Investigation of the sphalerite oxidation leaching by pyrolusite in chloride and sulfate medium

Mahmood Tirgham[1], Hossein Kamran Haghighi[1]*, Mehdi Irannajad[1]

Department of Mining Engineering, Amirkabir University of Technology, Tehran, Iran

*Corresponding Author: Email: h.kamran.h@aut.ac.ir

ABSTRACT

The most important resource for zinc metal is sulfide ores which have a dissolution problem due to an inactive layer of sulfur on their surface causing the low leaching efficiency. Extensive research has been done to dissolve sphalerite in an acidic environment with various oxidants such as oxygen. In most of these researches, disadvantages such as the high cost of oxidant production, high investment cost, high depreciation of equipment, and environmental hazards are observed. In this research, acidic leaching of a sphalerite concentrate, which contains 41.235% zinc, 26.24% sulfur, and 6.6% iron, by pyrolusite in sulfate and chloride medium has been investigated. The investigated parameters include pyrolusite concentration, acid concentration, temperature, time, and solid-to-liquid ratio, each of which has been investigated at 5 levels. According to the results, the efficiency of zinc leaching reaches 85% by increasing the temperature from 25 to 85 °C. By reducing the ratio of solid to liquid from 150 to 50 g/L, zinc efficiency reaches 99.78%. Also, the sulfate leaching medium is more efficient than chloride. Comparatively, the zinc efficiency of the chloride medium has decreased by 22% in comparison with the sulfate medium under the same conditions. In the optimum condition, the efficiency of zinc leaching during 5 h reached 99.87%.

KEYWORDS

Sphalerite, Atmospheric Leaching, Pyrolusite, Oxidation, Chloride, Sulfate

1. Introduction

One of the most important sources of zinc metal is sphalerite mineral, which about 70% of that in the world is supplied from this mineral[1-3]. Zinc sulfide minerals have low dissolution in common acids due to the existence of a passive layer [1, 4, 5]. The existing methods to produce zinc from sphalerite can be generally divided into pyrometallurgy and hydrometallurgy, . By comparing the two methods, in the terms of improving the rate and recovery of zinc dissolution from sphalerite, industries will be more inclined to hydrometallurgical processes. These methods are divided into pressure and atmospheric leaching. Atmospheric leaching has lower kinetics and efficiency compared to leaching under pressure, and different oxidants are used for the oxidation process to dissolve it. Oxygen is an important oxidant in the mentioed leaching processes which is more expensive and should be produced in an expensive plant [5-9]. Thus, an alternative one such as pyrolusite can overcome the oxygen usage challenge. Despite the fact that some studies have been done on the leaching of sphalerite with pyrolusite, but the aspects of the effect of various types of parameters and the comparison of sulfate and chloride environments are not seen in the literature. Therefore, in the current research, the effect of pyrolusite amount, acid concentration, temperature and solid to liquid ratio on the oxidative leaching of sphalerite was investigated.

2. Methodology

In this research, the sample was prepared from the concentrate of lead and zinc mine in Koshk, Yazd, which was treated in a flotation step. After drying, the sample was homogenized to determine the particle size. Finally, after the sieve analysis, d_{80}=106.6 micron was obtained. After a grinding step, d_{80}=48.6 micron was obtained. XRD analysis shows that sphalerite is the dominant mineral of the sample. The analysis also shows SiO_2 and FeS_2 minerals. The pyrolusite used as an oxidizer is the mineral concentrate with 40% content of manganese and no iron, with silicate gangue.

3. Results and Discussion

The effect of pyrolusite concentration on zinc recovery was investigated. The results are shown in Figure (1). The results indicate that by increasing the concentration of pyrolusite from 43.47 to 173.88 g/L, after 5 hours the recovery increased from 56.67 to 71.86%. By increasing the concentration from 173.88 to 434.7 g/L, the recovery decreased from 71.86 to 61%. The reason for this increase and then decrease can be considered as a decrease in mass transfer due to low mixing.

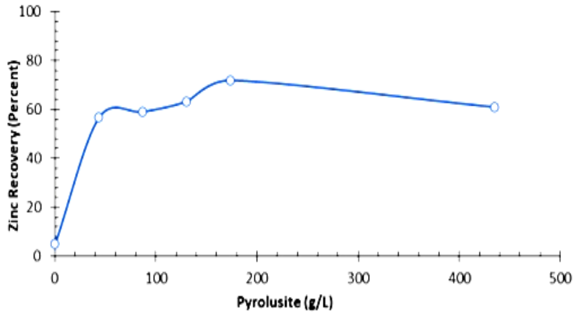

Figure 1. The effect of pyrolusite concentration on zinc recovery: dissolution time 5 hours, temperature 55°C, sulfuric acid 1.5 mol/L, solid-to-liquid ratio 100 g/L, stirring speed 500 rpm, and smaller particle sizes from 50 microns.

The reason for the increase and then decrease in recovery can be explained in terms of the iron and also the manganese presence in the solution phase. Manganese does not enter the solution phase, unless pyrolusite is reduced. Figure (2) shows the concentration of manganese and iron in the solution, respectively. By comparing Figure (1) with Figure (2), the cause of increase and decrease of recovery can be justified. As mentioned, increasing the concentration of manganese in the solution means that more pyrolusite has been reduced, which has caused the oxidation of iron and sphalerite (the higher the oxidation, the more reduced manganese). As seen in Figure (2), at the concentration of 173.88 g/L of pyrolusite, maximum iron and manganese are observed, as in this concentration, the maximum recovery has been achieved. By increasing the concentration from 173.88 to 434.7 g/L, the iron concentration has decreased due to the decrease in mixing and subsequently mass transfer [10-13]. Finally, the maximum recovery was achieved at the concentration of 173.88 g/L of pyrolusite.

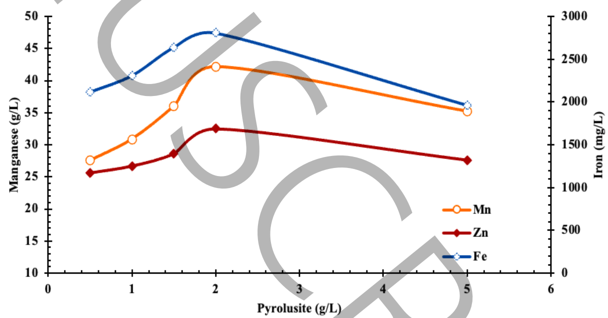

Figure 2. The concentration of manganese, zinc, and iron in solution in different amounts of pyrolusite: dissolution time 5 hours, at 55°C, sulfuric acid 1.5 mol/L, solid to liquid ratio 100 g/L, 500 rpm, and particle dimension under 50 microns.

The concentration of acid in the leaching process must be economically reasonable. In this study, the effect of sulfuric acid concentration in the range of 0.5 to 2.5 mol/L on the recovery of zinc under the following conditions was investigated: temperature of 55°C, pyrolusite concentration of 173.88 g/L, and the solid to liquid ratio of 100 g/L. The results indicate that by increasing the concentration of sulfuric acid from 0.5 to 2 mol/L after 5 hours the recovery increased from 32.06 to 74.62%. In general, temperature is one of the key parameters in this process and has a positive effect on recovery. In this study, the effect of temperature in the range of 25 to 85 °C on the recovery was investigated under conditions of 2 mol/L sulfuric acid, pyrolusite concentration of 173.88 g/L, and solid to liquid ratio of 100 g/L. The results show that the recovery increased with increasing temperature from 34.41 to 85%. Another important factor affecting zinc recovery is the solid-liquid ratio. Generally, with the increase of solid-liquid ratio, the recovery decreases due to the increase of solid particles per unit volume of the solution. In the current study by increasing the ratio of solid to liquid from 50 to 150 g/L, the recovery has decreased from 99.78 to 62.64 percent. After determining the optimal amount of each parameter involved in the process, the experiment was carried out with the same conditions in chloride environment to determine the effect of two environments (sulfate and chloride) on recovery. As can be seen, the recovery after 5 hours of leaching was 62.5%. This recovery has decreased by approximately 22% compared to the recovery obtained in sulfate medium which is equal to 85% under similar conditions.

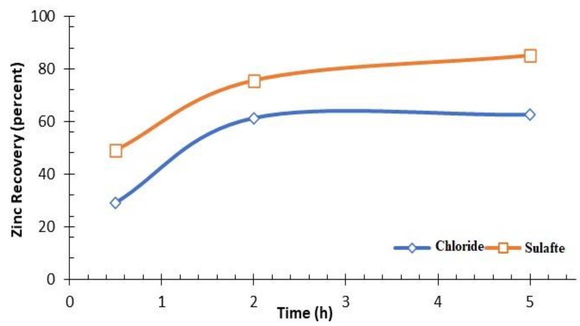

Figure 3. Zinc recovery at different times. 2 mol/L acid, pyrolusite concentration 173.88 g/L, temperature 85°C, solid to liquid ratio 100 g/L, stirring speed 500 rpm, and particle dimension under 50 microns.

4. Conclusion

In this research, the type of leaching medium and other parameters including pyrolusite concentration, acid concentration, temperature, time and solid-to-liquid ratio on the dissolution of sphalerite concentrate were investigated and compared. The optimal conditions obtained include sulfate dissolution medium, sulfuric acid concentration 2 mol/L, pyrolusite 173.88 g/L, reaction time 5 hours, reaction temperature 85°C, and solid to liquid ratio 50 g/L. One of the highlights of this research is the usage of pyrolusite instead of oxygen injection into the reactor, which reduces the capital costs of the process at higher scales.

5. References

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