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Oxygen enriched burners, CO2 utilisation and mineralisation

By Stephen B. Harrison | 14 July 2021

The global cement making industry is one of the largest emitters of carbon dioxide (CO_2) and is responsible f
four times more than the aviation sector.

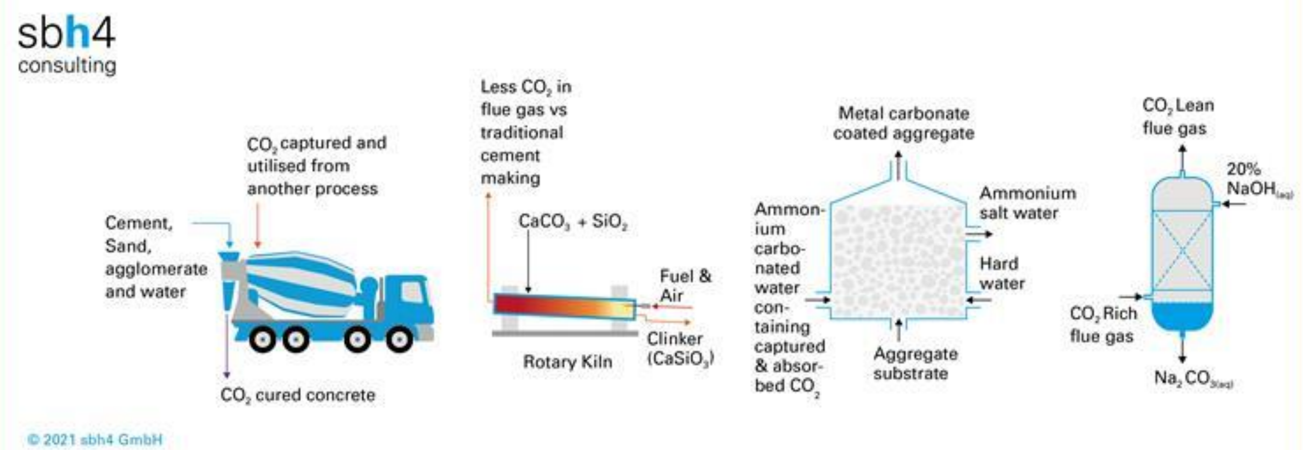
Annual global cement production in 2019 was 4.2 gigatonnes, of which 55% was produced in China. The wo
to 25% until 2050.

It is regarded as a 'hard-to-abate sector', as much of its CO_2 emissions are intrinsically connected to the chen
mitigated using electrification with renewable power. At 900°C limestone is decomposed into lime and CO_2.

In addition to CO_2 emissions from the process, there are also emissions associated with the burner in the cer
or petcoke are burned to make the heat and high temperature that are required to drive the chemical reactio

Accounting for the mixing of CO_2 released from the mineral processing and combustion, the typical CO_2 con
times higher than the CO_2 partial pressure in the atmosphere, it is still challenging to capture CO_2 from a flu

Mineralisation processes for CO_2 emissions reduction in cement making and concrete production



	CO_2 cured concrete	New cement type based on calcium silicate instead of tricalcium silicate	Agglomerate recycling	Sodium bicarbonate formation
Mitigation principle	Cement use reduction through increased concrete strength and CO_2 utilisation	Reduced CO_2 flue gas emissions from cement clinker kiln and CO_2 utilisation	CO_2 mineralisation reaction with recycled or waste cements	CO_2 mineralisation from cement kiln and / or calciner flue gas
CO_2 Mitigation potential	CO_2 utilisation during concrete curing ~5% reduction from cement use reduction	CO_2 utilisation during concrete curing ~50% reduction from different cement chemistry	~90% reduction from CO_2 capture & mineralisation	~90% reduction from CO_2 capture
Carbonate formed	$CaCO_3$	$CaCO_3$	$CaCO_3$ and $MgCO_3$	Na_2CO_3
Raw material	$Ca(OH)_2$ from fresh concrete	$Ca(OH)_2$ from fresh concrete	$Ca(OH)_2$ in re-used concrete, CaO and MgO from fly ash and steel slag	NaOH produced from electrolysis of NaCl
Technology maturity level	Commercial, eg CarbonCure	Commercial, eg Solidia	Demonstration, eg Blue Planet	Demonstration, eg SkyMine

the costs of the oxygen supply and equipment modifications.

An increased CO_2 concentration in the flue gases eventually makes carbon capture much more cost effective emissions such as NOx, SOx and particulates can be simplified using combustion with oxygen enriched air b downsized.

Separation of CO_2 streams from process and combustion off-gases

An alternative approach is to use air to provide oxygen for the combustion process and separate the process Carbon capture can then be focused on the process gas stream which has a higher CO_2 concentration.

About 65% of the CO_2 emissions from cement making are associated with the process gas stream so there is decarbonisation.

Within the European project Low Emissions Intensity Lime and Cement (LEILAC) a pilot plant has been built The 60m tall pilot plant has a capture capacity of about 18,000 tonnes of CO_2 per year which results from 24 production or 190 tonnes per day of ground limestone feedstock.

Core to the process is the direct separator reactor (DSR) which has been developed by Calix. It acts as a large thereby enabling separation of the combustion and process gas emissions streams. The exhaust of the proce captured and liquefied for further utilisation.

A similar technology is also employed by CarbonEngineering within its Direct Air Capture (DAC) process.

The follow-up project LEILAC2 started in 2020. Intended to be operational by 2023 at the Hannover plant of 100,000 tonnes of CO_2 per year. If natural gas is employed as the fuel to heat the limestone, conventional ca separate the CO_2 from the rest of the flue gas.

During the LEILAC2 project alternative fuels based on biomass and the use of electrical heating using renew calciner. Furthermore, the flexible combination of intermittent renewable electricity and fuel is to be validat additional dispatchable power consumption can be offered as a service to the electricity grid.

One important question remains. Even if all anthropogenic CO_2 emissions from cement making plants are ca

formation. Some primary minerals like olivine, a weak basalt rock with the chemical formula $(Mg, Fe)_2SiO_4$, ' environmental conditions. Lessons from this natural weathering process can be used to capture CO_2 emissio

To store CO_2 in a carbonate form, a raw material with a high metal oxide or metal hydroxide content is requi which has a distinctive calcium hydroxide fraction. Other raw materials include fly ash (CaO 10-40%, MgO 0- These materials also contain high concentrations of other metal oxides. For example, MgO can be utilised to magnesium carbonates ($MgO + CO_2$ □ $MgCO_3$).

Growing underground rocks with CO_2

To implement this mineralisation carbon capture process, two options are available. Either transport the raw transport the CO_2 to suitable rock formations to store the gas securely.

The latter approach has been developed by CarbFix in Iceland since 2007. CO_2 captured from flue gases or d aqueous solution of carbonic acid. This solution is pressurised and pumped underground where it heats in h water can bind less CO_2 than cold water, the CO_2 is released underground, and carbonation of basalt rocks t

Cement curing with CO_2

The Canadian-based company Carbon Cure takes advantage of the sequestration capability of concrete by in cement during concrete preparation. This increases the strength of the concrete as additional calcium carbo fraction of the concrete. The result is that 5% less cement is required to make the concrete, and a reduced a emissions from a reduced requirement for cement making.

The technology is readily available to reduce the CO_2 emissions of concrete and can be scaled up immediate production process. Several reference projects exist in the US, with the Amazon HQ2 the largest project to d

To sequester anthropogenic CO_2 emissions, Blue Planet has developed a new mineralisation process. It uses concrete contains aggregate and an old cement fraction. During the process, the aggregate is upcycled and c Whereas the old cement fractions are mineralised with CO_2 to form a new layer of calcium carbonate arounc seeds for the mineralisation process.

The CO_2-sequestered aggregate is used in addition to the upcycled aggregate in newly mixed concrete. In a used at the Interim Boarding Area B at San Francisco International Airport.

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About the author

Stephen B. Harrison is Managing Director of sbh4 consulting. Harrison has over 30 years' experience of the