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Particle Size Analysis of Morowali Nickel Laterite on Atmospheric Citric Acid Leaching

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Abstract

Atmospheric Pressure Acid Leaching (APAL) is one of nickel laterite processing which has a big potential to be applied in industry. The leaching process is significantly influenced by the particle size effect, agitation leaching speed, and leaching time. This research demonstrated that particle size has important role to determine leaching performances of nickel laterite. The main focus of this research is to study the effect of particle size of Morowali nickel laterite in order to increase nickel recovery on atmospheric citric acid leaching. Particle sizes of nickel laterite used on this experiment are 50 mesh, 100 mesh, 150 mesh, 200 mesh and range of leaching time of 10, 20, 30, 60, 90, 120 minutes. Other constant operating conditions applied in this study are concentration of citric acid (M), agitation speed (rpm), leaching temperature (°C). The results shown that the amount recovery of nickel tend to increases with smaller particle size of nickel laterite. But this research work indicated that particle size 100 mesh achieved good recovery of nickel at 2824 ppm.

Keywords: Particle size, Atmospheric leaching, Citric acid, Nickel laterite, Hydrometallurgy.

1. Introduction

In the future, hydrometallurgical methods or aqueous treatments will become the primary techniques for the recovery of nickel and other metals from nickel laterite ores, especially low-grade laterite ores, because they enable valuable metals such as nickel, cobalt, iron, magnesium, chromium, and aluminum to be extracted comprehensively (Watling et al., 2011; Liu et al., 2010; Fan and Gerson, 2013). Laterites are oxide ores widely distributed in the tropical regions. They were formed during laterization, a weathering process of ultramafic rocks that is favoured by warm climate and abundant rainfall. Lateritic deposits usually consist of three layers, namely the limonite, the saprolite and the garnierite layer. Limonite, which comprises the top lateritic layer, is a homogeneous ore consisting mainly of goethite associated with nickel (Gleeson et al., 2003; Golightly, 1981).

New, effective, energy saving, easily controlled and environmentally safe methods for nickel recovery from large quantities of low-grade laterites nickel ore are needed, since the established pyrometallurgical and hydrometallurgical industrial processes are either energy intensive or present severe engineering problems. One hydrometallurgical method that has not yet been used industrially, although its study is becoming increasingly important, is atmospheric acid leaching. Some researchers have investigated the atmospheric acid leaching of nickel laterite using inorganic acids such as sulfuric acid, hydrochloric acid, and nitric acid, and a range of organic acids (MacCarthy et al., 2014; Nosrati et al., 2014; Rice and Strong, 1974a,1974b;Wang et al., 2012;Wang et al., 2014). The use of organic acids in dissolution of the metals in nickel laterite ores is an alternative method that has advantages in terms of environmental issues. Many researchers have confirmed that citric acid is the most effective organic acid in the leaching of nickel laterites (Mc Donald and Whittington, 2008b). According to (Mubarok et al., 2011) The use of citric acid in nickel leaching has several advantages, especially in environmental issues such as providing leaching reagents that are non-toxic and biodegradable and overcoming the problem of agricultural waste. In addition, leaching of citric acid has high effectiveness and selectivity in nickel leaching. Therefore, citric acid leaching will be a suitable alternative technique for nickel extraction from Indonesian lateritic ores.

Recently, with continuous updation of the grinding equipment, mineral particle size distribution has become possible and has been industrialized in some factories. For heterogeneous reactions, the migration rate of reactive molecules from one phase to another must be related to the area of the interface them fine particles react faster because of the larger surface area of the former. Unfortunately, few studies have been conducted on the effects of particle size on the leaching of nickel laterite ore with citric acid. The effect of different particle sizes, after refining the mineral is undefined (Burgges et al., 2018).

2. Material and methods

2.1. Nickel laterite ore

Laterite nickel ore used in this experiment is a type of limonite from Morowali, Central Sulawesi Province. Before the leaching process is carried out, laterite nickel ore is prepared by drying in an oven at 110 ° C for 4 hours to reduce the water content, then grinded using a hammer mill. Later, the ore is heated to facilitate the shieving process by using shieve shakers. Different particle sizes are obtained by weight laterite nickel ore of 500 gram and shieve along 5 minutes. The investigation is done by 5 times shieving with persistent mass entry. The refined particle size are 50, 100, 150 and 200 mesh. The high amount of refined particle is 151,08 gram by particle size 50 mesh and the lower amount is 45,42 gram by particle size 200 mesh. The distribution of particle size by weight can be seen in Figure 1.

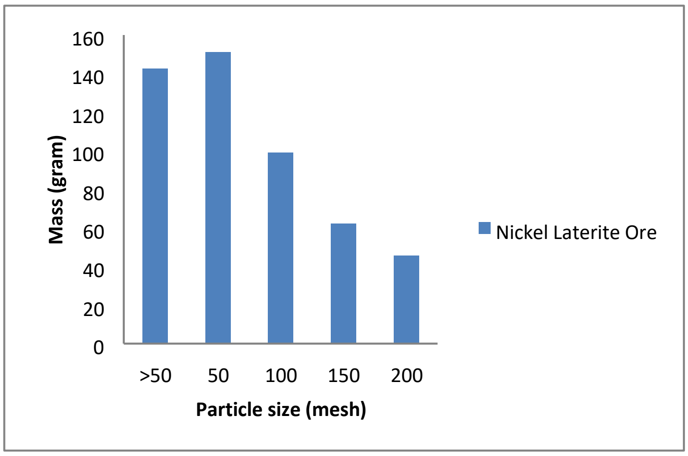

Fig. 1: Distribution particle size by weight (gr)

Sample was analyzed for its nickel content using an X-Ray Fluorescene (XRF) in the sample of 5.15% by weight. As for the metal content in nickel laterite ore can be seen in more detail in Table 1.

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

Table 1 shows that iron (Fe) is the main chemical component of Morowali nickel laterite as said (Purwanto, 2002) is laterite ore with low nickel content is recommended to have an iron content of about 50% by weight.

2.3. Leaching and analitycal methods

The methods used in this research is atmospheric pressure acid leaching. The process was conducted by pouring 360 ml of 1 M citric acid solution, heated until 70 °C and stired by agitation speed of 1000 rpm. 30 gram nickel laterite ore was added into the erlenmeyer after the temperature is reached. The variation of particle size are 50, 100, 150 and 200 mesh. The filtrate sample is taken periodically at time of 10, 20, 30, 60, 90, 120 minutes.

3. **Result and discussion**

3.1. Effect of leaching time

One of the factors that has an important role in the nickel laterite leaching process is the leaching time because the frequency of collisions between molecules increases with the leaching time. The results of the analysis using AAS are presented in Graph 2.

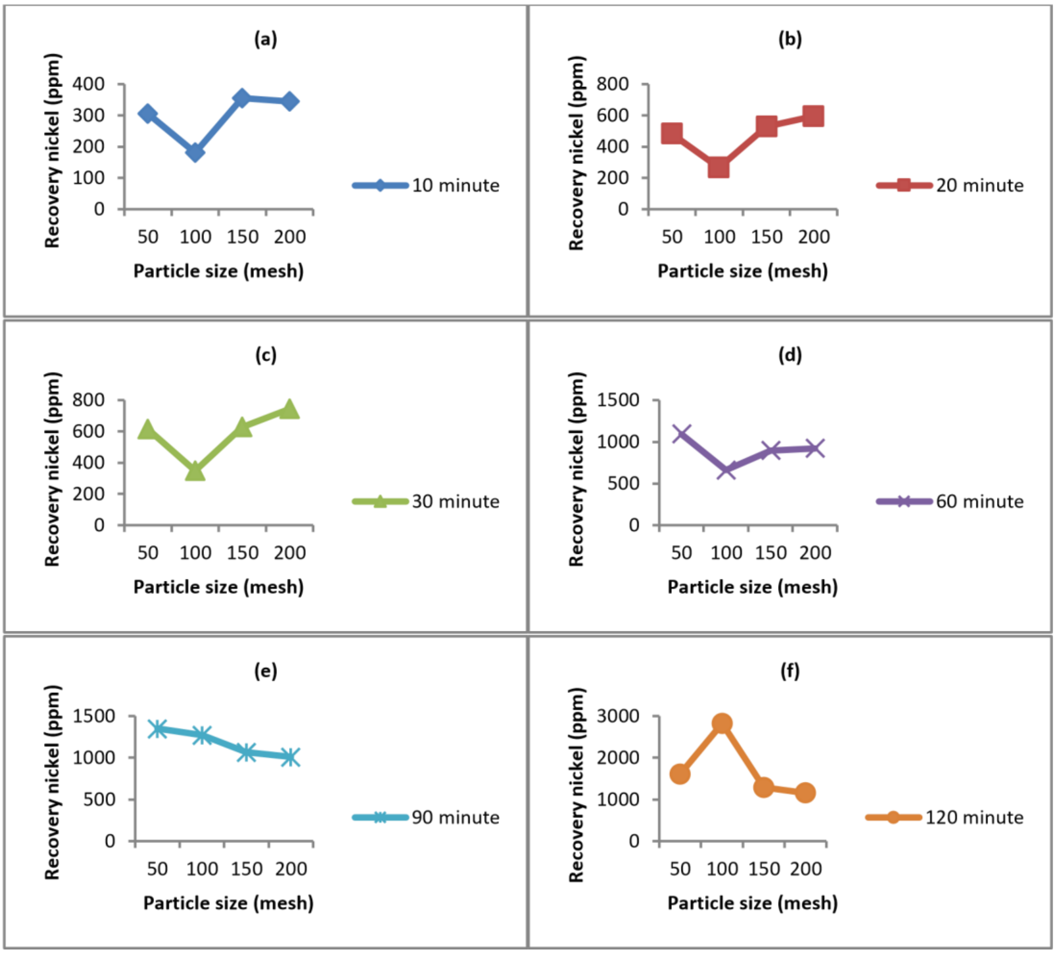

Fig. 2: Data of recovery nickel (ppm) variable of leaching time 10 minute (a), 20 minute (b), 30 minute (c), 60 minute (d), 90 minute (e) and 120 minute (f).

Figure 2 shows that the effect of particle size on atmospheric citric acid leaching of nickel laterite increases the nickel recovery. Time duration on leaching process also influence the recovery value of nickel. The longer the leaching process is carried out, the higher of nickel recovery obtained. This phenomenon can occur because the frequency of collisions between molecules increases as the leaching time increases. The dense of frequency intermolecular collisions, the higher product formed.

3.2. Effect of particle size

The particle size has main role in this nickel laterite leaching process. Analysis using AAS revealed that particle size of the are presented in Figure 3.

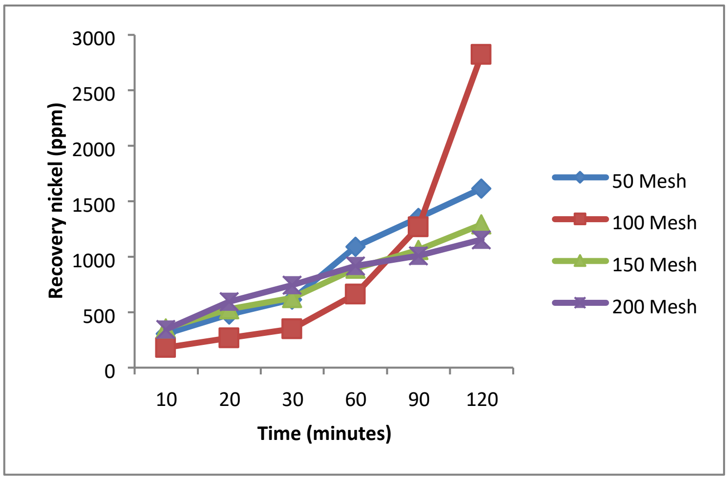

Fig. 3: Data of recovery nickel (ppm) variable of particle size

Figure 3 shows the influence of the duration of the leaching process on the concentration value of nickel recovery. According to the references, the value of nickel recovery enhanced with smaller particle size. However, in this the investigation the amount of nickel recovery show the high performance at 100 mesh that is 2824 ppm. It is probably because the particle size on the leaching process are heterogeneous reactions.

4. Conclusion

The nickel recovery of Morowali nickel laterite is performed using an atmospheric citric acid leaching. The results indicated that particle size and leaching time are influenced parameters to enhance nickel recovery. Based on the reference an increase in recovery value increases if the particle size gets smaller. However, in this research work nickel recovery greatly improved at particle size 100 mesh and reached 2824 ppm.

5. Nomenclature

T	temperature	C
M	Molarity	g/Mr
R	rotation speed	rpm

Subscripts

APAL	Atmospheric Pressure Acid Leaching
AAS	Atomic Absorbsion Spectrophotometry
XRF	X-Ray Fluorescene

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