

CO2 RECYCLING

Removing CO₂ from the air is difficult. Achieving this with an efficient benefit–cost ratio is pioneering work. Carbyon has done precisely this with two test machines, making the production of renewable fuel a financially attractive prospect. This process is measured and researched using three different precision sensors by KELLER Pressure.



Series 33X high-precision pressure transmitter,
© KELLER Pressure

Removing CO₂ from the air in a practical and affordable way is difficult. But that's not stopping Carbyon, the pioneering company based in Eindhoven. For one and a half years, they have been operating a machine that is capable of precisely that. This invention is based on the thin-film principle for solar cells by Hans de Neve – semi-conductor physicist, founder and CEO of Carbyon. His interest in CO₂ capture and the possibilities afforded by the thin film used on solar cells that is only one atom thick led to the process that Carbyon is now testing with such success. Two Carbyon employees shed light on how CO₂ is captured from the air, what prospects this process offers and how KELLER sensors play a key role.

Young research team from the Netherlands

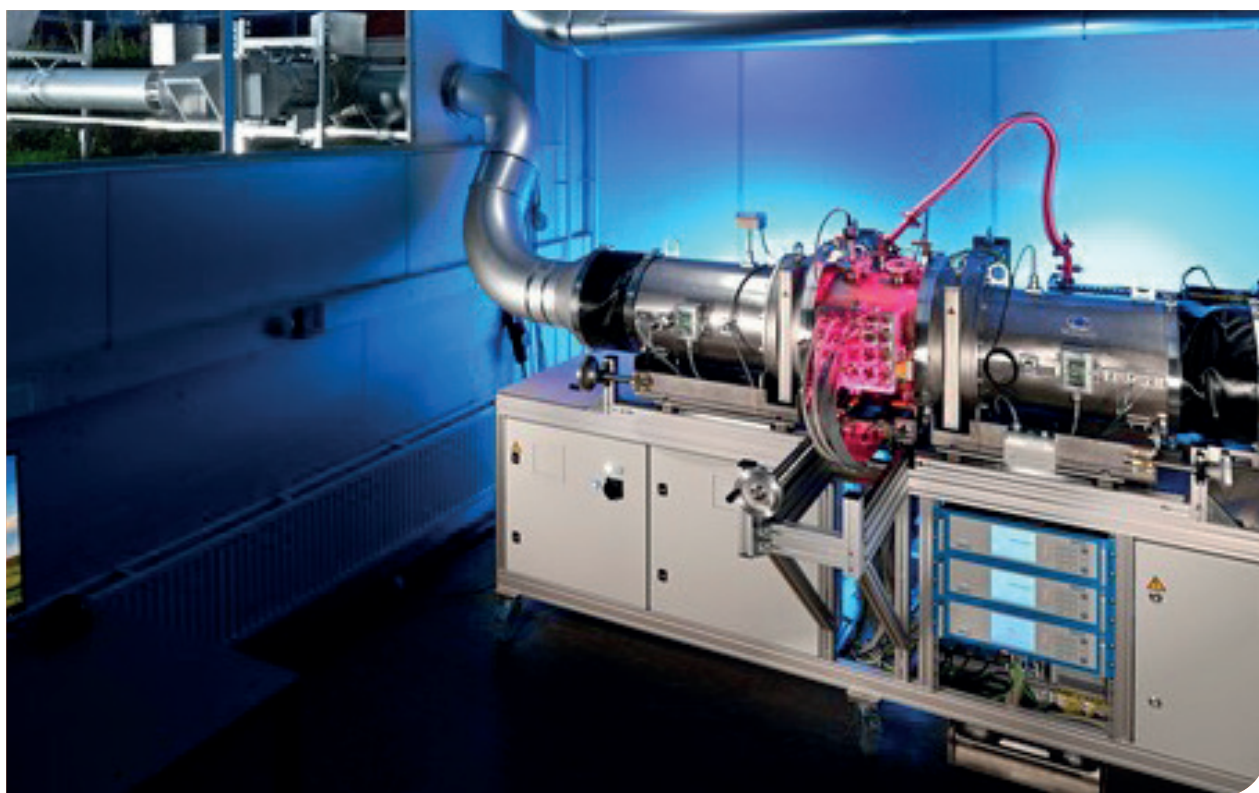
Beatrix Bos is a project manager and impact creator; Luuk van Voorst is a mechanical engineer and is concerned with the physics behind the machine.

"I'm interested in what happens when we increase parameters like size, temperature and speed. I analyse the effects on (energy) consumption, and evaluate and model the results," said Luuk about his role.

As a project manager, Beatrix is responsible for implementation, testing and validation, as well as for marketing and communications. "We use a large number of different pieces of software for transforming data into information. That's why data validation is so important for good modelling."



Beatrix Bos and Luuk van Voorst beside the test device,
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Beatrix Bos
project manager
Carbyon

«Capturing CO₂ in the sorbent enables CO₂ to be recycled, for example for the production of green paraffin.»

Promising prototype

One and a half years ago, after several years' work with smaller test devices, work started with the machines where the process can realise its potential. In the laboratory, samples of various material compositions are measured on a small scale. The secret behind Carbyon's process is in the chemical component used for its sorbent. This absorbs CO₂ and releases it again in a controlled manner, enabling CO₂ to be recycled, for example for the production of green paraffin.

This machine is still just for testing, so that Carbyon can identify the best working conditions for the sorbent. The machine has been built in a modular fashion so that it can work with different temperatures, pressures, quantities and sorbents.

The invention as a whole is based on the research into solar cell materials at TNO (Dutch Organisation for Applied Scientific Research) mentioned in the introduction. The combination developed by Carbyon, the self-designed system and the exactly right ratio of sorbent provide a performance that no one else can currently match.

The valuable sorbent

The sorbent is an impressively simple material that is and will remain readily available. It is frequently used to absorb leaked chemicals, lubricants, paints, heating oil or solvents and thereby neutralise their toxic effects. After all, in Latin, the word "sorbere" means something along the lines of to "absorb". Accordingly, sorbents are liquids or solids that are designed to absorb other substances.

The difficulty lies in the porous carrier material, since applying a wafer-thin layer to it proved to be more complicated than to a flat solar panel. This porous material is necessary as a large surface area is desirable in order to capture as much CO₂ as possible. Activated charcoal is a suitable carrier, because one gram of

activated charcoal has a surface area of 3000 square metres. The reactive layer, which consists of amines or potassium carbonate, is applied to the charcoal using a variety of processes.

Atomic layer deposition is the most important of these processes and involves exposing the carrier material to a gas so that the gas atoms are deposited onto the carrier. This creates a layer just a single atom thick. There are other techniques that are already in development or even being used. However, these create a thicker absorption layer, which the CO₂ must penetrate. This means the process takes more time and energy to work.

Carbyon is currently testing numerous options for heating the sorbent. The start-up sought out collaborations with various universities and institutions of higher education in the Netherlands and elsewhere for the individual parts of the process.

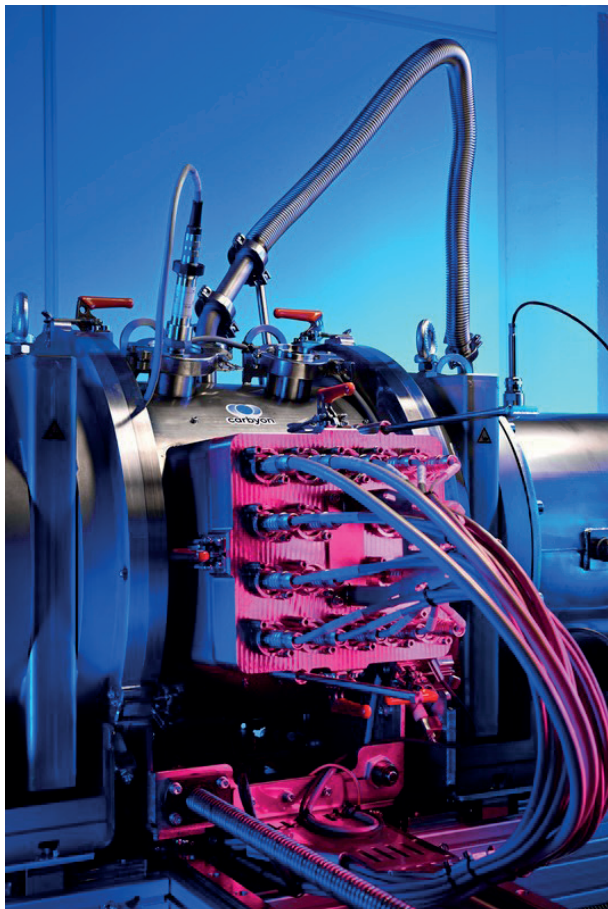
"We mainly spent the first two to three years doing research, but now we're testing the application and developing the machine. We might be described as a deep tech company, as a great deal of time needs to be invested before the technology is ready for the market. In the meantime, all kinds of new business models are springing up that may be able to further accelerate the process," said Beatrix, beaming with pride.

From grams to kilograms

The transition from the test rig to the real machine saw a jump from measuring in grams to kilograms. The next machine will be a hundred times larger, calling for high-performance sensors from KELLER.



Luuk van Voorst with Girmi Schouten, data scientist,
© Bart van Overbeeke Fotografie



Accurate sensors are invaluable for reliable test results,
© Bart van Overbeeke Fotografie

The test setup worked with bottled air in the gram range. This was necessary to guarantee stable testing conditions. Now a real machine and ambient air are being worked with, the project team has combined all technologies into a single machine for the first time and everything can be measured. This requires lots of sensors. At the end of the day, it's still a research facility. "When you're doing research, you don't know what you will find out from the tests. That's why you want the tests to be as accurate as possible," explained Luuk van Voorst for context.

Precise sensors for maximum accuracy

Carbyon uses a range of sensors from KELLER's 33X series. Two absolute pressure sensors that measure up to 1 bar plus one relative and one differential pressure sensor. These measure the drop in pressure above the sorbent and dust filter and create a sorbent cycle in this manner. There is also one sensor in front of the vacuum pump and an absolute pressure sensor in the reactor.

Luuk van Voorst helped to develop the specifications and deliberately chose high-precision pressure transmitters in order to keep measurement errors to a minimum. After all, measurement errors add up, so every measurement needs to be as precise as possible.

But accuracy isn't the only thing that's hugely important, service life is a key factor too. All in all, the measurement conditions are tricky. There are high concentrations of CO₂, large fluctuations in temperature and intense humidity.

Programmable interface

"It's fantastic that 33X series pressure transmitters have an RS485 modbus output directly on the sensor. This is perfect for us because it prevents loss of accuracy while retaining flexibility. Originally, we had three KELLER sensors installed and were able to add a fourth using the RS485 module without additional modifications. This is a big advantage as we want our setup to have flexibility," said Luuk, summing up the progress achieved by using KELLER.

Major contribution to hitting climate targets

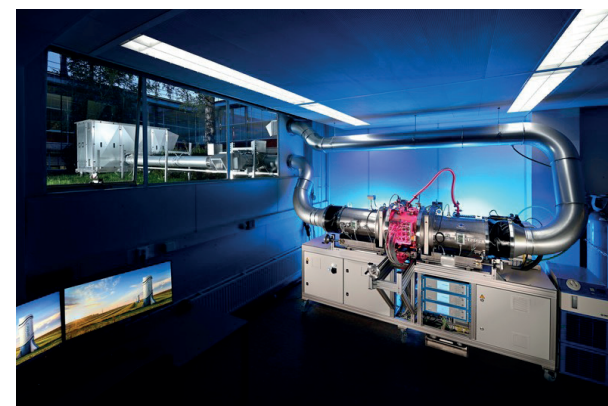
CO₂ storage is very important as climate targets cannot be hit with net-zero emissions alone. Atmospheric CO₂ is already at



Martijn Smit
Commercial Director KELLER
Netherlands

«Due to its selection of pressure transducers and digital compensation electronics, the 33X series is specified to meet the highest levels of precision of up to 0,05 %FS over the entire temperature range.

Accredited calibration laboratories corroborate an accuracy of up to ±0,01 %FS at room temperature for KELLER pressure transmitters in line with the guidelines of the German Calibration Service (DKD).»



Carbyon's third test device,
© Bart van Overbeeke Fotografie

420 parts per million. In order to remove this CO₂ from the air, it is fed through filters that trap CO₂ particles. Once the filters are full, they are heated up, which releases the CO₂ in order to capture it again, to be recycled or disposed of. Disposal alone cannot reverse climate change; however, strategic recycling for the production of synthetic paraffin offers real prospects for a new, economically self-sustaining fuel cycle.

End goal: renewable fuel

Since 2023, Carbyon has been in its test phase and will keep developing its machines until its end goal is achieved. Two test machines are ready for operation and a third is currently being built. In 2024, the main goal is to analyse information derived from the machines' output. What exactly does the captured CO₂ contain and what can be done with it? Answering this key question will open the door to a world of new possibilities.

With the processes that have been developed up to now, heating the CO₂ filters requires so much energy that recycling remains off the table; instead, only disposal is financially viable. Carbyon's new method reduces energy consumption considerably while producing a yield that is up to ten times higher. Carbyon's final goal is a price of USD 50 per tonne of CO₂. At this price point, the filtered CO₂ would become of interest for the production of renewable fuels. If this level is reached, almost nothing would be in the way of the dream of a climate-friendly future.

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