DISTILAT
Jurnal Teknologi Separasi

Distilat. 2022, 8 (4), 974-978
p-ISSN : 1978-8789, e-ISSN : 2714-7649
http://distilat.polinema.ac.id

THE EFFECT OF PH SOLUTIONS AND STIRRING SPEED ON NICKEL RECOVERY FROM PYROPHYLLITE ROCKS USING FROTH FLOTATION

Titi Pangesti Berlian Santoso, Sandra Santosa, Mas'udah
Jurusan Teknik Kimia, Politeknik Negeri Malang, Jl. Soekarno Hatta No. 9, Malang 65141, Indonesia
titipangesti030201@gmail.com; [sandra.santosa@polinema.ac.id]

ABSTRACT

Nickel is an important element in the metal alloy industry. In Indonesia, nickel resources are found in many areas in the form of rocks such as pyrophyllite. Froth flotation is a method commonly used in the mining industry to extract metals such as nickel from mineral rocks. However, the nickel concentrates yields tend to be relatively low. This is often influenced by several factors such as the pH solutions and stirring speed used in the process. Therefore, this study aims to investigate the effect of agitation speed and collector concentration on the nickel recovery results obtained from the froth flotation process. In this study, variations of pH solutions at 8,9, and 10 were used. Meanwhile, the stirring speed was varied to 700, 800 and 900 rpm. The results showed that the pH solutions and stirring speed had a significant impact on nickel recovery. Optimum results were obtained at pH of 10 and stirring speed of 900 rpm where the nickel concentration reached 27,55% from the initial concentration of 8,21%.

Keyword: *collector, frother, froth flotation, nickel, pyrophyllite*

1. Introduction

Nickel (Ni) is one of the most common elements on Earth and is widely found in the Earth's crust and nucleus. Nickel is also a metallic mineral that benefits a variety of industries, including the chemical industry. Pure nickel is found only in the Earth's crust and is predominantly found in several types of rocks, including pyrophyllite[1]. Nickel has physical properties of a glossy white colour, very hard, rustproof and resistant to dilute acids [2]. There are two types of nickel ore that are widely used in alloy industries: laterite nickel and nickel sulphide. Laterite nickel ore is located in a relatively shallow area 15 to 20 metres below the surface of the earth. Nickel sulphide ore is a nickel deposit containing complex minerals including copper, some precious metals and cobalt. The cost of mining nickel sulphate ore is relatively high because nickel sulphate ore is formed thousands of metres underground by the reaction of sulphur [3] The content of pure nickel in laterite nickel ore is about 4% or less. Some other studies showed that the nickel content is around 1% to 3%, at most 4%. This is because nickel ore is contained in various inclusions, especially peridotite and sulphide minerals [4]. About 70% of the world's nickel ore reserves are laterite ore, the remaining 30% is sulphide ore, almost 60% of the world's nickel production is nickel sulphide ore, and the rest is laterite nickel ore [5]. Pyrophyllite is a type of metamorphic rock rich in aluminium silicate. The distribution of pyrophyllite minerals in South Malang, especially in the Sumbermanjing area, is estimated to be about 1 million tons, and the mined area of pyrophyllite is about 20

Corresponding author: Sandra Santosa
Jurusan Teknik Kimia, Politeknik Negeri Malang
Jl. Soekarno-Hatta No. 9, Malang 65141, Indonesia
E-mail: sandra.santosa@polinema.ac.id

Diterima: 26 Agustus 2022
Disetujui: 07 Desember 2022

hectares [6]. Moreover, the Indonesian Mining Law No. 4 of 2009 requires that all mineral materials to be marketed must first be processed into semi-finished materials, concentrates or even finished materials. This means that the government has severely restricted the sale or export of low-grade mining products by mining industries.

Given the widespread use of nickel sulphide ore reserves as a raw material, it must be used appropriately and efficiently. Therefore, in this study, the remaining nickel sulphate ore contained in pyrophyllite rock was used as the main raw material for flotation. Operating conditions for the flotation process to work well are the presence of certain particles that float by adhering to bubbles and rising to the surface. Since particle size can determine the buoyancy of particles in the flotation process, particle size is one of the factors that determine whether the flotation process is successful [7]. Froth flotation is the process of using bubbles to bring solids, liquids, and other solutes to the surface of a solution. The flotation material adheres to the surface of the bubble, therefore it floats on the surface of the solution and is quickly separated from the solution and remains attached to the floating material [8]. The prerequisite for bubble flotation is that the substance must be hydrophobic so that it can adhere to the bubbles generated by the bubble flotation device. Substances that are not hydrophobic or are still hydrophilic can first be converted to hydrophobic substances by adding a compound called a collector.

According to the results of a previous study by Fajar Nurjaman (2020) [9], the laterite nickel ore reduction process reduces iron and nickel oxide compounds in laterite nickel ore to ferronickel concentrates at temperatures of 1100-1200°C and addition of sulphur as additives. The result showed that the more sulphur as additives used in froth flotation increased the concentration of nickel in the concentrates. However, from an economic point of view, the method was not efficient since the process required high amounts of additives and high energy consumption for heating the process. Furthermore, the results of the prior study carried out by Nida Khoirina (2017) [10], laterite nickel ore on nickel extraction using solid-liquid extraction, also known as leaching, used sulfuric acid as *leachant*. The results showed that this method could increase nickel recovery after extraction at 95^{o}C. However, this method takes 6 hours to process. In addition, according to a previous study conducted by Firmansyah in 2009 [11], examined the effect of oleic acid and pine oil as collectors on nickel recovery. The results showed that the addition of 895 grams of oleic acid and 30 grams of pine oil obtained nickel concentrate of 50.67%. However, even though the method gave better results compared to the other method, it required high-cost process production. Therefore, in order to solve all drawbacks of the prior studies, the purpose of this research was to investigate the effect of pH solutions and stirring speed of froth flotation on nickel recovery from phyropillite ores. The flotation process in this research utilised NaOH for pH control and high stirring speed for better results of nickel recovery.

2. METHODOLOGY

This research uses quantitative methods by conducting laboratory-scale experiments. This study used the variable pH of the solution and stirring speed to determine its effect on the recovery of nickel obtained after the froth flotation process. In this study, variations of pH solutions at 8,9, and 10 were used. Meanwhile, the stirring speed was varied to 700, 800 and 900 rpm. Analysis of the nickel content in the concentrate was carried out using an XRF (X-ray Fluorescent X-ray) device.

The study began with the raw material preparation of pyrophyllite ores, aquadest, NaOH, and Na_2CO_3. Pyrophyllite rock undergoes a crushing process using a crusher. The rock

is then crushed into powder and sieved with a 100-mesh sieving tool. Next, preparation of solutions was carried out by mixing 8 litres of distilled water, 75 g of NaOH and 35 g of Na_2CO_3. The next step was conducting the flotation process by mixing the solutions and pyrophyllite ores using stirring speed at the variables, i.e., 700, 800, and 900 rpm and at the pH of 8,9 and 10. The flotation process ran for about 15 minutes up to particles adhering to the surface of the froth flotation tank. The spills that have been wiped out by the top stirrer were first collected before being dried in an oven at a temperature of 220-250 °C for 1 hour. The last step was nickel content analysis of the dried concentrates using XRF

3. RESULTS AND DISCUSSION

The nickel content was analysed before and after the froth flotation process. The analysis results of the initial pyrophyllite ores before the flotation process are shown in Table 1. According to Table 1, it can be seen the content and grade of the original pyrophyllite rock containing nickel with a concentration of 8.21%.

Table 1. Initial component of pyrophyllite ores

Component	%Content
Si	46
S	6
Ca	0,93
Ti	3,4
V	0,10
Cr	0,18
Fe	17,2
Ni	8,21
Ga	0,046
Sr	0,91
Y	0,14
Zr	0,35
Nb	0,76
Mo	16
Au	0,093

Although the nickel content in pyrophyllite ores is quite high, it has not fully met the needs of the alloy and battery industry market where the nickel content required is at least 20%.

In this research work, the results of the study showed that the nickel content increased after the froth flotation process. As can be seen in Figure 1, the variable pH solutions and stirrer speed affects the nickel recovery. The nickel recovery rate was calculated use equation (1).

$$R = \frac{C.c}{F/f} \; x \; 100 \; \% \qquad (1)$$

Where R is nickel recovery (%), C is weight of concentrate (grams), F (Feed Weight), c (Nickel Content in Concentrate) and f is feed nickel content (%).

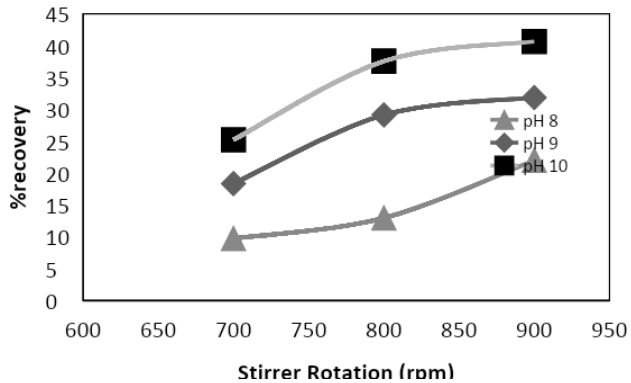

Figure 1. The Relationship between nickel recovery (%) to the stirring speed at different pH solutions.

From Figure 1, It can be seen that the pH solutions and stirring speed has a significant effect on the nickel recovery. The highest nickel recovery was obtained at stirring speed of 900 rpm and at pH solutions of 10. It can be observed that the froth flotation of nickel worked effectively under alkaline conditions and high stirring speed. The results of this study are in accordance with the theory which states that froth flotation works undel pH of 7-13 [12]. And also consistent with the findings in Pratama (2018) [13], which states that the greater the stirring rotation in the flotation process, the % recovery is getting bigger.

4. CONCLUSIONS AND OUTLOOK

From the results of the study, it can be concluded that the pH of the solution and the rotation of the stirrer in the froth flotation have a significant effect on nickel recovery. The higher the pH of the solution and the stirring speed, the higher the nickel recovery in the concentrate. Maximum nickel content was obtained at pH 10 and stirring rotation 900 rpm with nickel recovery 27,55%.

For further research, it is expected to add variables in order to find out many comparisons and the effect of using pH and stirrer rotation, in order to find out the value with the best, lowest and optimal operating conditions.

REFERENCE

[1] *Nikel Institute*, "*The life of Ni*,". Jerman: Nickel Institute, hal. 1–20, 2016.

[2] Windi Zamrudy, "Studi Literatur Faktor-Faktor Pengaruh Pada Pelapisan Nikel Dan Perkembangnya," *Distilat J. Teknol. Separasi*, vol. 7, no. 2, pp. 400–405, 2021

[3] W. Mayangsari and A. B. Prasetyo, "Proses Reduksi Selektif Bijih Nikel Limonit Menggunakan Zat Aditif $CaSO_4$," *Metalurgi*, vol. 1, pp. 7–17, 2016

[4] Srdjan Bulatovic, *Handbook of Flotation Reagents Chemistry, Theory and Practice: Flotation of Sulfide Ores*, 1st ed., Amsterdam, Netherlands: Elsevier Science & Technology Books, 2007.

[5] R. Subagja, A. B. Prasetyo, and W. M. Sari, "Peningkatan Kadar Nikel Dalam Laterit Jenis Limonit Dengan Cara Peletasi, Pemanggangan Reduksi dan Pemisahan Magnet Campuran Bijih Batu Bara. *Metalurgi*, vol. 31, no. 2, pp. 103, 2016

[6] D. A. Purwaningsih, "Rekayasa Material Pyrophyllite Sebagai Cementitious Pada Beton," *J. Tek. Sipil UMM*, vol. 2, no. 2006, pp. 4–18, 2018.

[7] J. Drzymala, *Mineral Processing: Foundations of Theory and Practice of Minerallurgy*, 1st Englis. Wroclaw, Poland: Wroclaw University of Technology, 2007.

[8] N. Basid, “Flotasi dan Contoh Aplikasinya,”. Lampung: Universitas Lampung, 2015.

[9] F. Nurjaman, F. Bahfie, U. Herlina, W. Astuti, and D. B. Suharno, “Kajian Literatur Parameter Proses Reduksi Selektif Bijih Nikel”*. Jurnal Metal Indonesia*, vol. 42, no. 2, pp. 63-71, 2020.

[10] N. K. Siregar, “Ekstraksi nikel laterit soroako menggunakan asam sulfat,” Yogyakarta: Skripsi Program studi Kimia Fakultas Matematika dan Ilmu Pengetahuan Alam Universitas Islam Indonesia, 2017.

[11] Ilham Firmansyah, “Penggunaan kolektor asam oleik dan frother minyak pinus pada proses flotasi bijih nikel limonit,” Depok: Laporan Skripsi Fakultas Teknik Program Studi Metalurgi dan Material Universitas Indonesia, 2009.

[12] M. M. Flotasi, I. D. Sardjono, and H. Poernomo, “Pemungutan uranium dan nikel dari air limbah menggunakan metode flotasi,”. *Puslitbang Teknologi Maju : Batan*, vol. 7, pp. 53–59, 2005.

[13] D. S. Pratama, “Pencucian Batubara Menggunakan Metoda Flotasi Untuk Menurunkan Kadar Abu Dan Kadar Sulfur Batubara Di Pt Atoz Nusantara Mining,” Padang: Sekolah Tinggi Teknologi Industri (STTIND), 2018.