METHOD OF BENEFICIATING ALUMINA-SILICAORES

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Int. Cl. B03c 1/00

Field of Search 209/8, 11, 214; 106/72, 106/288 B; 75/7, 2; 423/151; 241/23, 24

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ABSTRACT

A method of beneficiating aluminous clays or alumina-silica ores containing iron species by thermally treating the clays or ores at relatively high temperature in an air or oxidative atmosphere thereby agglomerating the iron species and subsequently separating the magnetic iron ore from the nonmagnetic ore or minerals.

5 Claims, No Drawings
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METHOD OF BENEFICIATING ALUMINA-SILICA ORES

This is a continuation, of application Ser. No. 74,169 now abandoned, filed on Sept. 21, 1970.

BACKGROUND OF THE INVENTION

The present invention is in the broad field of metallurgy and relates primarily to the beneficiation of aluminous clays or alumina-silica ores for subsequent use in the production of aluminum-silicon alloys.

Natural clays or ores containing aluminum-silicates or alumina-silica usually contain relatively large amounts of iron species generally in the forms of ferrous and/or ferric oxide. Such iron is a harmful impurity in the production of aluminum-silicon alloys. Unless the iron species are removed from the ore prior to carbothermic reduction for producing aluminum-silicon alloys, the resulting aluminum-silicon alloy end product will contain undesirable amounts of iron. In general, the freer an aluminum-silicon alloy is of other elements, the more useful is the alloy. Alloys containing low amounts of iron are therefore extremely desirable.

The present process is primarily adapted for removing or lowering the iron species content of alumina-silica ores prior to their carbothermic reduction into aluminum-silicon alloys. It has been discovered that calcining or thermal treatment of the raw ore or aluminum clay in an air or oxidative atmosphere promotes the agglomeration of the iron containing species and their more facile separation from the aluminum material by magnetic methods. An additional benefit of the calcination or roasting is that the grinding characteristics of the ore are modified so that less fines are produced on grinding thereby resulting in a lower loss of valuable material. It is therefore a primary object of the present invention to provide an economical method of physically beneficiating alumina-silica ores for use in the production of aluminum-silicon alloys.

SUMMARY OF THE INVENTION

Natural alumina-silica clays or clay minerals are heated in an oxidative atmosphere to a temperature of from about 1,100°C to about 1,400°C for a period of about 2 hours to about 48 hours. The calcined ore is then ground and/or crushed into fine particles of a mesh size from about 40 to +400 U.S. Sieve Series. The magnetic iron values are then separated from the non-magnetic mineral values by magnetic separation.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the preferred embodiment of the invention a natural alumina-silica clay or clay mineral such as diaspore clay previously crushed or ground to a convenient size usually about 3 mesh, U.S. Sieve Series is heated in a kiln or other suitable container to a temperature of about 1,300°C to 1,400°C in air, oxygen or other suitable oxidative atmosphere for a period of from about 2–5 hours.

Prior to calcining, the ore particles should be of a size to permit convenient handling thereof. Although the particle size of the raw ore is not critical, an initial particle size of about one-quarter inch to about one-half inch in diameter produces favorable results. After cal-

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cining or oxidative roasting, the ore is ground to a five particle size of about 40 on 400 mesh, U.S. Sieve Series.

The particles of ore are then magnetically separated by any suitable means. An induced roll high intensity magnetic separator has been found to be satisfactory. Calcination in air or an oxidative atmosphere agglomerates the iron species and improves their magnetic properties enabling the iron species to be more readily removed by magnetic separation. An air flush preheated to about 1,000°C and introduced during calcination of the clay or ore at a rate of about 2–3 cubic feet per minute produces exemplary results.

Preheating of the air or oxidation medium permits conservation of heat energy and makes the process more economical. The quantity of air, oxygen or other suitable oxidation medium should be sufficient to accomplish the desired oxidation or agglomeration. The rate of air or oxidation medium is introduced during calcining will vary with the size and type of equipment used in the process.

Although the present invention is suitable for beneficiation of any alumina-silica ores, it is especially useful in the beneficiation of diaspore clay and kyanite clay, or clays containing diaspore, boehmite and/or kaolinite and iron species. Although not wishing to be bound by any particular theory, it is believed that the following occurs during calcination:

\[
\begin{align*}
\text{FeCO}_3 + \text{O}_2 & \xrightarrow{1250°C} \text{Fe}_2\text{O}_3 \\
\text{Fe}_2\text{O}_3 & \xrightarrow{1538°C} \text{Fe}_3\text{O}_4 \\
\text{Fe}_3\text{O}_4 & \xrightarrow{1560°C} \text{Fe}_2\text{O}_3 + \text{CO}_2
\end{align*}
\]

The following examples are illustrative of the invention:

EXAMPLE A

A composite sample of diaspore clay containing diaspore, boehmite and kaolinite as predominant minerals and small amounts of siderite, goethite and hematite of about 4/40 mesh was heated in air for 2 hours in a furnace at a temperature of 1,380°C to 1,410°C. The resulting material had visible spots and nodules of magnetic iron oxide. The sample was crushed in a mortar and pestle to 100 percent minus 40 mesh. Approximately 17 percent was separated with a small hand magnet. The magnetic fraction was black and shiny in appearance. The non-magnetic fraction still had black particles in it. Conversely, no magnetic fraction could be separated from an original non-calcined diaspore clay sample with the same small hand magnet.

EXAMPLE B

A sample of diaspore clay of 4/40 mesh was heated at 1,350°C for approximately 6 hours. The extent of agglomeration was similar to that achieved in Example A. Results comparable to those of Example A were also obtained with a non-calcined diaspore clay sample.

EXAMPLE C

Two diaspore clay samples, containing diaspore, boehmite and kaolinite as predominant minerals and
small amounts of siderite, goethite and hematite, of 550 grams each were calcined in air at 1,300°C ± 15°C in a furnace for approximately 6 hours. The two batches were ground together for 15 minutes in a 9-inch labora-

From the foregoing examples, it is clearly seen that the non-calcined ore samples require a higher magnetic intensity to achieve the same amount of magnetic separation as obtained with the calcined ore samples. The results show in all cases that the calcined ore samples effected better removal of iron than the non-calcined samples except that of sample 4 of Table III which was calcined in static air for only 2 hours. It is therefore apparent that flowing air or oxidative medium is preferred.

The 40/100 and 100/200 mesh fractions were passed through an induced roll high-intensity magnetic separator. The separator reaches its magnetic rating of 16,000 gauss at a field current of 2.0 amperes. No direct measurement of the field strength was possible; however, assuming linearity between field current and field strength, 70–73 percent of the iron oxides was removed at a field strength of about 11,000 gauss (1.4 amp.). The result of these magnetic separations are set forth in Table II hereinafter.

Two diasporic clay samples, containing diasporic, boehmite, and kaolinite as predominant minerals and small amounts of siderite, goethite and hematite, of 670 grams each and of a particle size of 3/40 mesh were tested for their grindability or grinding characteristics. One sample was calcined at 1,300°C for approximately 6 hours. Each of the samples was then separately ground dry in a laboratory rod mill for fifteen minutes. Subsequently the particle size of the samples and the amount of each particle were determined. The calcined sample produced about 25 percent fewer fines (−400
mesh) than the non-calcined sample. The results of these tests are set forth in Table IV hereinafter.

Table IV

<table>
<thead>
<tr>
<th>Grindability of 3/40 Mesh Calcined and Non-calcined Diaspore Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Original (Non-calcined)</td>
</tr>
<tr>
<td>Calcined</td>
</tr>
</tbody>
</table>

As fines are difficult to process in beneficiation treatments of ores, and are normally considered to be a waste or lost product, calcination and/or roasting of the raw ore provides an economical means of substantially reducing the fines prior to further beneficiation.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A method of beneficiating aluminous clay containing iron oxides to effectively lower the content of said iron oxides in said clay comprising the steps of: crushing or grinding said clay to a convenient particle size of about one-quarter inch to about one-half inch in diameter, oxidatively roasting said crushed or ground clay in a flowing oxidative medium at a temperature of about 1,300°C to about 1,400°C for a period of at least about 2 hours to substantially agglomerate the iron oxides, crushing or grinding the roasted clay to a particle size of about -40 mesh to +400 mesh U.S. Sieve Series, and subsequently magnetically separating the magnetic iron oxides from the non-magnetic iron oxides and removing said magnetic iron oxides from said clay thereby effectively lowering the content of said iron oxides in said clay.

2. The method of claim 1, wherein the oxidative medium is air or oxygen.

3. The method of claim 1, wherein the oxidative medium is preheated.

4. The method of claim 1, wherein during oxidative roasting, the oxidative medium is substantially continuously introduced at a rate of at least about two cubic feet per minute.

5. The method of claim 1, wherein the aluminous clay is a diaspore clay.

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