4	86.56	27.19	78.45	195
N5	77.63	14.43	48.11	192
N6	87.46	23.49	74.39	237
N7	88.97	30.69	54.32	229
N8	94.79	24.46	80.22	214
N9	81.14	17.99	25.55	199
N10	89.42	19.58	49.19	188
N11	93.61	20.41	43.79	226
N12	92.73	19.66	66.75	218
N13	80.14	12.45	19.32	200
N14	87.24	19.44	68.3	197
N15	94.52	37.29	64.7	226
N16	92.1	29.37	85.85	214
N17	83.77	18.51	22.48	156
N18	85.9	25.82	50.79	72
N19	93.74	26	81.42	218
N20	91.68	26.22	64.53	221
N21	90.59	23.82	32.16	190
N22	85.58	17.88	36.12	184
N23	86.86	22.33	59.04	232
N24	91.87	23.02	62.45	218
N25	82.45	13.75	15.35	195
N26	90.29	18.28	37.14	196
N27	82.24	11.92	35.79	205
N28	95.34	24.28	52.75	220
N29	96.55	24.76	75.66	189
N30	89.49	26.98	80.16	10
N31	13.12	25.71	65.01	80
N32	94.36	19.64	29.82	222
N33	96.07	21.34	56.07	187
N34	89.69	24.73	32.83	110
N35	90.53	26.43	44.98	72
N36	87.74	22.17	37.7	50
N37	93.88	21.78	37.92	199
N38	88.94	16.53	52.63	199
N39	92.64	17.19	35.25	215
N40	79.93	13.3	17.77	164
N41	80.6	19.63	37.33	160
N42	83.85	20.39	29.89	92
N43	82.36	17.93	23.07	80
N44	77.18	14.22	19.43	101

Figure 6. The effect of grinding media on lead recovery

Figure 7. Effect of pH on recovery

Figure 8 shows the effect of the addition of a collector in a grinding environment on different parameters. The diagram shows that addition of the collector has the most recovery in lead concentrate and more iron content in lead concentrate, but adding the collector has not any effect on zinc percent in lead concentrate due to adding collector during grinding where freshly broken mineral surfaces are produced, and therefore interact with surfaces before they are oxidized, is also thought to be beneficial [11].

Figure 8. Effect of adding collector to grinding environment on lead recovery.

Figure 9 shows the effect of adding depressants to grinding environment on various parameters. The diagram shows that the addition of the depressant has not any effect on lead recovery, but decreases iron content in lead concentrate and increases zinc content in lead concentrate. Zinc sulphate has been also used as a depressant, mainly to depress sphalerite flotation [12-13].

Figure 9. The effect of adding depressant to the grinding environment and recovery.

Figure 10 shows the effect of particle size on various parameters. The graph shows that the particle size of 75 microns has the highest lead

recovery but the particle size of 150 microns has the lowest content of iron and zinc in lead concentrate.

Figure 10. The effect of particle size on lead recovery

Figure 11 shows the effect of water type in grinding environment with different parameters. The diagram shows that the water process has the highest lead recovery and lowest zinc and iron content in lead concentrate. It can also be observed that the mineral is generally depressed in process water; this could be due to the presence of a number of species including SO_4^{2-} , SO_3^{2-} [14], dissolved iron [15] in the process water which could form hydrophylic layers or iron oxidation species.

Figure 11. Effect of water type in grinding environment on lead recovery

Figure 12 show recovery of lead. It shows that experiments 29 and 33 have the most recovery in lead.

Figure 12. Lead recovery according to designed tests

4. Conclusion

The present paper build correlation between percentages of sulfides in the concentrate, grinding conditions and concentration of OH radical / H₂O₂ in the pulp as well as to study possible ways of flexibly controlling the formation of these species through known chemical means. The present paper reports our first results in our plan of work and it is the first time that consideration of H₂O₂ species is looked into flotation studies. In this work 6 parameters consist of composition of water, grinding media, particle size, adding collector among the grinding, adding depressant and pH was investigated. Finally, the optimize condition has been achieved. According to the results, the most recovery is related to the particle with 75 μ size and in the case of using of process water with adding all collector and without depressant and pH 10. The most recovery of lead in the case of use of fresh water is adding all collector, without depressant, pH 10 and 150 μ particle size. Maximum recovery in fraction size 45 μ in the case of water process is adding all collector, without depressant and pH 10. Maximum depressant of pyrite was in the fraction size 75 μ , distilled water, without collector, adding all depressant.

Declaration of Conflict of Interests

The author declares that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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