Chemical looping combustion for CO2-neutral gas facilities

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A novel gas combustion method removing the need for expensive gas separation has been successfully scaled-up. The novel method has gas-to-steam efficiency penalties much lower than alternative CO2 capture technologies, as well as a CO2 avoidance cost reduced by 60 % compared to amine scrubbing. The consortium is already looking to extend it to biomass combustion.

Although cleaner than crude oil or coal combustion, current methods for combusting natural gas still generate CO2 as part of a flue gas mixture including nitrogen, water vapour and other substances.

In this form, the CO2 cannot be stored or recycled. This has pushed researchers funded under the SUCCESS (Industrial steam generation with 100 % carbon capture and insignificant efficiency penalty—Scale-Up of oxygen Carrier for Chemical-looping combustion using Environmentally SuStainable materials) project to look for a viable, alternative combustion method which they found in 'Chemical looping combustion' (CLC).

What makes CLC such a high potential solution for carbon capture and storage?

The biggest advantage of the CLC technology is the fact that air and fuel are never mixed, whilst the energy intense gas-gas-separation step (separating CO2 out of an exhaust gas stream), which is common in other carbon capture technologies, is avoided. This dramatically reduces the energy penalty of CO2 separation.

What was the role played by SUCCESS in its further development?

The SUCCESS project focused on the two most important aspects of the technology: scaling-up of oxygen carrier production and scaling-up of the reactor system design. The main objective of the project consisted in making CLC technology ready for demonstration in the range of 10 MW fuel power input. For that purpose, production processes for oxygen carrier material were scaled-up to the multi-tonne scale and a reactor concept suitable for this size was presented.

What were the main difficulties you faced and how did you overcome them?

The main difficulties lay in the scaling-up of the oxygen carrier material from lab scale to multi-tonne scale. This scaling-up includes two critical aspects: the identification of raw materials available at industrial scale/quantities and the scaling-up of the production process itself.

Large-scale production of oxygen carrier material is performed using raw materials which have more impurities than clean chemicals used at lab scale. The challenge is to identify the impacts of these impurities on the final product and to select the most suitable raw material. These problems were solved during the project, and material production was successfully scaled up with the production of 3.5 tons of material.

The approach consisted in the iterative optimisation of large-scale production, i.e. regular feedback during scale-up process from testing in pilot units. However, we still see further potential for optimisation of the production process, leading to better-performing materials.

How did the validation phase go?

The validation phase went very well. The produced materials have been tested in several pilot units from 10 kW to 1 MW. Operation with these materials was successful in all units. Comparison with benchmark materials shows that the performance of the scaled-up material is similar to that of the benchmark material.

What did you learn regarding the commercial potential of CLC?

The techno-economic analysis of the technology showed that the biggest potential for CLC of gaseous fuels, such as natural gas or refinery gas, is in industrial steam production. We also saw how critical it is to make the step to move on to the next scale (in the order of 10 MW) to gain operational long-term experience with the CLC technology.

Do you have any follow-up plans?

Based on the results of the project, we are confident that the technology is ready for demonstration at the next scale. There are, however, no specific follow-up plans for demonstration projects yet.

It would also be of great interest to develop CLC technology for the use of biomass towards below-zero emission energy production. In light of the remaining carbon budget for a below 2 °C increase, Bio Energy CCS (BECCS) is gaining more and more importance. This has also been underlined in the last assessment report of the IPCC. We see a great potential for CLC in this field.

More information: Project page: cordis.europa.eu/project/rcn/110098

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