Embracing Net Zero: A Step Towards a Sustainable Future

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Abstract

As a major emitter of CO_2, the alumina industry takes initiatives to decrease its environmental footprint. In the process of alumina refining, alumina calcination contributes to the overall CO_2 emissions, accounting for approximately 31 % of an alumina refinery footprint. Therefore, reducing emissions from this specific process directly reduces the refinery's carbon footprint. FLSmidth after considerable research & development have implemented the latest generation alumina calciners which are presently in operation with fuel consumption below 2650 kJ/kg. FLSmidth has actively participated in change from high carbon intensive fuels like heavy fuel oil to low carbon dioxide emitting fuels like natural gas & hydrogen. The use of hydrogen in alumina refineries is under progress as industry seeks to reduce further their carbon emissions and FLSmidth is an active participant in this initiative.

Keywords: CO_2, Sustainability, Fuel efficiency, Emission reduction, Aluminium hydroxide calciner.

1. Introduction

1.1 Hindalco

Hindalco Industries Limited (Hindalco) is the metals flagship company of the Aditya Birla Group. A 26 billion USD metals powerhouse, Hindalco is the world's largest aluminium company by revenues, and the world's second largest copper rods manufacturer (outside China). Hindalco operates across the value chain, from bauxite mining, alumina refining, coal mining, captive power plants and aluminium smelting to downstream rolling, extrusion and foils. Along with its subsidiary Novelis, Hindalco is the global leader in flat rolled products and the world's largest recycler of aluminium.

Hindalco's global footprint spans across 52 manufacturing units over 10 countries. Hindalco has been ranked the world's most sustainable aluminium company in the Dow Jones Sustainability Indices (DJSI) for four consecutive years – 2020, 2021, 2022 and 2023. Hindalco has developed a well-defined decarbonisation plan and is committed to achieving Net Carbon Neutrality by 2050. In addition, Hindalco has set a target to reduce specific Greenhouse gas (GHG) emissions by 25 % by the fiscal year 2024-2025, measured against the base fiscal year 2011-2012.

1.2 FLSmidth

FLSmidth, now known as FLS, is a global supplier of engineering, equipment, and service solutions to the mining industries. They focus on enhancing productivity, reducing operating costs, and minimizing environmental impact for their customers. As a pioneer of decarbonization and digitalization, FLSmidth is always one innovation ahead, thanks to its ability to anticipate customer needs. FLSmidth is able to provide both environmental and economic performance globally, responding to the specific needs of each local market.

1.3 Collaboration and Government Policies

In India, as part of their global plan to reduce the SO_2 emissions, the government imposed stringent regulation on alumina refineries, which were using heavy fuel oil (HFO). New fuel such as Low Sulphur Heavy Stock (LSHS) and Natural Gas have been promoted. A pipeline from the states of Uttar Pradesh to Odisha was constructed by the government where the alumina refineries and smelters are located.

Utkal Alumina Ltd. & Aditya Alumina, a flagship companies of Hindalco Industries having its operations at Tikiri & Kansariguda, Odisha, partnered with FLSmidth to be the first refinery in India to use natural Gas (NG) instead of HFO in their 3 existing Alumina Calciners. This strategic project was decided and approved by the Hindalco Management team to comply with the state fuel policy guidelines as well as to support the carbon neutrality target by 2050.

2. Fuel Conversion – From Heavy Fuel Oil to Natural Gas

Natural gas, primarily composed of methane, produces less CO_2 upon combustion compared to other fossil fuels like fuel oil or coal. This direct reduction in emissions contributes to climate change mitigation. While natural gas is still a fossil fuel, it is a step towards a cleaner energy matrix for alumina refineries. It paves the way for integrating more sustainable energy sources like electrification, hydrogen or biomass in the future.

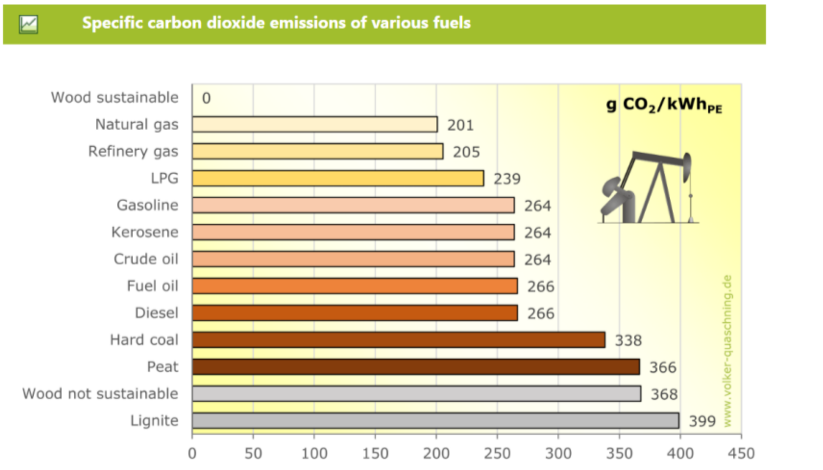

Figure 1. Specific carbon dioxide emissions of various fuels.

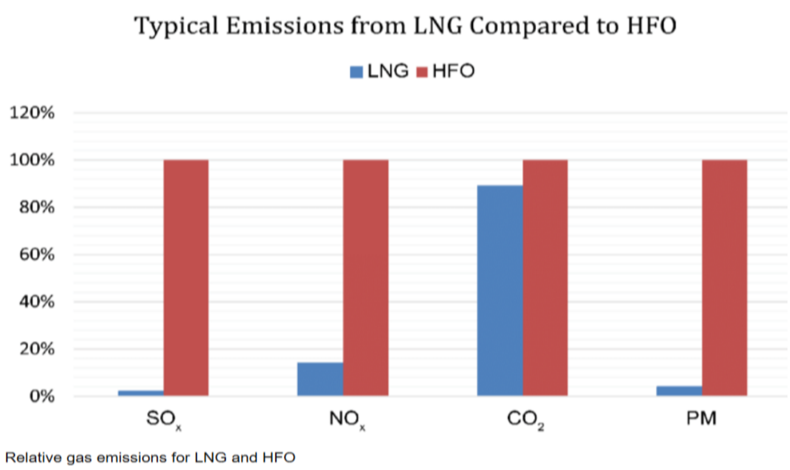

Figure 2. The reduction of CO_2, NO_x, SO_x & particulate matter emissions of NG vs HFO.

Combustion of HFO releases higher levels of emissions such as CO_2, NO_x, SO_x and ash particles when compared to NG. The combustion of NG releases very small amounts of SO_x and NO_x and virtually no ash or particulate matter. The emission loads resulting from using NG is considered very low compared to the HFO loads.

Natural Gas:

- **Lower CO_2 emissions:** Natural gas, when combusted, produces roughly 20-30 % less CO_2 than HFO.
- **Lower SO_x and NO_x emissions:** Natural gas combustion releases very low levels of sulphur dioxide and nitrogen oxides.
- **Minimal particulate matter:** Natural gas combustion produces very little particulate matter.
- The maintenance requirement is reduced in terms of burner handling due to natural gas being cleaner.
- The safety requirement for natural gas is greater compared to HFO. FLS safety design system integrates this additional requirement.
- **Methane slip:** Natural gas, being primarily methane, can leak during extraction, processing, and transport, contributing to greenhouse gas emissions. However, modern technologies aim to minimize this "methane slip".
- **Life-cycle considerations:** The overall environmental impact of natural gas, including extraction and transportation, also needs to be considered.

In summary: While natural gas is not a zero-emission fuel, it generally offers a significant reduction in harmful air pollutants and greenhouse gas emissions compared to HFO.

The fuel injection system at the refinery is designed to run on either HFO or natural gas mode. This dual fuel capability eliminates the risk of discontinuous availability of natural gas.

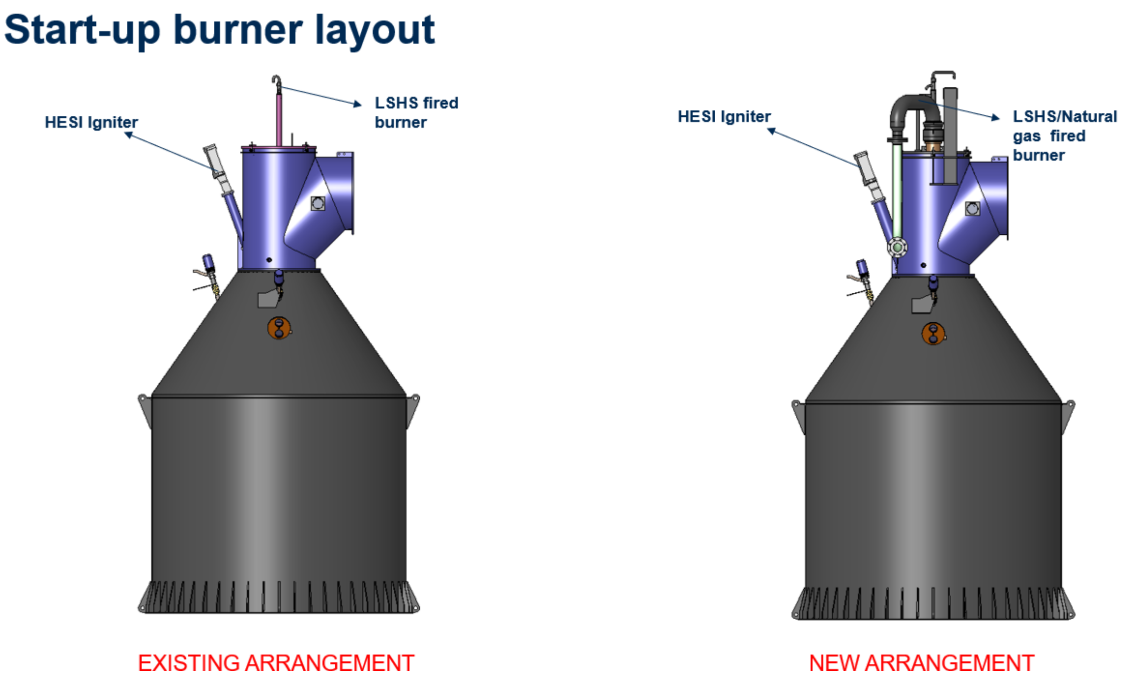

Figure 3. Start-up burner layout.

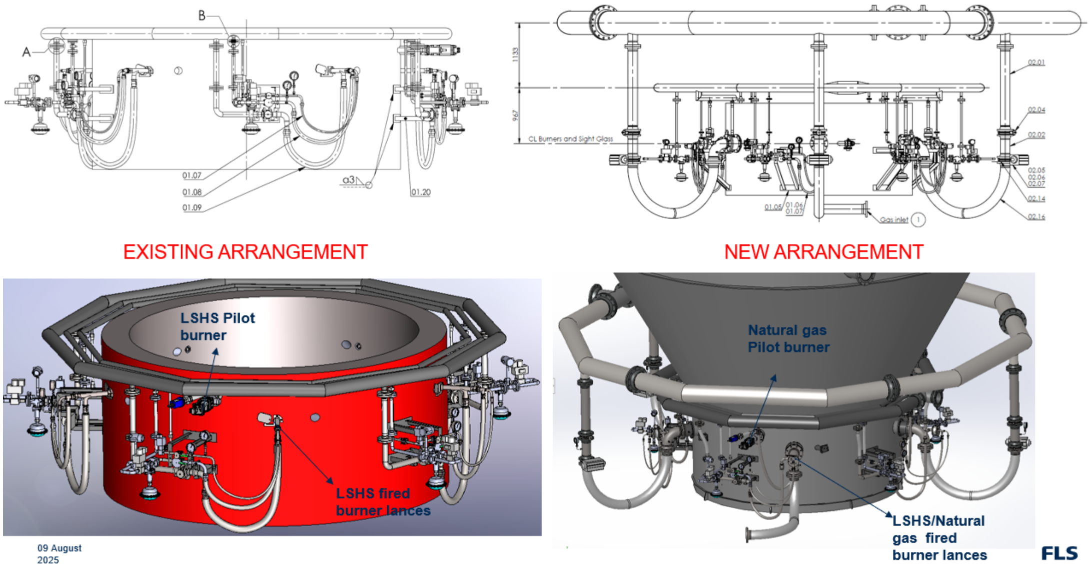

Figure 4. Main calciner burner layout.

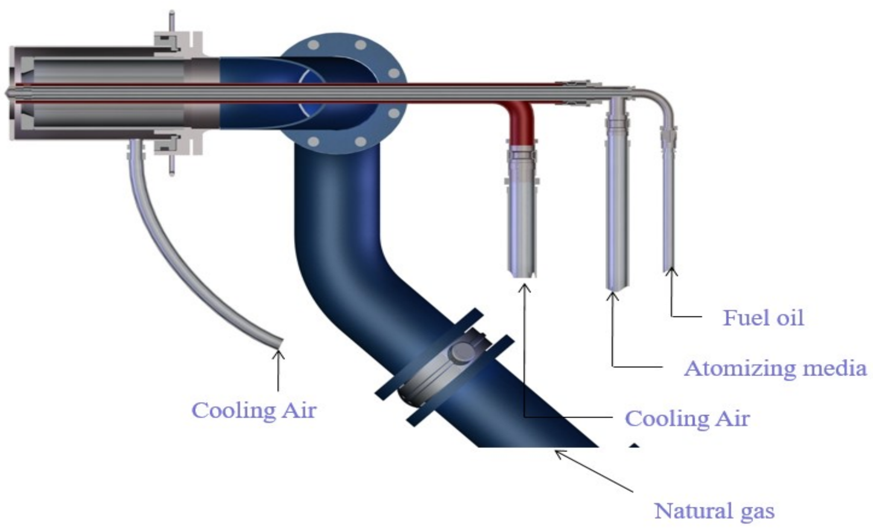

Figure 5. The scheme of dual fuel burner (HFO & natural gas).

Safety & Reliability features:

- Gas train scheme satisfies international safety standards ISO 13577-2 i.e. Safety codes for Combustion & Fuel handling system & also as per European standards EN 746-2.
- All safety instrumentations like pressure transmitters, flow meter, double shut-off valves, etc. are part of gas train.
- Gas train auto leak test is done during every start/stop of the burner which ensures that there is no gas that has been leaked into the system when gas burners are not running.
- Hazop / Safety Integrity Level (SIL) study ensures that required safety has been taken care of and also required SIL level for instruments have arrived based on SIL study. We have successfully completed Hazop study with client using third party consultant for this gas conversion project which will be benchmark for upcoming gas conversion projects.
- All instruments on gas train comply with the required SIL level which provide additional reliability of selected instruments.
- All instruments for gas line comply with the Hazardous area classification Atex Zone 2 requirements.

- FLS Burner Management System (BMS) provides the necessary safety & reliability of burner system with its continuous supervisory mode for all the safety instrumentations related to burner and trip the system which gets triggered when hazardous situation occurs.

Figure 6. Picture of dual fuel burner in calciner vessel.

3. Evaluation of Alumina Hydrate Flash Calcination using a Hydrogen Fired Flash Calciner with Air Transport Medium

The test results obtained during a pilot program strongly suggest that it would be viable to convert a commercial alumina gas suspension flash calcining system natural gas firing to air-based operation with hydrogen firing without compromising system stability and alumina product quality. It is also expected that no major commercial calciner modifications would be required to support this mode of operation The main focus would be on managing the operating and safety logics required from the transition to hydrogen firing which would reduce emissions from alumina refining by a significant 30 per cent.

Some of the results have shown that hydrogen burns differently from natural gas:

- Faster flame front
- Higher temperature
- Darker flame
- More water in the exhaust gas
- No CO_2 in the exhaust gas
- Most importantly, with a 100% CO_2 savings when using 100% H_2 combustion i.e. zero CO_2 emissions

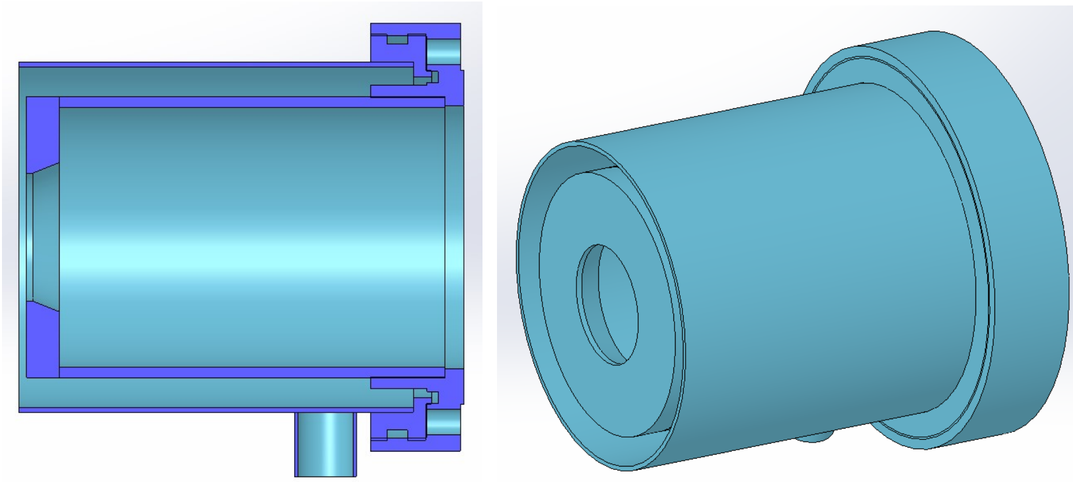

Figure 7. FLS calciner burner for H_2 gas.

Advantages:
- Custom made design.
- Simple, User friendly & robust construction.
- Low Nox design due to center injection.
- Computer Fluid Dynamics (CFD) modelling would be done for each H2 burner design.

FLS has in-house CFD capability to fine tune the H2 burner nozzle design to suit for specific process requirements.

4. FLSmidth Lastest Generation Calciners with Natural Gas or Hydrogen as a Fuel

FLSmidth in collaboration with Alcoa further developed a semi vertical Gas Suspension Calciner (GSC) arrangement using Hot Air Lift (HAL) and introduced Fluid Bed Cooler (FBC) replacing fluxo cooler.

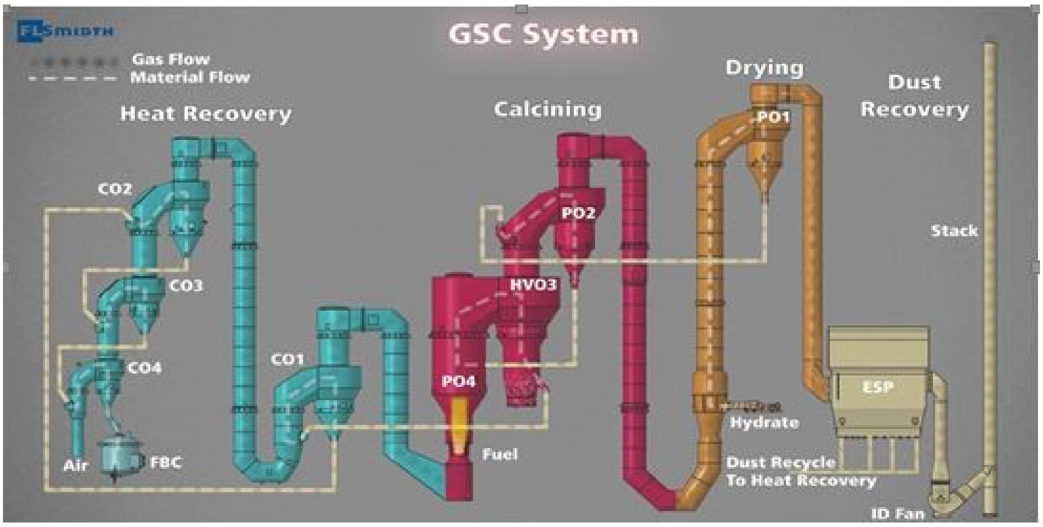

Figure 8. GSC with HAL and FBC, with holding vessel.

The modern GSC design, which was implemented in various alumina has four main process stages:
- Drying and pre-heating/pre-calcination (PO1/PO2).

- Calcination furnace (PO4), furnace cyclone (PO3) and Holding Vessel (HV).
- Direct heat recovery by direct air cooling, CO1-CO4.
- Indirect heat recovery by water cooling in a fluidized bed cooler (FBC).

Figure 9. Holding vessel body (left) and material discharge to CO1 at 900 Deg C (right).

Figure 10. Holding vessel internals.

The holding vessel increases the retention time for the material and ensure that the reactions have time to proceed to a desired degree in order to meet product specifications and provides significant energy savings as the temperature in the furnace is reduced and the reaction time is prolonged in this process stage. Higher temperature is substituted by longer retention times.

Advantages:

- Low alpha in alumina
- Improved Quality
- Lower Calciner temperature :
- Smaller Vessel-Lower CAPEX
- Lower thermal load on refractory
- Longer lining life-Lower OPEX
- Lower heat consumption
- Improved economy

4.1 Improved Refractory Design

A multi-layer lining with optimized performance of layers in the specific operating environment, and proper installation, improves the energy efficiency of a furnace and can contribute to saving specific fuel energy as stated by Pungkuntran [6].

The specific energy consumption of the latest generation calciners operates with fuel consumption in the range of 2650 kJ/kg as stated by Pungkuntran [6].

5. Summary and Conclusions

In conclusion, switching from HFO to natural gas in alumina production is a significant step towards reducing emissions and improving the environmental sustainability of the industry. Safety considerations and compliance measures need to be addressed.

The new refineries can work with the latest generation FLS Calciners which have the lowest fuel consumption calciners and its ability to operate on natural gas and potentially on hydrogen is proof of environmental sustainability of the industry.

The older generation FLSmidth calciners can be retrofitted by adding holding vessel to reduce fuel consumption.

Alumina Hydrate Flash Calcination using a Hydrogen Fired Flash Calciner is under implementation and will be commissioned shortly.

6. References

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