Enhanced Capture of CO_2 Newsletter

www.encapco2.org

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Volume 5

ENCAP Project's website

ENCAP Project is now successfully completed.

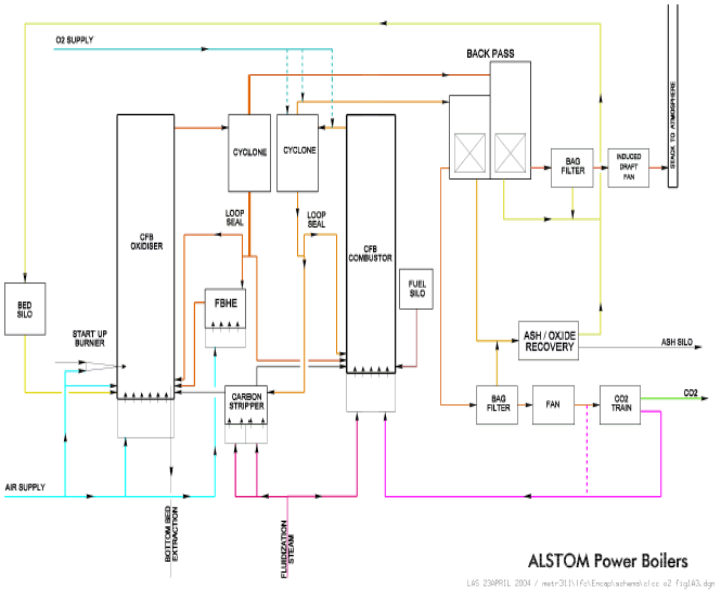
Still, project partners have agreed to maintain the Project's website, in order for it to continue to provide an extended web-based source of information usable to a wide target group in order to assure the effective dissemination of the project's results and the experience gained.

ENCAP Highlights

Chemical Looping Combustion

Feasibility study of a 455 MWe CLC boiler/plant and recommendations for the next step

A conceptual design for a greenfield advanced chemical looping circulating fluidized bed (CFB) coal-fired power generation plant has been developed for capture of CO_2 by ALSTOM Power Boilers. It's an entirely new combustion technology with no contact between fuel and combustion air, featuring the inherent separation of CO_2 and the avoidance of nitrogen oxide formation.



Scheme of CLC CFB for solid fuels

The Chemical Looping Combustion (CLC) integrates air separation into the combustion process and produces a separated CO_2/H_2O flue gas stream for CO_2 capture. The principle is to separate the fuel oxidation process from the air stream by carrying oxygen to the fuel in the form of a metal oxide. The design and costing of a 455 MWe CLC CFB plant have been performed. The following figure shows a scheme of CLC CFB for solid fuels. Investment costs including costs of all equipments and operating costs have been determined and a preliminary evaluation has shown that the CO_2 avoidance cost is between 7 and 10€/ton CO_2, depending on the type of fuel, and the electricity cost about 30€/MWh.

The work that has been done demonstrated that the CLC is a feasible concept. For the boiler island, there is no foreseen reduction in availability compared to a conventional CDFB boiler, due to the process simplicity. The CO_2 trains, mainly compressors, are proven units. No availability reduction is expected. Finally, an overview of the main technical data for CLC CFB operating for two different fossil fuels (bituminous coal and petcoke) is illustrated in the annexes A1 and A2 of the SP4 Public Summary Report, Del. 4.2.4.

Inside this issue:

Special points of interest:

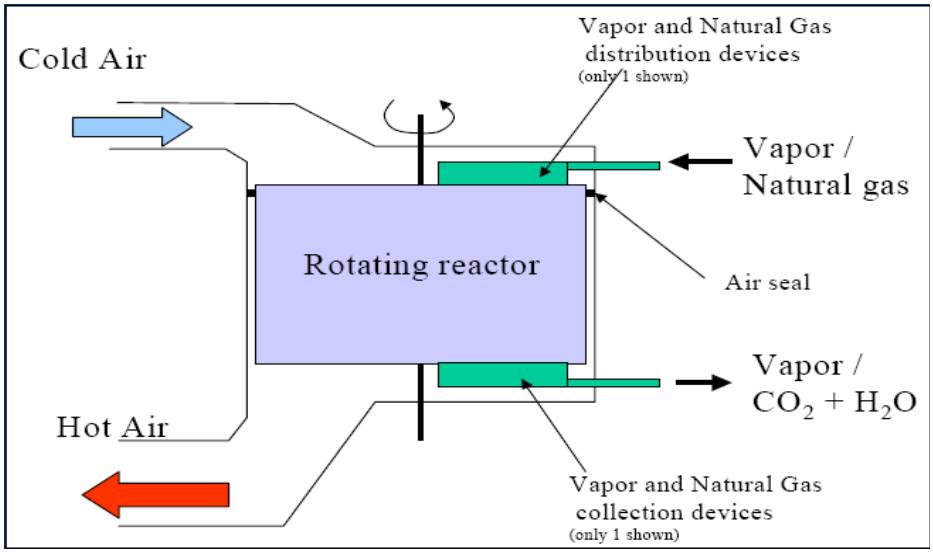
- Chemical Looping Combustion
- High-Temperature Oxygen Generation for Power Cycles

Alternative concepts

In ENCAP SP4 alternative concepts were also explored to evaluate the potential of novel fixed-bed reactor concepts in CLC. The study was focused on natural gas as the primary fuel. Two studies were carried out in parallel, on one side, IFP studied the case of rotating monolith based CLC and, on the other side, TNO developed the membrane assisted CLC reactor.

In order to avoid particles from a fluidized bed CLC reactor entering the gas turbine, IFP proposed a rotating reactor that allows for continuous production of hot air on one side and CO_2 on the other side. The oxido-reduction reactions take place in a monolith coated with appropriate material.

The conclusions derived from the simulations and the experimental work show that this concept is feasible; it involves fewer inventories than other reactor types and is compatible w/ turbine standards. Also, the technology that is used (regenerative heat exchangers) is close to state of the art solutions.



IFP rotating reactor

The reactor developed by TNO uses membranes to form a physical barrier between the active metal containing particles and the oxidizing and reducing gas streams. This barrier is a macro porous membrane allowing the gas streams to diffuse while the solid particles stay fixed. Some of the advantages are the smaller losses at the exhaust, the enhancement of the performance of the system by a higher reactivity and the immobilization of the particles that result in no attrition and less stress on the particles. Also, as the design does not contain any moving parts, high pressure could be applied switching between the oxidation and reduction step. A pilot reactor was set up at TNO and initial experiments (up till 1200°C) were run within the frame of the ENCAP project.

By integrating these concepts in a gas turbine power cycle, it was found that if using a double reheat process configuration, a process efficiency of 52% can be achieved.

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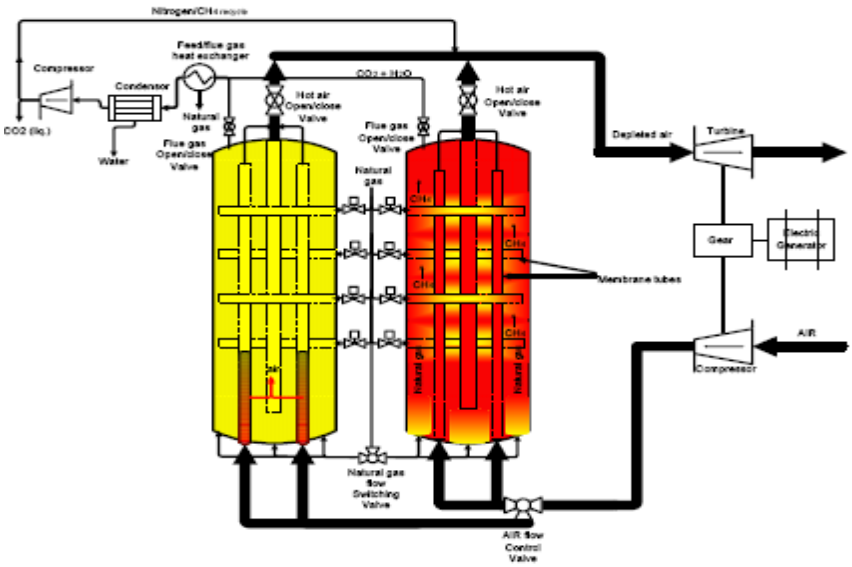

TNO membrane assisted reactor

High-Temperature Oxygen Generation for Power Cycles

Economic evaluation of components and sub-systems costs for process selection

Aim of this task was to perform the necessary engineering, cost, operability and reliability assessment of the leading process options in order to enable the recommendation of the most promising technology, i.e. a High-Temperature Oxygen generation system (HTO) integrated in fossil-fuels power plant with CO_2 capture. Final purpose of this integration was the achievement of the ENCAP targets, i.e. a CO_2 capture rate of at least 90% and a CO_2 capture cost reduction of 50%, with reference to the present CO_2 separation technology (scrubbing).

The three high-temperature working technologies for the oxygen supply considered for the process assessment were all based on special ceramic materials working at high temperatures (600-1000 °C).

In particular:

a) ***Oxygen Separator Membrane*** that is based on the transport of oxygen ions through a ceramic membrane made from perovskite or similar structures.

The ceramic membrane separates selectively the oxygen from air at high temperatures based on partial pressure ratios The oxygen flux through the membranes can be maximised by decreasing the thickness of the membrane material and by reducing the partial pressure at the permeate side by means of a carrier or sweep gas.

b) ***Oxygen Transport Membrane (OTM)*** works on the same principle as the oxygen separator. In this case, the "sweep" gas at the permeate side is replaced by a reactive fuel gas, partially or totally oxidised by the permeated oxygen.

c) ***Ceramic Autothermal Recovery (CAR)*** that utilises the oxygen storage properties of pyrovskite type materials at high temperatures.

ENCAP was organised as an integrated project (IP), which started on March 1st 2004 and was completed by February 2009.

In order to identify the most promising option, different candidate scenarios were screened and ranked.

The three finalized process options resulting from the selection procedure were:

1. OTM separator integrated in PF - oxyfuel boiler scenario,

2. CAR unit integrated in PF -oxyfuel boiler scenario

3. OTM reactor in an Integrated Reforming Combined Cycle (IRCC) scenario.

After the technical evaluation of the three process concepts, an economic comparison of the leading options was made and in the final step, the CAR process was selected by SP5 for a further validation work within ENCAP, in preparation to the eventual construction of a pilot plant. The criteria that determined the best option were that CAR process has higher availability and flexibility, the adsorption process is of higher maturity and a bypass of CO_2 capture is possible.

Scale-up trials of industrial CAR materials

The work was focused on the development of a commercial perovskite adsorbent with the best trade off between working oxygen capacity and chemical stability of the base perovskite composition and between the CAR process performance and mechanical stability of the pelleted sorbent.

The experimental work consisted of sample preparation and characterization, measurement of O2- sorption isotherms, dynamic oxygen sorption/ desorption studies and bench-scale CAR-process experiments to compare the performance of different CAR-materials. Additionally experiments have been carried out to investigate more complex pellet geometries.

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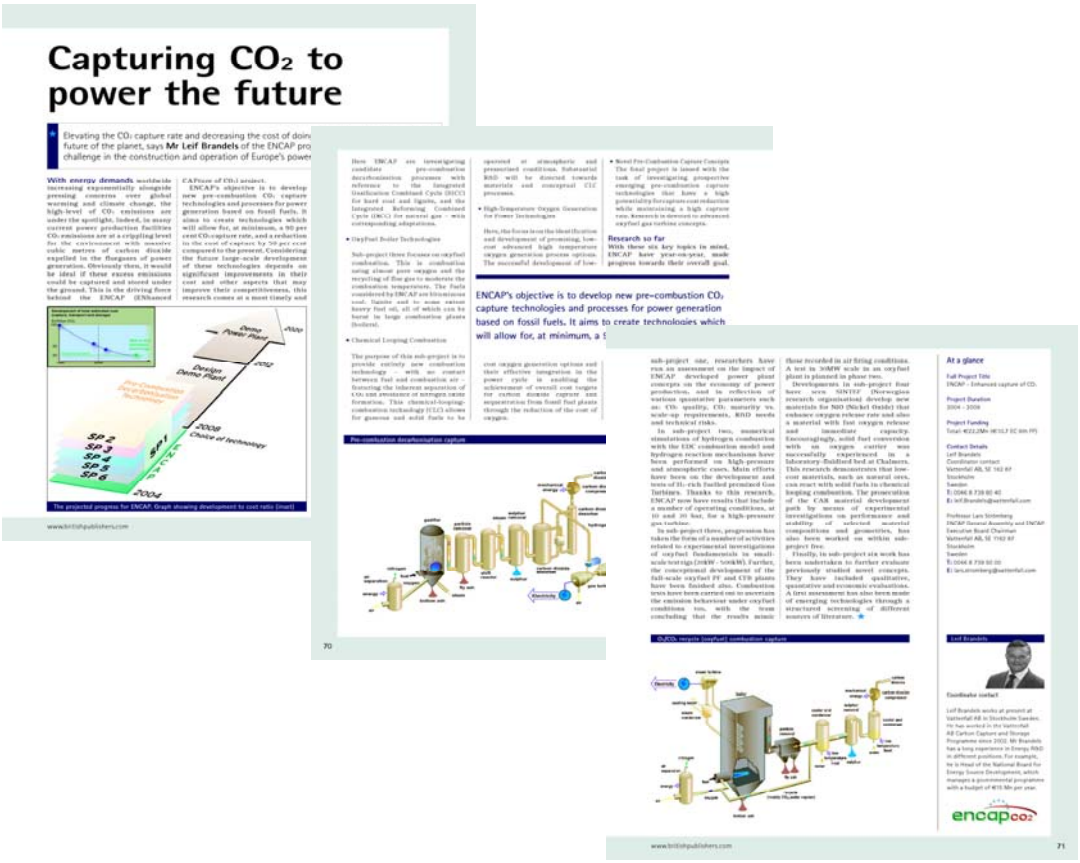
ENCAP in "*eStrategies Projects*" Magazine December issue



ENCAP Project was presented in *eStrategies Project* Magazine, published by British Publishers with a widespread exposure and dissemination for selected National Agencies, Framework Projects, academic institutions, Eureka projects and commercial research units is achieved via a high profile communications drive, targeting approximately 39,000 key policy and decision makers across both the private & public sectors throughout Europe.

Information on Upcoming Events related to power generation with CO_2 capture

- 4th International Conference on Clean Coal Technologies, *May 18-21, 2009*, Dresden, Germany
- The coherence of non technological aspects of CCS and monitoring, FENCO ERANet Workshop, 10th June 2009, Amsterdam, The Netherlands
- 5th Trondheim Conference on CO_2 Capture, Transport and Storage, *16-17 June, 2009*, Trondheim, Norway
- CarbonWorld Doha 2009, *14-15 October 2009*, Doha, Qatar

More info about the events can be found in http://www.encapco2.org/events.htm

Project Partners