CCP

CCP PROJECT FACTSHEET

3D-PRINTED MATERIALS FOR BOOSTING SORBENT-BASED CO_2 CAPTURE

OVERVIEW

Identifying potential solutions to reducing the cost of capturing CO_2 from oil and gas industry applications is one of central objectives of the CCP (CO_2 Capture Project).

Capturing CO_2 through adsorption is a relatively new approach and much work is being carried out by the CCS sector to improve efficiency, productivity and lower costs. Traditional 'packed bed' adsorption strips CO_2 molecules from a CO_2-containing gas stream by attaching them onto the surface of a solid adsorbent. Periodic regeneration of the adsorbents is required when they reach capacity. This can be achieved though temperature swing (TSA), pressure swing (PSA) or vacuum swing (VSA). Regeneration demands multiple packed beds in parallel to enable continuous operation. All of this typically results in relatively high capital cost, limiting potential in CCS applications.

However, fast-evolving advances in 3D printing offer the potential for tailor-made solutions that could create the step-change in productivity and lower costs needed to boost uptake in CCS applications. CCP has become a co-funding partner in the 3D-CAPS Project Consortium (ERA-NET ACT Program), with partners Aker Solutions, TNO, SINTEF, UBB, Suncor and 3D-CAT, to establish the potential of this new technology in delivering cost-effective adsorption CO_2 capture. This groundbreaking project could radically improve efficiency and lower costs significantly - it began in early 2018 and is due to last two years.

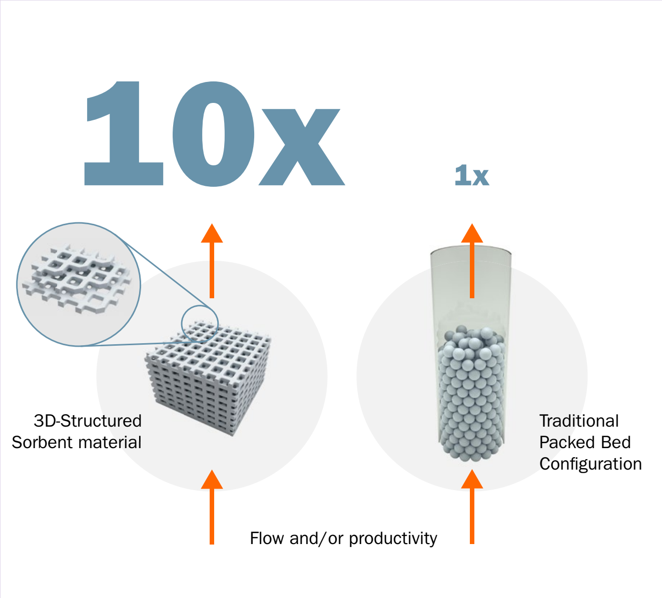
3D CAPS project summary

The objectives of the 3D CAPS project are two-fold:

- To achieve a 10-fold productivity increase (i.e. increasing flow and/or productivity of materials) for two sorbent-based technologies in CCS
- To optimize sorbent shapes with Computational Fluid Dynamics (CFD) and other modelling tools, with direct realization in 3D-printed objects for testing under relevant conditions.

Success in this project should lead to a substantial decrease in overall equipment size and costs. One of the challenges seen in traditional packed-bed solutions is the trade-off between flow-rate through the reactor, pressure drop and kinetics of the adsorption process. 3D-printing will allow bespoke material configuration solutions not available with current production technologies, allowing maximum interplay between these three competing and complementary elements.

Two types of structured sorbents will be developed – hydrotalcites for operation under pre-combustion conditions at elevated pressure (up to 30 bar) in the 350-550°C temperature range; and amine functionalised silica-supported sorbents for operation in post-combustion conditions in the 40-130°C temperature range. The dense and porous ceramic shapes that will be produced are bespoke and cannot be created by normal extrusion techniques.
Key outputs of the project will be to measure performance of both these materials up to Technology Readiness Level (TRL) 5 and to assess techno-economic performance in two CCS applications – NGCC (Natural Gas Combined Cycle) electricity production and decarbonised hydrogen production for refinery applications. 3D-CAPS will produce a blueprint of the technology for further implementation in pilot scale facilities.



Project detail

The 3D-printing process will be carried out on state-of-the-art Digital Light-based Processing (DLP) equipment. The main stages of the project are:

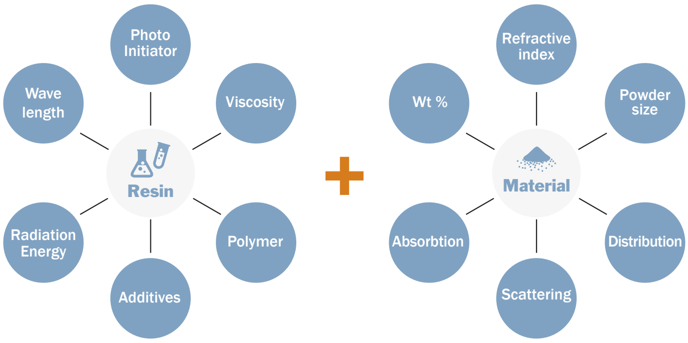
- Prepare pastes for high surface area 3D-printing technology, which, after heat treatment, have intrinsic properties (adsorption capacity and adsorption and desorption kinetics) without significant loss compared to the properties of the base powder material
- Formulation of pastes is one of the most crucial steps in the process to ensure precise viscosity, solids content, stickiness and delamination characteristics. The finished product will have to comply with stringent criteria around stability, geometry, sorption properties and catalytic activity
- Model five customized shapes for mixing concepts for the 3D-sorbents for both processes for separation performance at 10x nominal flow of packed-bed process with special consideration of the heat management that can be promoted by radial mixing
- Manufacture 3D-structures to be tested in relevant environment up to TRL5. Size indication: 2-4cm diameter and 5-10cm length. Requiring 20-100 structures per testing facility
- Test 3D-sorbents under process relevant conditions for 100-1000 cycles, at up to 10x the nominal flow of equivalent packed-bed process
- Devise 3D-sorbent shaping, structuring and packing plan for 3D-sorbents in a reactor system that reduces channelling to less than 1% at large scale implementation
- Prepare business and exploitation plan for further development, scale-up and market implementation of the materials for the relevant processes.

Challenges and Solutions

These are still early days for 3D printing. Much will be learned during the 3D-CAPS project, as only a few examples currently exist where the technology has been used to aid adsorption processes in CCS.

There are a number of specific scientific, technical and commercial challenges that need to be overcome during the course of the project. The main targets with respect to manufacturability vs performance are the shape, size and length of the channels and thickness of the structure walls, which will determine performance. A balance has to be found between feasibility of manufacturing the optimum structure and the levels of accessibility, pressure drop, density, cyclic capacity, adsorption and desorption kinetics that can be delivered at an appropriate TRL. This will need to show high enough promise and generate interest for further uptake from the CCS community.

Meeting these criteria is possible with the help of the toolbox developed for 3D printing.



Timing

During the first 12 months of the project (2018), the main focus was on producing the pastes for each system, while CFD and other techniques will explore possibilities for optimized shapes. The aim is that by midway through year two, the desired shapes can be printed, then tested so that by the end of 2019 the techno-economic analyses will be completed and a blueprint for TRL6 pilot scale implementation will be ready.

The ACT 3D-CAPS project # 271503 has received funding from RVO (NL), RCN (NO), UEFISCDI (RO), and is co-funded by the CO_2 Capture Project (CCP) and the European Commission under the Horizon 2020 program ACT, Grant Agreement No 691712

Accelerating CCS Technologies

ABOUT THE CCP

The CCP is an award-winning group of major energy companies working to advance the technologies that will underpin the deployment of industrial-scale CO_2 capture and storage.

To find out more visit www.co2captureproject.org

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