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STUDY OF FACTORS INFLUENCING THE OXIDATION OF COPPER CONCENTRATE

Oxidation of copper concentrate changes the phase of copper and iron, and the content of copper decreases. This has a significant negative impact on the economy. Therefore, we aimed to study the interactions between the factors affecting oxidation (temperature and humidity). Artificial oxidation in laboratory conditions was carried out in a «Temperature Humidity Chamber» at temperatures of 10°C, 30°C, 50°C, and humidity was adjusted to 10 %, 30 %, and 60 %, respectively, and a total of 9 experiments were performed. Total copper, oxidized copper and mass changes were determined in the copper concentrate. Also, a model based on oxidation factors was derived. The total copper content decreased from 21.96 % to 0.46–0.86 % at 10 degrees and decreased by 1.28-1.85% at high temperature of 50 degrees. The content of oxidized copper increases with increasing temperature and humidity. It increased 2.4 times from 0.28 % to 0.68 %. It can be seen from these that oxidation is taking place to a certain extent at low temperatures. At 50 degrees and 60 % humidity, the mass change increased from 1 000 to 1 012g. The regression equation shows that temperature and humidity should be kept very low.

Key words: *oxidation of copper concentrate, artificial oxidation, the regression equation.*

Introduction

Copper occurs in nature as sulfide, oxidized, mixed ores, and elemental copper. The most widespread of these is sulfide ore (oxidized, primary, and secondary sulfide). In our country, there are several large factories that produce copper concentrate by beneficiation of sulfide ore. Oxidation occurs when copper concentrate is stored for a certain period of time. The main components of copper concentrate are copper (22–25 %), iron (28–30 %), and sulfur (30–32 %) exists as sulfide minerals such as chalcopyrite (CuFeS2), chalcocite (Cu2S), coveline (CuS), pyrite (FeS2), and enargite (Cu3AsS4) [1]. Oxidation processes of copper concentrates in atmospheric conditions have not been studied much, and studies of the main mineral phases in copper concentrates are predominant [2; 3; 4]. The predominant minerals in copper concentrates are chalcopyrite and pyrite. Since pyrite is second only to chalcopyrite in terms of percentage in the concentrate, these two minerals are highly likely to cause galvanic oxidation. Chalcopyrite does not lose its hydrophobic properties when it is in a neutral or weakly alkaline environment for a long time, and when the pH of the environment is >10, it begins to oxidize to SO_4^{2-}, $S_2O_3^{2-}$, $S_4O_4^{2-}$ ions, and generate Cu^{2+}, Fe^{2+}, SO_4^{2-} ions in a weakly acidic environment (pH-6) [5; 6]. Oxidation of pyrite in an alkaline condition produces sulfate, which further oxidizes to form iron hydroxide. Oxidation of pyrite produces melantherite or iron sulfate [7]. Bacterial oxidation of pyrite occurs at pH below 4.5. In neutral conditions (pH=6-7), Fe(II) oxidizes to Fe(III) very quickly, while in acidic conditions, pH<4, the transition to Fe(III) is relatively slow, but Thiobacillus ferrooxidans (Thiobacillus ferrooxidans) bacteria increase the rate of this reaction [8].

The useful mineral content of the concentrate is the main parameter that determines its quality, and it is important for producers to control the copper content of the concentrate [9]. Chalcopyrite, the main mineral that makes up copper concentrates, is oxidized in warm weather to a heavier molecular weight mineral. As a result, the weight of copper concentrate increases and the content of copper in it decreases, which leads to economic losses. Therefore, it is necessary to determine the values of the factors affecting the oxidation of copper concentrate.

Material and methodology

Copper concentrate with a moisture content of 7.57 % concentrated in our country was used in the research, and artificial oxidation was carried out in the laboratory conditions of the wet concentrate at 3 different temperatures: 10°C, 30°C, 50°C, and 3 different humidity (10 %, 30 %, 60 %), a total of 9 experiments were conducted. It was assumed that the natural conditions for sulfide oxidation are 30°C and 30 % humidity, and in addition to the basic conditions, low temperature of 10°C and high temperature of 50°C were selected for the study. 1 000 g of sample was used for one experiment. From the artificially oxidized samples, samples were taken at intervals of 5, 10, and 15 days, and the total copper content, oxidized copper and mass changes were studied and oxidation simulations were made.

Results and Discussion

A. Total copper content

The change of total copper after artificial oxidation of copper concentrate at 10, 30 and 50°C for 15 days is shown in the Figure 1. It can be seen that the values of low temperature and humidity conditions or the first 3 experiments of tests decreased relatively less than the last set of experiments. At the high experiment value of 50 degrees and 60% humidity, there is a sharp decrease in copper content from 21.96 to 20.11 %. It can be seen that when the temperature is low and humidity is high, the copper content is reduced by 0.8 %, which means that temperature and humidity are highly dependent on each other.

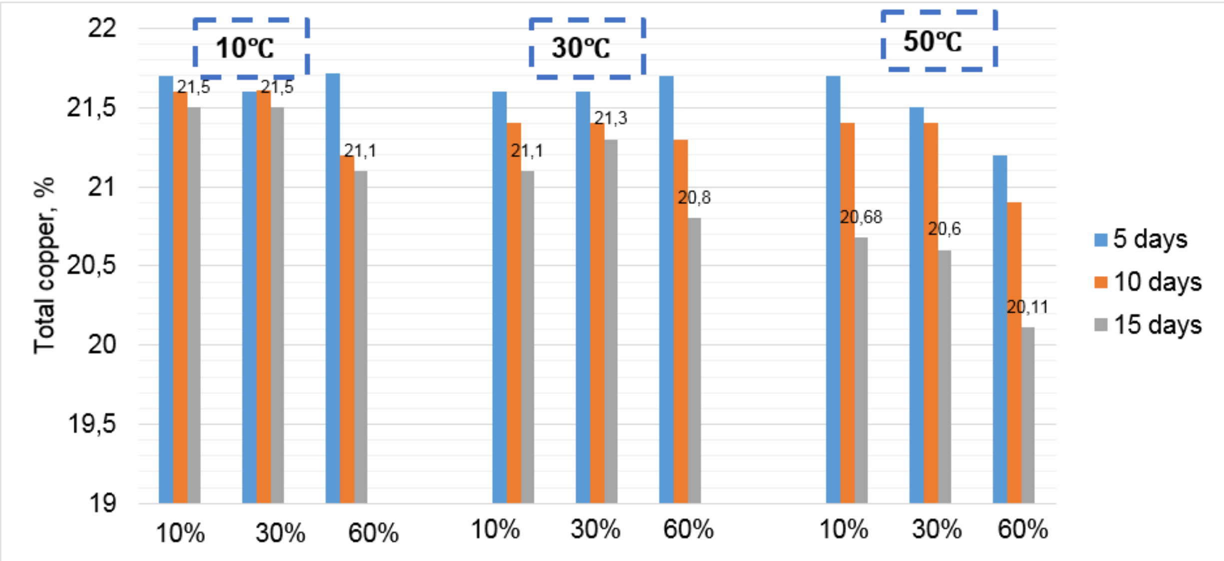

Figure 1. Total copper content at different temperatures and humidity

B. Content of oxidized copper

The content of oxidized copper in copper concentrate was initially 0.28%. According to the results of the experiments, it increased by 0.05-0.07% at low temperature and humidity, while at high temperature and humidity (50°C/60%) it increased by 2.5 times. The equation for the formation of oxidized copper is shown below.

$$2CuFeS_2 + O_2 = Cu_2S + 2FeS + SO_2 \qquad (1)$$

$$Cu_2S + 5Fe_2(SO_4)_3 + 14H_2O \rightarrow 2CuSO_4{*}5H_2O + 10FeSO_4 + 4H_2SO_4 \qquad (2)$$

C. Mass changes

Mass changes are observed due to the transfer and loss of electrons in that system and the formation of final products of oxidation. Figure 2 showed the mass change. At 50 degrees and 60 % humidity, the mass increased from 1 000 g to 1 012.5 g after 15 days. This indicates that electron transfer is more common at high temperature and humidity.

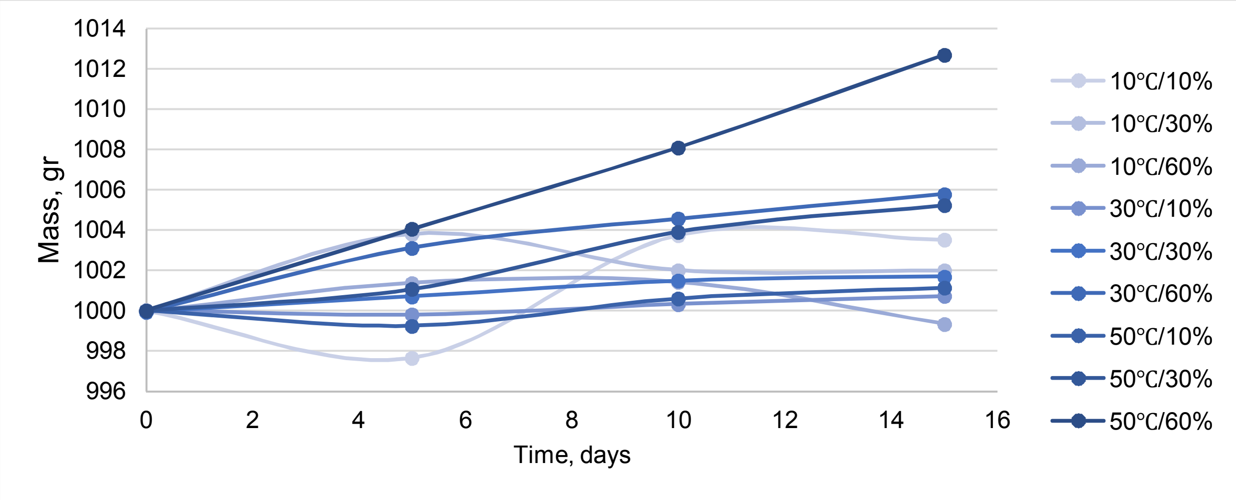

Figure 2. Mass changes at different temperatures and humidity

D. Regression analysis

The results of oxidation of copper concentrate were studied depending on two factors: temperature X_1 and humidity X_2. Table 1 shows the factor values and their units.

Labels	Factors	Units	Low label (-1)	High label (+1)
X_1	Temperature	‘K	10	50
X_2	Humidity	%	10	60

Based on these factors, the equation for copper content is shown below.

$$y = 20.92 - 0.11x_1 - 0.48x_2 - 0.21x_1x_2 \quad (3)$$

From this equation, it is necessary to reduce the temperature and humidity in order not to decrease the copper content.

Conclusion

The oxidation process is strongly influenced by the increase in temperature and humidity. The total copper content of the concentrate decreased by 0.46–0.86 % at a temperature of 50 degrees and a humidity of 10–60 %, and by 1.16–1.85 % at a high temperature of 50 degrees and a humidity of 10–60 %. As the environmental temperature and relative humidity increase, the mass of the concentrate increases. The factors of temperature and humidity affect the oxidation depending on each other. Looking at the model derived from the regression equation, it is necessary to reduce the amount of temperature and humidity.

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ИЗУЧЕНИЕ ФАКТОРОВ, ВЛИЯЮЩИХ НА ОКИСЛЕНИЕ МЕДНОГО КОНЦЕНТРАТА

Окисление медного концентрата изменяет фазу меди и железа, и содержание меди уменьшается. Это оказывает значительное негативное влияние на экономику. Поэтому мы стремились изучить взаимодействие между факторами, влияющими на окисление (температурой и влажностью). Искусственное окисление в лабораторных условиях проводили в «Температурно-влажностной камере» при температурах 10°С, 30°С, 50°С, а влажность регулировали до 10 %, 30 % и 60 % соответственно, и в общей сложности было проведено 9 экспериментов. В медном концентрате определяли общее содержание меди, окисленную медь и изменения массы. Кроме того, была получена модель, основанная на факторах окисления. Общее содержание меди снизилось с 21,96 % до 0,46–0,86 % при температуре 10 градусов и снизилось на 1,28–1,85 % при высокой температуре 50 градусов. Содержание окисленной меди увеличивается с повышением температуры и влажности. Оно увеличилось в 2,4 раза – с 0,28 % до 0,68 %. Отсюда видим, что окисление в определенной степени происходит при низких температурах. При температуре 50 градусов и влажности 60 % изменение массы увеличилось с 1 000 до 1 012 г. Уравнение регрессии показывает, что температуру и влажность следует поддерживать на очень низком уровне.

Ключевые слова: *окисление медного концентрата, искусственное окисление, уравнение регрессии.*