Decarbonizing Alumina Calcination by Fuel Conversion

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Abstract

Aluminium producers have launched low carbon emission initiatives to reduce their carbon footprint of aluminium production. The production of alumina in alumina refining plants also gets into the spotlight of the decarbonization discussion. As part of the alumina refinery, alumina calcination contributes significantly to CO_2 emission, which itself is accounting for approximately 30% of these carbon dioxide emissions. Emission reduction in the calcination process will directly reduce the carbon footprint of an alumina refinery.

Over the last decades Outotec built more than 60 alumina calcination plants worldwide, which covers a significant share of global smelter grade alumina production capacity. The development and implementation of fuel conversion is responding to the industry request to reduce mainly SO_2 and CO_2-emission. The industry can reach the decarbonization goals using mainly three levers: 1. Improving energy efficiency by deploying best available technologies, 2. Switching from high carbon intensive fuels to low carbon dioxide emitting fuels, and finally 3. by capturing CO_2 emissions. In the past heavy fuel oil was mainly used as fuel and is still being used as energy carrier in many refineries. Fuel conversion from heavy fuel oil to natural gas is already significantly reducing carbon emissions simply because the carbon content in the fuel is lower in natural gas, as compared to heavy fuel oil. Switching to natural gas will inherently lower emission. Further reduction will be possible using alternative fuels including hydrogen and/or bio-based fuels.

On the long run, hydrogen fuel seems to be a feasible green energy carrier. However, the availability of renewable energy to produce green hydrogen is a challenge. Fuel conversion from heavy fuel oil or coal gas to more climate-friendly natural gas is therefore considered as bridging technology.

Keywords: Alumina calcination, Sustainability, Fuel efficiency, Emission reduction.

1. Introduction

As the world focuses on environmental conservation and reducing carbon emissions, sustainability is a topic of growing importance in the alumina industry. Incorporating sustainability in alumina production involves a comprehensive approach that encompasses energy efficiency, emissions reduction, water conservation, responsible mining, waste management, recycling, and stakeholder engagement [1-3].

Alumina refining is an energy-intensive process. From a technology point of view, reducing energy consumption and associated greenhouse gas emissions is of particular interest. The use of renewable energy sources, such as solar, wind, or hydroelectric power, in alumina production can significantly reduce the carbon footprint. There are many ongoing initiatives and companies are already investing in renewable energy projects to power their operations and reduce their reliance on fossil fuels. One recent example is the joint development of the world's largest solar process steam plant for Ma'aden's Alumina Refinery [5].

The fuel consumption in alumina refining is depending on the technology used, the availability of fuels, and the emission standards. Figure 1 shows the energy consumption in metallurgical alumina production worldwide and by region, based on data from International Aluminium Institute [4]. It includes the consumed energy within the plant perimeter by bauxite refining processes (including calcination) and by those auxiliary operations on site which are directly connected with the total production process. Plants producing metallurgical alumina from nepheline ores or other non-bauxitic sources (e.g. fly ash), which globally contribute less than 1% of production, are not considered in the data.

Latest available data from 2021 on worldwide alumina refineries indicates a fuel energy consumption of 1.2 million of terajoules (TJ), with primarily use coal (with a share of 51.5 %), followed by natural Gas (31,4 %), and fuel oil (7.9 %). Coal is the dominant fuel in China with a share of 72% of the fuel used. Outside China Natural Gas is meanwhile the predominant fuel type contributing to 58% of the fuel used in alumina refineries.

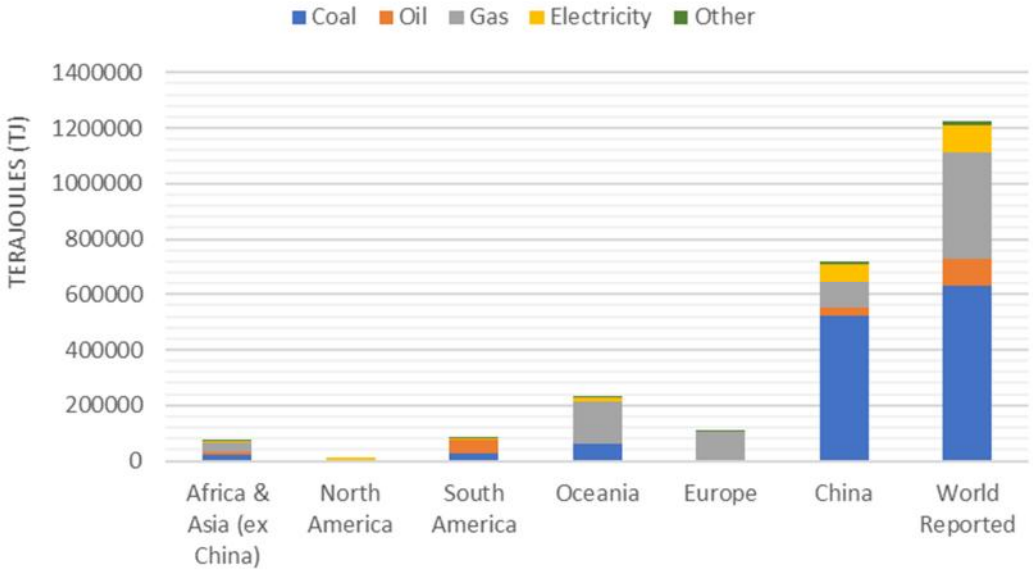

Figure 1. Metallurgical Alumina Refining Fuel Consumption worldwide and regional breakdown (based on data from International Aluminium Institute [4]).

There is no data available on the used fuel types for the calcination area only, however it can be assumed that the fuel type in the refinery power plant and in the calciner is in most cases the same. Coal is not directly used in alumina calciners and is a special case, as calciners can only be fuelled with coal gas for obvious reasons.

The development and implementation of fuel conversion is responding to the industry request to reduce CO_2-emissions. The industry can reach the decarbonization goals using mainly three levers:

1. Improving energy efficiency by deploying best available technologies,
2. Switching from high carbon intensive fuels to low carbon dioxide emitting fuels, and finally
3. By capturing CO_2 emissions by and implementing carbon capture and storage (CCS) technologies to capture and store CO_2 emissions

Carbon dioxide emission varies depending on the specific type of fuel. The carbon emission factor represents the amount of carbon dioxide (CO_2) emitted per unit of energy produced when a fuel is burned. In the following the focus will be on the first two points of the decarbonization levers listed above.

Fuel switching from heavy fuel oil to natural gas is a bridging technology; the next step to significantly reducing carbon emissions is achieved by using carbon free fuel sources.

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