Improvement of Brightness of Sri Lankan China Clay

by

DR. P. G. R. DHARMARATNE, B. S. MARASINGHE, & G. P. PERERA.
Department of Mining & Mineral Engineering

Abstract : China clay is widely used in many industries such as ceramics, paper, paints, plastics and rubber. As most of these industries require clay having high brightness, a number of techniques have been developed to achieve that. This paper briefly reviews the methods used in other countries and discusses the possibility of developing an electrolytic method to brighten Sri Lankan china clay.

An instrument to measure brightness of powders has been designed and fabricated in this department. The principle involved is the measurement of reflected light from specimens at an angle 45° electronically.

1. Kaolin or china clay

Kaolin or china clay is one of the more intriguing and certainly one of the most sophisticated industrial minerals. Kaolin is thought to have been formed by partial decomposition of the granitic rock masses, by hydrothermal gases and fluid which converted the feldspar in the granite to kaolin. The kaolin which is extracted by refining processes, is a hydrated form of aluminium silicate with individual particles in the form of thin hexagonal plates. China clay is the chief raw material used in the manufacture of high quality domestic pottery.

In Sri Lanka, kaolin (Al_2O_3. 2 SiO_2. 2H_2O) deposits are found presumably as sedimentary formations at varying depths in Boralesgamuwa and Meetiyagoda areas. These deposits are associated with quartz, mica, feldspar, ilmenite, iron oxides and organic matters.

Average composition of kaolin

SiO_2	—	45.82%
Al_2O_3	—	38.78%
Fe_2O_3	—	0.39%
TiO_2	—	0.70%
CaO	—	0.14%
MgO	—	Traces
Na_2O	—	0.29%

Loss on ignition 13.90%

2. Uses of china clay

Its somewhat unique uses include providing gloss coating for paper and as one of the main body materials in ceramic whiteware and it is also one of the principal white filler/extender materials used in paper, paints, plastics and rubber etc. Kaolin is excellent in paper since it has many useful qualities such as high reflectance, high refractive index (to increase opacity), chemical inertness and insolubility, soft and non-abrasive nature and good retention characteristics etc.

3. Refining of china clay

The mining and the processing of Sri Lankan kaolin are being carried out by the Ceylon Ceramics Corporation. Two kaolin refineries produce up to 1000 tpa. The entire process of refining is a wet physical concentration process in which clay mineral is removed from gritty and foreign materials by water washing using gravitational techniques. After removing associated gritty particles and most of the other non-clay substances from the raw-kaolin, china clay with fairly high purity is recovered. However, as some of the dark coloured impurities are still not removed during this initial refining, the brightness of china clay refined in this way would not exceed 70%.

4. Reasons for low brightness

Low brightness may be due to the presence of a variety of non-clay materials, particles of iron oxides, mica, and titania may be some of them. It is thought that organic matters also contribute to poor brightness. Presence of 'anatase' with surface staining oxides of iron is one reason for dark colour. Anatase is one of the crystalline forms of titanium dioxide. Stained anatase is considerably darker in colour than kaolin and is weakly paramagnetic and occurs with the kaolin as extremely fine particles (often less than 1 micron).

5. Why brightness should be increased ?

Brightness of refined local china clay is about 75%. Sometimes it may be as low as 70%. Paper industry requires kaolin of very high brightness (82%). Although the function of kaolin in paper industry started out to be merely a filler of the expensive cellulose fibre, the growth of a variety of paper types available, promoted its effect on optical and printing characteristics to equal importance. Bright china clays have been finding increased usage in rubber, latex-based paints and plastics.

The paper industry had been using local china clay with chemical agents such as Lencophor, Bleucophor, and Tinopal to overcome the low brightness of clay. Now they import china clay with the required specifications.

6. Increasing brightness (Existing methods)

A number of methods have been developed particularly during the past two decades to improve the quality of wet processed clay. Various chemical, physical and magnetic methods are used to improve the whiteness of clay most notably for the paper industry where that quality is vital.

6.1 Bleaching

In the bleaching (or leaching process) iron bearing minerals are removed by the addition of a reducing agent (usually sodium hydrosulphite) at low P_H environment. To achieve low P_H, sulphuric acid and/or aluminium sulphate is added. The coloured iron compounds are rendered colourless and soluble by bleaching and are removed during the filtration stage.

6.2 Ultraflotation

Extremely fine minerals can be separated using flotation. This removes fine particles of iron, titanium and mica and produce clay with brightness of over 90%.

6.3 Delamination

This is a process to break down large kaolin particles which consist of 'books' of hexagonal platelets into thin but wide individual plates. These particles with their newly exposed faces tend to be whiter than natural clay of similar fineness. The thin platelets resulting from delamination provide excellent coverage in paper coating at lower coat weight. However, prior to delamination it is better to carry out magnetic separation to remove dark coloured impurities such as ilmenite and iron oxides, because delamination will also increase the surface area of dark coloured impurities. Delamination is achieved by attrition grinding.

6.4 Magnetic Separation

Poor brightness is partly due to the presence of dark coloured compounds such as oxides of iron and titanium. They are considerably darker in colour than kaolin and are weakly paramagnetic. They occur with the kaolin as extremely fine particles (often less than 1 micron). High intensity magnetic separation can be used to improve fine particles of iron and titanium and can be used either to produce extra white clays from regular feed or to upgrade clays that would normally have been considered of marginal quality. Magnetic separation will also reduce the amount of chemicals used to brighten the product. However, magnetic separation as a commercial process is still in its primary stages.

7. Attempts to brighten Sri Lankan kaolin

7.1 Calcination

Calcination is generally carried out to enhance the refractory properties. This process can also be used to improve brightness and several other qualities such as hardness and opacity. It was found that when kaolin is heated to very high temperature (750°C), its brightness improves considerably. However, the main objection to this method is that china clay being a heat-sensitive material, loses some of its valuable properties (eg. Plasticity) during the process. So calcined china clay may not be suitable for the industries such as paper. However, calcined china clay is used in many industries such as rubber, latex-based paints and plastics etc.

Process :— Powdered china clay is heated in a furnace at about 600°C for about 30 mts. It is assumed that most organic matters get oxidised and go away during this process.

7.2 Electrolysis

One of the reasons for low brightness in china clay is the presence of iron oxides which are in ferric form. It is expected that hydrogen ions that form during the electrolysis can convert these oxides to more soluble ferrous form. Soluble ferrous oxide can be removed using filtration.

Process :— A suspension of clay was first subjected to cyclone separation in order to remove heavy mineral particles associated with the clay.

A part of the overflow from cyclone was filtered, dried and tested for the brightness. But there was no significant change in the brightness. Other part of the overflow from cyclone separator was subjected to electrolysis. This process was carried out using an electrolytic cell fabricated at the University of Moratuwa.

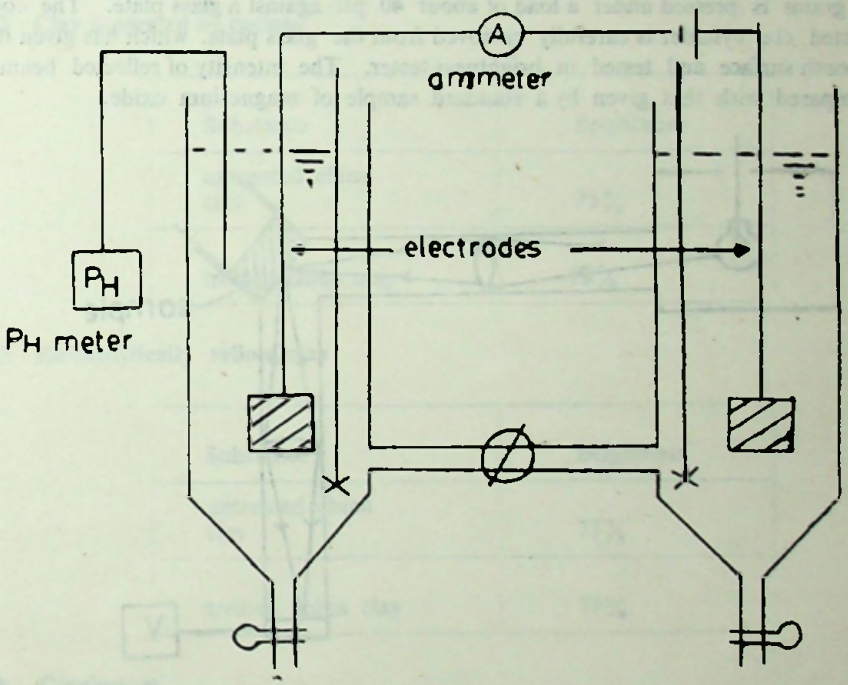

FIG 1 ELECTROLYTIC CELL

Diagram of the electrolysis cell

A d.c. voltage of 60 volts is applied across two platinum electrodes which are kept immersed in the suspension of china clay. The concentration of the suspension is about 10% w/w. Frequent stirring is done to ensure that the material does not deposit at the bottom of the cell. It is necessary to maintain a fairly low P_H(Say 5) to make sure an appreciable current passes through the cell. This is achieved by adding sulphuric acid. P_H is constantly monitored using a P_H meter. The process is carried out at room temperature. However, as the process progresses an increase of temperature is noticed. The electrolysis is carried out for about 2 hours and the suspension in cathode column is removed, filtered and tested for brightness. Results show an improvement of brightness. However, more work will have to be done before arriving at final conclusions.

8. Measurements of brightness

(*a*) International specifications

The clay to be tested is thoroughly dried at 105°C and then passed through a 200 mesh screen. A cylinder of clay $1\frac{1}{2}$" — $1\frac{5}{8}$ inches diameter and weighing about 15 grams is pressed under a load of about 40 psi against a glass plate. The compacted clay cylinder is carefully removed from the glass plate, which has given it a smooth surface and tested in brightness tester. The intensity of reflected beam is compared with that given by a standard sample of magnesium oxide.

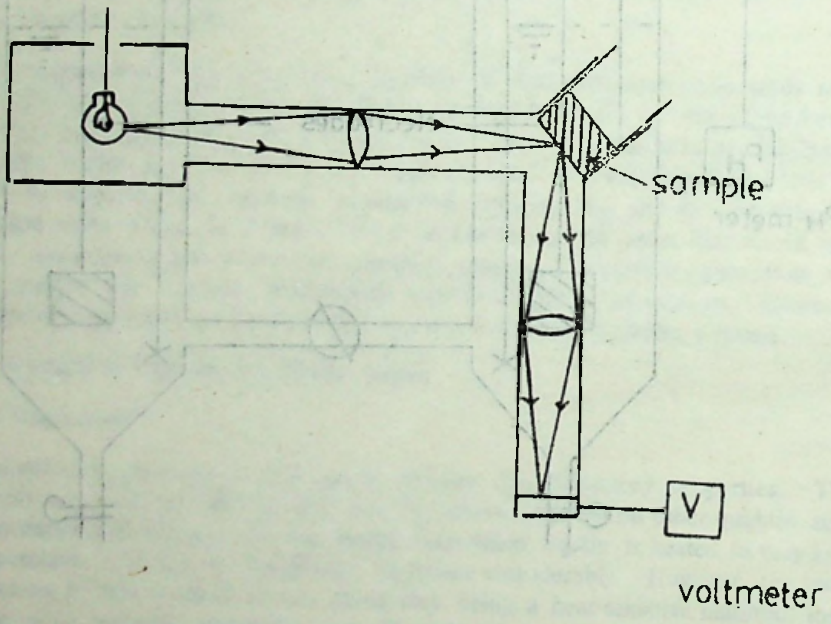

FIG 2 BRIGHTNESS TESTER

8.2 Testing Procedure

Place the MgO sample in the position and read the output voltage on the voltmeter. This is the standard sample and corresponds to brightness of 100. Now replace it with the clay sample and read the output voltage. Thus the brightness of the clay sample can be calculated.

9. Results

9.1 Calcined china clay

Nature of clay	Brightness
ordinary refined china clay	75%
calcined china clay	95%

9.2 Clay separated by cyclone

Substance	Brightness
untreated china clay	75%
treated china clay	75%

9.3 Electrolytically refined clay

Substance	Brightness
untreated china clay	75%
treated china clay	79%

10. Conclusions

(i) **Calcination** improves the brightness of china clay but this process may destroy some valuable properties of clay. However, calcined clays have been finding increased usage in industries such as rubber, latex-based paints and plastics.

(ii) Removal of heavy minerals using cyclone separation had little effect on the brightness.

(iii) Cyclone separation followed by electrolysis show an improvement in brightness. This experiment is still at preliminary stage and more work will have to be done to arrive at a final conclusion.

References

1. PETER HARBEN, Paper expansions spur kaolin in Georgia, Industrial Minerals, December 1979, pp. 23 - 49.

2. B. M. COOPE, Kaolin - A review of production and processing, Industrial Minerals, January 1979, pp. 31 - 48.

3. R. W. GRIMSHAW, The chemistry and physics of clays and allied ceramic materials, London 1975, pp. 918 - 925.