Enhanced Capture of CO_2 Newsletter

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CASTOR - ENCAP - CACHET - DYNAMIS Training Seminar — Workshop

The CASTOR, ENCAP, CACHET and DYNAMIS projects, funded by the European Commission under the 6th Framework Program, are pleased to invite you for a common Technical Training Workshop.

This event will be held in IFP-Lyon, from 22 to 24 January 2008.

The objective of the Workshop is to review what has been achieved by the different projects in terms of technology development for CO_2 capture (post-, oxy- and pre-combustion) and also in CO_2 geological storage (storage part of CASTOR).

It is also an unique opportunity for exchanging between stakeholders and researchers involved in the different projects.

ENCAP Training Seminar - Workshop

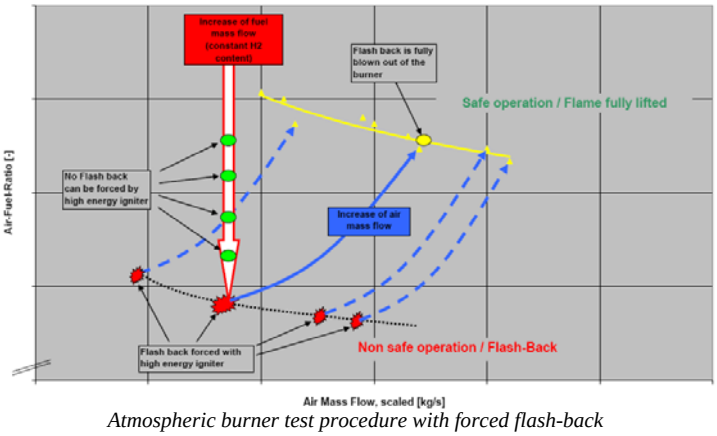
ENCAP Highlights

Pre-combustion Decarbonisation technologies

Limits of current burners using H_2-rich fuel mixtures

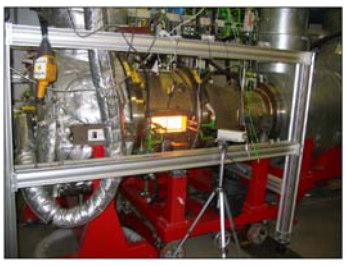
One of the objectives within the ENCAP project is to develop a lean premixed burner for H_2/N_2 fuel mixture with high percentage of H_2 volume content. To this attempt the two largest European gas turbine manufacturers, Siemens and ALSTOM, have decided to collaborate with two experienced R&D providers in this field in order to generate fundamental knowledge on the combustion of H_2-rich fuels in gas turbines to develop optimized combustors capable of safely burning H_2-rich mixtures with H_2 content approaching 100%.

Benchmark investigations of the current Siemens burner at atmospheric and at a pressure of 1 to 9.5 bar conditions with different fuel mixtures with 50 vol.% to 90 vol.% H_2 and different mass flows were performed and provided in the test ring. A procedure called "forced flash-back" was applied to determine the safe operations limits. It was not possible to achieve full load operation for any H_2/N_2 fuel mixtures, using this flash-back procedure to determine the burner stability.



Atmospheric burner test procedure with forced flash-back

High pressure tests at 9.5 bar slightly showed flash backs, using the forced flash back procedure while some part load points with a 70/30 vol.% H_2/N_2 mixture were found without the forced flash back procedure. Almost undiluted H_2 could not be run with the standard natural gas burner. The result of these tests showed, that the standard burner was not able to burn N_2 diluted H_2 fuels safely at base load conditions and needs to be modified.



Atmospheric test rig arrangement (SIEMENS burner)

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Special points of interest:

- CASTOR - ENCAP- CACHET and DYNAMIS Training Seminar — Workshop to be organized on 22-24 January 2007
- Highlights within the ENCAP Project

Analysis and Reduction of the Final Reaction Mechanism for H_2-rich combustion

The aim of this study was to find a reduced reaction mechanism that both efficiently and accurately represents H_2/O_2 kinetics over a large range of conditions, particularly for fuel lean mixtures at elevated pressures as present in a gas turbine combustor. Based on a thorough analysis of the detailed H_2/air mechanism of Li *et al.* (2004), several reduced mechanisms have been derived from the full detailed mechanism and tested for the prediction of laminar flame speed, ignition delay, and extinction using a 1D laminar flame code and a PSR model, respectively. Furthermore, these mechanisms have been applied to numerical simulations of two turbulent jet flames with the CFD code SPIDER using the EDC (Eddy Dissipation Concept) combustion model.

The results of this study show that a reduction of the detailed mechanism has a large effect on the prediction of the isolated processes of laminar flame propagation, extinction, and particularly of autoignition, whereas the effect of the reduction becomes small for predictions of the investigated turbulent jet flames. Hence, the reduced mechanisms are expected to yield satisfactory results for gas turbine applications.

Find out more at: *http://www.encapco2.org/publications/SP2_2_3_4_SummaryReportl.pdf*

Preliminary documentation of complete plant concepts for pre-combustion CO_2 capture

This work summarized the technical and financial details of power plant concepts for different fuels with and without CO_2-capture.

On the basis of the process engineering work during the first period, a complete documentation of all developed plant concepts, with and without CO_2 capture including a techno-economic assessment, has been acquired. The determination and comparison of all technical and economic key figures are examined in order to investigate the commercial introduction of such concept in Europe. Each participating party contributed a detailed description of their section in each concept. RWE, Lurgi and IFP (NG case) were responsible for description of the syngas generation and gas treating units. Siemens handled the Combined Cycle and Air Liquide covered the air separation unit (ASU). Statoil and Siemens contributed know-how for the natural gas concept while RWE and Statoil added their operational experiences. The cases examined and compared with the reference cases defined by SP1 were the following:

Hard coal IGCC without CO_2-capture (case 1)
Lignite IGCC without CO_2-capture (case 2)
Natural gas ATR with CO_2-capture (case 3)
Hard coal IGCC with CO_2-capture (case 4)
Lignite IGCC with CO_2-capture (case 5)

Find out more at: *http://www.encapco2.org/publications/D_2_5_1_SummaryReport.pdf*

		Case 1 Hard coal	Case 2 Lignite	Case 3 Natural gas plus capture	Case 4 Hard coal plus capture	Case 5 Lignite plus capture
Feedstock Mass Flow Feedstock LHV	kg/s MJ/kg	74,08 25,17	179,8 8,89	39,56 46,5	81,5 25,17	198,98 8,89
Thermal Input Feedstock (LHV)	MJ/s	1864,6 + 20,9 (NG)	1598,4	1838,9	2051,4	1768,81
Thermal Syngas Flow to GT	(MJ/s)	1508,94	1463,8	1468	1481	1477
Gross Power Output	MW	986,03	931,74	872,45	956,14	899,4
Gross Efficiency	%	52,82	58,53	47,44	46,61	50,85
Air mass flow to GT	kg/s	269,39	168,23	188,77	294,06	191,05
Total Aux. Consumption	**MW**	**111,94**	**105,33**	**117,8**	**219,6**	**182,2**
Net Power Output	**MW**	**874,14**	**826,41**	**754,65**	**736,54**	**717,1**
Net Efficiency	**%**	**46,36**	**51,7**	**41,04**	**35,9**	**40,54**
CO_2 captured	**kg/s**	-	-	**96**	**184**	**169**
CO_2 capture rate	**%**	-	-	**92,4**	**92,2**	**85**
CO_2 emissions	**g/kWh**	**746**	**799**	**38**	**79**	**146**

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Oxy-fuel boiler Technologies

Oxy - fuel combustion fundamentals, slagging and fouling and analysis of impact on flue gas treatment equipment

This sub-project is focused on oxy-fuel technologies where combustion using almost pure oxygen and recycle of flue gas to moderate the combustion temperature is carried out. To demonstrate the oxy-fuel process used for power generation of large scale coal fired boilers was required from several different areas such as combustion and boiler technique, oxygen production, flue gas treatment and storage, process and emission control, safety requirement, etc. A fundamental understanding of combustion in denitrogenated air has been obtained throughout the extensive experimental work performed in the 100 kW gas-fired test unit of Chalmers and in the 20 kW coal-fired of IVD at the University of Stuttgart.

The objectives of the experimental activities at Chalmers were to carry out tests during air-fired conditions and oxy-fuel tests with 21% and 27% by volume oxygen in the recycled feed using liquid petroleum gas (>98 mole% propane) as fuel. The results of the experimental work carried out was to improve the knowledge on the oxy-fuel combustion technique with respect to the flame characteristics with an emphasis given the radiative heat transfer and burn-out behavior.

The tests and experiments at IVD were carried out at the atmospheric 20kWth test facility for pulverized fuel combustion. The focus of interest at the IVD 20kWth unit was put on the characterization of pulverized fuel combustion under oxy-fuel conditions. Different coal qualities (bituminous coal and lignite) have been characterized in terms of combustion, emission and fly ash behavior under un-staged and staged combustion conditions, with both air and an O_2/CO_2 mixture containing 27% O_2. The tests and experiments carried out aimed at identifying characteristics of oxy-fuel combustion and to compare them with parameters characteristic for pulverized fuel combustion under air conditions. Several data sets were

compiled and delivered to validate combustion simulation models under oxy-fuel conditions. Primary measures to reduce NOx emission were tested for suitability for the oxy-fuel process. Further emission investigations related to the recirculation of flue-gases were performed successfully. Preliminary fly-ash analyses and deposit tests were performed to identify major effects of an oxy-fuel environment on fly-ash and deposit properties.

Find out more at: *http://www.encapco2.org/publications/SP_3_1_4_SummaryReport.pdf*

Feasibility study of an integrated 445 MWe oxy-fuel CFB supercritical boiler

A conceptual design for a greenfield advanced oxy-fuel Circulating Fluidized Bed (CFB) coal-fired power generation plant for CO_2 capture has been developed by ALSTOM Power Boilers. The main focus of the work carried out was the research, development and validation of applying the oxy-fuel combustion in CFB boilers.

This work has demonstrated that oxygen-fired CFB is a feasible concept, close to the conventional CFB process with existing proven components. The boiler size is different due to the operating conditions and for the boiler island there is no foreseen degradation of availability, resulting from the process simplicity. The cryogenic air separation unit (ASU) is a proven unit for this size (3300 tpd), even with routine teleoperation in some plants and very long runs between shutdowns while no availability degradation is expected. The most critical points of oxy-fired CFB are mainly O_2 injectors (70% O_2 content), back-pass fouling and O_2 heater. Furthermore, it has been noticed that CFB is the most suitable technology for biomass co-firing and the CO_2 not recovered in the CO_2 capture process (10% approx.) might be compensated by biomass co-firing. The value selected for O_2 fraction (70%) is not a limit of the process and higher values, up to 90%, have been investigated in this experimental work.

Construction of the Vattenfall 30MW oxy-fuel pilot plant in Schwarze Pumpe, Germany

Novel pre-combustion capture concepts

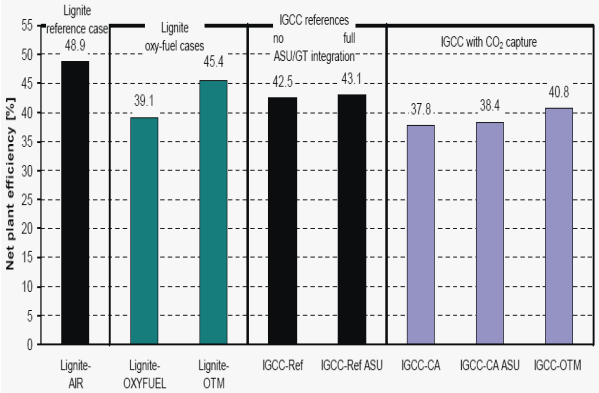
The aim of this sub-project was to investigate prospective emerging pre-combustion capture technologies having a high potentiality for capture cost reduction while maintaining a high capture rate. A vertical, three-step approach by screening, modelling and verification was decided. This involved actions like worldwide screening of energy conversion technologies, generating new ideas on advanced power generation and cycle development, classification of emerging technologies by in-depth investigation - supported by modelling, conceptual design, novel techniques for experimental clarification of selected key elements, and economic ranking.

ENCAP is organized as an integrated project (IP), which started on March 1st 2004 and will be completed by February 2009.

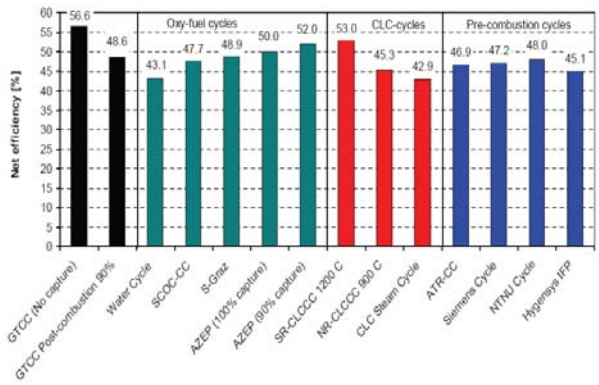
Substantial work has been carried out dealing with power cycle simulations in order to have a fair and extensive comparison of net efficiency and CO_2 capture rate of different power cycles concepts with CO_2 capture. There were separate comparisons of natural gas-fired cases and coal-fired cases (both lignite and hard coal).

This work-package had the objective of identifying the potential difficulties of practical implementation of these cycles in real world power plants, from the point of view of the equipment manufacturers. The mission was to examine the components (compressors, turbines, combustors, heat exchangers and novel components) of those cycles and to evaluate them with respect to the attributes (capital cost, efficiency, reliability, availability, maintainability and life expectancy).

Find out more at: *http://www.encapco2.org/publications/SP6_D6.1.4_D6.2.1_SummaryReport.pdf*



Net efficiencies of all coal-based cycles



Net plant efficiencies of the natural gas-fired cycles

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Project's Dissemination & Training Activities

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Information on Upcoming Events related to power generation with CO_2 capture

- CASTOR-ENCAP-CACHET-DYNAMIS Common Technical Training Workshop, *January 22-24, 2008*, IFP Premises, Lyon, France
- 7th European Conference on Coal Research and its Applications, *September 3-5, 2008*, Cardiff, Wales
- GHGT-9, 9th International Conference on Greenhouse Gas Control Technologies, *November 16-20, 2008*, Washington, DC, USA

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

Project Partners