The invention provides a process for extracting gibbsite from gibbsitic alumina containing bauxite, comprising: (i) providing a thick slurry of ground bauxite containing gibbsite; (ii) mixing the thick slurry with preheated spent Bayer process liquor stream to form a preheated combined slurry-liquor mixture; (iii) passing the preheated combined liquor/slurry mixture through a reaction tube or plurality of tubes sized such that the slurry-liquor mixture remains in the reaction tube for an average total residence time of up to about four minutes, said residence time being sufficient to extract the gibbsite from the slurry; (iv) separating red mud containing solids from the resulting pregnant liquor in which the gibbsite has been dissolved in a solid-liquid separator operating at substantially the same temperature and pressure as in the reaction tube; and (v) removing dissolved silica from the pregnant liquor by seeding the liquor with Bayer process desilication product and separating the desilitcated pregnant liquor from the solid desilication product. An apparatus for carrying out the above process is also described.
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Process and Apparatus For The Extraction of Gibbsitic Alumina From Bauxite

Technical Field

This invention relates to a process for extracting or digesting gibbsite (alumina trihydrate) from various forms of bauxite, such as those containing: (1) mainly gibbsitic alumina; (2) gibbsitic and boehmitic alumina; or (3) gibbsitic and diasporic alumina using caustic solution; and to an apparatus for carrying out the process. More particularly, the present invention relates to a process and apparatus where the extraction into caustic-aluminate liquor of alumina trihydrate from a bauxite can be carried out rapidly into caustic-aluminate liquor in a reaction tube interposed between vessel for slurrying the gibsite-containing bauxite and a solid-liquid separator for separating insoluble red mud solids or red mud solids plus undissolved boehmitic and/or diasporic alumina from the liquor containing the dissolved trihydrate or gibbsite.

Background Art

Although the Bayer process is more than one hundred years old, significant advances continue to be made which help to improve the efficiency of the process and the product. In addition, adaptations enable refiners to fine-tune the process to different varieties of bauxite. For example, as disclosed in Fulford et al U.S. Patent No. 4,994,244, a slurry of a bauxite containing both gibbsite and boehmite may be pressure digested in caustic soda solution or spent caustic-aluminate solution being recycled in the Bayer process to dissolve the aluminum hydroxides as sodium aluminate while leaving undissolved red mud solids. The resulting caustic solution, containing an increased concentration of sodium aluminate, is called pregnant sodium aluminate containing liquor, or pregnant liquor. As disclosed in this patent, red mud solids can be more easily and advantageously separated from the pregnant sodium aluminate containing liquor using separation techniques operating at above atmospheric
pressures, corresponding to temperatures above the atmospheric boiling point of the digested slurry.

A portion of the silica content of the bauxite may dissolve in the liquor to form soluble sodium silicates, some of which may slowly complex with sodium alumininate in solution to form hydrated sodium aluminum silicates, also known as the "desilication product." Precipitation of desilication product, while relatively easily accomplished, may cause an appreciable loss of expensive caustic soda. The dissolved silica contained in the desilication product may be removed in accordance with the disclosure of U.S. Patent No. 5,118,484 by contacting the pregnant Bayer process liquor with porous agglomerates of desilication product bonded together by a polymer resin selected to withstand the extreme conditions found in Bayer process slurries or other forms of desilication product seed. This technique, known as seeded post-silication of the extraction liquor, takes place after separation of the red mud.

Other work in the Bayer process focuses on improving the apparatus used therein. Toward this end, U.S. Patent Nos. 4,055,218 and 4,144,934 relate to a conduit surrounded with heat exchange media in which extraction of bauxite using sodium alumininate liquor takes place.

Similarly, Plass, in U.S. Patent No. 4,145,398, discusses a tubular reaction conduit having heating jackets or annular conduits extending along various portions of the tubular reaction conduit.

Nevertheless, and despite the foregoing improvements, bauxite digestion as carried out today still involves costly equipment, relatively long digestion times and significant maintenance costs in order to maintain the purity of the extracted liquor. It is therefore a principal object of the invention to further simplify method and apparatus used in bauxite digestion, particularly where the bauxite species involved contains significant amounts of gibbsite content.
Disclosure of the Invention

The disadvantages of the prior art are overcome by the present invention which provides a process for extracting gibbsite from a bauxite containing gibbsitic alumina, comprising: (i) forming a stream of ground bauxite containing gibbsitic alumina with a small portion of Bayer process spent caustic aluminate liquor used for digestion; (ii) mixing the stream with the remainder of the spent liquor stream previously preheated to form a preheated slurry-liquor mixture; (iii) passing the preheated liquor-slurry mixture through one or more parallel reaction tubes sized such that the slurry remains in the reaction tube for a residence time just sufficient to extract essentially all of the gibbsite from the slurry and no more than about four minutes; (iv) separating red mud solids, still containing undissolved boehmite and/or diaspor alumina, from the pregnant liquor in a solid-liquid separator operating at substantially the same temperature and pressure as in the reaction tube; and (v) removing dissolved silica from the pregnant liquor by seeding the liquor with Bayer process desilication product.

Preferably, the temperature of the preheated mixture in the reaction tube ranges from about 120°C to about 200°C, and the preheated slurry remains in the reaction tube for a mean residence time ranging from several seconds to about 3-4 minutes. The solid-liquid separator separates red mud solids from pregnant Bayer process liquor in a pressure decanter or other suitable means of pressure solid/liquid separation, preferably at a temperature above the atmospheric boiling temperature of the liquor in the slurry, and preferably at a temperature sufficiently high that the liquor phase of the slurry is not saturated with respect to gibbsitic alumina.

Following red mud separation, the temperature and pressure of the pregnant liquor in the pressure decanter is substantially the same as that of the mixture in the reaction tube apart from pressure drops due to the
friction of the flowing slurry. The seeded post-
desilication is carried out at similar conditions, or,
alternatively, the temperature and pressure of the
pregnant liquor may be reduced to its atmospheric pressure
and boiling point prior to desilicating the pregnant
liquor by a seeded post-desilication operation.

The invention also provides an apparatus for
extracting gibbsite from gibbsite containing bauxite which
comprises: a vessel for mixing a slurry of ground
gibbsite containing bauxite in a minimum portion of the
spent caustic aluminate liquor being passed to the
digester with the remainder of the spent liquor previously
preheated to a temperature comparable to or slightly above
the digestion temperature to form a slurry having a
predetermined temperature and liquid-solid ratio; an
elongated reaction tube, in fluid communication with the
mixing vessel, for retaining the slurry in the reaction
tube at a predetermined pressure and temperature for an
average mean residence time of up to about four minutes; a
pressure decanter, in fluid communication and sealed
relationship with the reaction tube, for separating red
mud particles from pregnant liquor; and a vessel for
contacting the pregnant liquor with Bayer process
desilication product so as to carry out a seeded post-
desilication operation and recirculating or retaining as
much of the seed material as is needed, either at the
temperature and pressure of the pressure decanter or after
cooling the pregnant liquor to its atmospheric boiling
temperature. The apparatus also includes means for
preheating spent Bayer process liquor to maintain the
slurry in the digester at a temperature in the range of
about 120°C to about 200°C.

Further features and advantages of the invention will
be apparent from the detailed description of the preferred
embodiments set forth below, together with the
accompanying drawings.
Brief Description of the Drawings

FIG. 1 is a schematic flow chart of the improved process of the present invention;

FIG. 2 is a schematic flow chart of the Bayer process improved in accordance with the present invention; and

FIG. 3 is graphical representation of plant-scale demonstration of the present invention in which the ratio of the concentration of dissolved Al₂O₃ (expressed in grams/liter) to the concentration of total caustic (expressed as g/l Na₂CO₃) is plotted against up to 2 minutes residence time in the improved digestion apparatus of the present invention, plus a further residence time of 2 to 18 minutes in a conventional low temperature digester.

Best Modes For Carrying Out the Invention

Extracting the gibbsite from bauxite in the Bayer process usually involves grinding the bauxite in a side stream of recycled spent caustic aluminate liquor. The ground bauxite may be mixed with the remainder of the liquor being recirculated to the digester, and the combined stream of liquor and bauxite heated to the digester temperature (typically - 100-160°C) (so-called "single-streaming"). Alternatively, the remainder of the liquor not used for grinding the bauxite may be preheated to a temperature somewhat exceeding the digester temperature and can then be mixed with the colder concentrated bauxite/liquor slurry so that the final temperature is close to the required digest temperature (so-called "double-streaming"). In both cases, the temperature may be further adjusted by addition of heat to the digester itself. The heated mixed slurry is held in agitated autoclaves or cascades of autoclaves for mean residence times from about 20 minutes to over 1 hour. During this holding period, most (typically 90-99%) of the gibbsite dissolves into the caustic solution as soluble sodium aluminate, and most of the reactive silica content (silica contained typically as clay-type minerals) dissolves as
well. Much of the dissolved silica reacts with dissolved alumina to produce a largely insoluble desilication product which redepots in the remaining insoluble red mud fraction of the bauxite, which may at this point also still contain undissolved boehmitic and/or diaspirc alumina, if these forms are present in the bauxite.

In certain cases, such as bauxites low in silica content, even holding the slurry for prolonged periods at the gibbsite digestion conditions does not suffice to control the dissolved silica to levels necessary to avoid silica problems subsequently in the process. In this case, it may be necessary to hold the slurry before digestion for prolonged periods at temperatures typically below the atmospheric boiling temperature of the liquor in order to generate some additional desilication product seed to speed the silica removal during digestion, since normal seeding (such as is applied in a seeded post-desilication operation) cannot be used in this case due to loss of the desilication product in the red mud. In extreme cases, it may be necessary to add clay to the bauxite to promote desilication, though this may cause otherwise unnecessary caustic soda consumption by reaction with the clay minerals.

Subsequently, the digested slurry is cooled to near the atmospheric boiling temperature. The red mud is then separated, typically by sedimentation, using flocculants if required, and/or filtration. The red mud slurry separated in this way, which contains supersaturated aluminate liquor, is washed to recover soluble values and is disposed of or further processed.

The clarified liquor is cooled, diluted, and seeded with gibbsite particles onto which a significant part of the dissolved alumina precipitates as gibbsite. The coarser part (larger particles) of the precipitate is calcined to produce alumina, while the rest is recirculated as seed. The final caustic-aluminate mother liquor (spent liquor) is reconditioned and recirculated to
digestion.

The disadvantages of the conventional technology for extracting gibbsite from bauxite are well known in the art, and include: a) the liquor productivity in digestion (kg of Al₂O₃ produced per m³ liquor circulated) is relatively low, since productivity is often restricted by the instability of the liquor at the red mud separation stage, so that the full dissolving power of the liquor for gibbsitic alumina at the digester conditions cannot be completely used; (b) the low liquor productivity combined with the long residence time requires large holding vessels capable of operating at 2-8 atmospheres pressure, during digestion; (c) the bulky equipment becomes scaled on all its wetted surfaces with tenacious scales of desilication product and/or boehmite (which is relatively insoluble at gibbsite digestion conditions), requiring periodic manual and/or chemical descaling; (d) the pressurized digesters require mixers to maintain the slurry in suspension, involving expensive and difficult to maintain shaft seals; and (e) the much lower solubility of boehmite than gibbsite in the extracting liquor means that the liquors during the gibbsite digest, which are necessarily undersaturated or only just saturated with gibbsite, are supersaturated with boehmite.

As a result, if the bauxite contains any boehmite, and "gibbsitic" bauxites typically contain up to 2% (expressed as Al₂O₃), it will not be extracted. This will serve as a seed material for the reprecipitation of gibbsitic alumina dissolved into solution as additional boehmite. This material gets lost along with the original boehmite with the red mud. In many plants carrying out gibbsitic digests only, such "reversion" losses of boehmite represent the largest loss of alumina in the process, and add significantly to the consumption of bauxite and generation of red mud per ton of alumina produced. This reversion of boehmite increases rapidly with increasing digestion time due to the self-catalyzing
nature of the reversion process.

In one important and advantageous aspect, the inventive process can be understood as essentially eliminating the gibbsite digester as such, and substitutes a preheated liquor/bauxite slurry mixer and pipeline conveying the combined mixed slurry during a minimum mean residence time directly to a pressure mud separator, followed by seeded post-desilication after red mud separation. Tests have demonstrated that the process has several advantages. First, the very short time of residence required only to achieve essentially complete gibbsite dissolution, which is known to occur rapidly means that the digester volume is minimal (a few percent of that of the conventional digester) thereby greatly reducing the cost of the pressure equipment required. See G.D. Fulford, *Light Metals 1985* (ed. H.O. Bohner) A.I.M.E., Warrendale, Pa., 1986, pp. 265-278: "Use of Conductivity Techniques to Follow Al₂O₃ Extraction at Short Digestion Times." Also, the small amount of digester surface area will greatly reduce the amount of periodic descaling required to be carried out, and also reduce heat losses from the equipment. Further, the small amount of digestion equipment will reduce the pressure drop of the flow through digestion, and hence the pumping costs for the process. Mechanical agitation will probably no longer be required, simplifying the equipment required and avoiding the need for pressure seals on rotating shafts in the digesters.

The very short digestion time coupled with the decreased red mud separation time will reduce to almost zero the amount of gibbsite to boehmite reversion which can occur, even in cases where the "gibbsitic" bauxite contains small amounts of seeding boehmite. As explained above, this in turn will reduce the bauxite consumption and red mud generation per ton of alumina produced.

Likewise, the short digest time makes it possible, with some gibbsitic bauxites, to extract essentially all of the
gibbsitic alumina content of the bauxite while only
dissolving a part of the clay mineral, thereby reducing
cauistic soda loss. By careful control of the digestion
time, one can maximize the fraction of the clay-mineral
silica which does dissolve which passes to the post-
desilication step. A minimum amount of the desilication
product will then fall out with the red mud, and most will
form a separate stream of relatively pure and highly
concentrated desilication product from the seeded post-
desilication operation. This will simplify the possible
recovery of bound caustic soda and alumina values from the
desilication product.

The process of the present invention can be used
for: 1) plants with single gibbsite digest operations;
2) plants with double gibbsite digest operations; and
3) plants carrying out gibbsite digests as the first part
of a double digest in which boehmite is recovered under
intermediate conditions in a second digestion step.

The present process can be carried out in a
single-stream mode, but the time for passing the slurry
through the heat exchange system may in some cases exceed
the optimum digest time required to achieve maximum
benefits of the proposed improved digest. A two-stream
mode is therefore preferred, since in this mode the
residence time and temperature of the mixed slurry can
both be precisely controlled.

The improved process of the present invention as it
may be used in the two-stream mode for digestion of
gibbsitic bauxite may be understood by reference to
Fig. 1. Gibbsite bauxite 13 is first wet-ground with a
small portion 10a of a stream of spent, unheated Bayer
process liquor 10 in a grinder 12. The remainder 10b of
the spent liquor stream 10 is preheated to digestion
temperature or above this temperature in preheater 11 and
the preheated liquor 14 is fed into a slurry mixer 16
together with a gibbsitic bauxite/liquor slurry 15 from
grinder 12. The weight of the solids in the slurry 15
from the grinding mill 12 preferably ranges from 30 to 70 percent by weight, although typically, solids content approaches about 50 percent. After addition of the remainder of the preheated spent liquor 14, the mixed preheated slurry 17 will typically have a solids content in the order of 10 percent w/w. Advantageously, the spent liquor should be preheated so that when the combined mixed slurry 17 is formed, it has a temperature ranging from about 110 to 170°C., with a temperature of approximately 130-145°C being preferred.

At this point, the combined slurry 17 undergoes digestion in an elongated reaction tube 18, which is preferably an insulated tube or pipe. This reaction tube is unheated through its external surfaces, although it may in some instances include means for final temperature adjustment by injection of live steam. The average residence time within the reaction tube 18 ranges from a few seconds to about 4 minutes (depending mostly upon the temperature, the caustic concentration of the slurry, and the rate at which the gibbsite fraction of the particular bauxite extracts into the liquor (easily determined from laboratory tests)). By the time the digestion in the reaction tube 18 is completed, at least 90% and preferably more than 98% of the gibbositic alumina has been extracted.

At this point, however, the dissolved silica content of the liquor would typically be quite high (perhaps several g/L SiO₂), since there has not been sufficient time for the desilication reaction to proceed to completion.

The digested slurry 19 proceeds to a red mud separation step 20 (Fig. 1) carried out at approximately digestion conditions, i.e. at approximately the same temperature and pressure as was present in the reaction tube or pipeline 18. A suitable improved method of separating red mud from pregnant liquor is described in U. S. Patent No. 4,994,244. Preferably, the red mud separation takes place in a pressure solid/liquid separator 20 which rapidly separates the red mud particles
21 from the digested slurry essentially at the digestion temperature and pressure, preferably at a temperature above the atmospheric boiling temperature of the liquor phase of the slurry.

Next, the liquor phase 22 from the red mud separation step 20 undergoes a seeded post-desilication step 23 (FIG. 1) preferably using an active seed 24 to promote the growth of desilication product. Excess product is removed via line 25 and desilicated liquor is withdrawn via line 26. An effective method for achieving desilication of dissolved silica in liquor is described more fully in U.S. Patent No. 5,118,484.

The total average residence or digestion time between the point at which the bauxite slurry and the preheated spent liquor are mixed and the entry to the pressure mud separation device should be kept to the minimum required for dissolving the gibbsite. The actual time needed will vary depending upon the type of bauxite and the bauxite grind, as well as the digest temperature, the caustic concentration of the extracting liquor, and the closeness of approach required to the gibbsite solubility value at the end of the digest. Typically, the mean residence time should fall between a few seconds and 3-4 minutes.

Following the seeded post desilication step, which may take place either at the same pressure and temperature as the red mud separation step or at about the atmospheric boiling point, the liquor proceeds after cooling and polish filtration, if required, to filtration precipitators where seeded precipitation of alumina takes place.

The improved process for digestion of gibbsite contained in bauxite may take place in an apparatus such as the one schematically diagrammed in Fig. 2. The apparatus, generally designated by the reference numeral 30 includes a conduit 32 through which ground bauxite is fed and mixed with a preheated spent liquor stream 34 (or a preheated stream of liquor containing intermediate alumina to caustic soda ratio in the case when the
gibbsite digest forms the first part of a counter-current double digest).

The combined preheated bauxite slurry is fed through an elongated reaction tube 36. The elongated reaction tube 36 is preferably an unheated but insulated pipeline connecting the mixing device in a sealed relationship with the pressure red mud separation device 39. In case that it is not desired to overheat the preheated spent liquor stream 34 to the extent that it will convey all the heat to the digest to bring the combined slurry stream to the digestion temperature and supply the heat of the gibbsite dissolution reaction also, it is not excluded that final adjustment of the digest temperature may be effected by the injection of live steam into the reaction tube at suitable points, such as steam injectors 35 and 37 in FIG. 2.

The diameter of the reactor tube 36 and number of tubes are not critical provided the tube or tubes are sized and arranged so as to achieve the velocity of flow normally required for conveying the solids fraction of a Bayer process slurry. The reaction tube may range in diameter from about 100 to about 500 or more millimeters in diameter with about 200 millimeters presently preferred. Its length depends upon several factors both related and unrelated to slurry concentration type, temperature and pressure. The length of tube is not critical, and while 40 meters appears optimal for digesting bauxite having a high percentage of gibbsitic alumina, the tube may range in length from a few meters to more than 100 meters as needed to maintain a residence time of several seconds to 3 to 4 minutes. If desired, the single tube may be replaced by a plurality of tubes. To some extent, the length and diameter will have to be determined empirically in order to balance space constraints, necessary velocity and turbulence to avoid settling of the slurry and too-rapid scaling of the reaction tube 36 with the objective of keeping the total
average digestion time long enough to permit substantially complete extraction of the gibbsite. It should be noted that some scaling of the reactor walls is tolerable in this invention, since heat is not transferred through the walls for purposes of heating the slurry. Likewise, the shape of the tubing used as the pipeline or tubular reactor can vary and may, for example, be fashioned as a serpentine or helically coiled circuit to conserve space and reduce heat loss.

As mentioned above, the reacted slurry 28 leaves the reaction tube 36 and enters a pressure red mud separation device 39 (such as a pressure decanter) which rapidly separates red mud particles from digested slurry at or above the digestion temperature and pressure (or close thereto). The separated red mud flows through pipeline 40 where it may undergo further processing or disposal. The pregnant liquor flows through pipeline 42 and enters a seeded post silication device 44. Desilication seed, one example of which is described in U.S. Patent No. 5,118,484, enters through pipeline 46 and excess product is withdrawn through line 50. Preferably, the desilication step may take place at digestion temperature or, alternatively, after cooling the liquor to about the atmospheric boiling temperature. Using the method and apparatus of the present invention simplifies post-desilication and yields a greater fraction of the total desilication product (containing chemically bound alumina and soda as well as silica) as a product separate from the red mud, thereby making it simpler to recover the bound values from it by known means, for example, a lime soda sinter step. The desilicated liquor continues via pipeline 48 to cooling, polish filtration, if required, and precipitation tanks (not shown).

The following example is intended to be illustrative and representative of the practice of the invention, and not to be construed as limiting the scope of the invention in any manner.
EXAMPLE 1

Plant-scale tests using 40 m³/h of a 50% w/w slurry in spent liquor of ground bauxite (from the Cape York area of Queensland, Australia), containing 28.5% gibbsitic Al₂O₃ on the dry bauxite basis, at approximately 60°C, was mixed with 100 m³/h of preheated spent caustic aluminate liquor (caustic concentration about 255 g/L Na₂CO₃, dissolved alumina concentration -82 g/L Al₂O₃) at approximately 162°C, leading to a temperature of about 130°C after mixing and the gibbsite dissolution was complete. The mixing was accomplished by injecting the bauxite slurry and preheated spent liquor into an insulated cylindrical mixing pot of volume 3.4 m³, which was connected to the inlet of an agitated digester vessel by approximately 40 m of insulated pipe of diameter 200 mm. The mean residence time of the mixed slurry was therefore

\[
\text{min} \quad 3.4\text{m}^3 \times \frac{1\text{h}}{140\text{m}^3} \times 60 \frac{\text{min}}{\text{h}} = 1.46
\]

in the pot and, at a mean velocity of -74.4 m/min in the 200 mm pipeline

\[
40 \text{m} \times \frac{1\text{min}}{74.4 \text{m}} = 0.54 \text{min}
\]

in the pipe or a total mean residence time of 2.0 minutes.

Samples taken at the end of the pipeline (entry into the digester vessel) showed that 95-99 percent of the gibbsite originally present in the bauxite had already been extracted after about 2 minutes of mean residence time, in spite of the fact that the digester was being charged to close to the equilibrium solubility of gibbsite. This observation is based on the alumina to caustic ratio curve shown in FIG. 3, wherein 100% extraction corresponds to a ratio of 0.700. (Ratio may be defined by the formula: concentration of dissolved Al₂O₃ g/l + concentration of total caustic (expressed as g/l Na₂CO₃).) Thus, an observed ratio of 0.680 is 98% of a target ratio of 0.700. Samples taken from the subsequent agitated digester vessel after a further 8 minutes of
average residence time in the digester showed no detectable gibbsitic alumina remaining in the solid residue.

FIG. 3 shows that the dissolved silica value found at this point varied from 4.0 to 4.5 kg/m$^3$ SiO$_2$, which is 7.5 to 8.5 times the equilibrium silica value in this liquor, since the relatively slow desilication reaction had not yet had time to remove the dissolved silica down to its equilibrium value. By following such a short digest with a rapid mud separation step, also at the digestion conditions (~ 130°C) and then feeding the liquor phase to a seeded post-desilication reactor, it is clearly possible to form a large part of the total desilication product as a separate product, not mixed with red mud, in the post-desilication operation, though a smaller amount of desilication product did form in the red mud even in the 2 minute short digest.

Also, only a very limited and readily manageable amount of scale was noted in the reaction tube, probably due to the high degree of turbulence at the pipe walls, despite the high dissolved silica contents of the liquor phase of the slurry. As noted previously, heat is not transferred through the walls of the reaction tube operating in the double-streaming mode, so that a small amount of scale on the inside walls of this tube causes no significant change in the ease or completeness of heat recovery in the process.
Claims:

1. A process for extracting gibbsite from gibbsite containing bauxite, comprising:
   forming a slurry stream of ground bauxite containing gibbsitic alumina in a minor part of a Bayer process spent liquor stream;
   mixing the slurry stream of ground bauxite spent process liquor with a major part of the spent Bayer process liquor stream preheated to a temperature sufficient to form a preheated combined slurry at gibbsite extraction temperature;
   passing the preheated combined slurry mixture through at least one reaction tube sized such that the slurry remains in the reaction tube for a brief residence time sufficient to extract essentially all of the gibbsite from the slurry and not more than about four minutes;
   separating red mud containing solids from the pregnant caustic aluminate liquor in a solid-liquid separator operating at substantially the same temperature and pressure as in the reaction tube; and
   removing dissolved silica from the pregnant caustic aluminate liquor using a seeded desilication reaction.

2. A process in accordance with claim 1 wherein the temperature of the slurry in the reaction tube ranges from about 110°C to about 200°C.

3. A process in accordance with claim 1 wherein the preheated combined slurry mixture remains in the reaction tube for a mean residence time ranging from several seconds to about 3-4 minutes.

4. A process in accordance with claim 1 wherein the solid-liquid separator is a pressure decanter, and the red mud containing solids are separated from the spent process liquor at a temperature in excess of the atmospheric pressure boiling point of the liquor.

5. A process in accordance with claim 4 wherein the temperature and pressure of the gibbsite containing liquor in the pressure decanter is substantially the same as that
of the mixture in the reaction tube.

6. A process in accordance with claim 5 wherein the dissolved silica is removed from the liquor by seeding the liquor with Bayer process desilication product.

7. A process in accordance with claim 4 wherein the temperature and pressure of the pregnant liquor is reduced to atmospheric pressure and its atmospheric pressure boiling point prior to removing dissolved silica from the pregnant liquor.

8. A process for extracting gibbsite from bauxite, comprising:

forming a slurry of ground bauxite containing gibbsitic alumina and preheated caustic soda solution having a temperature sufficient for gibbsite extraction;

passing the slurry mixture through a reaction tube sized such that the slurry remains in the reaction tube for a brief residence time sufficient to dissolve essentially all of the gibbsite from the slurry into solution and not more than about four minutes;

separating red mud containing solids from the liquor in which the gibbsite has dissolved in a solid-liquid separator operating at substantially the same temperature and pressure as in the reaction tube; and

removing dissolved silica from the gibbsite containing liquor by seeding the liquor with Bayer process desilication product.

9. A process in accordance with claim 1 wherein the temperature of the slurry in the reaction tube ranges from about 120°C to about 160°C.

10. An apparatus for extracting gibbsitic alumina from bauxite, comprising:

a vessel for mixing ground gibbsitic alumina containing bauxite with preheated spent Bayer process liquor to form a preheated combined slurry for digestion,

said slurry having a temperature sufficient for gibbsite extraction;
at least one reaction tube, in fluid communication and sealed relationship with the mixing vessel, sized to retain the slurry with the reaction tube for an average mean residence time of up to about four minutes;

a pressure decanter, in fluid communication and sealed flow relationship with the reaction tube, for separating red mud particles from the pregnant liquor at substantially the same temperature and pressure as in the reaction tube; and

means for removing Bayer process desilication product from the liquor, including means for adding desilication promoting seed to the liquor.

11. An apparatus in accordance with claim 10 wherein the reaction tube is a plurality of tubes.
FIG. 3
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 C01F/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 C01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>Y</td>
<td>EP, A, 0 382 383 (ALCAN INTERNATIONAL) 16 August 1990 cited in the application see column 4, lines 24-46; column 5, lines 25-29; example; claims ---</td>
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<td>Y</td>
<td>E. BARTHOLOME 'Ullmanns Encyklopädie der technischen Chemie, 4th. Ed 1974, VERLAG CHEMIE, WEINHEIM (DE) see page 312, left column, paragraph 2-5 ---</td>
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<td>P, X</td>
<td>EP, A, 0 564 659 (SUMITOMO CHEMICAL COMPANY) 13 October 1993 see page 6, lines 46-56; page 7, lines 15-17; page 8, lines 48-49; claims; figure 1 ---</td>
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Further documents are listed in the continuation of box C. Patent family members are listed in annex.

Date of the actual completion of the international search
23 March 1994

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HU Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax. (+31-70) 340-3016

Authorized officer
Zalm, W

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<td>US,A,4 144 934 (KÄMPF) 20 March 1979 cited in the application</td>
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<td>A</td>
<td>US,A,4 055 218 (KÄMPF) 25 October 1977 cited in the application</td>
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