Bayer + Pedersen the Perfect Match for the Future of Alumina Production, with Benefits

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Abstract

Within the EU-funded ENSUREAL project (GA No. 767533), significant efforts have been undertaken to recover and improve expertise from the past (Norwegian Pedersen process from the 1920s) and reach more sustainable alumina production.

The current work uses the data from ENSUREAL's upscaling study and demonstrates a possible way to use bauxite residues from the Bayer process as feed material for the Pedersen process. Generated and available data allowed for a case evaluation considering the foreseen process equipment. An initial approximate assessment of the economic feasibility was conducted.

Treatment of bauxite residue via the electrical route of the Pedersen process produces a significant amount of pig iron. This approach fittingly meets the increasing need to electrify and decarbonize the steel industry. Combining these two processes presents the alumina industry with a promising opportunity for diversification or joint-venture activities for making better use of the raw materials.

Considering a merging of the Bayer and Pedersen processes, the typical alumina extraction rate from the bauxite increases from approximately 80% to more than 95%. Valuable pig iron is generated, covering process oncosts and generating additional revenue. The utilization of the by-product gray mud is under evaluation, and initial positive market feedback has been received. In addition to decreasing its environmental footprint, shifting alumina production to a zero-waste process reduces the financial efforts for disposal and remedial activities.

According to Charles Darwin, "It is the long history of humankind (and animal kind, too) that those who learned to collaborate and improvise most effectively have prevailed," a perspective that could be applicable to the alumina industry as well.

Keywords: Alumina production, Merging Bayer and Pedersen processes, Valorization of bauxite residues, Grey mud, Pig iron coproduction, Diversification of alumina production.

1. Introduction

On May 23, 1925, Harald Pedersen of Trondheim, Norway, filed a priority patent application (with number NO252399X [1]) describing a process of leaching a slag with sodium carbonate to ultimately produce alumina. The US patent US1618105A dated February 15, 1927, is available online and documents this first mention of the Pedersen process. During that period, globalization was not an issue of concern, and, contrary to current times, easy and cheap access to transport was not available. Indeed, one of the advantages of the Pedersen process is the greater flexibility in raw materials, and no need for high-grade bauxites, which allows alumina plants to more easily use, for example, locally available resources. Melting and producing the slag is an equalization step, allowing the generation of a stable input stream for further processing steps. This might also explain why the US Bureau of Mines established, in 1949 [2], intensive testing procedures aiming to make low-grade bauxites available for alumina production. After the Second World War and at the start of the Cold War, such research undoubtedly had a more strategic than economic component.

In parallel to these efforts, an industrial Pedersen plant was in operation in Norway from 1928 to 1969 [3]. The growing and improved Bayer plants were most probably more economical in the 1960s. In addition, less emphasis was placed on sustainability at that time, consequently the Pedersen process fell into a slumber.

In 2017, a project consortium under the lead of SINTEF united its forces and was awarded funding by the European Commission to restart implementing the Pedersen technology for alumina production. The aim was to prove that low-grade bauxite can serve as a raw material for alumina production and that a zero-waste approach avoiding not easily treatable side streams, such as bauxite residues, is possible.

Following the Pedersen process route, the process concept, shown in Figure 1, was investigated within the ENSUREAL project. In the first step, limestone, bauxite, and coke are mixed to generate a slag, which, after melting, gains specific properties suitable for the leaching of the Al components. Mixing and pelletizing are the initial steps to reach a homogeneous feed material and ensure a dust-free rotary kiln treatment. Within the rotary kiln, the prereduction of the iron and calcination of the limestone takes place. Subsequently, the hot material is fed directly into a submerged arc furnace (SAF); this step involves slag design and pig iron production. The subsequent slag cooling stage seems trivial at first glance, but is critical for the further processing steps.

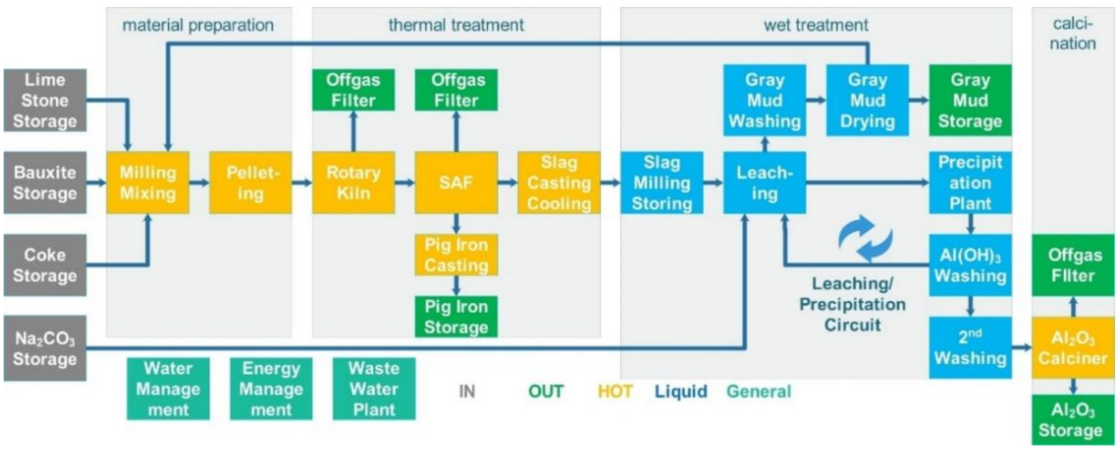

Figure 1. Block flow diagram of the Pedersen process investigated within the ENSUREAL project [4].

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