COMMITTING TO CARBON CAPTURE

Aniruddha Sharma, Carbon Clean, explains how carbon capture has become a feasible option for cement companies committed to climate action.

The cement sector is under no illusions about the urgent need to address its carbon emissions. The industry accounts for between 4 – 8% of global man-made carbon emissions and, according to the Paris agreement, carbon emissions from cement production need to fall by at least 16% by 2030 in order to achieve the 1.5˚C target.

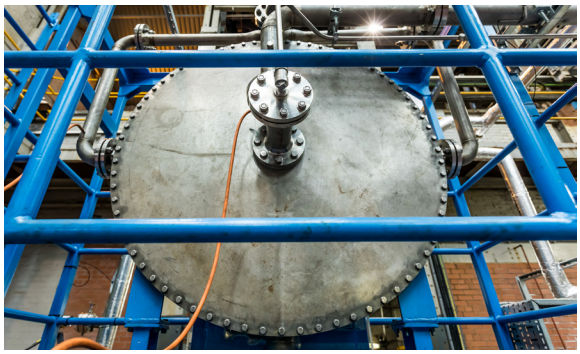
But this is a challenge. Cement is the second most consumed product in the world after water and the largest emitter of CO_2 in the built environment. Given that the world is expected to build the equivalent of another New York City every month for the next 40 years, action is required now to ensure that emissions do not actually go up rather than down.

Action is underway and incentives to accelerate this action are increasing. At COP26, for example, a new Industrial Deep Decarbonisation Initiative (IDDI) was launched that seeks to create new markets for low carbon concrete and steel to help decarbonise heavy industry.

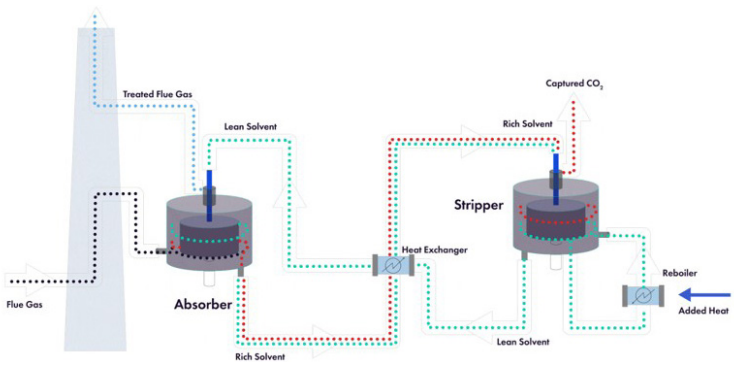
It began with the governments of the UK, India, Germany, the United Arab Emirates and Canada pledging to buy low-carbon concrete and steel. The IDDI will disclose the embodied carbon of major public construction projects by 2025, achieve net zero in major public construction steel and concrete by 2050, and set an emissions reduction target for 2030.

However, many low carbon initiatives are at an incredibly early stage of development and a long way from widespread commercial adoption. Carbon capture technologies are ready now, can capture over 90% of a plant's CO_2 emissions and are more cost-effective and feasible to install than ever before.

Carbon Clean's skid-mounted, modular carbon capture technology, CycloneCC, shown adjacent to a conventional carbon capture unit at Doosan Babcock's Emissions Reduction Test Facility in Renfrew, Scotland.



The innovation at the heart of CycloneCC is a rotating packed bed to enhance the CO_2 absorption process.



The CycloneCC plant block flow diagram.

Carbon capture – A solution for today

Carbon capture, utilisation and storage (CCUS) is, of course, not new. Post-combustion CCS using amine-based absorption has been in use for many years and is a proven technology.

This kind of carbon capture is a great solution for the cement sector. Cement factories are built to operate for an average of 40 years or more and require large investments. Simply replacing them is usually not an option, so retrofit options, like carbon capture, are needed.

Carbon capture can be adapted to suit a cement plant's current operations, with no real change in the operating process required. A cement plant's flue gas is also ideal for carbon capture given the high concentration of CO_2, making it easier to extract and resulting in high purity CO_2 that is ready for conditioning, export and utilisation or storage.

However, there have also been some concerns around the implementation of CCUS. Firstly, the costs have been high (historically between US$80 – 120/t) and secondly, it has been extremely challenging to secure the required onsite space to accommodate a conventional carbon capture plant.

A recent survey published by Decarb Connect found that onsite space remains a major concern and that industries need to be able to integrate carbon capture solutions within their existing footprint.

Both the cost and space barriers to deployment are being addressed with Carbon Clean's next generation technology – CycloneCC.

Launched late last year, CycloneCC is the world's smallest industrial carbon capture solution that is modular, pre-fabricated and skid-mounted to ease installation issues. It is up to five times smaller than conventional carbon capture units and can be installed in less than eight weeks. Crucially, the solution is expected to reduce the overall cost of carbon capture by up to 50%, to reach US$30/t on average.

Process intensification breakthrough

CycloneCC uses a combination of two proven process intensification technologies – rotating packed beds (RPBs) and the APBS-CDRMax® solvent.

The solvent has been formulated to optimise carbon capture performance using fast-reacting amines and high-capacity salts. The solvent chemistry allows for rapid removal of carbon dioxide from flue gases with CO_2 concentrations ranging between 2.5 – 25 vol.%, through the selective absorption of the CO_2 into the reactive solvent components. The solvent also has greater stability, lower corrosivity

and lower regeneration energy requirements than the benchmark amine.

The RPB contains a disk of packing material which rotates about its axis. This generates a centrifugal force within the packing, which enhances the CO_2 absorption process. Essentially, the solvent and flue gas can move past each other more rapidly, allowing for a higher rate of mass transfer. This enhancement of the absorption process results in 10 times less volume, and therefore a corresponding reduction in equipment size, to achieve the same performance as conventional options.

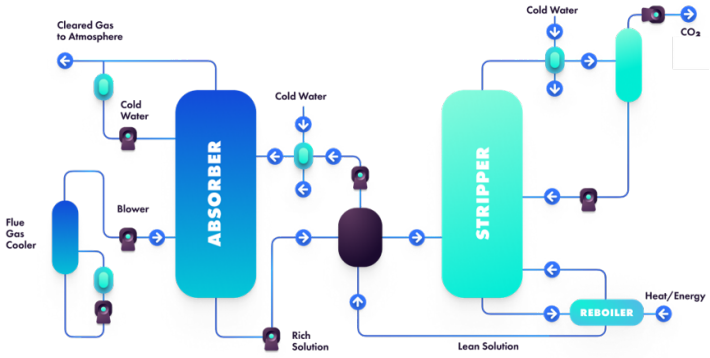
The solvent is introduced into the RPB at its centre and the flue gas is introduced to the RPB from the outer edge. The gas and the liquid contact each other in a counter-current fashion, ensuring maximum contact and greater absorption. RPBs are ideally suited to carbon capture as they can handle very high gas and liquid volumes and Carbon Clean has been working with academic and industry partners in the UK and US to test and develop the potential of RPBs.

CycloneCC technology in action

CycloneCC technology has been successfully pilot tested at rates of 1 tpd and is currently being commercialised at 10 tpd and 100 tpd with select partners for final product roll out by summer 2022 and market roll out in 2023.

It is particularly suited to the cement sector due to its modularity and CEMEX is one of Carbon Clean's technology development partners.

Globally, CEMEX has committed to reducing its CO_2 emissions by 35% by 2025 and 40% by 2030.



The CDRMax plant block flow diagram.

First steps with CCS

Each cement plant is distinct, so integrating carbon capture will require a thorough assessment. With Carbon Clean's expertise in process design and engineering, the company will work with cement companies to design the optimal solution for their needs, whether integrated with existing plants or new projects.

For companies interested in exploring CCUS, the following are some key considerations:

What do you want to accomplish?

Having a clear understanding of emissions reduction targets and trajectory will help Carbon Clean design the appropriate carbon capture solution. Currently, many cement businesses are exploring what carbon capture can deliver for them. Starting small and expanding capacity over time can be a good option.

On site space

The carbon capture system needs to be close to the emissions point-source, which in a cement plant is near the smokestack. The available space for the carbon capture plant and the processing of the captured carbon, will dictate the optimal solution. Conventional technology can require an area the size of a football pitch and the installation of a tall stack – both of which are not viable for many cement facilities. The latest semi-modular and modular technologies, however, are overcoming these space barriers. The modular, skid-mounted CycloneCC, for example, is a space-saver. A plant can start with one module and scale up over time, achieving both a small onsite footprint and flexibility of deployment.

Flue gas composition

To advise on the optimal solution, it is important to know the flue gas flow rate, the concentration of CO_2 in a flue gas, and what other gases are present. In general, the CO_2 concentration in cement plants' flue gas is high (between 11 – 20% concentration) making carbon capture much more efficient. However, if there are trace pollutants in the flue gas, these could influence solvent degradation and purity levels, so need to be well understood.

Operational costs

It is key to minimise the OPEX costs of the carbon capture solution. Efficient cooling and utilisation of waste heat can bring significant benefits.

Use/storage of the CO_2

To design an optimal carbon capture solution, it is crucial to know how the CO_2 is going to be used or stored. The market for CO_2 is growing and new applications for captured carbon are being explored. However, permanent storage will be the most likely option for most cement plants given the amounts of CO_2 that will be captured. Many storage projects are in development and will be in operation within the next few years – Northern Lights is a good example, with the first phase due to be completed mid-2024 with a capacity of up to 1.5 million t of CO_2 per year. Now is a good time to be exploring storage options. The choice between utilisation and storage will depend on the infrastructure available, the costs and the potential utilisation options.

The company is working with Carbon Clean on a project to capture 100 tpd of CO_2 from its Rüdersdorf plant in Germany, which it plans to combine with hydrogen from renewable sources to produce greener synthetic hydrocarbons that can be used in other industries. The aim is to then scale up by an additional 300 tpd and investigate how to achieve 2000 tpd.

Meanwhile in the US, a project is underway at CEMEX's Victorville plant in California that will demonstrate the potential to significantly reduce carbon capture costs using CycloneCC and analyse new opportunities for CO_2 utilisation. The project is part-funded by a Department of Energy grant and includes partners RTI and Oak Ridge National Laboratory.

Scaling up

In addition to CEMEX, Carbon Clean is working with LafargeHolcim España, Dalmia Cement, and Taiheiyo Cement Corporation in Japan, where the company has just commissioned a semi-modular 10 tpd plant to capture the flue gas of rotary kilns used for cement production.

The cement industry is embracing carbon capture as it seeks to transition to a net zero economy and Carbon Clean's aim is to create strategic partnerships so that the company can support the industry on this journey.

For many cement companies, a key question is what to do with the captured CO_2. The CCUS value chain is developing rapidly, with energy companies, for example, leveraging their experience and developing new capabilities such as transport, storage, and utilisation.

Clusters and industrial hubs are being developed in the UK and the US and these will allow economies of scale as multiple facilities combine to use the transport and storage networks.

Growth in utilisation options and the potential for companies to establish new revenue streams in the circular carbon economy has also been seen.

Working with a company that can provide guidance and contacts throughout this value chain is going to be essential for many cement companies.

Flexibility is also key. Many companies will want to stagger their investment in carbon capture, starting small and then adding capacity in line with their decarbonisation roadmap.

Doing nothing is not an option for the cement sector. Stakeholder pressure and market forces are having an impact and they will get stronger each year. Carbon capture technology offers cement producers a viable, cost-effective option to reduce their emissions now.

It will require finance but, with innovation in carbon capture, costs have come down and can be phased. Delaying deployment of CCUS is ultimately likely to cost companies more.

For industry, there has never been a better time to prioritise the capture of carbon emissions. ■

ECCO2 – Lighthouse Project

A joint venture with LafargeHolcim España, Carbon Clean and Sistemas de Calor – ECCO2 – is developing a novel large-scale carbon capture and utilisation project in Almeria, Spain.

The Lighthouse project will see CO_2 captured from the Carboneras cement plant using Carbon Clean's semi-modular CDRMax technology, cleaned and transported locally to be used in the region's greenhouses where it will improve crop productivity through a process known as 'carbon fertilisation'.

Around 80% of the carbon capture system will be modular and containerised, resulting in dramatically reduced installation time on site – saving time and money, while also improving safety. It will also use Carbon Clean's proprietary solvent – a formulation of amines and salts known as Amine-Promoted Buffer Salts – which produces CO_2 with a purity of 95 – 99.9%.

The carbon capture plant will be commissioned in 2023, initially capturing 10% of the Carboneras plant's carbon dioxide emissions. However, it is expected that this circular carbon economy business model will result in the capture and utilisation of 600 000 t of CO_2 per year.

The LafargeHolcim España Carboneras plant in Almeria, Spain.

About the author

Aniruddha co-founded Carbon Clean in 2009. As CEO Aniruddha leads and sets the company's strategy and goals, represents Carbon Clean externally, including on a variety of industry and other bodies, and maintains overall responsibility for our sales, marketing and project delivery operations. He is also a Board member.