TEST OF REMOVAL OF IRON MINERALS FROM KAOLIN USING HGMS

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ABSTRACT

Kaolin from Nagreg contains iron mineral particles approximately 0.58 % Fe that cause a grey color of the material . An effort to reduce iron content can be made by applying beneficiation test, using HGMS (High Gradient Magnetic Separator), so the kaolin may become white color and can reach the standard quality for paper industries.

A HGMS beneficiation test was conducted at magnetic field strength of 5,000 Gauss. The experiments were carried out using variable flow rates of 1, 1.5, 2, 2.5, 3 and 3.5 liter per minute and slurry density of 2.5, 5, 7.5, 10, 12.5 and 15 % solid.

The results of experiments show that the optimum condition with flow rate of 2.5 liters/minute gave the quality of kaolin concentrate with iron content of 0.29 %Fe.

Keywords: kaolin, iron, HGMS, beneficiation, magnetic separation

1. INTRODUCTION

Kaolin is an industrial earth material used as filler and whitener in paper industries, and also is used as based material for cosmetic industries. In ceramic industries, kaolin is used for refinement the surface of ceramic, and in electronics industries kaolin is used as an insulator material.

In Indonesia, kaolin deposit spreads in Sumatera, Java, Borneo, Celebes and West side of Nusa Tenggara. In West Java, Kaolin presents among other in Sukabumi, Tasikmalaya and Nagreg (Figure 1). Kaolin Nagreg contains iron of 0.58% Fe, caused a grey color to the kaolin. In order to improve the quality of kaolin for paper industries, the iron content should be removed. The specification of iron content in kaolin for paper industries must be near zero (Kogel 2006).

Kaolin deposit in earth performs as clay minerals. Its genesis was due to transportation and sediment processes in long times to perform the fine structure deposit of clay mineral, with specific mineral compositions.Kaolin minerals have chemical composition of $Al_2Si_2O_5(OH)_4$ that consists of several elements to perform its structure (Wikipedia, 2007) . Kaolin has many kind of quality, depend on the size of fine fraction performs and the chemical elements content.

The type of kaolin considered in ceramic and paper industries should have low iron content.The existence of iron in kaolin causes grey to pink color of kaolin. The paper industries require kaolin with iron content as low as possible to give a white color product.

Kaolin has an ultra fine particle size less than 400 mesh. The specific characteristics of fine size and sticky mud of kaolin,make it possible to be used as a filler materials in paper and presents good quality of paper product kaolin is also used as a basic element for ceramic industries and cosmetic, which presents good quality and well performs of skin surface (smooth and soft).

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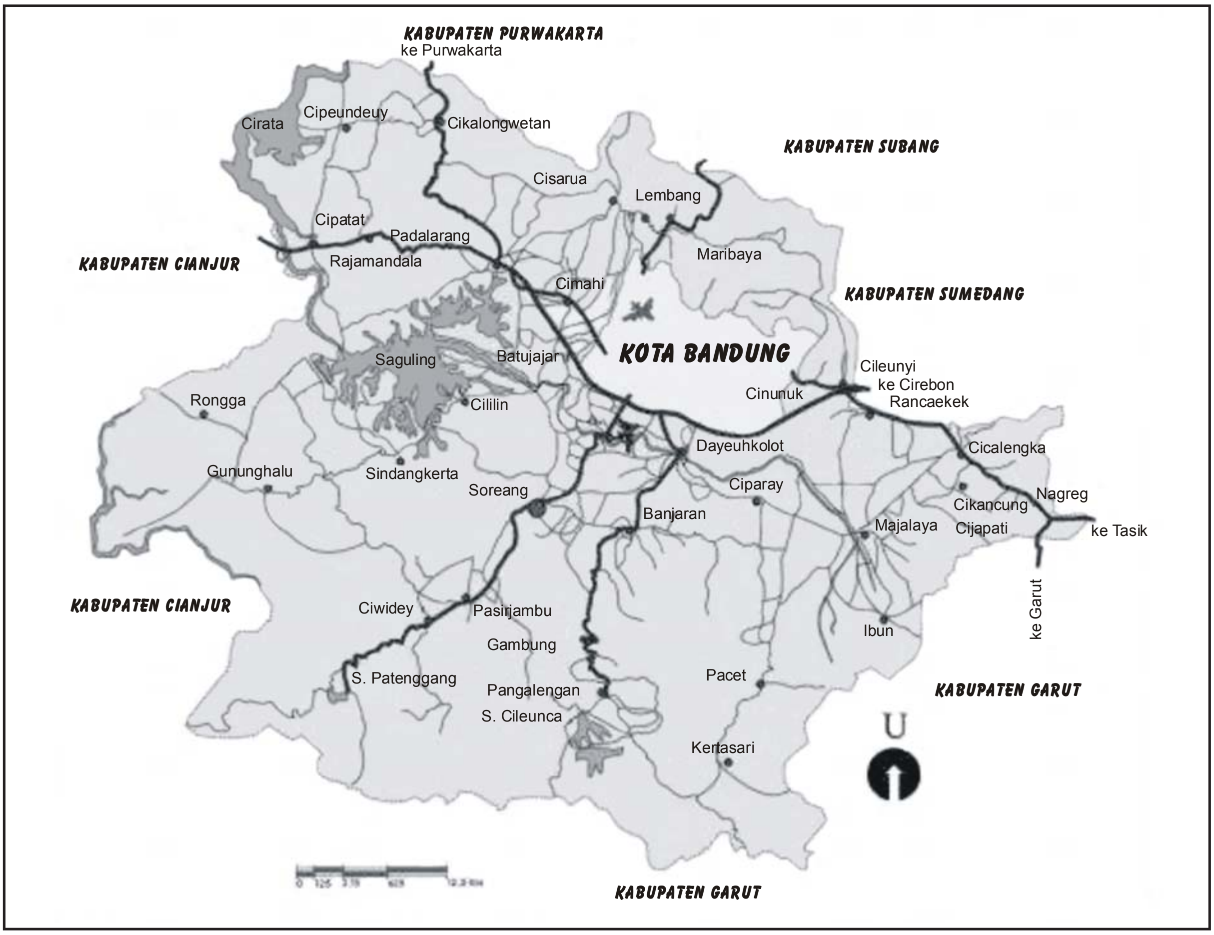

Figure 1. The location of Kaolin Deposit in Nagreg, Kabupaten Bandung

In general, kaolin with less white color is due to high content of iron minerals filling its structure. There are some kinds of minerals like pyrite, limonite, chalcopyrite, forming as a very thin film coating at the surface of kaolin (Lawver and Hopstok,1985; Wikipedia 2007). Separation process of iron particle minerals using decantation process or other gravitational processes were not working sufficiently, because the size of iron materials are very fine, caused static electrical force on particles, and tend to stick each others. Another possible beneficiation process to separate the iron particles is by using a HGMS (High Gradient Magnetic Separator) appliance. The principle operation of HGMS is a combination process between decantation and magnetic separation.

The aim of this laboratory work is to test the possibility of reducing iron content in kaolin as low as possible by using HGMS appliance.

2. METHODS

2.1. Separation Method

Kaolin of Nagreg containts 0,5% Fe. In general minerals content of iron particle can be pulled out by magnetic field with a certain magnetic strength to yield very low iron element as pollutant.

The beneficiation test of kaolin was conducted using HGMS appliance. Separation process was operated at magnetic field of 5,000 Gauss at different feed rates and slurry densities to get an optimum result of separation.

In a preliminary work, kaolin was roughly purified by decantation method to eliminate quartz and other coarse particles from kaolin. The gravitational method based on the different specific gravity with the contaminant that is quartz and other coarse particles have higher level of specific gravity compared to kaolin. To observe the HGMS separation results, the iron contants in the feed and product were analyzed.

Iron mineral in kaolin presents by weathering process of main rocks. There are some kinds of iron minerals of pyrite, limonite and chalcopyrite, that found in an ultra fine particles and difficult to separate because sticky each other in slurry. To separate those particles, it should be made in the form of slurry at certain density by adding more water and using continuous stirrer, so each particle mineral become disperse easily in the form of single free particles in water. The slurry was flew down through the cell of "canister" by magnetic force. The iron particle can be pulled out from kaolin and trapped on induction lattices canister to allow the clean kaolin flows down as concentrated kaolin.

The flowsheet of kaolin beneficiation test is shown in Figure 2:

RAW MATERIALS OF KAOLIN

↓

SIEVE AND CHEMICAL ANALYSIS

↓

DECANTATION

↓

SEPARATION WITH HGMS

↓

CHEMICAL ANALYSIS OF RESULTS

↓

FINAL CONCENTRATE

Figure 2. The flow work of present kaolin beneficiation tests

2.2. Equipment

The HGMS equipment used has strength of magnetic field on "canister". The equipment has a conical tube at the topside. Kaolin was stirred with water in a certain slurry density, with a certain flow rate. The stream flows down passing through "canister" having diameter of 3½ inch with volume of 866 cm^3. The magnetic field intensity at "canister" was 5,000 Gauss. The HGMS equipment can be seen in Figure 3.

Figure 3. HGMS (High Gradient Magnetic Separator) equipment

3. EXPERIMENTAL RESULT

3.1. Raw Material Analysis

Observation of raw material of kaolin was taken by using sizing and chemical analysis. Sieve analysis was conducted to observe the size composition of raw material whether larger or smaller than 400 mesh. The fraction size smaller than 400 mesh was used as feed in to HGMS. Chemical analysis was conducted to observe the iron content of both fraction size. The results are shown in Table 1.

The iron grade of fraction -400 mesh obtained from sieve analysis was used as basic data for recovery calculation.

3.2. Decantation

Decantation test was conducted to the kaolin raw material prior to be processed with HGMS. First, kaolin was mixed with water using continuous stirrer. The kaolin slurry was then poured through a sieve of 400 mesh in opening size, to get fraction size of -400 mesh. The weight of fraction size +400 mesh was measured and calculated. For further experiments, the slurry of fraction size of -400 mesh

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Table 1. Size Analysis 400 mesh and Chemical Analysis

NO	SIZE (mesh)	WEIGHT (gram)	(%)	Fe GRADE (%)	Fe DISTRIBUTION	
1	+ 400	50.10	10.02	0.13	1.30	Reject
2	- 400	449.90	89.98	0.63	56.69	use as feed HGMS
TOTAL	500.00	100.00	0.58	57.99		

was used as raw material for HGMS. To get appropriate slurry density needed for experiments, the quantity of water was calculated and added. The result of decantation is shown in Table 2.

Table 2. Fraction Size of Decantation tests

NO	FRACTION SIZE (mesh)	WEIGHT (%)
1	+ 400	10.05
2	- 400	89.95 (calculated)
TOTAL		100.00

3.3. HGMS Experimentation

Beneficiation test using HGMS was conducted with variable flow rates of 1.0, 1.5, 2.0, 2.5, 3.0 and 3.5 liter per minute, and slurry density of 2.5, 5, 7.5, 10, 12.5 and 15 % solid.

Feed of kaolin having size of -400 mesh mixed with water in a certain volume. The slurry density was set in fixed value of 10% solid, while feed rate was varied. The results can be seen in Table 3.

Table 4 shows the beneficiation test results with variable slurry density. While the flow rate was taken in fixed value of 2.5 L/min.

Table 3. Result of Experiments (Flow Rate Variation)

NO	Feeding Flow Rate	Feed		Kaolin Concentrate		Magnetic Material	
	(l/minute)	(gram)	(% Fe)	(gram)	(% Fe)	(gram)	(% Fe)
1	1.00	250	0.63	208.62	0.24	41.38	2.59
2	1.50	250	0.63	208.68	0.25	41.32	2.55
3	2.00	250	0.63	208.75	0.28	41.25	2.40
4	2.50	250	0.63	208.93	0.29	41.07	2.36
5	3.00	250	0.63	210.76	0.52	39.24	1.22
6	3.50	250	0.63	215.84	0.67	34.16	0.38

Table 4. Result of Experiments (Slurry Density Variation)

NO	Slurry density	Feed		Kaolin Concentrate		Magnetic Material	
	(% solid)	(gram)	(% Fe)	(gram)	(% Fe)	(gram)	(% Fe)
1	2.5	250	0.63	207.77	0.25	42.23	2.50
2	5	250	0.63	207.83	0.26	42.17	2.46
3	7.5	250	0.63	209.84	0.27	41.65	2.42
4	10	250	0.63	210.76	0.36	39.24	2.08
5	12.5	250	0.63	216.04	0.48	33.96	1.58
6	15	250	0.63	223.26	0.62	26.74	0.71

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4. DISCUSION

4.1 Raw Material

The results of sieve and chemical analysis of kaolin as shown in Tables 1 indicates that only a small part (10.02%) of raw material had fraction size of +400 mesh to be rejected. Another part was fine size of -400 mesh, that was 89.98%. However, this fine material contained higher part of iron grade (0.63%), designating the kaolin becomes grey color, so it should be removed to give white color.

4.2. Decantation

To abtain raw material of kaolin smaller than 400 mesh, it should be mixed with water using mechanical stirrer and then applying decantation tests. The kaolin slurry was then screened using sieve of 400 mesh. The fraction size of +400 mesh was weighed. The rest fraction of -400 mesh was calculated, to measure the quantity of water to be added as needed by HGMS experiment. There is no significant different in weight fraction of -400 mesh between size analysis and decantation, that was 10.02% and 10.05% respectively.

4.3. HGMS Experiment with Different Flow Rate

The results of experiment using HGMS with magnetic intensity of 5,000 Gauss, flow rates of 1.0, 1.5, 2.0, 2.5, 3.0 and 3.5 L/min, were presented in Table 3, and graphically illustrated in Figure 4.

Figure 4 shows that increasing flow rate yielded higher iron content of kaolin concentrate. In the early experiments, with flow rate of 1 to 2.5 L/min, the increasing flow rate gave a small effect to iron in kaolin concentrate, 0.24 to 0.29 % Fe. The graphic line was nearly flat, and the iron content only increased 0.05%, while the flow rate increased 2.5 times. However, with more increasing flow rate up to 3.5 L/min caused more increasing iron content in kaolin concentrate up to 0.52 and 0.67% Fe. The higher flow rate caused more iron far-off distance of "canister", and flows together with kaolin, therefore the iron content in kaolin concentrate increases. From Figure 4, it indicates that the ability of HGMS to resist the iron content is only up to the flow rate of 2.5 L/min. So, the optimum value of flow rate is 2.5 L/min. Similar results are also found by Fontes (1992), using different flowing of suspension, during HGMS process. At the slower flow velocity, almost all the clays are retained in the canister, so, the iron content in kaolin concentrate become lower than on the high velocity. Nevertheless, it is evidence that the lower flow rate , the lower iron content in kaolin. The optimum value of flow rate of 2.5 liters/minute is decided based on the capacity of raw materials processed.

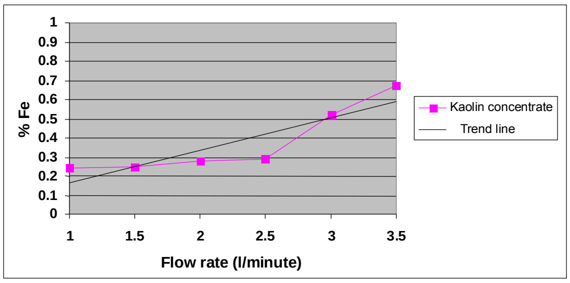

Figure 4. Effect of flow rate to kaolin concentrate

4.4. HGMS Experiment with Different Slurry Density

The experiment with variable slurry density (2.5, 5, 7.5, 10, 12.5 and 15 % solid) was operated with magnetic intensity of 5,000 Gauss. The flow rate was taken in fix value of 2.5 L/min. The results can be seen in Table 4, and graphically illustrated in Figure 5:

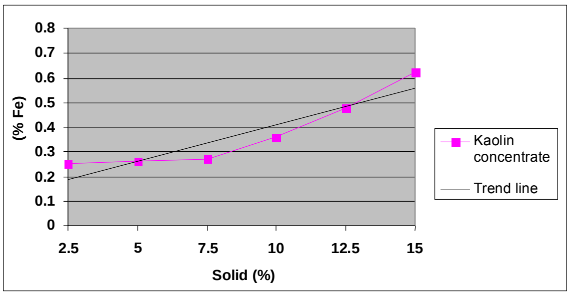

Figure 5. Effect of slurry density to kaolin concentrate

In Figure 5 it can be seen the influence of slurry density to the iron content of kaolin concentrate. In the beginning of experiments, with slurry density of 2.5, 5.0 and 7.5 % solid, the increasing slurry density only gave a small effect on increasing iron in kaolin concentrate, those were 0.25, 0.26 and 0.27 % Fe. However, increasing slurry

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density up to 10 % solid caused increasing iron content in kaolin concentrate up to 0.36 % Fe. The highest density up to 15 % solid, presents the highest iron content in kaolin concentrate up to 0.62 % solid. It indicates that the ability of HGMS to trap iron was optimum at applied density of 7.5 % solid. The higher slurry density caused the more iron unable to catch by "canister", and passing through to kaolin concentrate, so kaolin concentrate can not reduce the iron content. Fontes(1992) also found that at low slurry density, the iron particles retained easier on canister, exhibited a good separation and yielding a good quality of kaolin concentrate. It is recommended to use low slurry density during HGMS process.

5. CONCLUSION

- Result of sieve and chemical analysis for kaolin raw material indicates that kaolin fraction of - 400 mesh counted 89.98 % weight and the iron content of 0.63 % Fe.

- Result of beneficiation tests with variable of flow rate indicates that the optimum value was 2.5 L/min, in which the iron content of kaolin concentrate reached 0.29 % Fe.

- Result of testing with variable slurry density gave the optimum value of 7.5 % solid, in which the iron content of kaolin concentrate was reduced to reach 0.27% Fe.

- The iron mineral content in kaolin concentrate has not met the iron grade required by paper industry.

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