

## THE EFFECT OF PRETREATMENT ON MAGNETIC SEPARATION OF FERRUGINOUS MINERALS IN BAUXITE

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### Abstract

Bauxite sample of Jamnagar, India, is suitable for refractory applications after separation of iron minerals. Different magnetic separators and intensities are studied on different treated samples. The results of these investigations indicate that removal of ferruginous minerals from crude sample requires a magnetic intensity of 14 000 Gauss. The calcined sample at 800°C requires magnetic intensity of about 7000 Gauss, whereas the reduced bauxite needs less than 2000 Gauss for separation of iron and the product achieved contains 76% Al<sub>2</sub>O<sub>3</sub> with 62% iron removal and 69% Al<sub>2</sub>O<sub>3</sub> recovery. All these products are suitable for refractory applications.

### INTRODUCTION

High-alumina bauxite is used extensively in the manufacture of refractories and abrasives. However, major impurities such as iron, titania, silicon oxides and calcium carbonates that are often present at different levels in the bauxite deposits seriously offset the performance of these refractories. In order to meet the desired technical specifications, these impurities need to be removed by different beneficiation methods.

Magnetic separation has been widely used until recently to remove iron oxides and other weakly magnetic minerals. This often requires preliminary treatment [1] in

order to enhance the grain boundary detachment between the gangue minerals and valuable minerals [2], to improve magnetic susceptibility [3] and the efficiency of magnetic separation [4]. Most of the attempts to remove iron content from crude bauxite by using high-intensity magnetic separators have met with marginal success [5].

Pre-treatment operations such as scalping the fines, calcination [5] or magnetising roasting [6, 7] have thus been frequently used to prepare an ore for magnetic separation. Since such established technologies have not been applied to Indian refractory bauxite, an attempt has been made in this paper to investigate the effect of different pre-treatment methods on selective liberation, efficiency of magnetic separation and enhancement of magnetism.

### **MATERIALS AND METHODS**

The bauxite sample of Jamnagar mines, Gujarat, India, containing 53%  $\text{Al}_2\text{O}_3$ , with 4.5%  $\text{Fe}_2\text{O}_3$  (Table 1) was stage-crushed. The  $d_{80}$  passing 1 mm size was scrubbed and scalped. The scalped feed was classified to different sizes. The size fraction below 50  $\mu\text{m}$  and the slimes of the scalped feed were reported as  $-50 \mu\text{m}$  fraction.

Table 1: Chemical analysis of bauxite

| Compound                | Percent |
|-------------------------|---------|
| $\text{Al}_2\text{O}_3$ | 53.00   |
| $\text{Fe}_2\text{O}_3$ | 4.50    |
| CaO                     | 2.70    |
| $\text{SiO}_2$          | 1.70    |
| $\text{TiO}_2$          | 2.40    |
| LOI                     | 30.60   |

Close size fractions were subjected to permaroll magnetic separation. Thermal pre-treatment methods were carried out in a standard calcination/roasting furnace. Calcination was carried out at different temperatures varying between 800 and 1000°C. The calcination time of 30 minutes was constant for all experiments. The feed used for calcination was  $-1.0 + 0.05$  mm.

The effect of the calcination temperature on magnetic separation was investigated using the permaroll magnetic separator. The bauxite calcined at 800°C was subjected to different magnetic intensities by using laboratory Boxmag-Rapid belt magnetic separator.

The  $d_{80}$  passing 8 mm size bauxite was reduced at 800°C with 5% coke for 30 minutes. This sample was crushed to below 1 mm size and subjected to the belt magnetic separator at different magnetic intensities. Wet chemical analysis was carried out for determination of alumina and iron.

## RESULTS AND DISCUSSION

Data presented in Table 2 indicate that iron and alumina are equally distributed in all size fractions except in the fines. These observations indicate that by scalping the feed, the fines of 0.05 mm size can be removed ranging between 18 and 20% by mass containing 4.5% Fe.

Table 2: Size and chemical analysis of crushed product

| Size, mm | Wt%    | Fe%  | Al%   |
|----------|--------|------|-------|
| 1.00     | 32.40  | 3.70 | 28.50 |
| 0.50     | 8.80   | 3.10 | 27.40 |
| 0.25     | 16.30  | 3.20 | 27.50 |
| 0.12     | 13.10  | 3.50 | 28.40 |
| 0.05     | 10.60  | 2.80 | 28.00 |
| -0.05    | 18.80  | 4.50 | 27.90 |
| Total    | 100.00 | 3.60 | 28.10 |

The effect of magnetic separation on close sized fractions is shown in Table 3. The data indicate that separation of iron can be possible in the size ranges between 0.5 and 0.05 mm. Thus, by classifying the feed at 1 mm and 0.05 mm, a non-magnetic product containing 35% by mass and 2.4% Fe could be achievable.

Table 3: Magnetic separation of a crushed product using permarolls

| Size, mm | Magnetics |       | Non-magnetics |      |
|----------|-----------|-------|---------------|------|
|          | Wt%       | Fe%   | Wt%           | Fe%  |
| 1.00     | 1.30      | 15.50 | 31.10         | 3.20 |
| 0.50     | 1.00      | 13.50 | 7.80          | 1.70 |
| 0.25     | 3.10      | 9.40  | 13.20         | 1.70 |
| 0.12     | 3.70      | 8.20  | 9.40          | 1.60 |
| 0.05     | 5.60      | 4.80  | 5.00          | 0.60 |
| -0.05    | 3.50      | 10.70 | 15.30         | 3.10 |
| Total    | 18.20     | 9.20  | 81.80         | 2.50 |

The effect of heat treatment on removal of iron by using permaroll magnetic separation is shown in Table 4. As expected, with increasing temperature from oven to furnace temperature, the iron content in the feed increases. It is also seen that with increasing temperature the percentage of iron removal is progressive.

Table 4: Effect of heat treatment on permaroll magnetic separation

| Temp. °C | Magnetics |      | Non-magnetic |      | Feed Fe% | Removal Fe% |
|----------|-----------|------|--------------|------|----------|-------------|
|          | Wt%       | Fe%  | Wt%          | Fe%  |          |             |
| 100.00   | 33.60     | 7.40 | 66.40        | 1.70 | 3.60     | 68.60       |
| 800.00   | 44.80     | 6.80 | 55.20        | 1.70 | 4.00     | 76.20       |
| 900.00   | 49.00     | 6.80 | 51.00        | 1.70 | 4.20     | 79.30       |
| 1,000.00 | 50.70     | 7.50 | 49.30        | 1.80 | 4.70     | 80.90       |

These findings are observed due to a loss of moisture in the sample. It is also expected that with increasing temperature at certain atmosphere the feebly magnetic iron minerals may be attracted by higher magnetic field resulting in the increased mass percentage of magnetics.

Thus the results of these observations indicate that the oven dried sample may require 14 000 Gauss for separation of iron, whereas the calcined sample seems to require lower magnetic field for separation of partially converted magnetic minerals.

The results of different magnetic fields on calcined (800° C) sample are shown in Table 5. These results indicate that at the magnetic intensity of 1000 Gauss, about 28 to 30% magnetics containing 14.8% Fe could be rejected. Due to the scalping of highly magnetic particles by stages raise magnetism, a non-magnetic product containing 56% by mass with 1.7% Fe could be achievable compared to a product obtained from uncalcined feed at 14 000 Gauss by permaroll magnetic separation.

Table 5: Effect of magnetic intensity on calcination of crude bauxite

| Magnetic intensity, G | Product  | Weight % | Fe%   |
|-----------------------|----------|----------|-------|
| 1,000.00              | Mag1     | 28.50    | 14.80 |
| 1,300.00              | Mag2     | 2.00     | 2.40  |
| 1,800.00              | Mag3     | 2.20     | 2.00  |
| 2,500.00              | Mag4     | 2.10     | 2.00  |
| 3,400.00              | Mag5     | 2.80     | 1.90  |
| 4,500.00              | Mag6     | 3.20     | 1.90  |
| 7,100.00              | Mag7     | 4.00     | 1.80  |
| 7,100.00              | Non-mags | 56.20    | 1.70  |
| Total                 |          | 100.00   | 5.50  |

Since it is observed that heat treatment has an advantage of enhancing the magnetism of the particles as well as improves the separation efficiency, the crude

sample was roasted under reducing atmosphere and subjected to magnetic separation after size reduction. The results of the effect of magnetic intensity on reduced sample shown in Table 6 indicate that a non-magnetic product containing 1.8% Fe with 63% yield could be achievable at 1800 Gauss compared to a calcined sample at 7100 Gauss and oven-dried sample at 14 000 Gauss.

Table 6: Effect of magnetic intensity on roasting of crude bauxite

| Magnetic intensity, G | Product  | Weight, % | Fe, % |
|-----------------------|----------|-----------|-------|
| 1,000.00              | Mag1     | 14.60     | 19.00 |
| 1,300.00              | Mag2     | 10.60     | 12.50 |
| 1,800.00              | Mag3     | 11.20     | 2.00  |
| 1,800.00              | Non-mags | 63.30     | 1.80  |
| Total                 |          | 100.00    | 5.50  |

Summary of the results shown in Table 7 indicate that at 1400 Gauss a non-magnetic product containing 53%  $\text{Al}_2\text{O}_3$  and 2.2%  $\text{Fe}_2\text{O}_3$  could be obtained with 86% iron removal and 36% alumina recovery from an oven-dried sample. At 7000 Gauss the calcined sample gave a product containing 76%  $\text{Al}_2\text{O}_3$  with 77% iron removal and 56%  $\text{Al}_2\text{O}_3$  recovery. Reduced sample, at below 2000 Gauss, also gave a product containing 77%  $\text{Al}_2\text{O}_3$  with 62% iron removal and 69%  $\text{Al}_2\text{O}_3$  recovery. All the end products obtained at 14 000 Gauss, 7100 Gauss and 1800 Gauss are suitable as a raw material for refractory applications.

## CONCLUSIONS

The iron content is distributed equally at all size fractions in the bauxite sample. Removal of ferruginous minerals from crude sample requires 14 000 Gauss for obtaining a product containing 53%  $\text{Al}_2\text{O}_3$  with 36% recovery. The calcined sample at 800°C requires magnetic intensity of about 7000 Gauss for obtaining 76%  $\text{Al}_2\text{O}_3$  with 56% recovery, whereas the reduced bauxite needs less than 2000 Gauss for

Table 7: Summary of results and chemical analysis of the non-magnetic products

| Parameter                                   | Oven-dried | Calcined | Roasting |
|---|------------|----------|----------|
| Magnetic field, G                           | 14,000.00  | 7,100.00 | 1,800.00 |
| Yield (%)                                   | 35.40      | 56.20    | 63.30    |
| Recovery (%Al <sub>2</sub> O <sub>3</sub> ) | 36.00      | 56.00    | 69.00    |
| Removal (%Fe <sub>2</sub> O <sub>3</sub> )  | 86.00      | 77.00    | 62.00    |
| Al <sub>2</sub> O <sub>3</sub> (%)          | 53.80      | 75.80    | 77.00    |
| Fe <sub>2</sub> O <sub>3</sub> (%)          | 2.20       | 2.40     | 2.50     |
| CaO (%)                                     | 1.70       | 2.40     | 2.50     |
| SiO <sub>2</sub> (%)                        | 1.70       | 2.40     | 2.50     |
| TiO <sub>2</sub> (%)                        | 2.40       | 3.80     | 3.80     |

separation of iron and the product achievable contain 77% Al<sub>2</sub>O<sub>3</sub> with 69% recovery. All these products are suitable for refractory applications.

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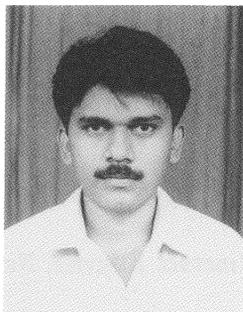
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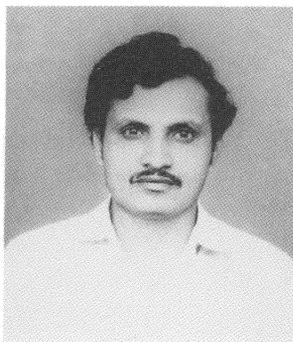
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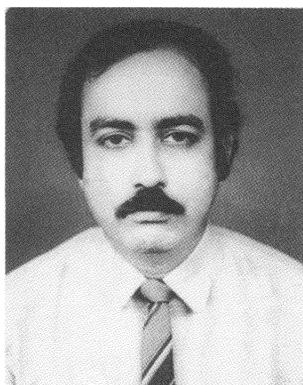
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