BAYER PROCESS

Bayer process is the process of refining alumina from bauxite (aluminum ore containing 30-50% of hydrated aluminum oxide) by selective extraction of pure aluminum oxide dissolved in sodium hydroxide.

Prior to the Bayer process bauxite is crushed and ground in mills to fine particles (max. size 0.06”/1.5mm).
A hot solution of the recycled sodium hydroxide (caustic soda, NaOH) is then added to the ground ore forming a bauxite slurry, which is stored in holding tanks and then pumped to the further processing stage.

Refined aluminum oxide (Al_2O_3) is obtained from the the bauxite slurry by the Bayer process comprising four steps:

- **Digestion**
- **Clarification**
- **Precipitation**
- **Calcination**

Digestion

In this step the bauxite slurry is pumped from the holding tanks to the autoclaves (digester vessels) where it is mixed with hot concentrated caustic soda liquor.
The digestion temperature and pressure depend on the mineralogical composition of the bauxite. Most bauxitic ores are composed of gibbsite ($Al(OH)_3$ or $AlO(OH)*H_2O$), boehmite (γ-AlO(OH)) and diaspore (α-AlO(OH)).

Gibbsite bauxite may be digested at 275-300ºF (135-150ºC) under atmospheric pressure:
$AlO(OH)*H_2O + 2NaOH = 2NaAlO_2 + 4H_2O$

Boehmite bauxite may be digested at 400-475ºF (205-245ºC) under atmospheric pressure:
$AlO(OH) + 2NaOH = 2NaAlO_2 + 2H_2O$

Diaspore bauxite may be digested at a temperature above 482ºF (250ºC) under a pressure of about 35 at.:
$AlO(OH) + 2NaOH = 2NaAlO_2 + 2H_2O$

Clarification

Except alumina and silica all other bauxite components (calcium oxide, iron oxide, titanium oxide) do not dissolve in the caustic soda liquor. Silica dissolved in the liquor is then precipitated from it by slow heating.

The undissolved solid impurities form **red mud**, which settles down at the bottom of the mud thickeners (settlers, clarification tanks).
After the settling operation has been completed the red mud is separated from the clear liquor solution of sodium tetrahydroxoaluminate ($NaAlO_2*2H_2O$), $NaAl(OH)_4$).

Precipitation

Crystals of aluminum hydroxide ($Al(OH)_3$)are recovered in this step:
The clear liquor is pumped from the settlers to the precipitators (thickening tanks) through heat exchangers, which transfer the heat from the solution to the cold spent (processed) liquor.
Precipitation of aluminum hydroxide is promoted by seeding the liquor with pure alumina crystals acting as nuclei for the precipitation process.

The crystals of aluminum hydroxide/alumina trihydrate ($Al_2O_3*3H_2O$) grow and aggregate. The coarser particles are separated from the fine particles and transferred to calcination.
The finer particles are filtered from the slurry and then used as seeding (nuclei) crystals.
90% of aluminum hydrate is recovered from the liquor.

Calcination

The aluminum hydrate crystals are washed, dried and then heated to a temperature 1850-2300ºF (1010-1260ºC) in a rotary kiln or fluidized bed calciners to drive off the molecules of hydrated water:

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

At 750-1110ºF (400-600ºC) chemically active low temperature γ-Al_2O_3 forms.
At the temperatures above 2100ºF (1150ºC) γ-alumina transforms into α-alumina (corundum), which is chemically inert.
The final product is a dry white anhydrous α-alumina powder with the particles 0.02-0.4 minch (0.5-10μm).
The main impurity of calcined alumina obtained from the Bayer process is sodium oxide (Na_2O) concentration of which may vary between 300 to 7000 ppm.

Source : http://www.substech.com/dokuwiki/doku.php?id=bayer_process