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High gradient magnetic separation of china clays

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Abstract. High gradient magnetic separation has proved to be a successful method for removing micron size colouring bodies from china clays. Clays from Chotanagpur, Bihar have been beneficiated to improve its brightness. The effect of field, flow rate and dispersing agents has been studied on both the run of mine (rom) clay and the washed clay. Significant improvement in the brightness of clay has been obtained.

Keywords. China clays, high gradient magnetic separation.

1. Introduction

High gradient magnetic separation (HGMS) removes micron size weakly paramagnetic particles. Its first commercial application was improvement of the brightness of kaolin clays used extensively in paper, pharmaceutical and other industries (Iannicelli 1976; Halaka *et al* 1977). HGMS is useful due to the high field gradient existing over a short distance which increases the magnetic force on the particle which, under suitable conditions, may be attracted towards the filaments in the canister placed in a magnetic field. The forces acting on the particle in HGMS are the magnetic force, the hydrodynamic force and the gravity force. Therefore, apart from the magnetic field and gradient, the flow velocity of the slurry and the solid content in the slurry significantly affect the quality of separation. The particles should therefore be highly dispersed for better separation and the use of a dispersing agent becomes inevitable. A systematic programme of investigation for improving the brightness of kaolin clays from various locations in India was undertaken and in this paper, our results on kaolin clays from Chotanagpur, Bihar are presented.

2. Methods and materials

Clay samples (rom and washed), obtained from the Chotanagpur Commercial Corporation (Chaibasa, Singhbhum District, Bihar) were in the form of lumps and were therefore ground in a micropulverizer. It was then passed through a 300-mesh sieve. The samples were dried in an oven at 105°C and used for HGMS studies. The nominal analysis of the washed clay sample as reported by the supplier was SiO_2: 47·60%; Al_2O_3: 37·70%; Fe_2O_3: 1%; TiO_2: traces; CaO: 0·80%; MgO: traces; alkalies: 0·51% and loss on ignition: 12·39%. However, the analysis for rom clay sample was not available. Both the clay samples were analysed for acid soluble iron using redox titrations (IS-505) which was: rom clay: 0·957% Fe_2O_3 and washed clay: 0·982% Fe_2O_3. Thus the acid-soluble Fe determined by us was more or less the same as that furnished by the supplier for washed clay. Therefore, most of the Fe present in the clay were acid soluble. Secondly, in both clay samples the percentage of acid-soluble Fe was more or less the same. It appears that Fe is not sufficiently removed during the conventional washing process.

3. HGMS experiments

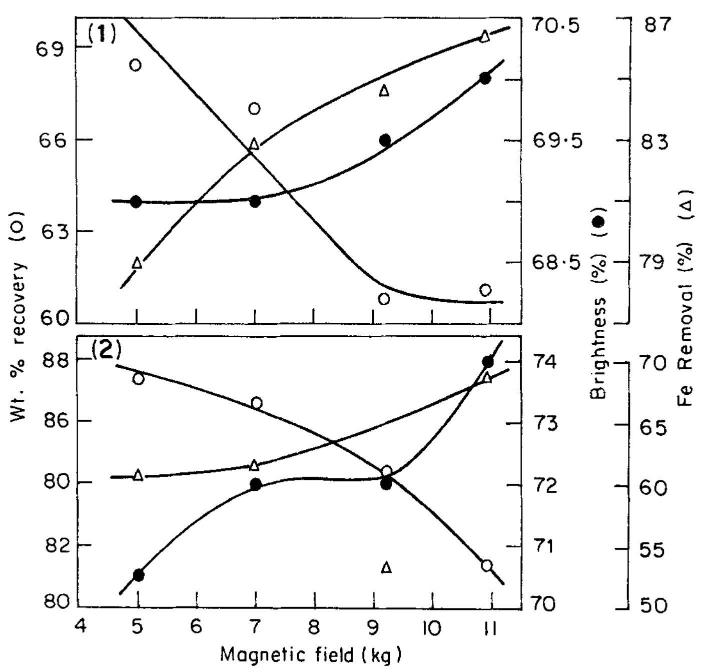
A laboratory model HGMS unit (SALA 10–15–20) which combines a magnet and matrix design to produce uniformly high magnetic flux densities in a large volume was used. The top-feed back flush mode of operation was adopted. Details of the experimental set-up were reported earlier (Maurya and Dixit 1988). A 10% slurry was prepared and subjected to HGMS. The magnetic and non-magnetic fractions were collected separately, filtered, dried and weighed. The brightness of the non-mag clay was measured by a gloss/reflectance meter using white light.

4. Results and discussion

The effect of process variables such as field intensity, flow velocity and addition of dispersant was studied.

4.1 *Effect of magnetic field*

The applied magnetic field intensity was varied from 5–10·9 kGauss and its effect on the recovery and brightness of the decolourized clay was studied. The samples were analysed for the removal of the acid-soluble Fe. Typical results of the effect of magnetic field on the rom clay and the washed clay are shown in figures 1 and 2 respectively for a flow velocity of 21·3 lit/s. m^2. Figure 1 shows that as the magnetic field increases the weight recovery of the non-magnetic (decolourized) clay decreases

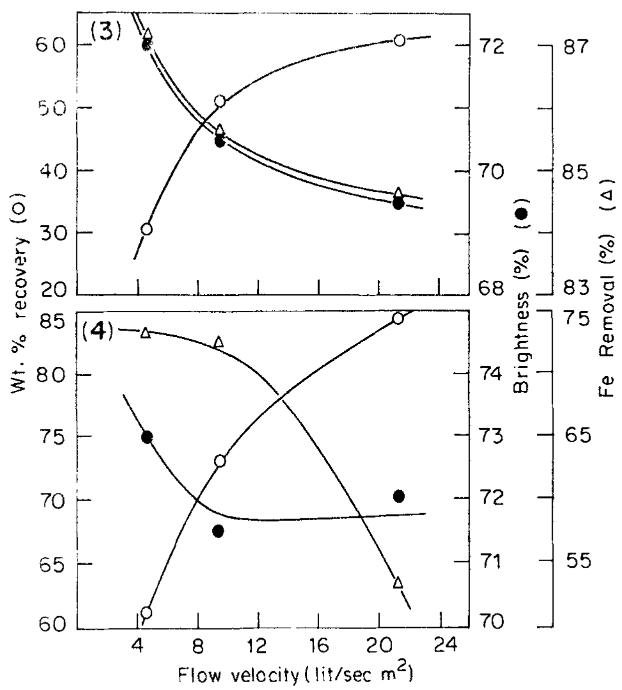


Figures 1, 2. Effect of magnetic field on recovery, brightness and iron removal of **1.** rom clay and **2.** washed clay.

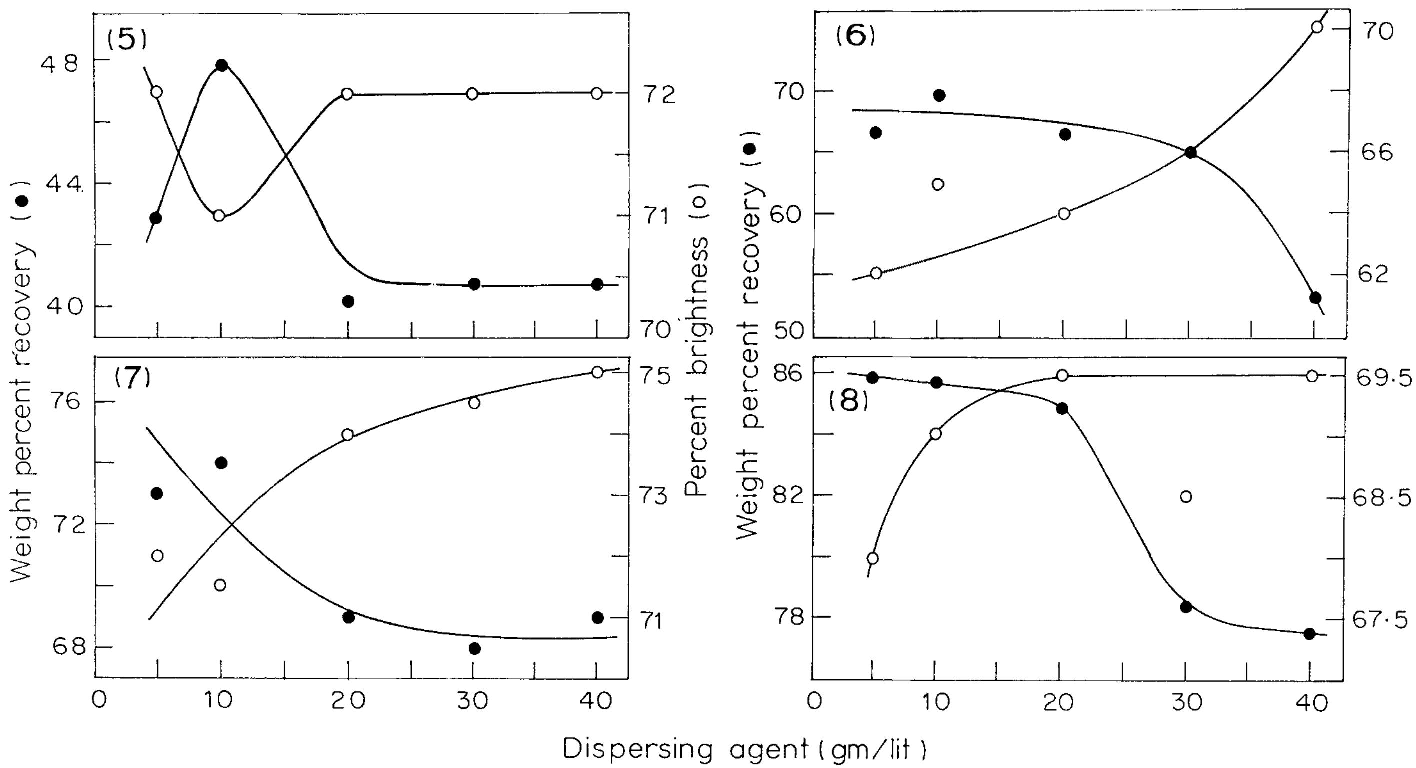
in rom and washed clays. At the same time the brightness and acid-soluble Fe removal increases in rom and washed clays. Almost 85% Fe is removed in rom clay and 70% in washed clay. There is thus a good correlation between the removal of acid-soluble Fe and the increase in brightness. This is expected because higher magnetic field would attract even weakly paramagnetic particles; thus the weight recovery of the magnetic clay increases while that of the non-magnetic clay decreases. Obviously, a greater percentage of Fe is also removed in the magnetic fraction resulting in improved brightness of the non-magnetic fraction.

4.2 *Effect of flow velocity*

Flow velocity is an important process parameter in HGMS because it determines the retention time of the solid particles in the magnetic field. In turn, the retention time determines the probability of the collection of the particles on the filaments. The flow velocity was varied from 4·6 to 21·3 lit/s. m^2. Typical results for both samples are shown in figures 3 and 4 respectively. As flow velocity increases, the retention time decreases reducing the probability of capture of the particles and resulting in increased recovery of the non-magnetic fraction. It is obvious that brightness decreases with increase in flow velocity as can be seen for both rom and washed clays. Figures 3 and 4 show that the removal of acid-soluble Fe agrees with change in brightness.



Figures 3, 4. Effect of flow velocity on the recovery, brightness and iron removal of **1.** rom clay and **2.** washed clay.



Figures 5–8. Effect of dispersing agents on the recovery and brightness of rom and washed clay, **5.** rom clay, sodium meta silicate, **6.** rom clay, disodium hydrogen orthophosphate, **7.** washed clay, sodium meta silicate, and **8.** washed clay, disodium hydrogen orthophosphate.

4.3 *Effect of addition of dispersant*

Before separation dispersion of the particulates in the liquid is necessary. The effect of sodium-meta silicate and disodium hydrogen orthophosphate as dispersing agents was studied and the results for rom clay are shown in figures 5 and 6. Similar results for washed clay are shown in figures 7 and 8. Figure 5 shows that brightness decreases with addition of 10 g/l of sodium meta silicate, otherwise it remains more or less the same. The recovery of the non-magnetics also shows a sudden increase with addition of 10 g/l of sodium meta silicate, otherwise it decreases only marginally as concentration is increased beyond 10 g/l. Thus sodium meta silicate has a marginal effect on the quality of the HGMS-treated rom clay. Addition of disodium hydrogen orthophosphate significantly improves the brightness as concentration of the dispersing agent is increased (figure 6). The recovery of the non-magnetics decreases considerably as is to be expected. In the case of washed clay, the addition of sodium meta silicate considerably improves brightness as its concentration is increased (figure 7). Similarly the recovery of non-magnetics decreases. This result is different from that of rom clay which did not respond well when sodium meta silicate was added. Figure 8 shows the results for disodium hydrogen orthophosphate addition in the case of washed clay. The results are similar to those of sodium meta silicate.

The maximum improvement in brightness in rom and washed clays was from 59 to 74% and 66 to 75% respectively. Thus rom clay responds well to HGMS and comparable results are obtained even without washing. Therefore, washing is unnecessary if HGMS is employed.

5. Conclusions

The rom kaolin clay from Chotanagpur area responds well to HGMS and there is an improvement of 15% points in brightness. The washed clay also responds to HGMS but the maximum brightness achieved is similar to that of the rom clay. Low flow velocity and high magnetic field results in increased brightness and removal of acid soluble Fe. There is a correlation between improvement in brightness and Fe removal. Sodium meta silicate when added as a dispersant does not significantly affect the quality of the HGMS-treated rom clay but significantly improves brightness in washed clay. Disodium hydrogen orthophosphate improves brightness in both rom and washed clays.

Acknowledgement

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