Iron Impurity in Liquor – Impact on Product Quality and Control Methods

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https://doi.org/10.71659/icsoba2024-aa015

Abstract

Alumina is generally produced from bauxites through the Bayer process and is the main raw material for the production of aluminium metal. In addition to this, chemical grade alumina is used for the production of adsorbents, abrasives, polishing agents, refractory materials, etc. In the Bayer process, bauxite is digested with caustic at temperatures ranging from 140 °C to more than 240 °C, depending on the bauxite characteristics, mainly tri hydrate alumina (THA) and mono hydrate alumina (MHA) which determine the digestion technology viz. low or high temperature, or a combination of both (i.e. double digestion). During bauxite digestion, some other impurity bearing minerals also react with caustic. One of the undesirable ones is iron which enters the liquor during high temperature digestion. This iron is present in the liquor in colloidal, suspended, and dissolved forms, and tends to co-precipitate with gibbsite (or THA) during agglomeration and growth stages. Beyond a certain concentration, this iron in THA is an undesirable impurity when the alumina is converted to aluminium metal, impacting its physical properties. Therefore, it is important to control the iron in liquor which involves studying its dissolution in liquor and its incorporation into THA. Several methods, such as the use of lime, some inorganic compounds to precipitate the iron in liquor and also operating at a higher charging A/C have been suggested to control the iron concentration in liquor to acceptable levels. Sand filtration and addition of bauxite residue also represent cost effective methods for controlling iron in liquor. This paper presents the study of iron dissolution and its incorporation into THA and also reviews the various methods available for reducing the iron in liquor to achieve acceptable product quality.

Keywords: Alumina, Bauxite, Digestion, Impurity, Iron.

1. Introduction

In the Bayer Process, bauxite is digested in caustic to form sodium aluminate liquor. It is well known that this liquor contains various impurities such as chlorides, sulphates, organics, and also iron. These impurities interfere with the precipitation of alumina from sodium aluminate liquor and get incorporated in the product alumina as an impurity.

One of these impurities is iron, which is present in three major forms namely suspended, dissolved and colloidal. Iron concentrations as low as 0.015 % in smelter grade alumina are sufficient to impact the cast house product specifications and also affecting the physical properties of the aluminium metal such as malleability and ductility.

Several methods have been developed and studied for the reduction of iron in Bayer liquor such as use of water-soluble ferrous salts for precipitating iron in liquor, sand filtration, addition of bauxite residue, hydrate fluidized bed technique and two stage precipitation.

This paper presents the study of iron dissolution and its incorporation into THA and also reviews the various methods available for reducing the iron in liquor to achieve acceptable product quality.

2. Origin and Nature of Iron in Bayer Liquor

2.1 Origin from Bauxite

Iron is the major impurity present in bauxite. Iron bearing minerals are mainly consisting of hematite, magnetite, limonite, goethite, and siderite. Dissolution of iron into Bayer liquor occurs during digestion. The iron input into the liquor depends on iron oxide concentration in bauxite, iron oxide particle's surface area, free caustic concentration, temperature of digestion, holding time and minerology of bauxite.

2.2 Nature of Iron in Bayer Liquor

Iron in liquor is present in three major forms namely : suspended, colloidal and dissolved iron. Generally, suspended iron accounts for ~ 20 %, and colloidal and dissolved iron account for 40 % each. Suspended iron can be measured through filtration of pregnant liquor and using turbidity meter, whereas colloidal iron can be measured by filtration and centrifugation. However, dissolved iron cannot be controlled and measured easily. Generally, 6–12 mg/L of iron is present in pregnant liquor and concentrations above 20 mg/L are not acceptable.

3. Effect of Iron in Liquor

The iron in liquor co-precipitates during THA precipitation and thus gets incorporated as an impurity into the product. The whiteness of the product is directly impacted by the iron concentration in the THA. It also reduces the current efficiency during the aluminium smelting process. Incorporation of trace amounts of iron into aluminium metal also influences its physical properties such as malleability and ductility.

4. Methods for Controlling Iron in Liquor

4.1 Optimising the Bauxite Quality

This method is the starting point for any refinery with an objective of controlling the iron in liquor and thereby improve the product quality. The major source of iron incorporation in liquor is from the bauxite processed in the refinery. Hence it is important to map the bauxite sources to understand the iron content as well as the mineralogical phases present in the bauxite and thereby assess the impact of these characteristics on the iron incorporation in liquor through detailed processability studies in the laboratory. Based on such studies, the bauxites with the lowest iron incorporation can be selected and the mine plan would be accordingly adjusted to ensure consistent supply of this bauxite to the refinery.

4.2 Use of Ferrous Salts and Flocculation for Iron Control

In this method [1], Bayer liquor is first treated with water soluble ferrous salts. These ferrous salts can be ferrous ammonium sulphate, ferrous acetate, ferrous citrate, ferrous fluoride, ferrous nitrate, ferrous sulphate, and ferrous sulfite. Required amount of a given ferrous salt is added to Bayer liquor maintained at a constant temperature and agitated four (4) times with a plunger. The precipitate is allowed to stand for some time to initiate the aging process, followed by addition of specified dose of polyacrylate flocculant. This method results in a reduction of iron in liquor by ~ 50–70 % [2].

Overall, it is important to control the iron in liquor by adopting the above methods based on the technical feasibility for ensuring the right quality of product.

7. References

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