ISBN 978-623-7525-37-0

Enhancing the Nickel Recovery of Morowali Nickel Laterite in Atmospheric Citric Acid Leaching

Feby Aryanhi[1,*], Regna Tri Jayanti[2]

[1,2]Departement of Mineral Chemical Engineering, Politeknik Industri Logam Morowali (PILM), Morowali- INDONESIA

* Corresponding author e-mail: febyaryanii16@gmail.com

Abstract

Morowali has a lot of laterite ore deposits wich is one of the mineral resources containing several kinds of metal elements, consist of Iron (Fe), Silicone (Si), Nickel (Ni), Chromium (Cr), Manganese (Mn), Calcium (Ca), Phosphate (P), Zinc (Zn), Vanadium (V), and Scandium (Sc). Nickel is a metal that have high economic value because it various benefits, such as the production of stainless steel, electric plates, coins, batteries, and catalysts. There are two common nickel laterite processing that are pyrometallurgy and hydrometallurgy. In this study, hydrometallurgy method is applied to process nickel laterite of Morowali. An important step in this process line is ore leaching. This research is conducted to find a condition in atmospheric leaching of Morowali nickel laterite. This investigation work deals with varying the concentration of citric acid of 0.5 to 2.0 M and reaction time 10 to 120 minutes. The constant parameter are leaching temperature (K), stirring speed (rpm), and particle size (mesh). The results showed that the higher concentration of citric acid, the higher nickel recovery. The good conditions is obtained at concentration of citric acid 2.0 M and leaching time of 120 minutes, it proved by the amount of nickel recovery reached 1197.50 ppm.

Keywords: laterite ore; atmospheric leaching; citric acid; hydrometallurgy; and nickel recovery

1. Introduction

In nature, nickel is found in the form of sulfides and oxides. Globally, around 72% of the world's nickel reserves are in oxide rocks, commonly called laterites and the remaining sulfide rocks. However, only around 42% of total world nickel production is sourced from laterite ore (Dalvi dkk., 2004). Laterites are oxide ores widely distributed in the equatorial regions. Lateritie deposits usually consist of three layers, namely the limonite, the saprolite and garnierite (Wellmer, 2002). Until now, nickel production continues to increase along with increasing world demand. However, the problem to be faced in the future is the depletion of nickel sulfide reserves. Therefore, the use of laterite as a source of nickel must be done even though the nickel content is lower than sulfide (Norgate, 2010). Nickel laterite recovery can be carried out by pyrometallurgy and hydrometallurgy process. Hydrometallurgy is a metal extraction process execute at relatively low temperatures by leaching using a chemical solution, whereas pyrometallurgy is a metal extraction process implement at high temperatures (Kyle, 2010). The processing of laterite ore in Morowali is accomplished on low-grade nickel ores namely limonite by pyrometallurgy to produce ferronickel. The hydrometallurgical process is more appropriate to be used to process laterites with low nickel content, namely limonite type (Gustiana, 2018). High pressure acid leaching (HPAL) is a type of hydrometallurgical process that is commonly used on an industrial scale. However, this process is still considered to have weaknesses in terms of environment, economy, and energy (Simate, et al., 2010). Atmospheric pressure acid leaching (APAL) requires low energy and operational costs than High pressure acid leaching (HPAL) (Kyle, 2010; Kusuma, 2012).

The APAL process can be executed using several types of acids, both inorganic acids and organic acids as leachants (McDonald and Whittington, 2008a and 2008b). Inorganic acids still cause environmental problems when the leaching treatment is not performed well. Nowadays, organic acids have been being studied as alternative leaching reagents for nickel extraction from laterite ores to address those issues and to provide environmentally acceptable techniques (McDonald and Whittington, 2008b; Tang and Valix, 2006; Tzeferis and Agatzini-Leonardou, 1994). Astuti (2015) has investigated either inorganic acids such as sulfuric, hydrochloric, and nitric acids or organic acids such as lactic and oxalic acids in the leaching of nickel laterites. It shows that citric acid gives the best nickel extraction because of its high dissociation constant and its ability to form nickel–citrate complexes during metal dissolution. The concentration of citric acid have a significant influence in the leaching process of nickel laterite. the higher the concentration of citric acid used, the higher the recovery value of nickel obtained. This is caused by the amount of acid that will be displaced the equilibrium to the right and increase the number of H^+ ions. Thus, the use of higher concentrations allows the phase of reactant diffusion, chemical reactions, and product diffusion in solids. These three phase act as controllers of the leaching process so that they have an influence that cannot be ignored in the mechanism of the leaching process of laterite nickel using citric acid solution (Wanta, 2017). The aim of this research is to determine the good concentration of citric acid in atmospheric leaching for Morowali nickel laterite.

2. Materials and Methods

The type of nickel laterite used in this study is limonite from Morowali, Central Sulawesi. Before the leaching process started, nickel laterite is prepared in advance by drying using an oven at temperature 110°C for 4 hours, then grinded by using a hammer mill and sieved by a shieve shaker until particle size 200 mesh. The chemical composition of Morowali nickel laterite obtained by chemical analysis using X-Ray Fluorescence (XRF) by Zetium Panalytical as listed in Table 1. The result shows that dominant chemical component of Morowali nickel laterite is iron (Fe) followed by Silicone (Si), Nickel (Ni), Chromium (Cr), Manganese (Mn), Calcium (Ca), Phosphate (P), Zinc (Zn), Vanadium (V), and Scandium (Sc).

Table 1: Chemical Analysis of the Main Elements Present in the Laterite Ore

Element	Si	P	Ca	Sc	V	Cr	Mn	Fe	Ni	Zn
Weight (mass %)	6.5	0.25	0.61	0.01	0.054	1.86	1.3	84.19	5.15	0.1

The leaching process is carried out in an Erlenmeyer equipped with a stirrer and thermometer, as displayed at Fig. 1. Before using the citric acid solution, the pH is measured using a pH meter by Lovibond®Water Testing, as shown at Table 2. Citric acid is taken 360 milliliters (various concentrations used are 0.5, 1.0, 1.5, 2.0 M) is heated using a hot plate until it reaches a temperature of 70°C. After the desired temperature is reached, the solution is stirred at agitation speed of 500 rpm. After that, 30 grams of nickel laterite samples with 200 mesh particle size are put into the acid solution. Entry time will be recorded as 0 minutes when the sample is added. Then, 30 milliliters sample is taken with time intervals of 10, 20, 30, 60, 90 and 120 minutes. The sample that has been taken is a suspension solution and will be separated between the liquid phase and the solid phase by filtration. The filtrate gathered is analyzed using Atomic Absorption Spectroscopy (AAS).

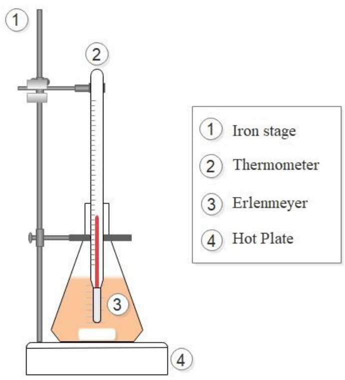


Fig. 1: Schematic of the leaching process

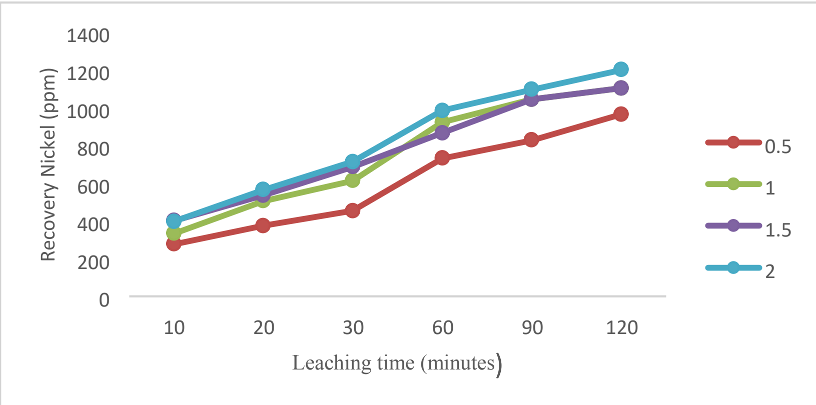
Table 2: pH of citric acid

Concentration (M)	pH
0.5	3.13
1.0	3.07
1.5	2.91
2.0	2.86

3. Results and Discussion

3.1. Effect of Citric Acid Concentration

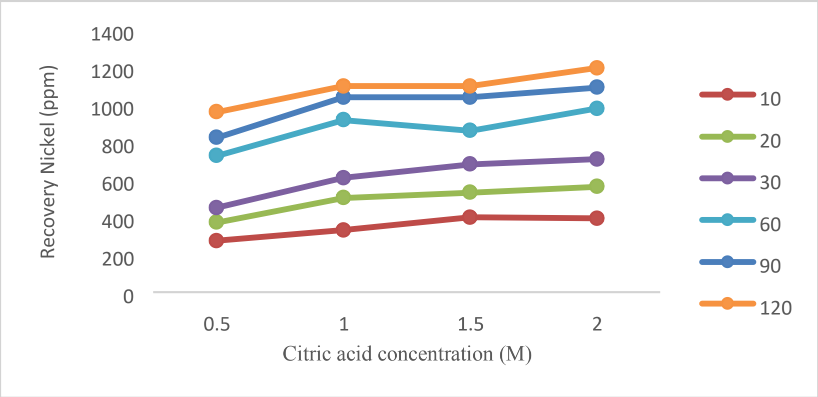
The acid concentration has main role in this investigation. As stated by Wanta (2017) Acid concentration shows the number of acid molecules in the leaching process. The results of nickel recovery by chemical analysis using Atomic Absorption Spectroscopy (AAS) are presented in Graphic. 1. The amount of nickel recovery is raised with the higher of acid concentration that is around 200 to 1200 ppm. The increasing of nickel recovery is appropriate with Le Chatelier principle where the addition of reactants will shift the direction of reaction to form the more progressive products (Solihin, 2014).



Graphic. 1: Effect of citric acid concentration on the nickel recovery

3.2. Effect of Leaching Time

The effect of leaching time on nickel recovery is presented at Graphic. 2. The longer of leaching time implemented the higher nickel is earned. As the increasing of leaching time the frequency of intermolecular collisions rise rapidly, it causes the formation of products (nickel citrate) higher (Wanta, 2017). The improvement of nickel recovery at concentration 2.0 M very significant along leaching time of 10 to 120 minutes that is around 900 to 1200 ppm.



Graphic. 2: Effect of Leaching Time on the Nickel Recovery

4. Conclusion

Nickel laterite can recovered by atmospheric pressure acid leaching using citric acid. The acid concentration and leaching time are two influence factors on nickel leaching process. The good conditions is obtained at concentration of citric acid 2.0 M and leaching time of 120 minutes, it proved by the amount of nickel recovery reached 1197.5 ppm.

5. Nomenclature

AAS : Atomic Absorption Spectroscopy
APAL : Atmospheric Pressure Acid
Leaching HPAL : High pressure acid
leaching
ppm : part per
million rpm :
rotation per
minutes XRF :
X-Ray Fluorescene

6. Acknowledgements

Authors are thankfull to Politeknik Industri Logam Morowali (PILM), Morowali, Central Sulawesi, Indonesia for supported this research.

7. References

Astuti W, Hirajima T, Sasaki K dan Okibe N. Comparison of Effectiveness of Citric Acid and Other Acids in Leaching of Low – Grade Indonesian Saprolitic Ores. Minerals Engineering 2016 ; 85: 1-16.

Dalvi AD, Bacon WG dan Osbourne RC. The Past and the Future of Nickel Laterites. Inco Limited, Ontario, Canada 2004; p. 27.

Gustiana et al., 2018, Pelindian Nikel dari Bijih LimonitLow-Grade Pomalaa Menggunakan Pelarut Asam Asetat, ISSN 1693-4393

Kusuma, G. D., 2012, Pengaruh Reduksi Roasting dan Konsentrasi Leaching Asam Sulfat terhadap Recovery Nikel dari Bijih Limonite, Skripsi, Universitas Indonesia.

Kyle, J., 2010, Nickel laterite processing technologies – Where to next?, ALTA 2010 Nickel/Cobalt/Copper Conference, Australia.

Levenspiel, O., 1999, Chemical Reaction Engineering, John Wiley & Sons, New York.

McDonald, R., G. dan Whittington, B., I., 2008, Atmospheric acid leaching of nickel laterites review : Part I. Sulphuric acid technologies, Hydrometallurgy, 91, 35-55.

McDonald, R., G. dan Whittington, B., I., 2008, Atmospheric acid leaching of nickel laterites review : Part II. Chloride and biotechnologies, Hydrometallurgy, 91, 56-69.

Norgate, T dan Jahanshahi. Low Grade Ores – Smelt, Leach or Concentrate? Minerals Engineering 2010 ; 23:6573

Purwanto, Hadi., Taihei SHIMADA., Reijiro TAKAHASHI., and Jun-ichiro YAGI., 2002, Recovery of Nickel from Selectively Reduced Laterite Ore by Sulphuric Acid Leaching, Vol. 43 (2003), ISIJ International, No. 2, pp. 181–186.

Sitorus, Lungguk., Julius Ponte., Vandal Kamu, 2019, Analisis Beberapa Asam Organik dengan Metode High Performance Liquid Chromatography(HPLC) Grace Smart Rp18 5μ, JURNAL MIPA UNSRAT ONLINE 4 (2) 148-152

Solihin., F. Firdiyono, 2014, PERILAKU PELARUTAN LOGAM NIKEL DAN BESI DARI BIJIH NIKEL

KADAR RENDAH SULAWESI TENGGARA, Majalah Metalurgi, V 29.2.2014, ISSN 0126-3188/ 139-144

Sukla, L., B., Behera, S., K., dan Pradhan, N., 2014, Microbial Recovery of Nickel from Lateritic (Oxidic) Nickel Ore : A Review, dalam Geomicrobiology and Biogeochemistry, vol. 39, Springer Berlin Heidelberg, 137-151.

Simate, G., S., Ndlovu, S., Walubita, L., F., 2010, The fungal and chemolithotrophic leaching of nickel laterites – Challenges and opportunities, Hydrometallurgy, 103, 150-157.

Tang, JA dan Valix M. Leaching of Low Grade Limonite and Nontronite Ores by Fungi Metabolc Acids. Minerals Engineering 2006; 19: 1274-1279.

Tzeferis, PG dan Agatzini-Leonardou, S. Leaching of Nickel and Iron from Greek Non-Sulphide Nickeliferous Ores by Organic Acids. Hydrometallurgy 1994; 36:345-360.

Wanta, K., C., Perdana, I., Petrus, H., T., B., M., 2017, Uji Validitas Model Shrinking Core terhadap Pengaruh Konsentrasi Asam Sitrat dalam Proses Leaching Nikel Laterit, Jurnal Rekayasa Proses Volume 11 No. 1, 2017, hal. 30-35.

WELLMER, F.W (2002): Leachable supergene base and precious metaldeposits worldwide.– ERZMETALL, **55**: 25-33.