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Processing of illite powder in Bidor, Perak : A study of the process and the potential use of illite clay

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Abstract: The wet process used by one of the local plants in processing illite is studied here. The crude clay is processed by passing through the sedimentation tanks, trommel, sluice box and the vibration screen to remove the coarse materials.

The product obtained contains mainly illite and very small amount of kaolin, quartz and montmorillonite. The chemical composition, particle size distribution, brightness and other physical properties of the raw clay and the product were also determined.

The product is mostly exported to Japan and used as a coating for welding rods. Illite can also be used as a white filler in the rubber products and possibly as a partial substitute for feldspar in certain ceramic applications.

INTRODUCTION

Besides the numerous kaolin processing plants, there are two plants which process illite in the Bidor area, Perak. The first plant, Foo Nyean has been in operation for more than a decade. The second plant, Tech Cera started operation in 1985. Both the plants use the wet process.

This paper describes the process used by Tech Cera. The chemical, mineralogical and physical characteristics of the raw clay and the wet, dry and powder products are studied. The potential uses of the illite clay are discussed.

Three samples each of the raw clay, processed wet, dry and powder clay were collected randomly from the factory. Besides these, one sample each of the rejects from the trommel and sluice box were collected. It is assumed that the samples studied are representative of the clay produced by the plant. Compositional variation within each type of sample is outside the scope of this paper.

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PROCESSING OF ILLITE POWDER

The method of processing is shown schematically in Figure 1. The aim of processing is to remove as much as possible the coarse-grained impurities from the raw clay. The whole refining process is summarised as follows:

The raw clay is excavated from the pit located near the plant and stockpiled near the agitation tank. The clay is fed manually into the agitation tank. The water and the rotating steel blades in the tank help to break up the clay and turn it into a slurry. The slurry is led into a cement sedimentation tank where the coarse impurities settle to the bottom. The lighter slurry is led into the trommel where the sand is removed. Any finer impurities which remain in the slurry are removed after passing through the second sedimentation tank, the sluice box and the 150 mesh vibration screen. The refined slurry is stored in four slurry tanks. The filter pump pumps the slurry into the filter press. The wet cake from the filter press is placed on wooden trays and stacked up in open sheds for air drying. The dry cake is then pulverized before bagging for sale.

METHODS OF INVESTIGATION

The chemical and mineralogical composition, particle size distribution, brightness, moisture content and the firing characteristics of both the raw clay and product were studied. For chemical analysis, a combination of methods was employed. Major components such as silica and alumina were determined by gravimetric method, while the analysis for the minor elements such as sodium, potassium, calcium and magnesium involved the use of atomic absorption method. The colorimetric method was used to determine the iron and titanium contents.

The brightness of the clay samples was measured by means of the Carl Zeiss Photoelectric-Reflectance Photometer at 457 nm, while the particle size distribution was determined by the Andreasen pipette method.

To determine the moisture content, all the crude clay samples and wet cakes were weighed and sun dried. The moisture content was noted. A known weight of the sun-dried sample was taken and dried at 105 °C. The total moisture content was then computed. For the dry cakes and powder samples, a known amount of the sample was taken and dried at 105 °C.

The raw clay and the processed powder clay samples were selected for the firing test. The test specimens were prepared by means of plastic moulds. After drying, the briquettes were fired in 100 °C intervals over the range of 900 °C and 1200 °C. On completion of the firing process, the firing/drying shrinkages, porosity, fired colour and hardness of the test pieces were determined.

The mineralogical composition of all the clay samples was determined by X-ray diffraction method on the minus 50 micron fraction.

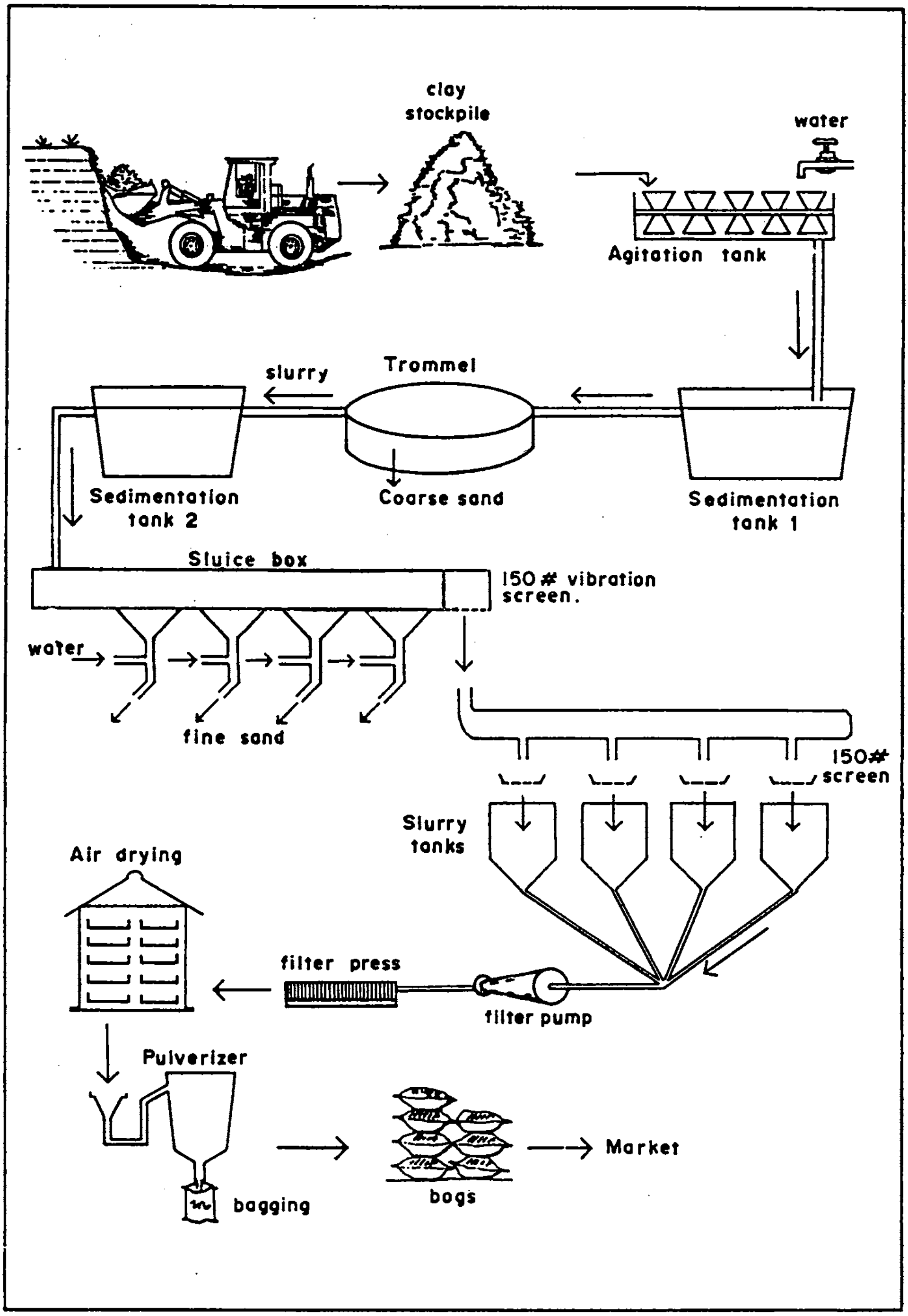

Figure 1: Flowchart showing the processing of illite powder.

Analysis were also carried out on the samples of rejects from the trommel and the sluice box. A clay sample collected from the same site but processed in Japan was also included in the study for comparison purposes.

RESULTS OF INVESTIGATION

(a) Mineralogical Composition

The results of XRD on the minus 50 micron fractions show that both the raw clay and the processed clay contain mainly illite and very small amounts of montmorillonite, kaolin and quartz.

(b) Particle size distribution

The particle size distribution of the samples is given in Table 1.

The raw clay contains about 20 percent of grit materials (plus 350 mesh fraction). This is largely removed by processing and the product contains less than 2% of grit. The clay content (minus 2 micron fraction) shows a slight increase from 16 percent in the raw clay to 24 percent in the product.

(c) Chemical Composition

The chemical composition of the samples is shown in Table 2. A comparison of the average chemical content of the raw clay and the product is given below.

	Raw Clay (N = 3)	Product (N = 9)
SiO_2	60.00	49.80
Al_2O_3	23.50	30.10
Fe_2O_3	1.42	1.71
TiO_2	0.74	0.93
CaO	0.03	0.02
MgO	1.80	2.19
Na_2O	0.10	0.12
K_2O	6.91	8.53
L.O.I.	5.26	6.59
Total	99.76	99.99

Table 1: Size distribution of the samples (%)

	Raw Clay			Wet Cake			Dry Cake			Powder		
	C1	C2	C3	W1	W2	W3	D1	D2	D3	P1	P2	P3
+ 350 # B.S.S.	21.3	20.7	21.9	1.1	1.7	1.3	1.1	2.4	1.5	1.2	1.5	1.8
+ 30 μ e.s.d.	3.2	4.5	5.1	2.4	1.2	5.3	2.7	0.6	2.0	1.8	0.5	1.2
+ 20 μ e.s.d.	3.2	6.2	6.6	4.2	3.9	4.5	5.4	0.6	3.0	3.6	0.2	5.0
+ 10 μ e.s.d.	13.3	16.2	11.8	16.1	19.4	16.4	17.3	15.6	12.2	12.9	10.5	11.6
+ 5 μ e.s.d.	22.4	18.6	18.6	29.0	29.8	28.5	26.9	27.6	27.8	30.2	35.5	29.1
+ 2 μ e.s.d.	20.8	18.3	18.9	28.7	24.8	27.0	28.1	30.1	34.7	27.8	25.0	28.0
– 2 μ e.s.d.	15.8	15.5	17.1	18.5	19.2	17.0	18.5	23.1	18.8	22.5	26.8	23.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

B.S.S. = British Standard Sieve

e.s.d. = Equivalent Spherical Diameter

Table 2: Chemical composition, moisture content and brightness of the samples

	Raw Clay			Wet Cake			Dry Cake			Powder		
	C1	C2	C3	W1	W2	W3	D1	D2	D3	P1	P2	P3
% SiO_2	59.0	61.8	59.1	49.7	49.7	50.3	49.4	50.4	49.4	49.5	49.4	50.1
Al_2O_3	24.2	22.2	24.2	29.9	30.4	30.1	30.0	29.5	29.9	30.5	30.4	30.4
Fe_2O_3	1.48	1.34	1.44	1.75	1.76	1.71	1.66	1.68	1.69	1.69	1.69	1.66
TiO_2	0.75	0.71	0.77	0.89	0.87	0.89	0.92	0.94	0.94	0.98	0.99	0.95
CaO	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.04
MgO	1.89	1.71	1.80	2.19	2.20	2.19	2.15	2.13	2.18	2.22	2.20	2.21
Na_2O	0.11	0.10	0.10	0.12	0.11	0.12	0.11	0.12	0.12	0.12	0.12	0.12
K_2O	7.03	6.85	6.85	8.70	8.72	8.91	8.50	8.34	8.48	8.32	8.43	8.37
L.O.I.	5.33	5.06	5.38	6.50	6.29	6.24	6.73	6.57	6.85	6.75	6.73	6.65
Total	99.84	99.79	99.66	99.77	100.07	100.52	99.54	99.67	99.56	100.10	99.98	100.50
% Moisture at 105 °C	19.4	20.1	26.0	34.2	35.7	34.3	0.95	2.36	2.20	0.50	0.55	0.55
% Brightness at 457 nm	73.5	70.9	74.6	74.5	75.3	73.8	74.0	72.9	72.5	73.5	75.4	73.8

The higher-SiO_2 content in the raw clay is mainly attributed to the quartz in the grit materials which is removed in the product. All the other oxides, especially alumina and potassium are higher in the product than in the raw clay.

(d) **Moisture content**

The average moisture content of the samples computed from Table 2 is given below.

	Moisture (%) at 105 °C
raw clay	21.8
wet cake	34.7
dry cake	1.80
powder	0.53

(e) **Brightness**

The average brightness of the samples computed from Table 2 is given below.

	Brightness (%) at 457 nm
raw clay	73.0
wet clay	74.5
dry clay	73.1
powder	74.2

(f) **Firing test**

The results of firing test on 6 samples of raw clay and product are given in Table 3. The product shows better firing characteristics than the raw clay. It is noteworthy that the drop in porosity of the product at about 1200 °C denotes vitrification has taken place. This is due to the high potassium content. The effect of the iron content in the product is reflected by the change in the fired colour from cream at 1000/1100 °C to yellowish brown at 1200 °C. Although the product has good plasticity the greenstrength is low.

Table 3 : Results of firing tests on raw clay and processed clay

Sample Markings a	Tempering Water (%) b	Drying Shrinkage (%) c	Green-strength d	Firing Temperature (C°)	Firing Shrinkage (%) e	Fried Colour	Porosity f	Hardness g
C1	43.3	1.1	low	1000	4.5	cream	39.5	L.S.
				1100	8.3	cream	25.5	S.
				1200	14.5	yellowish brown	9.4	S.
C2	33.3	1.6	low	1000	3.2	cream	39.1	L.S.
				1100	7.6	cream	28.0	S.
				1200	12.2	yellowish brown	11.7	S.
C3	38.7	2.2	low	1000	7.8	cream	38.5	L.S.
				1100	8.3	cream	25.4	S.
				1200	12.9	yellowish brown	9.8	S.
P1	48.3	3.1	low	1000	3.6	cream	42.7	L.S.
				1100	11.2	cream	25.8	S.
				1200	17.7	yellowish brown	0.9	S.
P2	48.0	2.5	low	1000	4.5	cream	43.1	L.S.
				1100	10.0	cream	28.2	S.
				1200	16.8	yellowish brown	0.9	S.
P3	48.0	3.7	low	1000	3.0	cream	44.3	L.S.
				1100	9.6	cream	26.4	S.
				1200	15.2	yellowish brown	1.4	S.

a. Type of samples : C = Raw Clay, P = Processed Clay

b. Tempering water is the proportion of water required to bring out the best working qualities of the clay, expressed in percentage of the dry clay weight.

c. Drying shrinkage is the linear measurement of shrinkage expressed as percentage of the original length of the test piece.

d. Greenstrength is assessed subjectively by breaking the unfired briquette.

e. Firing shrinkage is the difference between the total shrinkage and the drying shrinkage.

f. Porosity is the ratio of the volume of the open pores to the volume of the test piece.

g. Hardness : L.S. = less than steel hard, S. = steel hard

(g) Comparison with illite processed in Japan

A sample of illite collected from the same site but processed in Japan was compared chemically with the locally processed illite as follows:

	Illite processed in Japan	Illite processed locally
SiO_2	48.5	49.8
Al_2O_3	31.0	30.1
Fe_2O_3	1.47	1.71
TiO_2	0.82	0.93
CaO	0.44	0.02
MgO	2.26	2.19
Na_2O	0.15	0.12
K_2O	8.63	8.53
L.O.I.	6.40	6.59
Total	99.67	99.99

Basing on the above result, it appears that the sample processed in Japan is slightly superior on account of its high alumina and alkali content and low silica, iron and titanium content.

(h) Analysis of waste products

The particle size distribution of the 2 waste product samples is shown below.

	Trommel reject	Sluice box reject
+ 350 # B.S.S.	74.3	10.9
+ 30 / μ e.s.d.	1.7	1.6
+ 20 / μ e.s.d.	2.1	6.0
+ 10 / μ e.s.d.	3.9	17.2
+ 5 / μ e.s.d.	5.6	17.8
+ 2 / μ e.s.d.	6.4	26.8
- 2 / μ e.s.d.	6.0	19.7
Total	100.0	100.0

More than 70% of the reject from the trommel constitutes material coarser than 45 microns (350 mesh B.S.S.), whilst the reject from the sluice box is mostly material finer than 45 microns.

The chemical composition of the 2 waste product samples is shown below.

	Trommel reject	Sluice box reject
% SiO_2	82.00	54.50
Al_2O_3	10.90	27.60
Fe_2O_3	0.65	1.56
TiO_2	0.32	0.82
CaO	0.03	0.22
MgO	0.73	2.00
Na_2O	0.04	0.12
K_2O	2.83	7.64
L.O.I.	2.58	5.99
Total	100.08	100.45

The coarse nature of the trommel reject and the high SiO_2 content denote that it is mostly made up of quartz. On the other hand the reject from the sluice box is mainly illite as shown by the low SiO_2 and high Al_2O_3 and K_2O contents.

DISCUSSION

The wet processing method is effective in removing the coarse-grained impurities. Much of the grit material is removed at the trommel. This is indicated by the large particle size and high silica content in the material from the trommel. Any grit materials that escape separation is removed at the sluice box. Analyses of the materials collected from the sluice box shows that much clay is also lost.

The product contains mainly illite with very small amount of montmorillonite, kaolin and quartz. The moisture content of the powder product is about 0.5 percent. The product contains more than 8 percent of K_2O and 2 percent of MgO. This accounts for its good fluxing properties as indicated by the firing test. However the product has comparatively low brightness.

The product understudy is mostly exported to Japan. It is mainly used for the coating of welding rods because of its fluxing properties. Illite has also found its use in many industries. Illite is used in the manufacture of white-filled mixes, sponge rubber and latex foam. According to Leong *et al.* (1970) the use of illite in these rubber products have certain advantages over other fillers.

In order to reduce the requirement of feldspar which is more expensive, pottery stone is used by some ceramic manufacturers as a partial substitute for feldspar. It is found that some of these pottery stones which are made up mainly of sericite have fairly similar chemical composition with the illite understudy, hence the possibility of exploiting it in the ceramic industry.

Illite can also be used as a base for certain cosmetic products. Unfortunately the illite under discussion was found to be less favourable because of its high iron content.

SUMMARY

The commercial processing of illite under discussion succeeds in removing most of the silica impurties and produces a product which consists mainly of illite and very small amounts of montmorillonite, kaolin and quartz. This product at present is almost solely being exported to Japan; reportedly being used as a coating for welding rods. The illite can also be used as a white-filler in rubber products. Basing on its fluxing properties, the illite may be used as a partial substitute for feldspar in certain ceramic applications.

REFERENCE

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