CEMCAP

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CEMCAP

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CO_2 capture from cement production

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Clinker cooler film

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VDZ gGmbH

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Abstract
CEMCAP has produced a film of testing the oxyfuel clinker cooler and additional elements for dissemination. The testing of key technologies for the oxyfuel capture in cement plants included the operation of the prototype oxyfuel clinker cooler in industrial environment in WP9. In collaboration with WP2 it was decided to use the opportunity of the tests in the cement plant to produce a film document for publication in YouTube. Furthermore, additional elements and descriptions for dissemination of the success achieved in the CEMCAP project were developed. These were especially samples of the world's first clinker cooled with oxyfuel technology, a photo documentation, websites, VDZ bulletin articles and blog content.

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1 CLINKER COOLER FILM

1.1 Publication of the clinker cooler film on Youtube

CEMCAP - CO_2 capture from cement production

https://youtu.be/QSmEJgVKz-A

The film recorded 720 visits at YouTube by October 2018.

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1.2 News on ECRA/CEMCAP/CLEANKER Workshop and Clinker cooler film as published on VDZ website

https://www.vdz-online.de/en/latest-news/newsdetails/news/workshop-zu-carbon-capture-technologien-in-der-zementindustrie-am-17-oktober-2018-und-neuer-cemcap/cobj/19025/

News
Monday, 16. April 2018
Workshop on carbon capture technologies in the cement industry on 17 October 2018 and new CEMCAP film.

A workshop on innovative carbon capture technologies in the cement industry will take place in Brussels on 17 October 2018. The event, organised by ECRA and the research groups CEMCAP and CLEANKER, will investigate the technological and economical boundary conditions for application of carbon capture and storage technology in the cement industry. Participation is free of charge. The CEMCAP project on carbon capture and storage in cement production has also recently released a film providing information about the innovative oxyfuel cooler technology. VDZ is involved both in the CEMCAP project and in the CLEANKER project, which researches carbon capture and storage by means of calcium looping.

The CEMCAP project is funded from the European Union's Horizon 2020 research and innovation programme as part of grant agreement number 641185. CEMCAP pursues establishment of the conditions necessary for using carbon capture and storage technologies in the European cement industry. Presentations from the second ECRA/CEMCAP workshop held in November 2017 can be downloaded here < https://ecra-online.org/research/ccs/presentations-and-posters/>.

The CEMCAP film now released details the project's goals and background and documents a number of project stages. It is available for download here. <https://youtu.be/QSmEJgVKz-A>

The CEMCAP film

The CLEANKER project, brought to life in 2017, is also funded from the EU's Horizon 2020 programme (grant agreement number 764816). CLEANKER is engaged in testing carbon capture by calcium looping at industrial scale.

By using CO_2 capture technologies, Europe's cement industry could contribute substantially to climate protection, particularly in respect to future reductions of process-related CO_2-emissions.

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For more details about CEMCAP and CLEANKER, including on who the project partners are, visit VDZ's websites:

VDZ's CEMCAP Project Website <https://www.vdz-online.de/en/research/current-projects/cemcap/>

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2 THE WORLD'S FIRST CLINKER COOLED WITH OXYFUEL TECHNOLOGY

2.1 Clinker sample from the oxyfuel clinker cooler prototype

Samples of the clinker from the oxyfuel clinker cooler prototype, which were cooled in CO_2–rich atmosphere, have been prepared in small cylinders with the reference to the CEMCAP project and partners involved in WP9. These cylinders were used as presents to raise the attention on the project and the successful result of the tests and operation of the pilot installation of oxyfuel cooler technology in the industrial environment at the HeidelbergCement plant in Hannover. Samples have especially been distributed to key stakeholders for further development of capture technologies in the cement industry at the Climate Change working group of CEMBUREAU and at the ECRA/CEMCAP/CLEANKER workshop on "Carbon Capture Technologies in the Cement Industry" in Brussels, 17.10.2018.

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2.2 News on successful testing of the oxyfuel clinker cooler prototype as published on VDZ website

https://www.vdz-online.de/en/latest-news/newsdetails/news/first-cement-clinker-produced-with-oxyfuel-cooler-technology/cobj/20677/

News
Thursday, 4. May 2017
First cement clinker produced with oxyfuel cooler technology

The CEMCAP partners IKN, HeidelbergCement and VDZ have successfully managed to produce cement clinker using the oxyfuel cooler technology. The innovative oxyfuel clinker cooler prototype has been tested during the last 6 months, as part of the EU research project CEMCAP. The project is focused on preparing the ground for large-scale implementation of CO_2 capture at cement plants for later storage or use (CCS, CCU). The European cement industry could make a significant contribution to climate protection through CO_2 capture technology, which is essential for future mitigation of cement industry's process emissions.

The overall aim of this experimental work was the testing of an oxyfuel cooler in an industrial surrounding in order to ensure sufficient cooling performance (efficiency) and clinker quality. Despite the challenges in the project, CO_2 concentration levels of the cooling medium higher than 70 vol.% have been achieved repeatedly by the team and clinker samples were taken.

With the objective to bring CO_2 capture technologies for the cement industry to a higher

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Technological Readiness Level (TRL) and hence closer to deployment, VDZ tested the oxyfuel clinker cooler prototype from September 2016 to March 2017 in a HeidelbergCement plant located in Hannover, Germany. The prototype was based on theoretical concepts developed within the European Cement Research Academy's project phase III. The most demanding task of the prototype design was to manage the extraction of hot clinker from an operating kiln line. It was accomplished through the development of an innovative clinker extraction system by IKN GmbH. The testing process parameters were recorded continuously and exhaust gas streams were sampled and analysed by VDZ to rate the sealing efficiency against false air ingress. Clinker samples (input and output) were taken periodically for further analysis.

The oxyfuel cooling medium (CO_2–rich gas) was synthetically produced on-site through the injection of CO_2 into the pilot plant from a filling station equipped with CO_2 bottles. As CO_2 has a higher density compared to air, and the risk of accumulation in sublevel areas, special safety measures were implemented on-site, like the installation of a static CO_2 warning system at ground level and mandatory use of a mobile CO_2 detectors. No leakages of CO_2–rich gas have been detected during the experiment. A continuous injection of CO_2 into the pilot plant was required during the trials to maintain a constant CO_2 concentration of above 70% in the cooling medium. A further challenge during the trials was the maintenance of a stable clinker feed into the clinker cooler prototype due to inherent instabilities in the clinker manufacturing process. First findings regarding the operation of the oxyfuel clinker cooler prototype indicate that boundary zones such as the cold clinker discharge system demand special attention regarding minimisation of false air inleakage also in industrial scale projects.

A detailed assessment of the pilot plant performance and of the impact of CO_2–rich gas on clinker quality are currently being carried out by VDZ and IKN GmbH and the final results are expected to be presented in the CEMCAP research project at the end of July 2017.

CEMCAP is a research project funded from the European Union's Horizon 2020 research and innovation programme under grant agreement No 641185. It aims to prepare the ground for large-scale implementation of CO_2 capture in the European cement industry. Project partners in CEMCAP Workpackage 9 "Oxyfuel clinker cooler prototype" are IKN GmbH, HeidelbergCement AG, VDZ gGmbH and SINTEF as coordinator of the CEMCAP project.

Click here for VDZ's project information about CEMCAP and a movie which introduces into the project.

2.3 Publications in the VDZ-Bulletin 164, September 2017, page 7

2.3.1 ECRA „Carbon Capture"-Projekt in entscheidender Phase

Zwei Zementwerke wurden als möglicher Standort für ein Demonstrationsprojekt ausgewählt
Das ECRA-CCS-Projekt hat eine entscheidende Phase erreicht. Nachdem in den ersten Projektphasen theoretische und Laboruntersuchungen sowie Simulationen durchgeführt wurden, wird nun ein Oxyfuel-Demonstrationsprojekt geplant. In einem Auswahlverfahren wurden zwei Werke identifiziert, die dafür die Voraussetzungen bieten würden.

Klimaschutz ist eines der wichtigsten Zukunftsthemen unserer Gesellschaft.
Die Zementindustrie ist sich ihrer Verantwortung zur Erreichung der festgelegten Klimaziele bewusst und hat unter der Federführung der ECRA vor

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über 10 Jahren ein Forschungsprojekt zur CO_2-Minderung begonnen. Während dieser Zeit wurde die Entscheidung getroffen, die weiteren Arbeiten auf den Oxyfuel-Prozess zu fokussieren. Dabei wird ein Gemisch aus Sauerstoff und rezirkuliertem Abgas anstelle von Luft für den Verbrennungsprozess verwendet. Daraus resultiert ein Abgasstrom mit einer hohen Anreicherung von CO_2, der nach weiterer Aufbereitung einer Speicherstätte oder Verwertung zugeführt werden kann.

Planung eines Oxyfuel-Projekts
Um den technischen Stand dieses Verfahrens weiterzuentwickeln, soll nun ein Demo-Projekt an einer industriellen Anlage durchgeführt werden. Dazu wurde ein Auswahlverfahren mit Anlagenaudits und sogenannten „Opportunity Studies“ durchgeführt, um den bestmöglichen Standort zu finden und die voraussichtlichen Kosten zu ermitteln. Schließlich wurden die Werke Colleferro (Italien) und Retznei (Österreich) ausgewählt, die gute Voraussetzungen für ein solches Projekt bieten.
Im Werk Colleferro steht eine Ofenanlage für das Projekt zur Verfügung, die für die laufende Produktion nicht durchgehend erforderlich ist. An der Anlage werden keine alternativen Brennstoffe eingesetzt. Aufbauend auf den Erfahrungen an dieser „einfachen“ Anlage soll das Verfahren in einem zweiten Schritt im Werk Retznei getestet werden, das aufgrund seiner komplexen Betriebsweise (z. B. alternative Brennstoffe, Bypass) repräsentativ für viele europäische Zementwerke ist. Die Hauptaufgabe in den kommenden Monaten ist nun die Suche nach geeigneten europäischen und nationalen Fördermöglichkeiten.

2.3.2 Erster Oxyfuel-Klinkerkühler getestet

Praktische Erfahrung mit einer Technologie zur CO_2-Abscheidung
Das EU-Forschungsprojekt CEMCAP soll die Voraussetzungen für den Einsatz von CO_2 -Capture-Technologien in Zementwerken schaffen. Diese könnten CO_2 -Emissionen der Zementindustrie vermeiden und stattdessen eine spätere Lagerung (CCS) oder Nutzung (CCU) des CO_2 ermöglichen. Gerade im Hinblick auf die Minderung von prozessbedingten CO_2-Emissionen der Zementindustrie könnte die Oxyfuel-Technologie langfristig einen wichtigen Beitrag zum Klimaschutz leisten.

Zusammen mit den Projektpartnern IKN GmbH und HeidelbergCement AG hat der VDZ im Zementwerk Hannover Anfang 2017 die Kühlung von Klinker unter Oxyfuel-Bedingungen erfolgreich in einer Pilotanlage getestet. Die experimentellen Arbeiten an der Pilotanlage dienten dazu, den Oxyfuel-Kühler mit heißem Klinker in einer industriellen Umgebung zu testen und dabei die Kühlleistung (Effizienz) und die Klinkerqualität zu untersuchen. Das Oxyfuel-Kühlmedium, ein CO_2 -reiches Gas, wurde vor Ort durch die kontinuierliche Eindüsung von CO_2 in die Pilotanlage synthetisch hergestellt. Während des Tests wurden alle Prozessparameter kontinuierlich aufgezeichnet. Trotz zahlreicher technischer Herausforderungen wurden im Kühlmedium wiederholt CO2-Konzentrationsniveaus von über 70 Vol.-% erreicht und Klinkerproben entnommen, die jetzt im VDZ-Labor untersucht werden. Die Ergebnisse der Laboranalyse werden bis zum Jahresende im CEMCAP-Forschungsprojekt prä-

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sentiert werden (https://www.sintef.no/projectweb/cemcap/). Die Pilotanlage basiert auf einem theoretischen Konzept, das im ECRA CCS-Projekt – Projektphase III – entwickelt wurde (https://ecra-online.org/research/ccs/).
Erste Erkenntnisse aus den Tests Erste Ergebnisse aus dem Betrieb des Oxyfuel-Klinkerkühlers zeigen, dass der Gasaustausch in den Übergangszonen am Ein- und Ausgang, z. B. durch das Entladesystem für Kaltklinker, besondere Aufmerksamkeit erfordert, um Falschlufteintritt so weit wie möglich zu minimieren. Diese Erkenntnis ist wichtig für mögliche zukünftige Projekte im industriellen Maßstab.

CEMCAP ist ein Forschungsprojekt, das aus dem Forschungs- und Innovationsprogramm Horizon 2020 der Europäischen Union im Rahmen der Fördervereinbarung Nr. 641185 finanziert wird.

Pilotanlage des Oxyfuel-Kühlers im Zementwerk Hannover

2.4 Publication in Cement International 2017, Vol.15(6), page 14

2.4.1 First cement clinker produced with oxyfuel cooler technology

Practical experience with CO_2 capture technology

The CEMCAP partners IKN, HeidelbergCement and VDZ have successfully managed to produce cement clinker using the oxyfuel cooler technology. The innovative oxyfuel clinker cooler prototype has been tested during the last six months, as part of the EU research project CEMCAP. The project is focused on preparing the ground for large-scale implementation of CO_2 capture at cement plants for later storage or use (CCS, CCU). The European cement industry could make a significant contribution to climate protection through CO_2 capture technology, which is essential for future mitigation of the cement industry's process emissions.

The overall aim of this experimental work was the testing of an oxyfuel

cooler in an industrial surrounding in order to ensure sufficient cooling performance (efficiency) and clinker quality. Despite the challenges in the project, CO_2 concentration levels of the cooling medium higher than 70 vol.% have been achieved repeatedly by the team and clinker samples were taken. With the objective to bring CO_2 capture technologies for the cement industry to a higher Technological Readiness Level (TRL) and hence closer to deployment, VDZ tested the oxyfuel clinker cooler prototype from September 2016 to March 2017 in a HeidelbergCement plant located in Hannover, Germany. The prototype was based on theoretical concepts developed within the European Cement Research Academy's project phase 111 . The most demanding task of the prototype design was to manage the extraction of hot clinker from an operating kiln line. It was accomplished through the development of an innovative clinker extraction system by IKN GmbH . The testing process parameters were recorded continuously and exhaust gas streams were sampled and analysed by VDZ to rate the sealing efficiency against false air ingress. Clinker samples (input and output) were taken periodically for further analysis.

The oxyfuel cooling medium (CO_2 rich gas) was synthetically produced on-site through the injection of CO_2 into the pilot plant from a filling station equipped with CO_2 bottles. As CO_2 has a higher density compared to air, and the risk of accumulation in sublevel areas, special safety measures were implemented on-site, like the installation of a static CO_2 warning system at ground level and mandatory use of mobile CO_2 detectors. No leakages of CO_2-rich gas have been detected during the experiment. A continuous injection of CO_2 into the pilot plant was required during the trials to maintain a constant CO_2 concentration of above 70 % in the cooling medium . A further challenge during the trials was the maintenance of a stable clinker feed into the clinker cooler prototype due to inherent instabilities in the clinker manufacturing process. First findings regarding the operation of the oxyfuel clinker cooler prototype indicate that boundary zones such as the cold clinker discharge system demand special attention regarding minimisation of false air inleakage also in industrial scale projects.

A detailed assessment of the pilot plant performance and of the impact of CO_2-rich gas on clinker quality are currently being carried out by VDZ and IKN GmbH and the final results will be presented in the CEMCAP research project by the end of 2017.

CEMCAP is a research project funded from the European Union's Horizon 2020 research and innovation programme under grant agreement No 641185. It aims to prepare the ground for large-scale implementation of CO_2-capture in the European cement industry. Project partners in CEMCAP Workpackage 9 "Oxyfuel clinker cooler prototype" are IKN GmbH, HeidelbergCement AG, VDZ gGmbH and SINTEF as coordinator of the CEMCAP project.

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Figure 1: Clinker cooled with oxyfuel technology

Figure 2: On-site measurements performed by VDZ

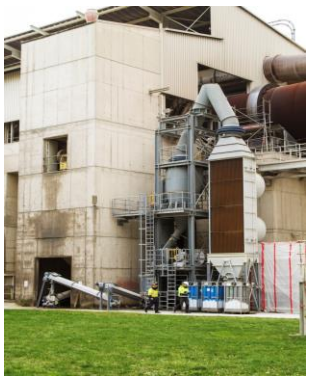

Figure 3: Oxyfuel clinker cooler pilot plant

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2.5 CEMCAP Blog; "One step closer to implementation of oxyfuel technology in the European cement industry"

April 12, 2018
Guest bloggers: Marco Lindemann Lino (VDZ) and Johannes Ruppert (ECRA)

2.5.1 Reducing CO_2 emissions from the cement industry with oxyfuel technology

Climate protection is one of the most important future issues for our society. CO_2 emissions from the cement industry contribute to 6-7 % of global anthropogenic CO_2 emissions. An important option to significantly reduce the CO_2 emissions from the cement industry is to capture CO_2 for storage (CCS) or utilization (CCU).

Cement plants typically have a lifetime as long as 30-50 years. Thus, a CO_2 capture technology must be retrofitted to existing cement plants. Four CO_2 capture technologies are currently being assessed in the CEMCAP project, with focus on retrofitability. CEMCAP is coordinated by SINTEF and funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 641185. The project aims to promote the readiness of technologies for CO_2 capture in the European cement industry.

The cement industry started a research project for investigation of technologies for cement CO_2 capture under the leadership of the European Cement Research Academy (ECRA) more than 10 years ago. During this period the decision was taken to focus the ongoing work on the oxyfuel technology. A mixture of oxygen and recirculated exhaust gas is used instead of air for fuel combustion. This results in an exhaust gas flow that is highly enriched in CO_2, which, after further processing, can be transferred to a storage site or for utilization. In CEMCAP, the ECRA oxyfuel research has been taken further by means of component testing and further process simulations and optimization of the cement manufacturing process under oxyfuel conditions.

2.5.2 First oxyfuel clinker cooler tested in industrial environment

Clinker coolers are considered key-equipment for energy efficient operation of a cement plant. Clinker cooler operation not only impacts the fuel consumption of the cement plant, and thus indirectly CO_2 emissions, but also influences clinker quality, which must be always guaranteed to produce high quality cement. VDZ and its partners IKN and HeidelbergCement (HC) were able to design, construct and operate the world's first oxyfuel clinker cooler prototype tested in an industrial environment

This project has received funding from the European Union's Horizon2020 Research and Innovation Programme under Grant Agreement No 641185

The overall aim of this experimental work was the testing of an oxyfuel clinker cooler in an industrial environment in order to assess its cooling performance (efficiency), as well as the potential impacts of CO_2–rich cooling gas on clinker quality. Based on the existing designs for single-stage and two-stage gas-tight clinker coolers, which had been developed in ECRA's CCS project phase III, a choice for a layout of the prototype was made. It took into account the potential for up-scaling, as well as the technical feasibility to be operated in prototype scale. The oxyfuel clinker cooler prototype was designed with a capacity of 80 t/d, which corresponds to about 3% of the clinker production of a reference cement plant (3000 t/d).

Despite some unexpected experimental challenges, several samples of clinker cooled down in an oxyfuel environment were taken during the trials for further analysis in VDZ's laboratories.

The experimental results were first presented in the 2nd ECRA/CEMCAP workshop on 7th November 2017 at VDZ in Duesseldorf. Final results will soon be published at the CEMCAP webpage and disseminated in the ECRA/CEMCAP/CLEANKER Workshop, which will take place on the 17th October 2018 in Brussels. This workshop will highlight the final conclusions from CEMCAP research, including the techno-economic comparison of the four investigated CO_2 capture technologies. An important topic at the workshop will be to discuss the technological and economic framework for the application of CO_2 capture in the cement industry.

2.5.3 Next step: Industrial-scale

Testing a pilot oxyfuel clinker cooler in an industrial environment within CEMCAP project was a unique opportunity to gain valuable know-how before up-scaling to the industrial scale. The CEMCAP experimental experiences gained by application of oxyfuel technologies will help to give guidance in future design of an industrial scale oxyfuel kiln and clinker cooler.

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With a comprehensive list of lessons learned during the trials, cement producers and clinker cooler constructors can now minimize economic and technical risks. The dissemination of CEMCAP experimental results in ECRA/CEMCAP workshops and its intensive discussion with experts and stakeholders from the industry has been one of the keystones for future implementation of industrial-scale carbon capture projects in the cement industry. One industrial-scale project is already in preparation.

ECRA is launching a project with the objective to test and demonstrate oxyfuel technology in industrial-scale (please see ECRA press release). Two European cement plants, which are able to fulfil all the necessary technical prerequisites, have been identified in a selection procedure. The main task is now to find the required European and national sources of funding for this technology demonstration project. It seems that the cement industry has never been so close to an oxyfuel industrial-scale demonstration for capturing CO_2 before. It would be a significant technological step and option required for significant reduction of CO_2 emissions.

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