KAOLIN CLAY PURIFICATION BY DRY HIGH GRADIENT MAGNETIC SEPARATION [1]

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ABSTRACT

A new method-dry High Gradient Magnetic Separation (HGMS)—to remove iron from ultrafine kaolin powder is described. A new kind of disperser, which breaks down the particle clusters in the powder by high speed gas flow from an air compressor, is used to completely disperse the powders. The dispersed particles are passed through vibrating HGMS by a vacuum pump to remove the iron. The magnetic and nonmagnetic fractions are separately collected by cloth collectors. Dry HGMS laboratory experiments are carried out. A product containing 0.90% Fe_2O_3 was obtained, and the recovery was 70%.

Key words: magnetic separation kaolin purification dry high gradient magnetic separator

1 INTRODUCTION

Kaolin, a white aluminium silicate mineral, is principally employed as a filling and coating agent in producing papers. All economically significent deposits of kaolin are containted by small amounts of ferruginous minerals, including iron oxide, anatase, rutile, siderite, pyrite, mica and tourmaline.

Since iron contaminations are harmful to clay brightness, they should be removed. The methods generally used for the removal of iron contaminants are chemical bleaning, flotation and wet HGMS[1-4]. However in some factories, all kaolin processing techniques are completely dry, and wet methods are not suitable in these cases. Therefore, dry separation method-dry HGMS must be introduced.

In the process of dry HGMS of ultrafine particles, there exist two serious problems. First, the attractive electrostatic and Van Der Waal's forces among the particles cause stickiness and formation of aggregates, thus seriously affecting the selectivity of magnetic separation. Second, permanent retention of particles in the matrix causes a decrease in metallurgical performance and complete clogging of the system[5-8].

To solve these two problems, a new kind of disperser and an electromagnetic vibration system were employed in our dry HGMS technique. Experimental results show that a dry HGMS technique involving a disperser and a vibration system is effective to the purification of kaolin clay.

2 RAW MATERIAL PROPERTIES AND ANALYSIS

Kaolin clay samples were produced according to the kaolin processing flowsheet shown

[1] The project was financially supported by China National Science and Technology Committee
[2] Manuscript recieved June 15, 1992.

in Fig. 1. A small amount of the sample was heated in an oven at 120 ℃ for 4 h, and its constituents were analyzed. The result of typical chemical analysis was shown in Table 1.

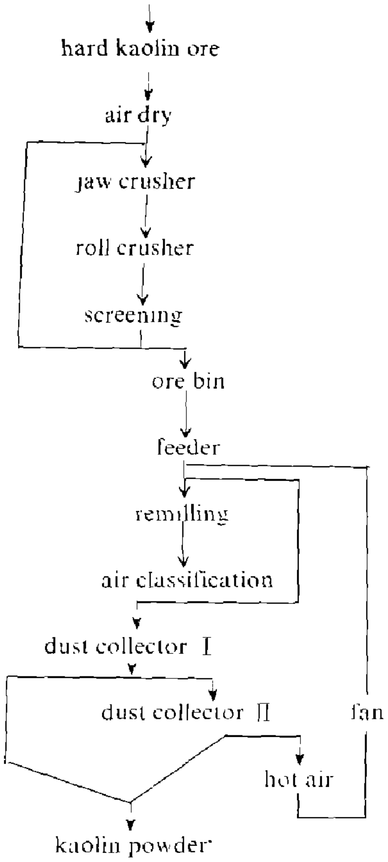

Fig. 1 Kaolin processing flowsheet

Table 1 Chemical analysis of kaolin powder

constituents	wt.-%
Al_2O_3	36.79
SiO_2	45.18
Fe_2O_3	2.20
TiO_2	0.75
Weight loss due to burning	15.36
K_2O	0.04
Na_2O	0.05

X-ray diffraction analysis of the sample confirmed that the main mineral is kaolinite; magnetite, hematite, siderite and anatase are present in lesser amounts; and there are possible traces of quartz. The particle size distributions of the sample were detemined by an image analyser and the average size was calculated to be 8.44 μm.

3 EXPERIMENTAL

The flowsheet for the dry HGMS experiment is illustrated in Fig. 2. Due to the high surface tension force, ultrafine kaolin particles absorb the moisture in air thus causing them to stick to each other. They must be dried before entering the separater. Dried powder is fed into the stainless steel pipe by a spiral feeder in which the feed rate can be controlled by changing its rolling speed. Gas flows from an air compressor carry the particles into the disperser. The disperser follows principles similar a jet mill. It makes use of collisions between the high speed gas-solid flows and breaks down the particle clusters originally present in the powder. Dispersed particles enter the dry HGMS by the force from the vacuum pump. the nonmagnetic fraction passes through a matrix canister and is collected by cloth collector Ⅰ. When the magnet is deenergized, the magnetic fraction is flushed out from the matrix canister by the high speed gas and vibration system, and then collected by cloth collector Ⅱ.

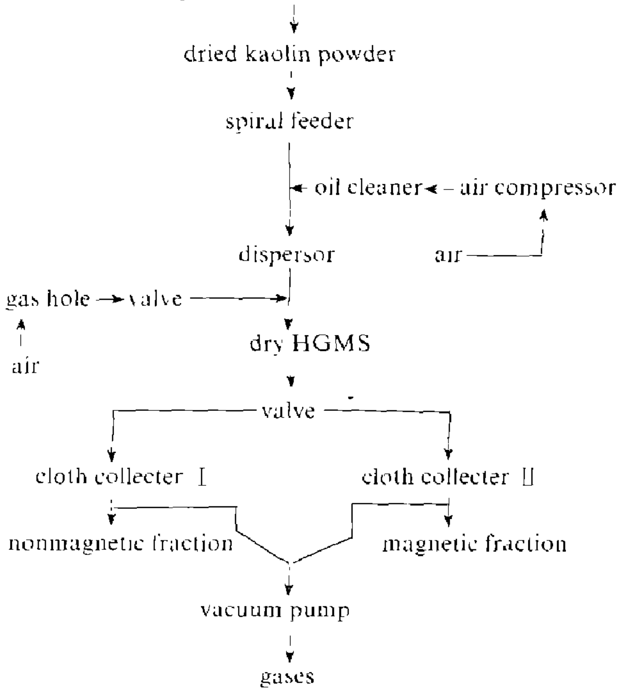

Fig. 2 The flowsheet of dry HGMS for purificiation of ultrafine kaolin powder

The dry high gradient magnetic separator is cyclic with an electromagnetic vibration system. Electromagnetic vibration is produced by a coil on the canister energized with an alternating current, at a frequency in the sonic range. A vibration force is exerted on the coil by the magnet and by the AC field in the coil. The amplitude of vibration can be adjusted by changing either the AC or DC field. Thus, the vibration of the matrix propels the particles through the matrix and assists the cleaning of the matrix.

4 RESULTS AND DISCUSSION

Dry HGMS is influenced by a number of variable factors. In our tests, only four factors that have a decisive effect on the efficiency of dry HGMS are involved. According to previous experiments, other factors are kept unchanged as follows:

matrix type (mesh size / mm)	(1.5 × 3)
filling factor of matrix	12 %
pressure of air compressor	0.2 Mpa
gas-solid flow rate in the disperser	120 m / s
solid content	10 wt.−%
flushing speed	4.0 m / s

4.1 *Effect of Magnetic Field Strength*

Conditions:

matrix loading	850 kg / m^3
flow speed in the canister	3 m / s
vibration current	3 A

The effect of a magnetic field on the iron content in the nonmagnetic fraction and its wt.−% is shown in Fig. 3.

Fig. 3 shows that with increasing magnetic induction, the nonmagnetic fraction (wt.−%) and its iron content decrease. High magnetic field strengths are often desirable to bring about an efficient removal of iron from kaolin powder. But the results of the removal of iron can be impaired by the undesirable losses of kaolinite due to entrainment in the magnetic fraction.

4.2 *Effect of Flow Speed in the Canister*

Conditions:

matrix loading	850 kg / m^3
vibration current	3.0 A
magnetic induction	1.0 T

The effect of flow speed on the iron content in nonmagnetic fraction and its wt.−% is shown in Fig. 4.

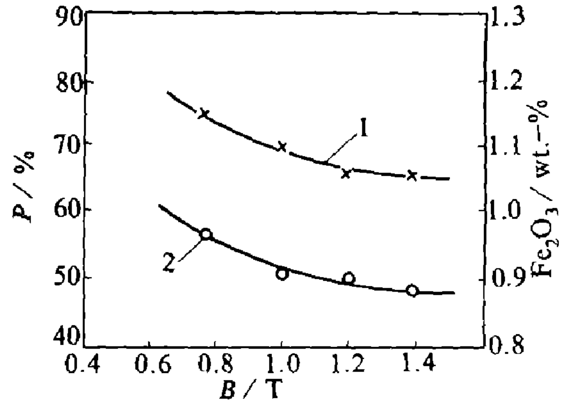

Fig. 3 The effect of the magnetic field strength (*B*) on the nonmagnetic fraction (*P*) and its iron content in kaolin

1—*P*–*B*; 2—Fe_2O_3–B

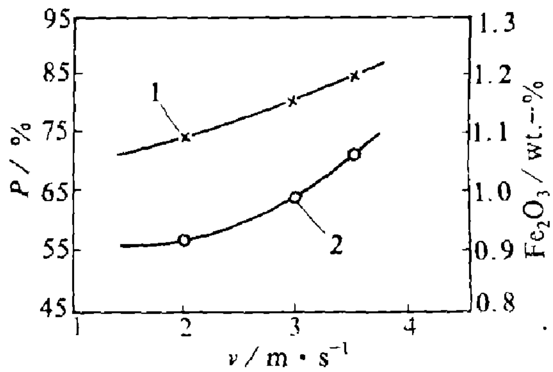

Fig. 4 The effect of flow speed (*v*) on the nonmagnetic fraction *P* and its iron content.

1—*P*–*v*; 2—Fe_2O_3–*v*

Fig. 4 shows that the nonmagnetic fraction wt.−% and its iron content increase with increasing gas flow speed.

4.3 *Effect of Matrix Loading*

Conditions:

magnetic induction	1.0 T

flow speed in the canister 2 m / s
vibration current 3 A

The effects of matrix loading on wt.–% of the nonmagnetic fraction and its iron content are shown in Fig. 5.

Fig. 5 shows that the nonmagnetic fraction wt.–% and its iron content increase with matrix loading increases. This is because the matrix can only carry a limited amount of mineral particles. With matrix loading increases, the deterioration of matrix performance is marked.

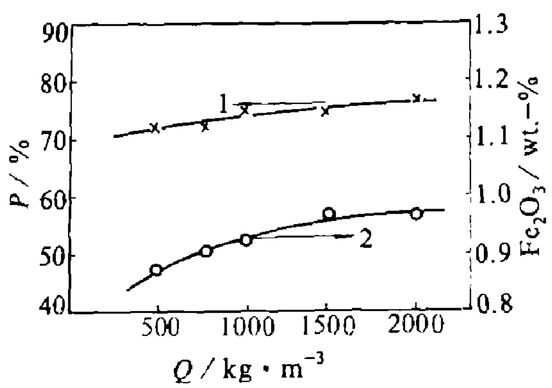

Fig. 5 The effects of matrix (Q) loading on the nonmagnetic fraction (P) and its iron content
1—P–Q; 2—Fe_2O_3–Q

4.4 *Effect of Vibration Current*

Condition:

magnetic induction 1.0 T
gas flow speed in the canister 2 m / s
matrix loading 500 kg / m^3

· The effect of the vibration current on the wt.–% of the nonmagnetic fraction and its iron content is shown in Fig. 6.

Fig. 6 shows that the nonmagnetic fraction wt.–% increases with increasing vibration current. In the range of 0~2 A, the increase of the wt.–% is very significant while the iron content changes only a little. This denotes that vibration propels the particles through the matrix. Under these conditions, a product with 0.90 % Fe_2O_3 is obtained, and the recovery is 70 %.

4.5 *Performance of the Disperser*

As there exist particle clusters in raw kaolin powder, a disperser is needed. A new type of disperser was used in our tests. Its dispersal principle is as follows: gas-solid flow into the conical channel of the disperser, eject at the Lawar jet tip and collide at the conical point. The performance of the disperser is primarily influenced by the gas pressure from an air compressor and the gas speed in the disperser. In order to examine the performance of the disperser, the powder passing through the dispersor at different pressures is photographed. Fig. 7 is a high-speed micrograph of the powder under conditions: $Kp = 0.2$ MPa, $v = 120$ m / s. The figure shows that the disperser can break down particle clusters, thus dispersing ultrafine particles.

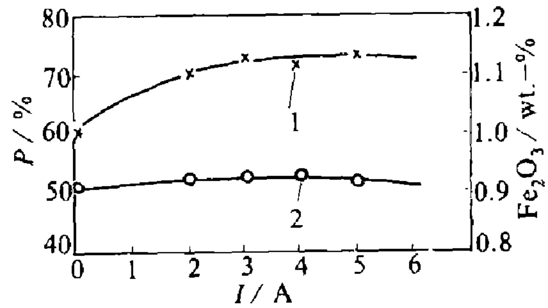

Fig. 6 The effect of vibration current (I) on the nonmagnetic fraction (P) and its iron content
1—P–I; 2—Fe_2O_3–I

Fig. 7 The high speed micrograph of processed Powder with $P = 0.2$ MPa, $v = 120$ m / s

5 CONCLUSIONS

(1) Dry HGMS technique which includes vibration system and a new kind of disperser is effective for the purificiation of kaolin powder;

(2) The vibration of matrix propels the particles through the matrix and assists cleaning;

(3) The disperser can break down particle clusters and enable ultrafine powder to be completely dispersed:

(4) Under appropriate conditions, a product containing 0.90 % Fe_2O_3, can be produced from a koalin powder originally as sayed to contain 2.2 wt.−% Fe_2O_3. There is a recovery of 70 % of the iron free kaolin powder.

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nomical benefits, the runtime is also acceptable.

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