PROCESSING OF HIGH GRIT BALL CLAYS

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ABSTRACT: In Sri Lanka high grit ball clay is not mined at all from the ball clay deposits as the process adopted in purification is Dry Processing. It involves dry grinding causing high wear and tear to the grinding mill. Hence the cut-off grade of ball clay for Mining and processing is determined by the grit content which is limited to a maximum of 2%. In this research the authors have experimented on high grit ball clay and have suggested a flow sheet for its processing. Though the capital outlay is high in the method suggested, authors' aim is to make use of this mineral deposit industrially with optimum utilization.

INTRODUCTION:
In Sri Lanka, high quality ball clays are located in Dediyawala in the Kalutara District (Fig.1). High Plasticity, low grit content and fine particle size associated with the ball clays are very desirable qualities in the manufacture of ceramics and porcelain. However, ball clay also finds many applications in Industry, very particularly Rubber and Plastics as a filler. It is the latter use that the authors are interested in. In this research various methods for the recovery of high quality ball clay from high grit ball clays have been tried; of these the authors have isolated three separation routes depending upon the final quality of the product and the capital equipment to be utilized.

PRESENT METHOD OF EXTRACTION OF BALL CLAY.
The method of extraction of Ball clay from Dediyawala is by open cast mining. In this method the overburden soil cover approximately 4 to 5 ft. is removed either by hand or by using an excavator shovel attachment; thereafter the clay is mined. Present mining makes use of the power shovel attachment (Fig. 2). As the depth increases, the sand and grit content of clay increases and when the grit (mostly sand) content of the clay reaches 2% mining is stopped and thereafter no more extraction of clay takes place from there even if there is clay to the extent of 93% (Fig. 3). This shows that the cut-off grade for Ball clay is controlled only by the grit content and not by the other factors. As a result vast quantities of Ball clay are going to be unutilized and wasted. The grit content of clay is the non-clay fraction retained on 300 mesh B.S. sieve.

Ball clay is an industrial mineral, whose formation dates back to millions of years geologically. Therefore it is of paramount importance that this valuable resource is utilized to its maximum in Industry by adopting a suitable processing technique. With this view in mind a research program was initiated to process ball clay with high grit content on lab scale which can be scaled up to a processing plant.
VARIOUS PROCESSES ADOPTED:


A method similar to the present method of processing using Drying, Crushing, Grinding and air separation (Fig. 4) may be adopted. The coarse particle fraction by a single pass is separated out (Single pass classification) using the air separator (Fig. 5) without closed circuit grinding.

Disadvantages:

Since there is a high grit content in the starting clay, it will be subjected to further grinding action to fine particles leading to a higher percentage of very fine non-plastic fraction as shown in the size distribution graphs (Fig. 6) where the reduction of raw clay particle size from 74 microns to about 10 microns is apparent.

High wear and tear of the Hammer mill leading to the replacement of Hammers of the mill frequently. Above all, finely ground grit is a silicosis hazard to which the mill workers are exposed.

Process 2 - Flow Sheet

The flow sheet in the Process 2 is the next strategy adopted to process the high grit ball clay where a grade similar to one obtained by processing mined clay with less than 2 % grit. was possible.

In this method a solar drying similar to what is being used at present (Fig. 7) was used followed by the reduction of moisture content of clay to less than 1% after passing through an indirectly heated spiral conveyor dryer. Unless the moisture is reduced below 1% the size reduction using a jaw crusher or a cone crusher is going to be a failure.

Advantages:

High grit ball clay can be processed and can be utilized in Industries
Less silicosis hazard
Powdered product meeting specifications as a filler mineral.

Disadvantages:

Utilisation of a Jaw, roller or cone crusher and other capital equipment.
Process 2 – Flow Sheet

Lumps of Clay with less than 1% moisture

↓

Jaw/roller/Cone crusher

↓

Water addition

Attritor / Scrubber

↓

Coarse sand discharge ↔ Vibratory Sieve (1 mm mesh size)

↓

Spiral Classifier

↓

Centrifuge

↓

Dryer

↓

Hammer mill Air Classification Ball clay powder

Advantages: High Quality ball clay powder, optimum resource Utilisation.

Disadvantages: Utilisation of additional capital equipment, such as; Jaw or cone crusher, attritor scrubber, vibratory sieve, spiral classifier, centrifuge & dryer.
Process 3 – Flow Sheet

Lumps of clay with moisture less than 1%

Jaw Crusher → Cone Crusher

Attritor/Scrubber

Vibratory Screen (Mesh 1 inch)

Coarse particle discharge (Tailings)

Spiral Classifier

Add Water

Underflow Discharge (Tailings)
Via Centrifuge

Dryer

Hammermill

Air Classification Closed Circuit

Powder

Hydrocyclones

Overflow

Centrifuge

Dryer

Hammermill

Air Classification Closed Circuit

High Quality Ball Clay Powder

Process 3- Flow sheet

In this flow sheet there are several capital equipments used to minimize the Ball clay losses and at the same time the clay produced will conform to the standards with respect to the particle size, plasticity and the grit content.

Advantages: Two powder grades can be recovered with the optimum utilization of the Reserves.
Disadvantages: Utilisation of capital equipment such as jaw/or cone crusher, Attritor scrubber, vibratory screen, spiral classifier, two centrifuges, hydrocyclones, two dryers, two hammer mills and two air classifiers because of products having different qualities.

TEST RESULTS

By subjecting the Processed Ball clay from the Process 3 to chemical, X-Ray, Thermal and Electron Microscopical analysis, the following results were obtained.

Chemical Analysis:

**Table 1: The Chemical analysis of Processed Ball clay**

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>SiO₂</td>
<td>49.65</td>
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<tr>
<td>Al₂O₃</td>
<td>33.25</td>
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<tr>
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<td>MgO</td>
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<td>Na₂O</td>
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<tr>
<td>L.O.I.</td>
<td>12.47</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>99.87</strong></td>
</tr>
</tbody>
</table>

X-Ray analysis

X-Ray Analysis of very common clay minerals are shown in (fig.8) using Copper Kα radiation in the following range

\[12^\circ < 2\theta < 25^\circ\]

Compared to the X-ray diffractometer curves A, 1 and 3 of the China Clays, the Ball Clay at Dediyawala do not show sharp and well split peaks corresponding to the 111, 110 and 020 which are very prominent in English China Clay.

The Sharpness of peaks is very apparent in Meetiyagoda China Clay but is not so in Boralasgamuwa China Clay.

The full X-Ray diffractometer traces with the 20 angle in the range $6^\circ < 20 < 41^\circ$ for the above three Clays are shown in (Fig. 9), where the sharp peak splitting within the 20 range 19° and 22° is very prominent. From these
observations the degree of crystallinity of Sri Lankan industrial Clays can be arranged in the following order.

**English China Clay > Meetiyagoda Clay > Boralesgamuwa Clay > Dediyawela Ball Clay**

**Differential Thermal Analysis**

Differential Thermal Analysis of Dediyawala Ball Clay is compared with the China clays from Boralesgamuwa and Meetiyagoda. (Fig. 10)

Dediyawala Ball Clay - DTA trace 2 has the following peaks:

A broad endothermic peak between 100 °C to 250 °C due to the elimination of water.

An endothermic peak between 300 °C to 350 °C due to decomposition of hydrated iron oxide impurities.

An exothermic peak at 450 °C to 500 °C due to the oxidation of Carbonic matter.

An Endothermic peak at 580 °C which is apparent in all the clays

An Exothermic peak at 950 °C, which is rather broad and diminished in the case of Ball Clay but fairly sharp in the others.

**Electron Microscopic Studies.**

The Electron Microscopical Examination of Dediyawala Ball clay reveals that some particles of Ball clay are irregular where as the rest look hexagonal with less clearly defined edges (Fig. 11).

From the micrograph it is evident that overall clay particles falls into semi crystalline variety having an average particle size of about 0.2 microns. This feature might have some connection with the high plasticity of Ball Clay

**CONCLUSION:**

In this research, it has been shown that it is possible to process high grit Ball clays using the sequence of operations shown in Processes 1, 2 and 3. To obtain high quality Ball clay powder flow sheet corresponding to the process 3 is suitable even though there is going to high capital outlay. The research is preliminary at this stage as there are more detailed areas to be experimented using a spiral classifier and continuous centrifuge on pilot scale.
ACKNOWLEDGEMENT:

The authors would like to thank Lanka Ceramic Ltd for giving permission to collect samples of High grit Ball clay and specially to Mr. P.B. Costa, the Factory Manager, Ball Clay Plant at Dediyawala. Also, thanks are due to Mr. S. Weerawarnakula Head, Department of Earth Resources Engineering, Mr. S.A.S. Perera Head, Department of Chemical Engineering and the technical staff of both the Departments and specially to Mr. G.P. Perera and Mr. H Waidyasekera of the Department of Earth Resources Engineering, and Mr Sarath Chandrapala in the Department of Materials Engineering.

REFERENCES-

Fig. 1  Clay mineral provinces
Fig. 2  Mining of Ball clay at Dediyawala using the power shovel

<table>
<thead>
<tr>
<th>Overburden</th>
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<tr>
<td>Ball Clay- &lt; 2 % Grit</td>
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<tr>
<td>Ball Clay with &gt; 2 % Grit</td>
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<tr>
<td>BED ROCK</td>
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Fig. 3  Profile of Ball Clay deposit- Sectional view
Fig. 4 Flow chart of Ball clay processing in the existing plant

Fig. 5 Air Separator
Fig 6. Particle size distribution patterns for Ball clay and the associated grit particles in the run of mine ball clay and the processed clay.

Fig 7. Solar drying of ball clay using the paved area
Fig. 8 X-ray diffractometer traces for common clay minerals using Cu Kα radiation
Fig. 9. Full X-ray diffractometer traces for three clay minerals indicated as above.
Fig. 10 Differential thermal curves for the processed clays
Fig. 11 Scanning electron micrograph of the final product