CEMCAP
TECHNOLOGICAL ACHIEVEMENTS AND KEY CONCLUSIONS

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About CEMCAP

Duration: May 2015-October 2018
Budget: €10,030,120.75
EU contribution: €8,778,701.00

Main objective: To prepare the ground for large-scale implementation of CO₂ capture in the European cement industry
A consistent project

- Tight connection analytical ↔ experimental work
- A common framework document established to ensure project consistency
CO₂ capture technologies in CEMCAP

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The capture technologies are fundamentally different, with different strengths and challenges

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CO₂ capture requires energy and costs money – CEMCAP did not change this fact but we have decreased the uncertainty about the numbers for the cement industry.
Chilled Ammonia Process (CAP)

• Principle
  • Aqueous ammonia absorbs CO₂ in absorption column
  • Solution is regenerated through heating at pressure

• Research:
  • In pilot scale investigate process differences between cement and power
  • Thermodynamic and kinetic model development
  • Process optimization for cement application
CAP: achievements in CEMCAP

- Validated process models
- CAP exploits high CO$_2$ concentrations for highly efficient capture
- Validated CAP functionality
  - All process units that are affected by new flue gas composition tested
  - CAP ready for on-site demonstration

NH$_3$

- commodity chemical
- globally available
- chemically stable

Product Validation Facility at the Mountaineer power plant, WV (50 MW$_{th}$): 8000 h in 2009-2011
Membrane-Assisted Liquefaction (MAL)

- Principle: Flue gas is CO₂-enriched through membranes to "low-end oxyfuel" conditions. Thereafter compressed, cooled and condensed.

- Research:
  - Membrane testing in lab
  - Development of MAL process schemes
  - Demonstration of CO₂ liquefaction on pilot scale
MAL: achievements in CEMCAP

• Polymeric membranes
  • Tested selectivity and permeability of two membrane materials
  • CO₂/N₂ selectivity sufficient: provides sufficient CO₂ concentration for efficient liquefaction

• Demonstrated operability of CO₂ liquefaction in 5-10 ton/day scale
  • Binary CO₂/N₂ mixtures with CO₂ concentration relevant for MAL applications
  • Very high CO₂ product purity measured, up to 99.8 %
Calcium looping Capture (CaL)

• Principle: CO₂ is captured in a carbonator through the reaction of CaO → CaCO₃, and released in a calcinator through the opposite reactions. Requires heat.

• Research:
  • Two configurations investigated
  • Tail-end & Integrated entrained flow
  • Experimental investigation at two scales: 30 kWₜₜ and 200 kWₜₜ
Calcium Looping (CaL): Achievements in CEMCAP

- Two configurations investigated
  - Tail-end: most mature
  - Integrated entrained flow: more energy efficient
- High CO₂ capture rates (up to 98%) with tail-end CaL. Ready for on-site demo after CEMCAP
- Integrated entrained flow CaL spin-off: CLEANKER project (on-site demo)
Oxyfuel: Achievements in CEMCAP

Oxyfuel burner testing and simulations

Entrained flow oxyfuel calcination testing

Oxyfuel clinker cooler prototype testing

The existing ECRA/VDZ oxyfuel process model was adapted in accordance with the experimental results
Oxyfuel: Achievments in CEMCAP

- Successful operation in industrial environment
- Technological Readiness Level: TRL 6 of key technologies achieved!
- Modelling of the entire oxyfuel process with 55% recirculation, up to 80% CO2-enriched gas and variation of false air ingress from 4% to 8% of flue gas volume.
The next steps for the CEMCAP technologies

• Oxyfuel: ECRA CCS project plans for 2 demos at Colleferro (IT) and Retznei (AT)
• CAP: Pilot plant of 100,000 tCO₂/year envisioned
  • GE has full EPC capacity
• MAL: needs on-site screening of different membranes at operating cement kiln.
  • Liquefaction needs to be tested/demonstrated with flue gas impurities
• Tail-end CaL: ready for on-site testing
• Entrained-flow CaL: Is being brought to on-site demo in the CLEANKER project
Post-capture CO₂ management

- Cement production is a potential carbon source in a fossil-free future
  - But CO₂ is a very stable molecule, its conversion processes are normally highly energy intensive
- 16 CO₂-based products evaluated in CEMCAP
  - Current CO₂ utilization (CCU) routes have limited opportunity for climate change mitigation in the cement industry context
  - Likely < 10% of CO₂ from a cement plant can be used for CCU
  - Niche applications with positive CCUS business cases
- “CCU” always needs “S”: either market or raw material availability poses limitation on the amount of CO₂ that can be utilized.
To sum up

• CEMCAP has expanded the knowledge base for future CCS deployment
• CEMCAP delivers a techno-economic decision base for retrofittable CO₂ capture from cement
  • The framework and results are suitable for in-house evaluations of CCUS in the cement sector. Use them!
• CEMCAP has provided 5 candidate technologies for CO₂ capture demos in the cement sector
  • Presentations on Norcem and LEILAC projects later today
• Funding and industrial ownership required for demonstration
• Business models required for moving to full scale CCS
CEMCAP Partners

Cement Producers

[Logos of Italcementi, NORCEM, HEIDELBERGCEMENT Group]

Technology providers

[Logos of GE, IKN, thyssenkrupp]

R&D providers

[Logos of SINTEF, ecra, TNO, ETH zürich, University of Stuttgart, Politecnico Milano 1862, CSIC, vdz]

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More about CEMCAP

Sign up for our final webinars on October 29-31: www.sintef.no/cemcap
CEMCAP deliverables repository: www.zenodo.org/communities/cemcap/

Twitter: @CEMCAP_CO2