Technology to Produce Scandium Oxide from Sintering Red Mud

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https://doi.org/10.71659/icsoba2025-br013

Abstract

The paper describes further development of RUSAL's technology to produce scandium oxide from red mud using the residue of the RUSAL Krasnoturyinsk alumina refinery. RUSAL Krasnoturyinsk and RUSAL Kamensk-Uralsky refineries process local boehmite-diasporic bauxites that are characterized by a high content of calcite and pyrite. To balance the sulphates and carbonates in the process, the refineries use sintering areas where low-quality bauxite is processed. In the course of development of the technology to extract scandium oxide from sintering red mud, the transformation of scandium-containing bauxite minerals (boehmite, diaspore, hematite, chamosite, goethite, zircon, apatite, etc.) during the sintering process and the formation of new scandium phases were studied. When the sinter is digested, scandium also forms new phases. Up to 400 kt of sintering red mud having Sc_2O_3 content of 140 ± 10 ppm are disposed in the bauxite residue disposal area (BRDA) annually, i.e. more than 55 tonnes of Sc_2O_3 are placed annually to the disposal area. The behaviour of scandium, thorium, hafnium, copper, REMs, and other impurities was studied during the soda-bicarbonate digestion of sintering red muds. The possibility to significantly simplify the equipment and process is shown as compared with soda-bicarbonate digestion of the Bayer red mud. Additionally, the possibility of reducing operating costs is presented. Processing sintering red mud allows increasing the concentration of scandium in the solutions after digestion and in a Sc-containing concentrate. Moreover, soda-bicarbonate digestion also enables to extract alumina and alkali from sintering red mud and return them to alumina production. Thus, RUSAL's technology for producing scandium oxide from red mud further evolved resulting in minimal Capex and Opex for its implementation.

Keywords: Sintering red mud, Scandium oxide, Soda- bicarbonate digestion.

1. Introduction

RUSAL established pilot facilities for producing scandium oxide from the Bayer red mud (Bayer RM) at two alumna refineries, i.e. RUSAL Krasnoturyinsk (BAZ refinery) and RUSAL Kamensk-Uralsky (UAZ refinery). The Bayer RM is generated from processing boehmitic and diasporic bauxites from two deposits located in the north of European Russia, i.e. North Urals (SUBR) and Middle Timan (STBR) bauxites by the Bayer method. Red mud from these bauxites contains on average 140−180 ppm Sc_2O_3. Non-pressure sodium bicarbonate digestion is used to extract scandium from the Bayer RM. Sodium bicarbonate ($NaHCO_3$) is obtained by absorption of carbon dioxide (CO_2) from flue gases with partial conversion of soda into sodium bicarbonate. Sodium bicarbonate digestion of scandium from the Bayer RM allows reducing carbon footprint of alumina production, as well as the hazard class of production wastes.

Testing two pilot facilities for producing scandium from the Bayer RM revealed a number of issues, which affect capital expenses and performance indicators of the process, namely as follows:

- Scandium is distributed in the Bayer RM at a ratio of ~ 30:70 between iron minerals (hematite, goethite, chamosite of type $(Mg,Fe^{+2})Al[Si_3AlO_{10}](OH)_6 \times nH_2O$) and scandium digested from boehmite and diaspore. 70 % of scandium extracted from alumina-containing materials form the phases, which are sorbed on red mud particles. Depending on the matrix substrate, scandium forms various phases. Thus, scandium is sorbed on hematite and goethite as oxyhydroxide γ-ScO(OH) and a more "solid" tertiary oxide with yttrium and iron $Y_3ScFe_4O_{12}$; scandium is sorbed on the DSP as a silicate having eringaite structure $Ca_3Sc_2(Si_3O_{12})$; scandium is sorbed on alumino-iron-calcium hydrogarnet as davisite $CaAlScSiO_6$. Davisite and tertiary oxide with yttrium and iron prevail in the Bayer RM. Sodium bicarbonate digestion extracts only part of scandium, which is sorbed on the Bayer RM surface. Scandium contained in the crystal lattice of iron-containing minerals is not recovered [1];
- Preparation of the finely-dispersed Bayer RM (containing over 60 % of ≤ 10 µm particles) for sodium bicarbonate digestion followed by separating the mud and Sc-containing product solution requires use of high-rate batch-operated filter presses. Filter presses are expensive to manufacture and operate; said factor affects the Capex and Opex of scandium production;
- Sodium bicarbonate digestion of the Bayer RM yields the Sc-containing liquor with relatively low scandium content, i.e. 8–15 mg Sc_2O_3 /dm^3.
- Concentrating scandium from the Sc-containing product solution to obtain primary scandium concentrate proved to be ineffective. Primary scandium concentrate is obtained for the pregnant liquor from the main alumina process thus increasing the cash cost of Sc_2O_3 production.

To overcome said challenges, as well as to reduce Capex and Opex of scandium production, RUSAL decided to produce scandium from the sintering red mud (sintering RM). The sintering RM is available at the UAZ and BAZ refineries as SUBR and STBR bauxites are characterized by a high content of calcium carbonate in form of magnesium calcite (4−16 %) and sulphide sulphur S^{2-} in form of pyrite (FeS_2), chalcopyrite ($CuFeS_2$), sphalerite (ZnS). To obtain sulphate and carbonate balances the UAZ and BAZ refineries use sintering to causticize the recycled soda and remove sulphate as soda-sulphate mixture. Soda produced at RUSAL's Achinsk alumina refinery is added to the process to compensate the alkali losses.

The previous tests on scandium extraction from a mixture of the Bayer RM and sintering RM by heap leaching showed that this process occurs even on the BRDA at low temperatures [2].

A 1.2 m column setup was designed and 3D-printed to test main processes of counter-current leaching and select the conditions for the reaction zones (see Figure 1). Operation of the column allowed to define 3 distinct zones as described further.

8. References

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