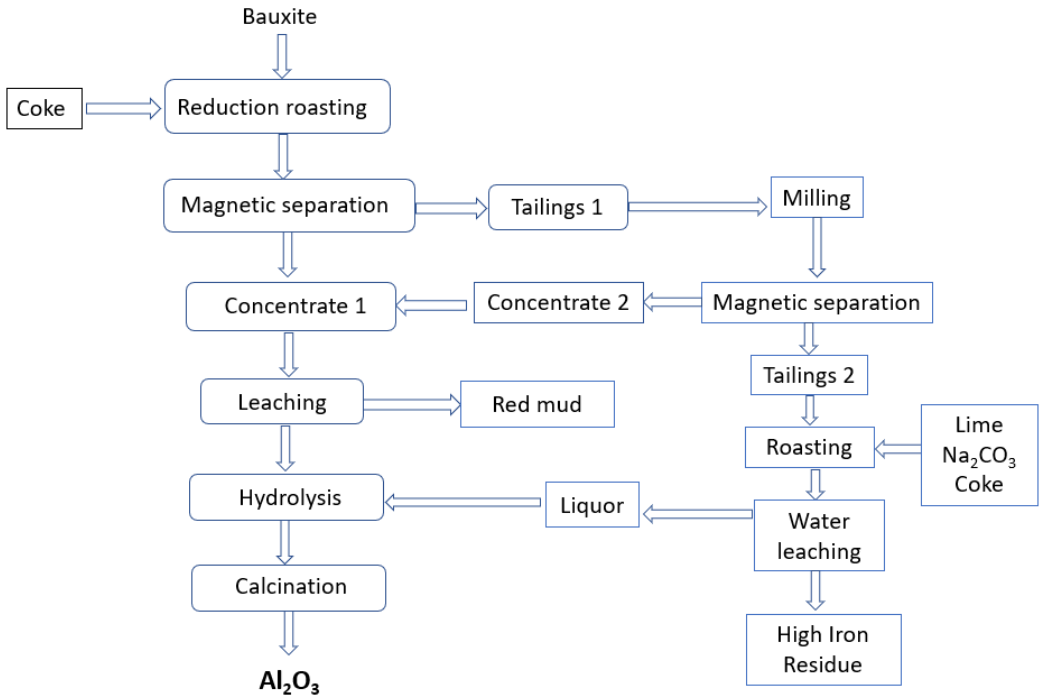

Figure 1

ANJAN SEN
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IN/PA-199

FORM 2
THE PATENT ACT 1970
(39 OF 1970)
&
The Patent Rules, 2003
COMPLETE SPECIFICATION
(See Section 10 and Rule 13)

1 **TITLE OF THE INVENTION:**

A process for energy efficient recovery of alumina and iron from bauxite ore

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PREAMBLE TO THE DESCRIPTION

3 **COMPLETE**

The following specification particularly describes the invention and the manner in which it is to be performed.

FIELD OF INVENTION

The present invention discloses a method/process for separating and recovery of iron, aluminium, and silicon from bauxite ore. More specifically, the present invention is related to the enrichment of alumina content in bauxite ore feed in the Bayer process to decrease the amount of red mud generation and energy consumption. The present invention thus relates to the recovery of alumina and iron from the bauxite ore. More particularly, a partial reduction roasting and two-stage magnetic separation have been adopted in the present process for the separation of high alumina and iron fractions in the bauxite ore, with high alumina fraction sent for alkali leaching stage and the high iron fraction sent for the reduction roasting to produce alumina and metallic iron, respectively. By way of this advantageous process of the present invention the alkaline solid waste generation in the bauxite ore processing has been minimized by half as compared to conventional processes allowing 90% of alumina recovery through this process, with further advantages being both alumina and iron parts could be extracted from bauxite ore and that energy required in the alkali leaching stage is minimized.

BACKGROUND ART

Aluminium is one of the major metal substances for the national economic development of any developing country like India. Bauxite ore is the only natural resource for alumina available in India. Along with the alumina, other impurities like iron oxide, silica, titania etc. also exist in the bauxite ore.

The entire alumina industry in India follows Bayer's process for the recovery of alumina from bauxite ore. In Bayer's process, the impurities present in the bauxite ore are separated as red mud from alumina which is disposed into the environment.

Around ~1.5 tons of waste red mud is generated for every ton of alumina production which is disposed of into the environment, which is hazardous. Apart from the waste generation, these impurities also increase the input reactant

(NaOH) consumption, energy consumption, and alumina losses in the overall processing.

Yuan et al. (https://doi.org/10.1016/j.powtec.2020.05.112) described a method for the enrichment of alumina content in the high iron bauxite feed or iron removal using the two-stage roasting technique followed by magnetic separation of iron content. In the first roasting stage, the hydrates present in the bauxite ore are decomposed prior to the hydrogen reduction roasting in the second stage. After partial reduction, the material is put under a magnetic field to separate the iron-rich magnetic fraction and high alumina content non-magnetic fraction.

CN103614547B by Li Guanghui et al. patented a method for the selective separation of iron, aluminium, and silica from the diasporic bauxite ore. This process comprises of following steps; (i) oxidizing roasting, (ii) reducing roasting with carbon as the reducing agent, (iii) water quenching and grinding of the roasted bauxite, (iv) dissolving out silicon dioxide with an alkali solution, (v) low-intensity magnetic separation of the filter residue to obtain a magnetite concentrate and an alumina concentrate, wherein the alumina concentrate is used for producing alumina by a Bayer process, and the magnetite concentrate is used as an iron making raw material. This process involves complete reduction of iron present in the bauxite for the separation.

Inspite of the above known state of the art, there is thus a long felt need to explore and provide for bauxite ore beneficiation process that would not only minimize solid waste generation but would also allow significant alumina and iron recovery at minimized energy costs required for alkali leaching.

THE OBJECTIVES OF THE INVENTION

The objective of the present invention is to provide a process for energy efficient recovery of alumina and iron from bauxite ore or bauxite ore beneficiation process to decrease the impurities content in Bayer's process feed.

Another objective of the present invention is to provide said process with decreased red mud generation and energy consumption in Bayer's process.

Yet another objective of the present invention is to provide for said process that would enable the separation of iron oxide, titania and silica from the bauxite ore.

Another objective of the present invention is to provide for a process that would maximise the alumina recovery in Bayer's process.

Yet another objective of the present invention is to provide for said process that would enable production of metallic iron from the iron oxide present in bauxite ore.

SUMMARY OF THE INVENTION

Thus according to the basic aspect of the present invention there is provided a process for energy efficient recovery of alumina and iron from bauxite ore comprising the steps of

(i) subjecting the bauxite ore to partial reduction roasting for partial conversion of iron oxide present in bauxite ore to magnetite and collecting therefrom partially reduced roasted mass;

(ii) magnetic separation of said partially reduced roasted mass to provide for alumina-rich content based non-magnetic fraction and iron oxide rich content based magnetic fraction including recovering locked alumina from said high iron oxide content based magnetic fraction following wet milling/grinding followed by wet magnetic separation for recovery of locked alumina such as to generate non-magnetic fractions including locked alumina recovered alumina rich fractions and iron rich magnetic fractions separately;

(iii) subjecting the non-magnetic fractions including locked alumina recovered alumina rich fractions to steps of silica load reduction to obtain low silica porous bauxite residue retaining alumina in said residue;

(iv) subjecting the residue of step (iii) above to alkali leaching to obtain therefrom high alumina fraction as aluminate for alumina recovery therefrom, and, also generating said iron rich magnetic fractions for metallic iron recovery following efficient energy and solid waste management.

Preferably in said process for energy efficient recovery of alumina and iron from bauxite ore wherein

said step (i) involves providing and subjecting the bauxite ore to temperature controlled partial reduction roasting for said partial conversion of iron oxide present in bauxite ore to magnetite and said collecting therefrom partially reduced roasted mass;

said step (ii) magnetic separation of said partially reduced roasted mass is to provide for alumina-rich content based non-magnetic fraction (70%) and high iron oxide content based magnetic fraction (30%), also including for recovery of locked alumina from said high iron oxide content based magnetic fraction following said wet milling/ grinding of the same and performing supplementary magnetic separation in sub-stages for said recovery of locked alumina so as to generate combined alumina-rich non-magnetic fractions and said iron rich magnetic fractions separately;

said step (iii) of silica load reduction is based on performing selective silica extraction of said combined alumina-rich non-magnetic fractions attained in step (ii) above by alkali of low strength to obtain low silica porous bauxite (1-3%) as residue by retaining alumina in said residue;

said step (iv) includes performing alkali leaching by selecting high strength alkali of said porous bauxite residue attained in step (iii) above to obtain therefrom high alumina fraction as aluminate with reduced energy followed by hydrolysis for alumina recovery, and, performing reduction roasting of iron oxide rich fractions of step (ii) to obtain therefrom from this step 90% recovered alumina from said

ore by minimizing solid waste generation by half in respect of conventional processes.

According to another preferred aspect of the present invention there is provided said energy efficient process for recovery of alumina and iron from bauxite ore wherein said step (i) of providing bauxite ore for partial reduction roasting involves reduction of the bauxite ore to convert the iron oxide present in the bauxite to magnetite by adding carbon/coal as reduction source in the range of 0.05 wt.% to 0.15 wt.% and by maintaining controlled temperature and time range for partial reduction roasting between 300°C to 900°C and 5 min to 12 hr, respectively, enabling collection of said alumina-rich content based non-magnetic fraction (70%) and iron oxide rich content based magnetic fraction (30%) after passing said partially reduced roasted mass through weak dry/wet magnetic separation stage at magnetic strength maintained at 200 Gs to 1500 Gs, whereby prior to roasting, goethite and bayerite present in bauxite ore decompose into hematite and alumina due to said high temperatures;

wherein alumina-rich content based non-magnetic fraction thus attained has alumina to iron ratio between 3 to 4, and iron oxide rich magnetic fraction has alumina to iron ratio is around 1 to 1.2.

Preferably, in said process said step (ii) said wet milling of iron oxide rich content based magnetic fraction to improve recovery of additional alumina based non-magnetic fraction therefrom includes grinding to -90 mesh size by involving wet ball milling operation followed by wet magnetic separation wherein the operational parameters for ball milling operation includes ball to powder weight ratio is 10:1, rpm 500, time 1-2 hr with magnetic strength varied between 200 Gs to 15000 Gs to obtain maximum recovery of alumina whereby added 15 to 20% of excess alumina based non-magnetic fraction is obtained with similar Al to Fe ratio between 3 to 4.

More preferably, in said process for energy efficient recovery of alumina and iron from bauxite ore said step (iii) of silica load reduction/extraction of said combined alumina-rich non-magnetic fractions includes providing said combined non-magnetic fraction having iron (15 to 20%) and silica (7 to 10%) along with alumina (70-73%) for leaching with alkali of 100 to 150 grams per liter (GPL) preferably NaOH at temperatures of 100 to 120 ^{o}C in a pressure leaching bomb for 2 hr to 4 hr time periods to enable leach liquor including sodium silicate and residue of low silica (1-3%) porous bauxite as pulp residue.

According to another preferred aspect of the process of energy efficient recovery of alumina and iron from bauxite ore wherein said step (iv) of alkali leaching said porous bauxite residue includes the sub-steps of

(a) treating said residue/ pulp residue with 200-250 GPL alkali solution preferably NaOH in a pressure leaching setup at temperatures 140-160°C for 4 to 6 hr time periods to obtain aluminate based high alumina fraction as alkali based leach liquor and residue preferably reddish in color of red mud including 22% Al_2O_3 (4g), 43% iron oxide (9.5g), 11% silica (2.4g), and 5% TiO_2 (1.1 g);

(b) hydrolyzing said leach liquor by constant stirring at a low temperature (30-80°C) for 2-3 days to precipitate 50-70% of alumina from alkali leach liquor that is separated by filtration and thereafter calcined in furnace at temperatures maintained at 1000°C to 1200°C for 1 hr to 2 hr, with the filtrate further combined and re-circulated into step (a) above, or, alternatively, performing conventional hydrothermal precipitation for obtaining aluminum hydroxide from said leach liquor.

Preferably in said process for energy efficient recovery of alumina and iron from bauxite ore wherein said step (iv) including reduction roasting of iron rich and low alumina content magnetic fraction as attained from step (ii) includes steps of

(a) alkali reduction roasting at high temperatures (>900°C) by involving carbon, Na_2CO_3, together with added lime to neutralize any silica content present in the magnetic fraction in this stage to enable a grey colored mass as residue that is

leached with hot water to dissolve sodium aluminate therein to enable a leach liquor for alumina recovery therefrom;

(b) filtering the leach liquor (pH>12) from the residue followed by purging CO_2 gas into the liquor to precipitate out alumina with the residue containing iron usable as DRI feed in iron making processes, or, alternatively performing conventional hydrothermal precipitation for obtaining aluminum hydroxide from said leach liquor.

In an aspect, the present invention provides insight into the recovery of alumina and the separation of impurities from the bauxite ore with minimal waste generation. The process comprises partial reduction roasting of bauxite ore using coal as the carbon source at a temperature of 300-900°C for a 5 min to 12 hr time period.

In another aspect, magnetic separation is carried out for the reduced bauxite product to separate the magnetic part or high iron/low alumina and the non-magnetic part or high alumina/low iron fraction.

In another aspect, the magnetic fraction obtained in step [009] is grounded to -90 mesh and sent for the wet magnetic separation to further extract the alumina as a non-magnetic fraction.

In another aspect, the non-magnetic parts obtained from the [009] and [010] steps are mixed and sent for the silica removal process which comprises alkali leaching followed by lime treatment. This step results in a residue consisting of calcium silicates and a liquor consisting of NaOH.

Yet in another aspect, the residual alumina and iron oxide contents from the magnetic part obtained from step [010] are recovered using the solid-state alkali reduction roasting with carbon as the reducing agent and Na_2CO_3 as the alkali source. The reduced product is leached with hot water to recover the sodium aluminate from the metallic iron.

BRIEF DESCRIPTION OF FIGURES

Fig. 1. Illustrates process flow chart.

DETAILED DESCRIPTION OF THE INVENTION

As discussed hereinbefore, the present invention provides for a process/ method of separating the iron, aluminium, and silicon from bauxite ore. More specifically, the present invention is related to energy efficient recovery of alumina and iron from bauxite ore by enrichment of alumina content in bauxite ore feed in the Bayer process to decrease the amount of red mud generation and energy consumption. The present invention thus relates to the recovery of alumina and iron from the bauxite ore. More particularly, a partial reduction roasting and two-stage magnetic separation have been adopted in the present process for the separation of high alumina and iron fractions in the bauxite ore, with high alumina fraction sent for alkali leaching stage and the high iron fraction sent for the reduction roasting to produce alumina and metallic iron, respectively. By way of this advantageous process of the present invention the alkaline solid waste generation in the bauxite ore processing has been minimized by half as compared to conventional processes allowing 90% of alumina recovery through this process, with further advantages being both alumina and iron parts could be extracted from bauxite ore and that energy required in the alkali leaching stage is minimized.

The present invention summarized above and defined by the enumerated claimed scope may be better understood by referring to the following description, which should be read in conjunction with the accompanying claims. This description of an embodiment, set out below to enable one to build and use an implementation of the present invention, is not intended to limit the invention but to serve as a particular example thereof. Those skilled in the art should appreciate that they may readily use the conception and specific embodiments disclosed as a basis for

modifying or designing other methods and systems for carrying out the same purposes of the present invention.

The present invention discloses a flow chart for the recovery of alumina, iron oxide, and silica from the bauxite ore which consists of reduction roasting, milling, magnetic separation, and alkali leaching steps. The entire process flow chart related to the present invention is given in Figure 1.

The reduction roasting step in this process comprised of partial conversion of iron oxide present in the bauxite ore to the magnetite form with the addition of carbon in the range of 0.05 wt.% to10 wt.%. The temperature and time range of the partial reduction roasting processes are maintained between 300°C to 900°C and 5 min to 12 hr, respectively. Prior to the roasting process, goethite, gibbsite and boehmite present in the bauxite ore decompose into hematite and alumina because of the high temperatures. The reactions that occur during the partial reduction roasting step are expressed as follows;

$$2\ FeO(OH) = Fe_2O_3 + H_2O$$

$$2\ Al(OH)_3 = Al_2O_3 + 3\ H_2O$$

$$2x\ Fe_2O_3 + 0.5y\ C = 2y\ Fe_3O_4 + (2x\text{-}3y)\ Fe_2O_3 + 0.5y\ CO_2$$

In the partial reduction roasting process there is 20 to 30% weight loss occurred due to calcination and oxygen loss. This reduced mass is gone to the weak dry/wet magnetic separation stage to collect the magnetic and non-magnetic fractions. The magnetic strength in this stage is maintained at 200 Gs to 1500 Gs. Through this stage, an alumina-rich content non-magnetic fraction (70%) and high iron oxide content magnetic fraction (30%) are obtained in this process. In the non-magnetic fraction, the alumina to iron ratio is obtained between 3 to 4, and in the magnetic fraction alumina to iron ratio is around 1 to 1.2.

The magnetic fraction obtained in the above step is processed through wet milling and magnetic fraction to further improve the recovery of the alumina part. For this, the magnetic fraction obtained in above paragraph is ground to -90 mesh size

using a wet ball milling operation followed by wet magnetic separation. In the ball milling process, the operational parameters ball to powder weight ratio 10:1, rpm 500, and time 1-2 hr are used. The magnetic strength is varied between 200 Gs to 1500 Gs to obtain the maximum recovery of alumina. Through this stage, a further 15 to 20% of the excess non-magnetic fraction is obtained which has similar Al to Fe ratio obtained in the step of above paragraph.

The non-magnetic fractions obtained in both stage 1 and stage 2 in Figure 1 are mixed before sending into the silica extraction step. The combined non-magnetic fraction has iron (15 to 20%) and silica (7 to 10%) in it along with alumina (70-73%). To extract the silica selectively from this an alkali leaching step is used. In the alkali leaching stage, the combined non-magnetic fraction is leached with 100 to 150 grams per liter (GPL) NaOH at temperatures of 90 to 120 ^{o}C for 30 min to 4 hr time periods. The leach liquor obtained from the leaching stage consists of sodium silicate and the residue consists of low silica (1-3%) porous bauxite. The reactions that occur in the silica extraction stage are described as follows;

$$SiO_2 + NaOH = Na_4SiO_4$$

The pulp residue obtained from the alkali leaching stage is sent to step 4 in Figure 1, from which pure alumina is recovered. In this stage (step 5), the pulp residue is treated with the alkali solution made of 200-250 GPL NaOH in a pressure leaching setup at temperatures 120-160°C for 30 min to 6 hr time periods.

$$Al_2O_3 + 2\ NaOH = 2\ NaAlO_2 + H_2O$$

The leach liquor obtained from step 4 is sent to the hydrolysis stage in which the alumina is precipitated at a low temperature (30-90°C) using constant stirring. The precipitation step is carried out in a conventional procedure. Around 50-70% of the alumina precipitated from the alkali leach liquor during the hydrolysis process, which is separated using a filtration process. The liquor obtained after filtration is sent back to step 5 for recirculation. The precipitate formed in the hydrolysis stage is filtered and sent to the calcination stage. During the calcination, the temperature of the furnace is maintained in the range of 1000°C to 1200°C, and the calcination

is progressed for 1 hr to 2 hr. The reactions occur in the hydrolysis stage and calcination stage described as follows;

$$NaAlO_2 + H_2O = Na^+ + Al(OH)_3$$

$$2\ Al(OH)_3 = Al_2O_3 + 3\ H_2O$$

The low alumina content magnetic fraction obtained in step 3 was recovered using the alkali reduction roasting at high temperatures (>900°C) using carbon and Na_2CO_3. Some amount of lime is also added to neutralize the silica content present in the magnetic fraction in this stage. The product obtained after the reduction roasting process is leached with hot water to dissolve the sodium aluminate leaching the metallic iron and impurity oxides residue. The reactions that occur during the reduction roasting stage are given below;

$$Fe_2O_3 + C = 2\ Fe + 3\ CO$$

$$Al_2O_3 + Na_2CO_3 = 2\ NaAlO_2 + CO_2$$

$$SiO_2 + CaO = CaSiO_3$$

This invention thus comprises of following steps; (i) reduction roasting of the bauxite ore to convert the iron oxide present in the bauxite to magnetite using carbon as the reduction source, (ii) magnetic separation to separate the high alumina/low iron oxide (non-magnetic) fraction and the high iron oxide/low alumina fraction (magnetic), (iii) grinding the magnetic fraction to liberate the locked alumina, (iv) second stage magnetic separation to separate the high iron oxide (magnetic) and high alumina (non-magnetic) fractions in magnetic fraction obtained from step ii, (v) silica separation from the non-magnetic fractions obtained from step ii and iv using alkali treatment at temperatures 90-120°C, (vi) feeding the silica removed residue into the Bayer's leaching set up to recover the alumina, (vi) the magnetic fraction obtained from both magnetic separation stages were mixed and reduced at high temperatures (>900°C) to separate the metallic iron and residual alumina.

WORKING EXAMPLES

The advantages and benefits of the present process according to the embodiments of the present invention would become more apparent from the below experimental details to a person skilled in the art.

Example 1:

A mixture of 100 g of bauxite and 1.2 g of activated charcoal were blended thoroughly before placing into a muffle furnace using an alumina crucible. The crucible was covered with graphite sheets and wood to prevent the reoxidation of reduced mass. Then the furnace was heated to 700°C, and after reaching the temperature it was held there for 2 hr. After that, the furnace was cooled to room temperature and the reduced mass was collected and weighed before sending to the magnetic separation step. The total weight of the reduced mass was obtained as ~76 g.

The reduced mass (76g) obtained from the reduction step was sent to the dry magnetic separation stage. The Teflon magnet with a magnetic intensity of 200 Gs was used as the tool for magnetic separation. From this stage around ~50g of the reduced fraction is divided into the non-magnetic fraction, and ~26g was obtained in the magnetic fraction.

The chemical analysis shows that the Al/Fe ratio and silica content in the non-magnetic fraction is 3 to 4±0.2 and 5 to 6%, respectively. The chemical analysis of the magnetic fraction shows Al/Fe ratio of 0.98±0.2.

The magnetic fraction obtained was further grounded to -90 mesh using a planetary ball mill. The operational parameters like ball-to-power ratio 10, rpm 500, and time 60 minutes were kept constant in the milling process. The ball mill was passed in between every 10 mins for cooling. The grounded mass was sent to the wet magnetic separation in which the milled mass was suspended in water. A magnetic strength of 300 GS was used to separate magnetic fractions in the milled mass. Approximately 14g of mass was attracted to the magnetic fraction, and ~12g remained in the water. The chemical analysis shows that Al/Fe in the

magnetic fraction is less than ~0.67, and Al/Fe ratio non-magnetic fraction was obtained as ~2.4.

The non-magnetic fractions obtained from the two stages (~62g) were sent to the silicon removal step. In this stage, 62 g non-magnetic fraction is leached with the 100 GPL NaOH solution at 120°C for 2 to 4 hr for the extraction of silica. The leach liquor containing silica and the residue was filtered.

The residue obtained after the silica removal is sent to Bayer's leaching step, in which the residue is leached with 220 GPL NaOH at a temperature of 160°C to convert the alumina into soluble sodium aluminate. The sodium aluminate containing leach liquor and residue (reddish color) called red mud (22g) was separated using the filtration setup. Red mud contains 22% Al_2O_3 (4g), 43% iron oxide (9.5g), 11% silica (2.4g), and 5% TiO_2 (1.1 g).

Aluminum hydroxide can be obtained from the sodium aluminate leach liquor by conventional hydrothermal precipitation.

The magnetic fraction (14g) obtained above and grounded to -90 mesh is reduced with carbon (2.52g) in presence of Na_2CO_3 (5.88g) and lime (0.91g) at a temperature of 950°C. After reduction, a grey color mass of ~16g powder is obtained which is fed into hot water leaching unit to recover the alumina. The leach liquor (pH>12) is filtered from the residue and CO_2 gas is purged into the liquor to precipitate out alumina from the solution. However, aluminum hydroxide can also be recovered from this solution by conventional hydrothermal precipitation. A mass of 5g gram alumina hydroxide is recovered through this process which is sent to the calcination step to produce Al_2O_3 (3.3g). The residue (11g) consists of high iron can be used as the DRI feed in the iron making processes.

Total of 88-90% of the alumina is recovered through this process and red mud generation is 0.55 ton/ton of alumina produced when significantly selective process sequence based methodologies of the present invention are followed of partial reduction roasting of bauxite ore, followed by magnetic separation of said

partially reduced roasted mass to generate non-magnetic fractions including locked alumina recovered alumina rich fractions and iron rich magnetic fractions separately, further followed by selective silica load reduction of said non-magnetic fractions including locked alumina by leaching with alkali of select low strength and obtaining a residue, yet further followed by select high strength alkali leaching of said residue to obtain therefrom high alumina fraction as aluminate for alumina recovery therefrom, and thereafter performing reduction roasting of said iron rich magnetic fractions attained earlier to recover metallic iron therefrom by minimizing solid waste generation by half in respect of conventional processes.

It is thus possible for the present invention to provide for energy efficient recovery of both alumina and iron from bauxite ore with minimized waste generation and with energy efficiency whereby energy required in the alkali leaching stage could be minimized.

WE CLAIM:

1. A process for energy efficient recovery of alumina and iron from bauxite ore comprising the steps of

(i) subjecting the bauxite ore to partial reduction roasting for partial conversion of iron oxide present in bauxite ore to magnetite and collecting therefrom partially reduced roasted mass;

(ii) magnetic separation of said partially reduced roasted mass to provide for alumina-rich content based non-magnetic fraction and iron oxide rich content based magnetic fraction including recovering locked alumina from said high iron oxide content based magnetic fraction following wet milling/grinding followed by wet magnetic separation for recovery of locked alumina such as to generate non-magnetic fractions including locked alumina recovered alumina rich fractions and iron rich magnetic fractions separately;

(iii) subjecting the non-magnetic fractions including locked alumina recovered alumina rich fractions to steps of silica load reduction to obtain low silica porous bauxite residue retaining alumina in said residue;

(iv) subjecting the residue of step (iii) above to alkali leaching to obtain therefrom high alumina fraction as aluminate for alumina recovery therefrom, and, also generating said iron rich magnetic fractions for metallic iron recovery following efficient energy and solid waste management.

2. The process for energy efficient recovery of alumina and iron from bauxite ore as claimed in claim 1 wherein

said step (i) involves providing and subjecting the bauxite ore to temperature controlled partial reduction roasting for said partial conversion of iron oxide present in bauxite ore to magnetite and said collecting therefrom partially reduced roasted mass;

said step (ii) magnetic separation of said partially reduced roasted mass is to provide for alumina-rich content based non-magnetic fraction (70%) and high iron

oxide content based magnetic fraction (30%), also including for recovery of locked alumina from said high iron oxide content based magnetic fraction following said wet milling/ grinding of the same and performing supplementary magnetic separation in sub-stages for said recovery of locked alumina so as to generate combined alumina-rich non-magnetic fractions and said iron rich magnetic fractions separately;

said step (iii) of silica load reduction is based on performing selective silica extraction of said combined alumina-rich non-magnetic fractions attained in step (ii) above by alkali of low strength to obtain low silica porous bauxite (1-3%) as residue by retaining alumina in said residue;

said step (iv) includes performing alkali leaching by selecting high strength alkali of said porous bauxite residue attained in step (iii) above to obtain therefrom high alumina fraction as aluminate with reduced energy followed by hydrolysis for alumina recovery, and, performing reduction roasting of iron oxide rich fractions of step (ii) to obtain therefrom from this step 90% recovered alumina from said ore by minimizing solid waste generation by half in respect of conventional processes.

3. The process for energy efficient recovery of alumina and iron from bauxite ore as claimed in claims 1 or 2 wherein said step (i) of providing bauxite ore for partial reduction roasting involves reduction of the bauxite ore to convert the iron oxide present in the bauxite to magnetite by adding carbon/coal as reduction source in the range of 0.05 wt.% to 0.15 wt.% and by maintaining controlled temperature and time range for partial reduction roasting between 300°C to 900°C and 5 min to 12 hr, respectively, enabling collection of said alumina-rich content based non-magnetic fraction (70%) and iron oxide rich content based magnetic fraction (30%) after passing said partially reduced roasted mass through weak dry/wet magnetic separation stage at magnetic strength maintained at 200 Gs to 1500 Gs, whereby prior to roasting, goethite and bayerite present in bauxite ore decompose into hematite and alumina due to said high temperatures;

wherein alumina-rich content based non-magnetic fraction thus attained has alumina to iron ratio between 3 to 4, and iron oxide rich magnetic fraction has alumina to iron ratio is around 1 to 1.2.

4. The process for energy efficient recovery of alumina and iron from bauxite ore as claimed in claims 1-3 wherein in said step (ii) said wet milling of iron oxide rich content based magnetic fraction to improve recovery of additional alumina based non-magnetic fraction therefrom includes grinding to -90 mesh size by involving wet ball milling operation followed by wet magnetic separation wherein the operational parameters for ball milling operation includes ball to powder weight ratio is 10:1, rpm 500, time 1-2 hr with magnetic strength varied between 200 Gs to 15000 Gs to obtain maximum recovery of alumina whereby added 15 to 20% of excess alumina based non-magnetic fraction is obtained with similar Al to Fe ratio between 3 to 4.

5. The process for energy efficient recovery of alumina and iron from bauxite ore as claimed in claims 1-4 wherein said step (iii) of silica load reduction/extraction of said combined alumina-rich non-magnetic fractions includes providing said combined non-magnetic fraction having iron (15 to 20%) and silica (7 to 10%) along with alumina (70-73%) for leaching with alkali of 100 to 150 grams per liter (GPL) preferably NaOH at temperatures of 100 to 120 ^{o}C in a pressure leaching bomb for 2 hr to 4 hr time periods to enable leach liquor including sodium silicate and residue of low silica (1-3%) porous bauxite as pulp residue.

6. The process for energy efficient recovery of alumina and iron from bauxite ore as claimed in claims 1-5 wherein said step (iv) of alkali leaching said porous bauxite residue includes the sub-steps of

(a) treating said residue/ pulp residue with 200-250 GPL alkali solution preferably NaOH in a pressure leaching setup at temperatures 140-160°C for 4 to 6 hr time periods to obtain aluminate based high alumina fraction as alkali based leach

liquor and residue preferably reddish in color of red mud including 22% Al_2O_3 (4g), 43% iron oxide (9.5g), 11% silica (2.4g), and 5% TiO_2 (1.1 g);

(b) hydrolyzing said leach liquor by constant stirring at a low temperature (30-80^oC) for 2-3 days to precipitate 50-70% of alumina from alkali leach liquor that is separated by filtration and thereafter calcined in furnace at temperatures maintained at 1000^oC to 1200^oC for 1 hr to 2 hr, with the filtrate further combined and re-circulated into step (a) above, or, alternatively, performing conventional hydrothermal precipitation for obtaining aluminum hydroxide from said leach liquor.

7. The process for energy efficient recovery of alumina and iron from bauxite ore as claimed in claims 1-5 wherein said step (iv) including reduction roasting of iron rich and low alumina content magnetic fraction as attained from step (ii) includes steps of

(a) alkali reduction roasting at high temperatures (>900^oC) by involving carbon, Na_2CO_3, together with added lime to neutralize any silica content present in the magnetic fraction in this stage to enable a grey colored mass as residue that is leached with hot water to dissolve sodium aluminate therein to enable a leach liquor for alumina recovery therefrom;

(b) filtering the leach liquor (pH>12) from the residue followed by purging CO_2 gas into the liquor to precipitate out alumina with the residue containing iron usable as DRI feed in iron making processes, or, alternatively performing conventional hydrothermal precipitation for obtaining aluminum hydroxide from said leach liquor.



Dated this the 19th day of July, 2023

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ABSTRACT

TITLE: A process for energy efficient recovery of alumina and iron from bauxite ore

An energy efficient process for recovery of alumina and iron from bauxite ore is provided enabling a comprehensive and energy-efficient process flow for the maximum recovery of both alumina and the iron from bauxite ores, and also to decrease the amount of red mud generation in Bayer's process.

Fig. 1