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THE EFFECT OF STIRRING SPEED AND COLLECTOR CONCENTRATION ON NICKEL RECOVERY FROM PYROPHYLLITE USING FROTH FLOTATION

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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 yield tends to be relatively low. This is often influenced by several factors such as the stirring speed and the concentration of the collector 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 stirring speed at 500, 600, and 750 rpm were used. Meanwhile, the collector concentration varied to 2,5%, 4,5% and 6,5%. The results showed that the stirring speed and collector concentration had a significant impact on nickel recovery. Optimum results were obtained at 750 rpm and 6,5% where the nickel concentration reached 2,475% from the initial concentration of 8,21%.

Keywords: *nickel, froth flotation, collector, pyrophyllite, stirring speed*

1. INTRODUCTION

Nickel is one of the most common elements on earth and is widely transferred to the earth's crust and core [1]. Nickel is widely used in various industrial applications for alloying elements, coatings, batteries and some other applications such as kitchen utensils, mobile phones, medical devices, transportation, buildings, power generation and jewellery because of its resistance to oxidation and corrosion, resistant to high temperatures and can form alloys with other metals [2]. Based on Permana and Zamrudy (2021) it is stated that nickel (Ni) is a metal that has physical properties, among others, is shiny white, very hard, does not rust, and resistant to acid [3]. Nickel laterite is formed on a prolonged chemical coating process of ultramafic rock containing ferromagnesian minerals. Ultramafic rocks consist of dunite, peridotite, pyroxenite, hornblendite, and serpentinite [4]. One of the main characteristics of nickel ore is that the contained nickel recovery does not exceed 4% Ni. Typically, the nickel recovery is between 1% and 3% Ni and in some cases, does not exceed 4%. This is because such nickel ore is contained in various inclusions, especially peridotite and sulphide minerals that cause nickel concentrations to have low levels [5]. The distribution of pyrophyllite minerals in South Malang, especially in the Sumber Manjing area,

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is estimated to be about 1 million tons, and the mined area of pyrophyllite is about 20 hectares. 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. Efforts in raising the level of nickel ore have been widely done in the mining industry. One of the efforts that can be carried out in increasing nickel ore levels is beneficence process. The beneficence process can be done chemically as well as physically. The beneficence process can also be done through gravitational and magnetic methods whereas beneficence chemically and physically can be performed by flotation methods. Flotation concentrations dominate mineral processing in large-scale copper, gold, and base metal mines. This is because the process does not depend on the density and the difference in gravitational force as well as is easily controlled through certain reagents in changing the surface properties of minerals. Flotation represents one of many separation methods and can be used for phase separation, for example, to remove solid particles or oil drops from water [6]. Moreover,

Based on Sujiono, et al (2014), the results of the laterite nickel composition analysis consist of Si 5.2%, Al 14.96%, Fe 61.31%, Ni 0.52%, Cr 1.66%, and some other compounds in smaller quantities [7]. Flotation can be a highly efficient process for the separation of solids and minerals. Nevertheless, flotation is greatly affected by the surface properties of the mineral itself. The main condition for the flotation process to proceed well is the presence of certain particles (to be applied) adhering to air bubbles and then together rising to the surface. Particle size is also one of the factors determining whether the flotation process can proceed well because it can determine the applicability (floatability) of a particle [8]. In addition, the type of reagents in the flotation also affects the flotation process. Chemical reagents are used to create a condition for the flotation process to take place properly and the minerals emanate as concentrates. Based on Saleh, et al (2015), large round stirrers greatly affected the sulphur levels obtained at the end of the froth flotation process [9]. Based on Madilen, et al (2015) % nickel content tends to increase when the variable amount of Na_2CO_3 is increased [10]. 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.

2. METHODOLOGY

The study used quantitative research on an experimental pilot scale. The study began with the preparation of pyrophyllite, aqua, NaOH as frothers, and Na_2CO_3 as collectors. Pyrophyllite rock undergoes a crushing process using a crusher. The rock is then crushed into around 100 mesh. The study used variations of stirring speed at 500, 600, and 750 rpm were used. Meanwhile, the collector concentration varied to 2,5%, 4,5% and 6,5% from the total of pyrophyllite ores used in the experiment (%w/w). The work began with the raw material preparation of pyrophyllite ores, aqua, 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 of 500, 600, and 750 rpm and at collector concentration varied to 2,5%, 4,5% and 6,5%. 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 analysis XRF. XRF Spectrometry use the X-rays emitted by the material that is subsequently captured detector for analysis of elemental content in material. The material being analyzed can in the form of solid massif, pellets, or powder. Elemental analysis was carried out qualitatively as well as quantitative. Qualitative analysis the types of elements contained in materials and quantitative analyzes carried out to determine the concentration elements in materials [11]. The samples tested at XRF are samples with stirring speed at the variables of 500, 600 and 750rpm and at collector concentration varied to 2.5%, 4.5% and 6.5%. Calculating % recovery to determine the efficiency of the pretreatment and preparation processes so that a recovery test is carried out.

The nickel recovery (%) were calculated using the following Equation (1):

$$R = \frac{\%product - \%raw}{\%raw} \quad (1)$$

Description:
R: Nickel Recovery (%)
%product: Nickel XRF results (%)
%raw: Nickel contain in the rock (%)

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%. 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 stirrer speed and collector concentration affects the nickel recovery.

Figure 1 presents the relationship of percentage of nickel recovery to the collector concentration at three different stirring speed. From the graph, it is interesting to note that the highest stirring speed used in froth flotation, the highest % nickel recovery obtained in the concentrates. However, the collector concentration does not really affect significantly to the nickel recovery in the concentrate product. The highest nickel recovery value occurs at collector concentration of 6.5% with a stirring rotation of 750 rpm. Whereas the lowest nickel recovery value occurs at collector concentration of 2.5% with stirring rotation of 500 rpm.

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

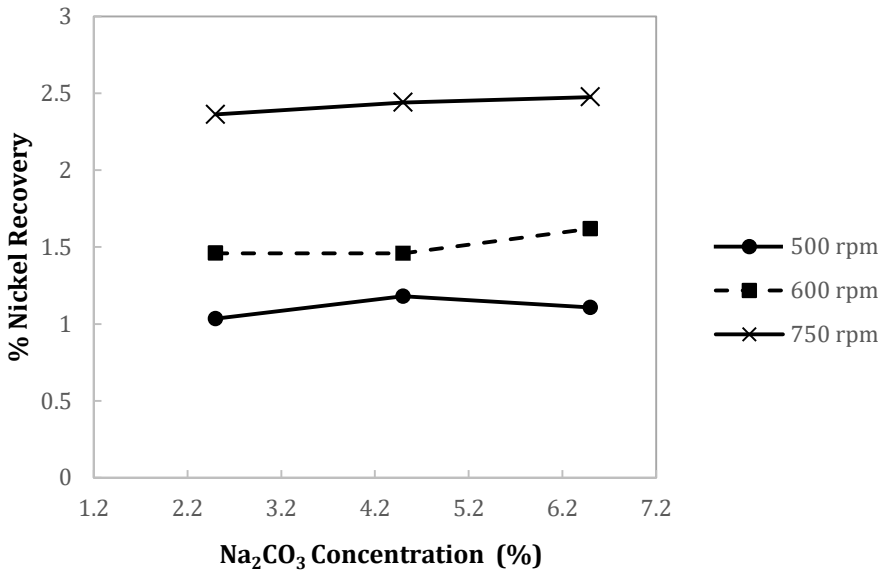

Figure 1. The relationship of % nickel recovery to the collector concentration at different stirring speed

According to Madilen, et al (2015) % nickel content tends to increase when the variable number of collectors is increased [10]. In Alfredo, et al (2021) research, big round the stirrer greatly affects the sulfur content obtained at the end, in the results of this study the speed of the stirrer greatly affects the nickel content obtained in the process [8].

4. CONCLUSION AND FUTURE OUTLOOK

From the research results, it can be inferred that the collector concentration and stirring rotational speed of the flotation froth have a significant impact on nickel recovery. The higher the concentration and the stirring speed, the higher the nickel recovery is

obtained in the concentrate. The maximum nickel recovery is obtained at a collector concentration of 6,5% and the stirring speed of 750 rpm with a nickel recovery of 2,475%

For further research, it is expected to add variables to know the many comparisons and effects of collector concentration and stirrer rotation, so that the values with the best, lowest, and optimal operating conditions can be known.

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