ECN

Energy research Centre of the Netherlands

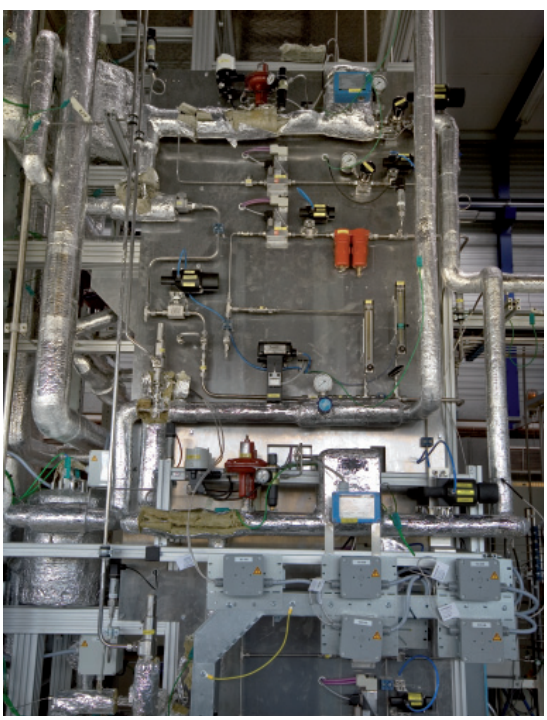
Strong Solution for CO_2 capture: SEWGS

A novel technology for capturing CO_2 in natural-gas and coal fuelled power plants is being developed at ECN. This technology is particularly attractive for decarbonising gas turbine fuel, and hence provides opportunities for power generation with low CO_2 emissions, high power efficiency, and lower cost of capturing CO_2 for storage. In collaboration with Air Products, ECN have designed and constructed an experimental unit. The unit has demonstrate continuous CO_2 capture and generated process data that is needed to quantify industrial-scale performance and the effect on power plants.

The unit consists of six reactors, each six meters tall. The reactors contain beds of pellets that catalyse chemical reaction and adsorb CO_2. By switching valves the reactors are operated in cycles of CO_2-adsorption and desorption. Since at any time there is always at least one reactor in adsorption mode and at least one reactor in desorption mode, a continuous production is obtained. Design, engineering, construction, and commissioning of the unit took less than one year.

Advantages of the technology include high carbon recovery rates exceeding 90%, considerable saving of investment costs for heat exchanging equipment, and high efficiency since the decarbonised fuel is produced without noticeable loss of compression energy. The technology first developed for natural-gas fuelled combined cycle power plants, showed also potential for coal gasification plants and industrial applications.

Frontal view of the experimental unit, showing three reactors



Feed section for supplying, mixing and heating gases and steam

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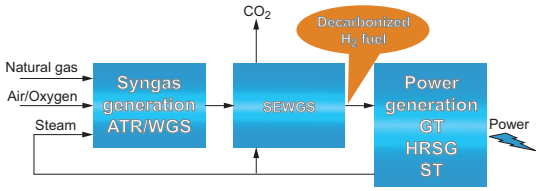
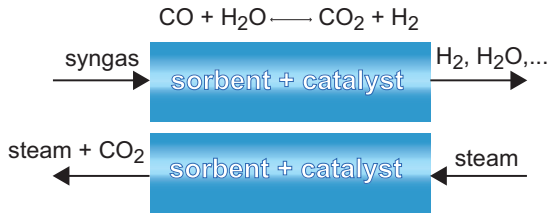
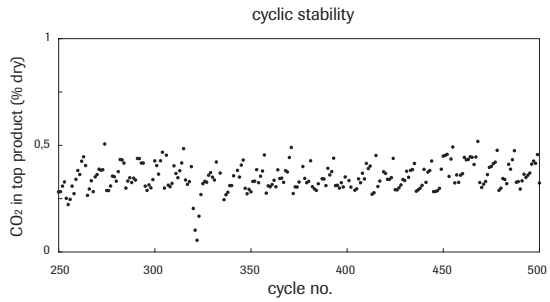


Power production with CO_2 capture by SEWGS. Power is generated by gas turbines (GT) and steam turbines (ST), heat is recovered for steam generation (HRSG). Steam is needed for autothermal reforming and water gas shift (ATR/WGS), and for CO_2 removal by SEWGS.



SEWGS principle: (upper) adsorption and reaction at high pressure (lower) desorption at low pressure



Long term stability test of new K-MG30 sorbent

The Process

The Sorption Enhanced Water Gas Shift process (SEWGS) is a technology that combines the water-gas shift reaction with CO_2 capture at high temperature. The feed to the SEWGS unit is syngas, which is produced by reforming and high temperature shift. The products are a pure CO_2 stream at low pressure and a H_2-rich stream at high pressure and high temperature. The CO_2 can be compressed and transported to a suitable storage location, e.g. geological formations. In a reactor CO is converted with H_2O to CO_2 and H2 (water-gas shift reaction). Simultaneously, CO_2 is removed from the gas by sorption on a promoted hydrotalcite-like material. The sorbent is regenerated by purging counter currently with steam at low pressure. Since adsorption of CO_2 is thermodynamically favoured at high pressure and desorption at low pressure, parallel reactors are operated in pressure swing cycles.

The SEWGS development

Promoted hydrotalcites can be used in the sorption enhanced water gas shift based capture system. The experiments in the SEWGS unit proved good long term stability of the hydrotalcite sorbents for CO_2 capture. Combined WGS and CO_2 capture experiments confirmed the technical feasibility of the SEWGS process for pre combustion CO_2 capture. Continuous SEWGS experiments have been performed on the multi column SEWGS test rig. Several cycles were tested and they all yielded in a relatively pure hydrogen product, which means a high CO_2 capture ratio.

The SEWGS technology is also tested for application in coal gasification combined cycles (IGCC). In the EOS LT CAPTECH consortium, ECN and KEMA have shown that the sorbents of choice (promoted hydrotalcites) are capable of capturing CO_2 in presence of hydrogen sulphide. H_2S also adsorbed on the material and was also desorbed in the regeneration step of the cycle. Multiple cycles were performed and no deactivation of the sorbent was observed.

Recent results

The EU FP7 project CAESAR has taken forward the SEWGS development to the next phase of pilot plant design. In the CAESAR project a new hydrotacite sorbent (K-MG30) has been identified and tested for more than 1000 cycles.
This new sorbent showed good stability of the working capacity, low steam demand for regeneration as well as catalytic shift activity demonstrating that in this process a shift catalyst is superfluous. This also brings substantial economic and technical benefits.

Together with our partners: Air Products, BP, ECN, SINTEF and Poly Tecnico di Milano, the application in coal gasification (IGCC) power plants is being investigated. Detailed studies on refinery and blast furnace applications are also performed. More site specific assessments of these the latter applications will be executed in the framework of the Dutch National programme $CATO_2$.

Outlook

In the coming four years the SEWGS development will progress into the next phase i.e. demonstrating the SEWGs process in a pilot plant demo of which the capacity is roughly 100 (2.5 MWth) times larger (reactor diameter 10 times lager) than the current multi column SEWGS installation, but still 100 times smaller than a commercial scale installation. This pilot will use real syngas and will be located on an industrial site or power plant site.

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