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Processing of china clay by super-conducting high gradient magnetic separation

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ABSTRACT

Super-conducting high gradient magnetic separation tests on a typical china clay from the western part of India showed that the brightness of the clay can be enhanced from 72.8% to 79% ISO by suitably manipulating the process variables. Important variables studied are feed solid content, retention time, production rate (number of canister volumes), number of passes etc. keeping the magnetic field strength constant. The secondary magnet (wire wool matrix) and its packing volume were also not changed during these tests. A brightness of 79% was achieved with a two pass operation for 5 canister volume feed slurry having 15% solid content and with retention time of about 20 secs. The overall clay recovery is 86% (94% for the first pass and 92% for the second pass). Understandably, the feed solid content of second pass was lower than 15%. While the iron (Fe_2O_3) could be reduced by about 55% the reduction in TiO_2 was about 12% indicating that there still exists scope for removing TiO_2 from this clay and enhancing brightness further. All the SC-HGMS tests were conducted at Bhabha Atomic Research Centre, Trombay, Bombay, India.

Key Words : *China clay, Beneficiation, Super-conducting high gradient magnetic separation, Brightness, Retention time*

INTRODUCTION

India has got substantial reserves of china clay spread over almost all the states of the Union. Many of these are not exploited optimally since modern technologies are not yet incorporated to most of the clay beneficiation plants in the country. Many units still employ the levigation method which is a time-consuming batch operation. More over, discrete ancillary mineral impurities still remain with the clay thus making the product unsuitable for many value added applications. Modern processing methods are mostly continuous and utilises centrifugal size classification, high gradient magnetic separation, ultraflotation, oxidative and reductive bleaching etc. by which impurities such as iron, titanoferrous and carbonaceous minerals even in ultrafine size range can be removed or reduced thus enhancing the brightness of the clay.

Superconducting High Gradient Magnetic Separation (SC-HGMS) which is an important operation in china clay processing flow-sheet is yet to get firm footing in our country whereas this is a standard operation in most of the modern clay processing plants elsewhere in the world. A high gradient magnetic separator was patented for the first time by S.G.Frantz[1] in 1937. Though this could develop high gradient, the field was relatively small. In 1955 G.H.Jones[2] invented the wet high intensity magnetic separator which could develop very high fields up to 20 kG. J. Iannicelli, combined these two properties and along with the important concept of retention time he could develop the first high gradient magnetic separator (also with high field) which was used for beneficiating kaolin[3]. HGMS went through many phases of modification and development from 1970's to 1990 in magnetics, mechanical designs and more importantly in cryogenics when super-conducting magnets were introduced in place of high power-consuming, heavy-built conventional magnets. J.H.P. Watson[4] gives an informative account of the status of super-conducting magnetic separation in kaolin industry. There are many papers dealing with different aspects of HGMS as well as SC-HGMS from a number of authors[5,6,7,8]. From an ordinary conventional 'switch off and on' type batch separator, the equipment and technology has grown now to have high field, low weight, low power consuming, continuous (reciprocating) separators which can give capacities in the order of 60-100 tons of dry solids per hour.

With a view to introduce modernisation in china clay processing in the country, SC-HGMS tests were carried out on a typical clay sample so as to establish the viability of its value addition by this method. Impurities normally removed by SC-HGMS are iron, titanoferrous and micaceous minerals.

EXPERIMENTAL

The experimental procedures adopted, equipment and test materials used are as follows

Feed Material

The feed material is a semi-processed china clay sample measuring 72.8% ISO brightness. The raw clay of this sample was collected from north western part of India and is subjected to size classifications so as to obtain~80 % particles below 2μm in the product. The feed clay analysed 0.36% Fe_2O_3, 1.6% TiO_2 and 0.39% Na_2O.

Reagents

Sodium hexa meta phosphate (calgon) 0.4 % with respect to dry solids was used as the dispersing agent for the clay in all the tests.

Water

Demineralised water was used for the test work.

Equipment

i) The super-conducting high gradient magnetic separation test set up of BARC, Bombay.

   The system constitutes a feed slurry preparation unit, separator unit and the control unit. The feed preparation unit consists of a s.s. tank, a stirrer and a slurry pump. The separation unit consists of the magnet, the cryogenic system, the canister, the wire wool matrix and the necessary pipings and control valves. The control unit consists of all electrical and electronic regulators for the ramping and deramping of the magnet.

ii) The brightnessmeter, Color Touch, ISO model of M/s. Technidyne Corporation US for measuring the brightness of product samples.

Chemical Analysis

Na_2O, Fe_2O_3 and TiO_2 were determined by standard analytical procedures[9]. Na_2O was estimated using flamephotometer whereas others are by colorimetry.

PROCEDURE

The super-conducting high gradient magnet is made ready for operation by pouring the required quantity of liquid helium in the chamber and allowing to attain the set temperature level. Necessary liquid nitrogen bath is also provided. The current is passed through the super-conducting coil so as to energise the magnet and to ramp up the field to the required level (3 tesla). The required slurry with a pre-determined solid content is prepared in the feed preparation unit by adding the dispersant. The feed slurry is pumped through the canister at a specified flow rate from bottom to top while the product clay slurry (nonmagnetics) is collected from the top of the separator. Once the feed slurry pumping is over, the matrix is rinsed with de-mineralised water in the same direction as the feed slurry flow and the resultant material is also collected along with the product. After the rinsing, the power is switched off so that the magnet gets deramped and the field becomes almost zero. Flush water at high volume and pressure is now pumped through the canister in the opposite direction to the field flow and the impurities (magnetics') are collected from the bottom of the separator. The batch operations are continued in the same fashion by changing the variable as required.

RESULTS AND DISCUSSION

This preliminary SC-HGMS study was conducted so as to understand the behaviour of the impurity minerals in the clay towards the magnetic separation and also to establish the feasibility of removal. Important process variables such as feed solid content, retention time or the feed solid flow rate, production rate or number of canister volumes and number of passes were tried. One canister volume measured 226ml. Coarse wire wool of 55 μm dia. at 3% packing volume was used for all tests. The magnetic field strength was kept constant at 3 tesla. The feed slurry was dispersed using calgon (0.4 %) and the pH was maintained at~8.0 using sod. carbonate solution. The product (nonmagnetic fraction) slurries were thickened by decantation and filtered and dried at 80°C and brightness is measured. Following variables have been studied.

Feed solids

The feed solid content was varied from 7.5 to 15% at constant conditions of retention time and canister volumes of slurry. Though the brightness remained more or less same for lower solids, the same is found increased for 15% (Fig. 1). Due to some design limitations of the set up, higher solid slurries could not be fed to the separator.

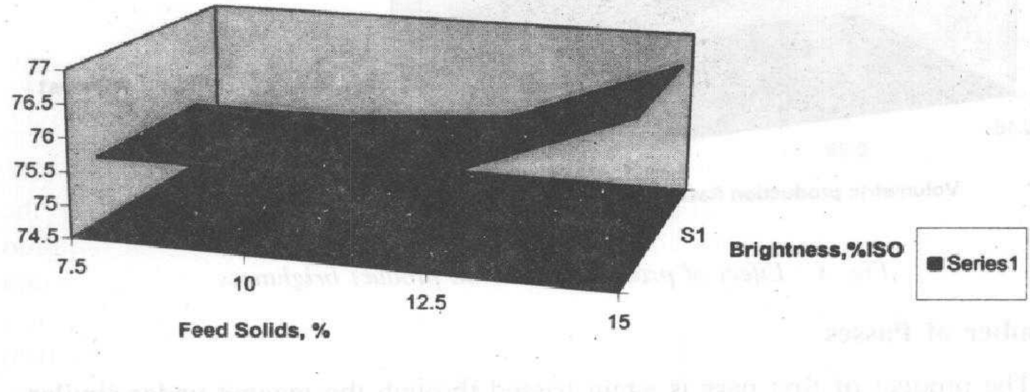

Fig. 1 : Effect of feed solid content on product brightness

Retention Time

Perhaps the most important operating variable is the retention time. This could be varied only in a relatively lower range. Expectedly, the maximum brightness gain was for the highest retention time (Fig. 2) that could be given to the slurry under the present operating conditions.

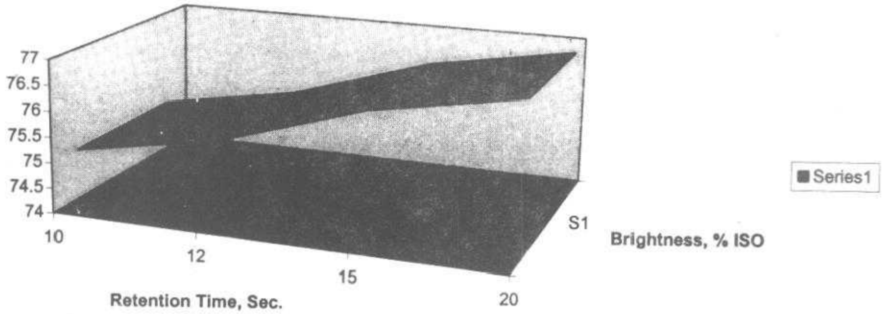

Fig. 2 : Effect of retention time on product brightness

Production Rate

Variation of number of canister volumes fed showed that more than seven canister volumes reduces the brightness drastically (Fig. 3). Production rate may have to be set pegging around this feed volume.

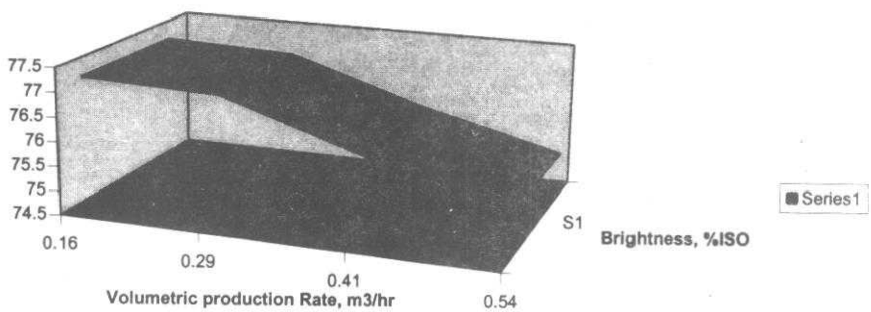

Fig. 3 : Effect of production rate on product brightness

Number of Passes

The product of first pass is again passed through the magnet under similar conditions of separation. The brightness increased by another two units indicating that a second pass is beneficial for removing more impurities from the clay.

All the tests more or less showed a clay recovery in the range 94-96% for single pass operations. Due to the relatively low feed solid content, the production rate was very low i.e., in the range 0.1 to 0.2 tons/hr of dry solids. The chemical analysis of product clay from 2nd pass showed 0.15% Fe_2O_3 and 1.4%

TiO_2 which, in turn, indicated that while the iron removal was about 55% that of TiO_2 was a meagre 12%.

CONCLUSION

1. SC-HGMS tests clearly showed that the impurity minerals are susceptible for capture and hence the removal can be effected.

2. While more than half of the iron (in term of Fe_2O_3) is removed, the capture of TiO_2 is very minimal. This shows that still higher field and gradient may have to be applied in order to effect more of TiO_2 removal.

3. The range of many of the operational variables were too small to have a realistic feel of the process conditions. Perhaps a state-of-the -art machine may give better results.

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