OXY-FUEL COMBUSTION FOR DECARBONISATION

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ABSTRACT

Government legislation is constantly tightening to move towards net zero carbon dioxide (CO_2) emissions. Many companies are planning their journey towards decarbonisation to include developing technologies and emerging markets that can drastically reduce their carbon footprint. However, roadmaps towards net zero CO_2 emissions must also include short-term goals, which need to be achievable with current technology. Oxy-fuel combustion is a well-established technology that has been proven to improve fuel efficiency and thus save up to 40% CO_2 emissions and can be retrofitted to existing furnaces. Decades of experience in implementing and operating oxy-fuel combustion have proven to bring benefits in safety, productivity, cost, emissions, and aluminium recovery.

CLIMATE CHANGE IMPLICATIONS ON INDUSTRY

Climate change has become a prevalent issue throughout society as people are recognising the effects of global warming. Since the first industrial revolution, there has been a continuing rise in global temperatures, which has worsened since 1980 and is causing more extreme weather events. Governments around the world are beginning to tackle the issues of emissions and waste, leading to circular economies, which are vital as the population further increases. There is significant focus around greenhouse gas emissions, particularly CO_2, as these gases prevent the heat from sunlight escaping the atmosphere. As a result, low carbon initiatives are being implemented, whereby government legislation and taxation on fossil fuels are being introduced and constantly tightened as we progress towards net zero goals.

The majority of countries that have pledged to become carbon neutral have set a target of net zero CO_2 emissions by 2050. So far, there are only six countries that have set their net zero targets into law, including the UK. Following the Climate Change Act in 2008, the UK has set carbon budgets that govern the total amount of greenhouse gases that can be emitted for a given time period. The UK's sixth carbon budget is set to bring emissions down by 78% by 2035, compared with 1990 levels. As part of this commitment, the UK government are setting policies into law and providing funding for development programs for feasibility and engineering studies to prepare industry for the transition to a lower carbon economy.

POTENTIAL LONG-TERM INDUSTRIAL OPTIONS

The industrial energy transition journey will be complex, involving various technologies and infrastructures to pave the way for diminishing CO_2 emissions. Companies with energy intensive processes, such as aluminium smelting and remelting are putting together roadmaps that include current and developing technologies to reach their goals. Electrification, fuel switching, and carbon capture are some of the likely options for future furnace operations, depending on individual circumstances, such as location, operation, and budget. Electrification utilises green energy, such as wind and solar, to power industrial processes either directly from the grid or from on-site power generation. In an example case for an aluminium recycling plant with gas-powered furnaces, manufacturers would be required to change to electric powered furnaces, which may not be economical or suitable for processing particular types of materials. Fuel switching involves changing from fossil fuels to a low carbon alternative energy carrier and there are several potential options including hydrogen, biofuels, and ammonia. Fuel switching options are likely to involve retrofit technology, which may be an easier and more cost-effective solution when compared with electrification. Carbon capture facilities can be added to the downstream equipment to directly remove the CO_2 from the effluent gas stream before it goes into the atmosphere. The captured CO_2 can then be either stored or used in another process, although due to technical and economical constraints might not be feasible for most aluminium recycling plants.

OXY-FUEL FOR SHORT-TERM GOALS

The options discussed above are considered emerging technologies, as the markets, infrastructures, and the technologies themselves are currently in development and therefore can be used as part of long-term solutions to achieve climate goals. Roadmaps towards net zero CO_2 emissions must also include shorter-term goals to remain in line with ever-tightening government legislation. Significant reduction in CO_2 emissions can be achieved with current technology by focusing on improving efficiencies.

In recent years there has been significant development in digitisation for industry, with Industry 4.0 technology providing new ways to optimise production using big data analytics, shifting focus onto improving efficiency, which impacts on carbon footprint. Waste heat recovery

• High yield burner flame

technology can be used to capture the heat from a process and convert it either into electricity or use it to preheat combustion reactants to improve efficiency. These technologies can provide decent reductions in CO_2 emissions through fuel savings of up to 15%.

Oxy-fuel combustion is a well-established technology, which has historically been implemented to increase productivity and aluminium yield, whilst also reducing fuel consumption and emissions. The potential for oxy-fuel combustion to achieve short-term climate goals as part of a roadmap towards decarbonisation is worth highlighting. Switching from a traditional air-fuel combustion system to an oxy-fuel combustion system has proven to save up to 40% energy consumption, which can be directly translated to 40% savings in direct CO_2 emissions. Companies like Air Products are also working on reducing CO_2 emissions for oxygen production and transport, leading to green oxygen. Oxy-fuel technology is suitable for retrofit and has been bringing environmental benefits to the aluminium industry for decades.

Dry air contains 20.95% oxygen, 78.09% nitrogen, 0.93% argon, and small amounts of other gases. Combusting fuel with pure oxygen is more efficient than air-fuel combustion, as the fuel can react much faster with the oxygen, which increases the flame temperature by around 1000°C.


• Transient heating burner flame

This increases the heat transfer rate from the flame to the metal, resulting in significant improvements in specific energy usage of up to 40% and potentially doubling productivity. With correct burner design and combustion staging, oxy-fuel combustion can also improve aluminium yield up to 2%. Due to the lack of nitrogen present in the reaction, nitrogen oxide production can be eliminated with proper consideration to burner design and furnace operation. Oxy-fuel combustion also results in more complete combustion, leading to a considerable reduction in unwanted combustion emissions, such as carbon monoxide, soot, volatile organic compounds and unburned hydrocarbons.

CONCLUSION

Oxy-fuel combustion can provide up to 40% savings in direct CO_2 emissions, as well as increased productivity and aluminium yield. Oxy-fuel technology is well-established and proven throughout the aluminium industry as a safe, economic, and accessible solution for reducing carbon footprint. Decades of operating experience and implementation on new furnaces, as well retrofits have shown to reduce specific energy usage by up to 40%, increase production by up to 100% and increase aluminium yield by up to 2%. Switching from air-fuel to oxy-fuel combustion is an ideal solution for starting out in the roadmap to net zero CO_2 emissions.

• Oxygen tank and tanker

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