BAUXITE RESIDUE VALORISATION AND BEST PRACTICES CONFERENCE

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New hydrothermal methods for the transformation of iron oxides in bauxite residue into magnetite

Amy Van den Bulck & Yiannis Pontikes

Introduction

Transformation

Hematite to magnetite

?

Magnetic separation

Magnetic fraction

Non-magnetic fraction

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European Aluminium Association. Bauxite residue management: Best practice, August 2014.

Refluxing with ferrous salts

100 °C
1.30 hours
Inert environment

$$FeSO_4 + 2\ NaOH + Fe_2O_3 \rightarrow Fe_3O_4 + H_2O + NaSO_4$$

1. Pure hematite reflux process:
   - Maximal transformation: 75 %
     - Agitation
     - Ratio of $FeSO_4$ over Fe_2O_3
2. Bauxite residue reflux process
   - Very little or insignificant amount of magnetite
   - Further research is needed

Addition of metallic aluminum

200 – 250 °C
3 hours

$$2\ NaOH + Al + 2\ H_2O \rightarrow Na_2AlO_2 + H_2$$
$$3\ Fe_2O_3 + H_2 \rightarrow 2\ Fe_3O_4 + H_2O$$

1. Bauxite residue and metallic aluminum
   - No magnetite formation
   - Difficult control of $\left(\frac{p_{H_2O}}{p_{H_2}}\right)$

New hydrothermal methods for the transformation of iron oxides in bauxite residue into magnetite

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Abstract

This work presents two novel ways to approach the possibility of transforming hematite (Fe_2O_3) and/or goethite (FeOOH) into magnetite (Fe_3O_4) in bauxite residue. This magnetite could be magnetically separated from the rest of the bauxite residue. The first process was based on the process of refluxing under an inert environment and the addition of ferrous salt. Initial experiments were performed on pure hematite and goethite. The XRD results indicated a maximal transformation yield of 72 % and 75 % for goethite and hematite, respectively. Similar experiments were performed on bauxite residue. XRD results indicated the presence of hematite and goethite in the bauxite residue. It was concluded that the ferrous hydroxide did not react with the hematite and goethite present. The second process consisted of introducing metallic aluminum as a hydrogen gas agent in the gravity pressure vessel (GPV) of Innovation Concepts B.V., Gorinchem, Netherlands. . The XRD results of these experiments indicated no formation of magnetite.

Methods and Materials

Refluxing with ferrous salt

- A solution of Fe2O3, NaOH and ferrous salt was heated to 100 °C for 1.30 hours, under nitrogen.
- A solution of bauxite residue, NaOH and ferrous salt was heated to 100 °C for 1.30, 3.00, 4.30 and 6.00 hours, under nitrogen.
- The solid was filtered and dried at 60 °C in air.

Addition of metallic aluminum

- A mixture of 150 g of bauxite residue and H_2O.
- Pressure: 50 and 100 bar & Temperature: 200 and 250 °C
- Metallic aluminum varied from 3 to 10 g.
- Time: 3.00 hours
- The solid was filtered and dried at 60 °C in air.

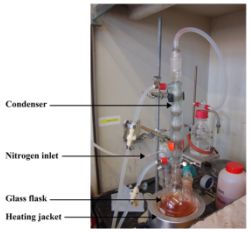

Fig. 1 Refluxing setup

Results

Refluxing with ferrous salt

$$FeSO_4 + 2\,NaOH \rightarrow Fe(OH)_2 + NaSO_4$$
$$2\,FeOOH + Fe(OH)_2 \rightarrow Fe_3O_4 + 2\,H_2O$$
$$Fe_2O_3 + Fe(OH)_2 \rightarrow Fe_3O_4 + H_2O$$

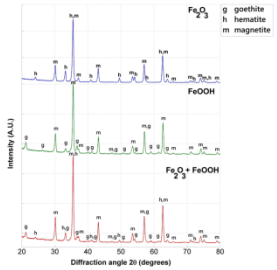

Fig. 2 XRD patterns of refluxing with pure hematite and goethite

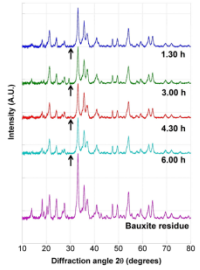

Fig. 3 XRD patterns of refluxing bauxite residue

Addition of metallic aluminum

$$2\,NaOH + Al + 2\,H_2O \rightarrow Na_2AlO_2 + H_2$$
$$3\,Fe_2O_3 + H_2 \rightarrow 2\,Fe_3O_4 + 2\,H_2O$$

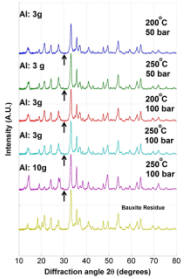

Fig. 4 XRD patterns of additions of metallic aluminum to bauxite residue

Conclusions

- A maximal transformation of pure hematite and goethite to magnetite were determined at 75 % and 72 % respectively for refluxing with ferrous salt.
- A temperature increase from 25 °C to 100 °C has a significant effect on the reaction rate of pure hematite to magnetite .
- The ferrous salt did not react with the hematite and goethite present in the bauxite residue .
- Refluxing time had no effect on the transformation in bauxite residue.
- Further research is needed on the effect of other minerals on the adsorption of ferrous hydroxide in bauxite residue.
- The addition of metallic aluminum led to no magnetite formation due to inadequate control of the ratio of the partial pressure of water over the partial pressure of the hydrogen gas.

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Thank you for your attention

Questions?

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