Improvement of reagent flotation modes of sphalerite and pyrite from deposits of copper-zinc pyrite, polymetallic copper-zinc pyrite and polymetallic ores

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Abstract. Copper-zinc pyrite (Sulphide) and polymetallic ores of Russia are complex and difficult to process mineral raw materials. The main technology for the enrichment of this ores are flotation. Currently, the improvement of the flotation technology of this mineral raw materials is carried out in several way. It has been established by the practice of beneficiation of copper-zinc ores that obtaining high-quality zinc and pyrite concentrates is impossible without adding flotation modifiers of sphalerite and pyrite to various flotation operations. This reagent are copper (II) sulfates, zinc and iron (II) sulfates in an alkaline calcareous medium. Therefore, studies on the flotation of sphalerite and pyrite in an alkaline calcareous medium with the addition of one of these metal sulfates to the mineral flotation operation were performed. The effect of each copper (II) sulfates, zinc, and iron (II) on the flotability of sphalerite and pyrite was studied during flotation of the mineral and xanthate and dithiophosphate at pH = 8, 10, and 12. The aim of this work was to study the effect of the flotation size class (- 0.074 + 0.044 mm) sphalerite and pyrite of one of the Russian deposits by sulfhydryl collectors in the presence of copper, zinc and iron sulfates in the liquid phase of flotation pulp.

1. Introduction

Enrichment is not a final technological process in the chain of obtaining finished goods (metal). Consequently, further costs (material, time, labor, etc.) in subsequent technological chains depend on the quality of the produced concentrate [1]. It should be noted that the quality of the concentrate depends on the previous productions; ore preparation quality; the enrichment method and the reagents used in the enrichment process [2, 3].

So in the process of extracting minerals from the bowels in order to minimize losses [4], increase the safety of underground mining [5], control the stress-strain state of the rock mass [6], utilize man-made waste [7, 8] use systems with backfilling space.

With all the positive factors of the application of geotechnology with backfill, it has a negative consequence for the subsequent enrichment process [9]. The ingress of filling material into the ore leads to a decrease in the quality of the concentrate, an increase in the consumption of the reagent and an increase in the cost of the ore preparation process. To ensure a high-quality and uninterrupted beneficiation process, it is necessary to pay attention to: improving the quality of ore crushing [10, 11]; controlling the grain size in ore [12], uninterrupted and dosed supply of ore to the beneficiation...
plant [13, 14]; carrying out preliminary activation treatment of ore [15 - 17] and the selection of chemical reagents [18 - 21].

It should be noted that the choice of reagents can neutralize the low quality of the supplied ore [18, 22].

Therefore, the selection variety of chemical reagents, including collectors, foaming agents, surface modifiers and pH adjusters is a fundamental task. Without reagents, there would be no flotation, and without flotation, the mining industry, as we know it today, would not exist [23]. Froth flotation separation involves many types of reagents. Reagents are mainly used to prepare the surface of ores and/or to improve operating conditions and to increase the efficiency of flotation separation [24]. Reagents can affect the chemical composition of the pulp and turn flotation into a complex system that includes the interaction of all additives (including collectors, depressants, activators, pH regulators and foaming agents) [25]. Froth flotation reagents can remain on the products (suspension, tailing and concentrate) and lead to many environmental problems [26 – 28] or have a big impact on subsequent processes, such as biological leaching. Therefore, fundamental knowledge about chemical reagents, the development of their new types, their use for various conditions, as well as the study of minerals and surface chemistry in the presence of various reagents are typical and important studies in the extraction of minerals.

The work of the indicated classes of sulfhydryl collectors on the flotation of sulfide minerals, as well as studies aimed at improving the flotation technology of copper-zinc and polymetallic ore are the focus of the authors [29 – 32], which indicates the relevance of the research problem.

The main collectors of copper-zinc pyrite ores for froth flotation are xanthates and alkali metal dithiophosphates [33]. Therefore, potassium butyl xanthate and sodium butyl dithiophosphate were used as collectors in the froth flotation of sphalerite and pyrite.

2. Materials and Methods

A sample of sphalerite and pyrite was crushed by laboratory jaw crusher to a particle size of 5 ± 0 mm, after which dry grinding was performed in a porcelain ball mill with porcelain balls. To isolate various classes of size, a sample of ground pyrite and sphalerite was scattered on a set of sieves to obtain a class of size -0.074 + 0.044 mm.

Froth flotation was carried out by laboratory flotation machine FL-189 that chamber volume is 100 cm³.

A sample of sphalerite and pyrite of the specified size class (5 g) was loaded into the chamber of a flotation machine, in which it was mixed with water of a given pH = 8, 10, 12 (lime, 10 min), and then one of the iron (II) sulfates, copper (II) or zinc (5 min mixed), a collector (potassium butyl xanthate and sodium dithiophosphate 3 min mixed) and a foaming agent (methyl isobutyl carbinol (MIBK) 1 min). Froth flotation was carried out with portioned removal of the foam product. The total flotation time was 5.

3. Results and Discussion

3.1. Flotability of sphalerite and pyrite with xanthates in the presence of copper (II) sulfates, zinc and iron (II) in an alkaline calcareous medium

Figures 1, 2, and 3 show the dependences of the extraction of pyrite and sphalerite on the flow rates of these metal sulfates at pH of mineral suspension of 8, 10, and 12 during flotation of the mineral with potassium butyl xanthate. Collector flow rate was 100 g / t.
As follows from fig. 1(a), With the feeding of copper sulfate into the flotation pulp during flotation of pyrite with potassium butyl xanthate, activation of flotation of pyrite is observed at all studied pH values. At the same time, the maximum activation of flotation is observed at a consumption of copper sulfate 200 g / t of pyrite. At pH = 10, the extraction of pyrite in the foam product increase to 65%. Fig. 1(b) describe consumption rate of copper (II) sulfate from 20 g / t to 800 g / t feed in the flotation pulp during flotation of sphalerite by potassium butyl xanthate, activation of its flotation was observed at all pH values studied. According to this figures that the most activating effect of copper sulfate on pyrite flotation is occured at pH = 10.

From Figure 2(a), show that iron sulfate has a strong activating effect on the pyrite flotation when using potassium butyl xanthate as a collector at pH = 8 and 10. The maximum activation of pyrite flotation is achieved starting from the consumption of iron sulfate 200 g / t. At pH = 12, when iron sulfate feed more than 200 g / t pyrite flotation is depressed. An analysis of Figure 2(b). Show that at pH = 8 with an increase in the consumption of iron (II) sulfate in the flotation pulp from 20 g / t to 800...
g / t during flotation of sphalerite with potassium butyl xanthate, activation of its flotation was observed at pH = 8 and 10. Even more ambiguous is the effect of this reagent at pH = 12. When flotation of sphalerite with xanthate, low reagent consumption strongly activate sphalerite from 2% to 54%. A further increase in the consumption of iron (II) sulfate from 20 g / t to 800 g / t steadily depresses flotation of sphalerite at a level of 12%.

Figure 3 shows the dependences of the extraction of pyrite and sphalerite on the costs of zinc sulfate obtained under similar conditions with the previous ones. Fig. 3(a) describe, when zinc sulfate is feeding into the flotation pulp during the flotation of pyrite with potassium butyl xanthate, the activation of pyrite flotation is also observed at the studied pH = 8 and 10. Moreover, the maximum, but much weaker activation of pyrite flotation is observed at zinc sulfate consumption 400 g / t. At pH = 10, pyrite recovery is increased to 38% in the foam product. Fig. 3(b), show that with an increase consumption rate of zinc sulfate in the flotation pulp from 20 g / t to 800 g / t during flotation of sphalerite with potassium butyl xanthate, activation of its flotation was observed at the studied pH = 8. Upon transition to pH = 10 (Fig. 3b), sulfate zinc exhibits a greater depressing effect on the floatability of sphalerite than at pH = 8. Unlike the first two cases, at pH = 12 (Fig. 3b), the activating effect of zinc sulfate is observed, but the activating one, which is most manifested when using potassium butyl xanthate as a collector.

3.2. Flotability of sphalerite and pyrite by dithiophosphates in the presence of copper (II) sulfates, zinc and iron (II) in an alkaline calcareous medium

Figures 4, 5, and 6 show the dependences of the extraction of pyrite and sphalerite on the consumption rates of these metal sulfates at a pH of the mineral suspension of 8, 10, and 12 during the flotation of the mineral with sodium dithiophosphate. Collector consumption rate was 100 g / t.
When replacing potassium butyl xanthate with butyl sodium dithiophosphate, the activating effect of copper sulfate appears to be significantly weaker at all the studied pH values of the liquid phase. As follows from the figures, the most strongly activating effect of copper sulfate on pyrite flotation is manifested at pH = 10 using any of the studied collectors. When flotation of sphalerite with sodium dithiophosphate rice. 4b., With an increase in the consumption of copper (II) sulfate in the flotation pulp from 20 g / t to 800 g / t during flotation of sphalerite with sodium butyl dithiophosphate, its flotation was activated at all pH values studied. It follows from the figure that the most activating effect of copper sulfate on pyrite flotation is manifested at pH = 8.

Figure 5. The floatability of pyrite with sodium dithiophosphate (a) and the floatability of sphalerite with sodium dithiophosphate (b) depending on the consumption of iron sulfate when using BAF 100 g / t and different pH values.

Figure 5(a) describe, when copper sulfate is feeding into the pulp flotation during pyrite flotation with sodium butyl dithiophosphate, small amounts of iron sulfate (20 g / t) are observed leading to a decrease in pyrite flotation at pH = 8 and 10. An increase in consumption rate to (100 g / t) returns the flotation of pyrite to its flotation with one collector. At pH = 12, the consumption of iron sulfate into the flotation pulp does not effect on the flotation of pyrite. As follows from fig. 5(b), with an increase
the consumption of iron sulfate in the flotation pulp from 20 g / t to 800 g / t during flotation of sphalerite with sodium butyl dithiophosphate, activation of its flotation was observed at the studied pH = 10. Upon transition to pH = 10 (Fig. 5b) sulfate iron exhibits a greater depressing effect on the flotability of sphalerite (200 g / t) than at pH = 8. In contrast to the first two cases, at pH = 12 (Fig. 5b), the activating effect of iron sulfate is observed, but the most pronounced when using butyl sodium dithiophosphate as collector.

Figure 6 shows that the dependences of the extraction of pyrite and sphalerite on the consumption of zinc sulfate obtained under similar conditions with the previous ones. Fig. 6(a) describe, when zinc sulfate is feeding into the flotation pulp during pyrite flotation with sodium butyl dithiophosphate, the activating effect of zinc sulfate is manifested much stronger, especially at pH = 8. However, increasing flotation pH to pH = 12 leads not to the activating but depressing effect of zinc sulfate on pyrite flotation, which is not observed during its xanthate flotation (Fig. 3a). An analysis of Figure 6(b) shows that with an increase in the consumption of zinc sulfate in the flotation pulp from 20 g / t to 800 g / t during flotation of sphalerite with sodium butyl dithiophosphate, its flotation was activated at pH = 8 and 10. At pH = 12, introduction to flotation pulp of zinc sulfate does not affect the floatability of sphalerite.

4. Conclusion
The collective effect of potassium butyl xanthate and butyl sodium dithiophosphate on the flotability of the pyrite and sphalerite at different pH values was studied.

The effect of copper, zinc, and iron sulfate on the flotation of pyrite and sphalerite by two sulfhydryl collectors at a pH of phases 8, 10, and 12 was studied.

The different effect of sulfate on the flotability of pyrite and sphalerite is shown when using potassium butyl xanthate and butyl sodium dithiophosphate as a collector.

The effect of copper, zinc and iron sulfate on the pyrite flotation when using potassium butyl xanthate as a collector with increasing consumption in the flotation pulp from 20 g / t to 800 g / t during pyrite flotation, its flotation activation was observed (200 g / t) during the studied pH values are 8 and 10.

When adding butyl xanthate with butyl sodium dithiophosphate, the effect of copper, iron, and zinc sulfates on the flotation of sphalerite with an increase in flow rate in the flotation pulp from 20 g / t to 800 g / t is activated at a flow rate (100 g / t) of all the studied pH values = 8, 10 and 12.
In the flotation of sphalerite with potassium butyl xanthate, and the effect of copper, zinc, and iron sulfates on the flotation of sphalerite is least manifested at pH = 8; when the flotation pH is 10, the supply of copper and iron sulfate to the flotation activates, and zinc depresses the flotation of sphalerite.

The activating effect of iron sulfate on the flotation of sphalerite is most pronounced in a highly alkaline calcareous medium at its low (20 g/t) costs.

The most contrasting effect of the studied of copper, zinc and iron sulfate is manifested in the flotation of sphalerite with sodium dibutyl dithiophosphate at pH = 10, when sphalerite flotation is activated by copper, and depression by zinc and iron sulfates.

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