Flowsheets that Can Turn BR into Building Materials and Save CO_2

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Abstract

Within the EU-funded ReActiv project (GA No. 958208), significant efforts have been undertaken to convert bauxite residue BR into valuable building materials for the construction industry. In this study, the environmental implications of different BR conversion projects, focusing on co-calcined BR, Vitrified BR and iron-free BR slag by smelting were investigated. The CO_2 emissions per ton of product for each processing route were estimated. Additionally, to provide a basis for comparison, the current CO_2 emissions associated with the production of 100% cement clinker, which serves as the conventional material in the cement industry is presented. The advantage of this approach is that the BR contains only a very low content of chemically-fixed carbonates that will be released during its thermal treatment procedure, as is the case with limestone during the clinker production process. Consequently, replacement of standard clinker by a ReActiv SCM (Supplementary Cementitious Material) has the potential for a direct reduction of the overall CO_2 footprint in the cement industry. The paper in hand shows flowsheet concepts for the three BR processing technologies and discusses mass and energy requirements. It also shows the available state-of-the-art equipment such as multiple hearth furnaces, rotary kilns, submerged arc furnaces and treatable mass streams. An indicative SWOT analysis for each technology together with a business concept summary will also be presented. The aim is also to show a possible path in how two or even three currently parallel-acting industrial sectors, i.e., alumina, cement and steel could reduce their overall environmental footprint through smart cooperation.

Keywords: Valorization of bauxite residues, flow sheet, cement substitute, SCM, pig iron coproduction, industrial symbiosis.

1. Introduction

Advancements in sustainable practices within the construction industry are of the utmost importance in the quest to mitigate environmental impacts. 30 billion tons of concrete used each year are responsible for at least 7 to 8% of global CO_2 emissions [1,2]. In this context, the EU-funded ReActiv project (GA No. 958208) has made significant strides towards transforming bauxite residue (BR) into valuable building materials and helping to reduce the CO_2 footprint of the building industry. Additionally, the valorization of BR represents a significant improvement in the alumina industry footprint, since over 160 million tons of BR are being produced every year globally. This paper presents an overview of some of the current project's key findings and technologies developed, with a particular focus on the potential to reduce the carbon footprint of the cement industry.

Traditionally, the addition of small amounts of BR to the clinker production process, as alumina and iron oxide source, has been a common practice, with approximately < 3% weight utilized. However, through the innovative approaches developed by the ReActiv project, BR can be transformed into a Supplementary Cementitious Material (SCM) and added as a clinker substitute in concrete. Clinker replacement levels of up to 30% and beyond can be achieved with the BR SCMs, depending on the specific system and the properties to reach.

One crucial advantage of this approach lies in the absence of chemically-fixed carbonates within bauxite residues. Typically, a significant amount of CO_2 is released from limestone during the thermal treatment process within standard Portland cement production. The current values of CO_2 emissions per kilogram of cement clinker produced vary depending on several factors, including the specific production processes and technologies used. On average, the production of 1 ton of cement clinker emits approximately 0.84 tons of CO_2 [3]. As a result, every ton of standard clinker replaced by a ReActiv binder translates to a direct reduction in the overall CO_2 footprint within the cement industry.

The ReActiv initiative explores three distinct technologies to harness the potential of bauxite residue:

- Co-calcination of BR with kaolin at approx. 700 °C
- Vitrification of a mix containing at least 70% of BR and corrective components such as C, SiO_2 and/or CaO above 1250°C
- Smelting and granulation of a mix containing BR, 15-20% CaO and 15-20% C to reduce iron above 1600 °C and recover an iron-free amorphous material.

In addition to the technical aspects, the paper concludes with an indicative SWOT analysis for each technology and a summary of the business concept, emphasizing the potential for collaboration among parallel-acting industry sectors to collectively reduce their environmental footprint. Through this work, a viable pathway is presented towards a more sustainable future, where mutually beneficial cooperation leads to tangible environmental gains in multiple industries.

1.1 Co-calcination of Bauxite Residue Introduction

The chemical basics of co-calcination of BR together with kaolinite were developed by Danner et al. [4] and in previous ReActiv work [5] showing that low-grade kaolin and its use as a SCM was presented at the ICSOBA 2022 in Athens [6]. Work is ongoing and reaching out to process

8. References

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