Solutions for heat tracing in the decarbonisation of cement

Heat tracing solutions are instrumental in addressing several challenges in the cement industry, playing a pivotal role in reducing its carbon footprint

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The cement industry is at a critical juncture in its journey towards net-zero emissions. As one of the most energy-intensive and carbon-emitting industries (~8% of global CO_2 emissions (*Facts on climate*, 2019), cement manufacturing faces numerous technical challenges in reducing its carbon footprint (*Lehne & Preston*, 2020). These challenges are primarily related to the inherent nature of cement production, which involves high-temperature processes and significant CO_2 emissions.

Heat tracing solutions are emerging as a key technology to enhance process efficiency, reduce energy consumption, and facilitate the integration of low-carbon technologies.

Technical challenges in cement industries:

❶ High-temperature process requirements

Cement production involves several high-temperature steps, particularly in the kiln, where raw materials are heated to 1,450°C (2,642°F) to produce clinker. This process is not only energy-intensive but also results in significant CO_2 emissions due to the decomposition of limestone (calcination) and the combustion of fossil fuels. The challenge lies in finding ways to reduce energy consumption and emissions without compromising the high temperatures required for clinker production.

❷ Energy efficiency and heat loss

The high-temperature processes generate significant heat, much of which is lost to the environment due to poor insulation and process inefficiencies. Improving energy efficiency is essential to reducing the carbon footprint of cement production, but this requires innovative solutions to capture and utilise the excess heat generated during the process.

❸ Integration of alternative fuels

The cement industry is exploring the use of alternative fuels, such as biomass, waste-derived fuels, and hydrogen, to replace traditional fossil fuels. However, these alternative fuels often have different combustion characteristics, affecting the stability and efficiency of the kiln operation. Biomass and waste-derived fuels have lower calorific values and higher moisture content, which can lead to incomplete combustion and higher energy consumption. Ensuring consistent and efficient combustion of alternative fuels is a significant technical challenge.

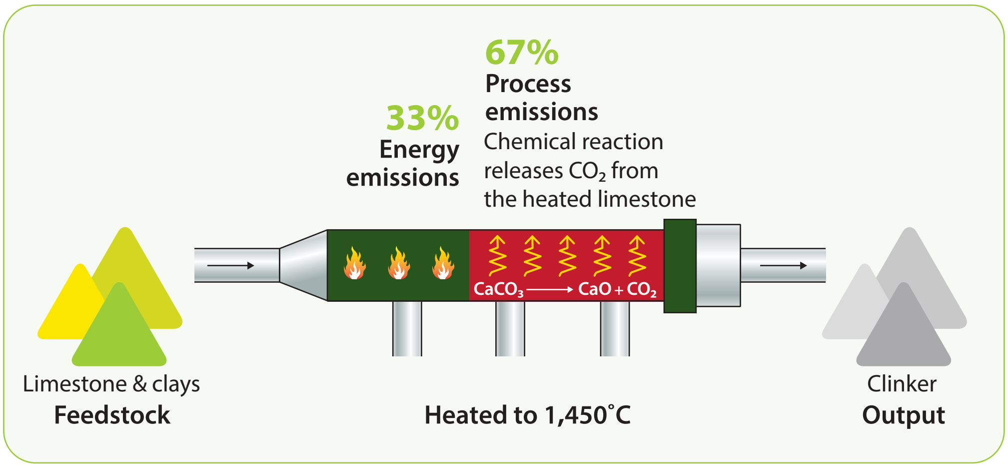

Figure 1 Process emissions during concrete production

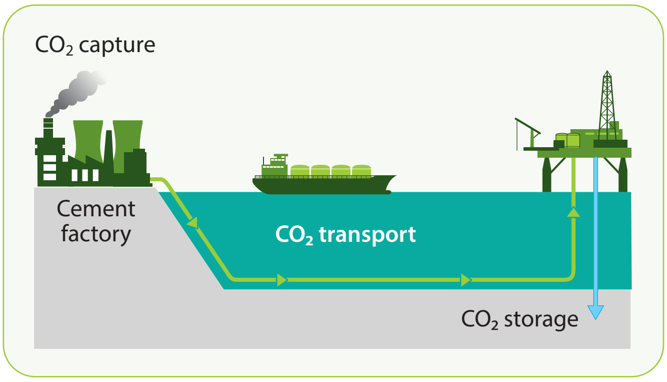

Figure 2 Carbon capture and storage schematic

❹ Carbon capture utilisation and storage

Carbon capture and storage (CCS) or carbon capture, utilisation and storage (CCUS) technologies are critical to reducing the industry's carbon footprint. However, capturing CO_2 from the high-temperature flue gases of cement kilns presents technical challenges.

The flue gases should be cooled before CO_2 can be captured, which involves further energy input.

Additionally, for CCS to be effective, precise thermal management is required. The process of capturing CO_2, whether through post-combustion, oxy-fuel combustion, or pre-combustion technologies, involves several temperature-sensitive steps. Maintaining optimal temperatures is crucial for the efficiency of solvents, membranes, or other capture mediums. Any deviation from the required temperature range reduces the CCS efficiency and increases its energy consumption.

Role of heat tracing

Heat tracing involves the application of electrical heating cables to pipes, vessels, and other equipment to maintain or elevate temperatures to a desired level. In the context of the cement industry, heat tracing solutions are instrumental in addressing several challenges outlined above.

❶ Enhancing energy efficiency

Heat tracing systems can significantly improve the energy efficiency of cement plants by minimising heat loss in critical areas. For instance, in the clinker production process, heat tracing can be applied to maintain the temperature of raw materials and prevent heat loss during transportation through preheaters, kilns, and coolers. This ensures that less energy is required to maintain the high temperatures necessary for calcination, thereby reducing overall energy consumption and CO_2 emissions.

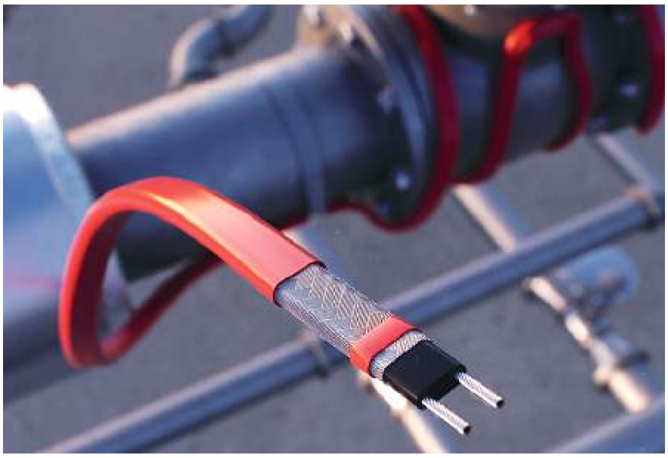

Figure 3 Self-regulating heating cable maintains or elevates temperatures to a desired level

Heat tracing can also be used to optimise the operation of heat exchangers and waste heat recovery systems, which are integral to improving energy efficiency in cement plants. By maintaining optimal temperatures in these systems, heat tracing helps maximise the recovery of waste heat, which can then be reused in the production process, further reducing the need for external energy inputs.

❷ Supporting the use of alternative fuels

The integration of alternative fuels into cement production processes requires careful thermal management to ensure consistent and efficient combustion. Heat tracing solutions can be employed to preheat alternative fuels with high moisture content, such as biomass, before they enter the kiln. This preheating reduces the moisture content of the fuel, improving its combustion characteristics and ensuring a stable and efficient burning process. As a result, the use of alternative fuels becomes more viable, helping to reduce the industry's reliance on fossil fuels and lower its carbon footprint.

❸ Optimising CCUS processes

Heat tracing plays a crucial role in the optimisation of carbon capture systems. In post-combustion carbon capture, for example, flue gases must be cooled to a specific temperature range before CO_2 can be efficiently captured. Heat tracing systems can be used to precisely control the cooling process, ensuring that flue gases reach the required temperature

Case study: Empowering world's first CO_2 capture facility in the cement industry

A global cement manufacturer selected Chemelex Raychem heat tracing solutions for the construction of the world's first full-scale CCS plant, located in Norway.

One of the main ingredients in cement, clinker, is made by heating limestone ($CaCO_3$) to extreme temperatures. This process releases carbon trapped in the stone, which reacts with oxygen in the atmosphere to form CO_2. The client owns many cement factories around the world and plans to reduce its footprint drastically over the coming years by investing in CCS installations. This Norwegian project is the first of its kind and was completed in 2024.

The CCS process involves three key steps: capture, transport, and storage of CO_2 emissions. The capture technique in this plant is CO_2 amine absorption, and has the following equipment:

- Pre-scrubber to cool down the flue gas and remove particles.
- Absorber (or scrubber) to bond CO_2 to a chemical amine (at ~50°C/120°F).
- Desorber (or stripper) to release the CO_2 from the amine (at ~160°C/320°F).
- Reboiler: 4-5 bar (58-72 psi) steam required to heat the desorber.

The captured CO_2 will then be liquefied and transported for final underground storage 3,000 metres under the seabed in the North Sea. Chemelex played an important role in supplying electrical materials, including heat tracing solutions. Raychem HTV high-temperature self-regulating heating cables with high power retention (HPR) and BTV heating cables proved ideal for this plant's freeze protection and process maintenance applications. Chemelex engineers also provided design assistance to ensure the best performance and system longevity and to reduce power distribution requirements, lowering total installed costs.

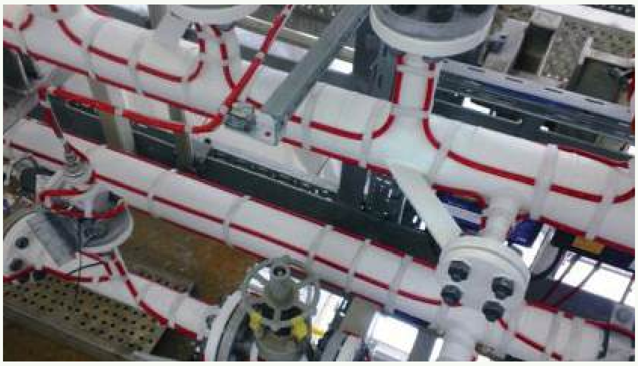

Figure 5 Raychem heating tracing installation

The high-temperature Raychem HTV self-regulating heating cables boast impressive performance, retaining more than 95% of their power even after 10 years of use. With a design life of 30+ years, they provide long-lasting reliability. Additionally, Chemelex provides customers with peace of mind through its 10-year product warranty.

Through its Raychem brand, Chemelex has an extensive track record of bringing heat tracing experience to CCS projects. Since 2012, its heat tracing solutions have been playing a crucial role in the operation of the world's first CCS demonstration plant in Mongstad, Norway. Also, it continues to bring its heat tracing experience to CCUS projects worldwide, in oil and gas, biofuels, power and other industries, fostering a more sustainable future.

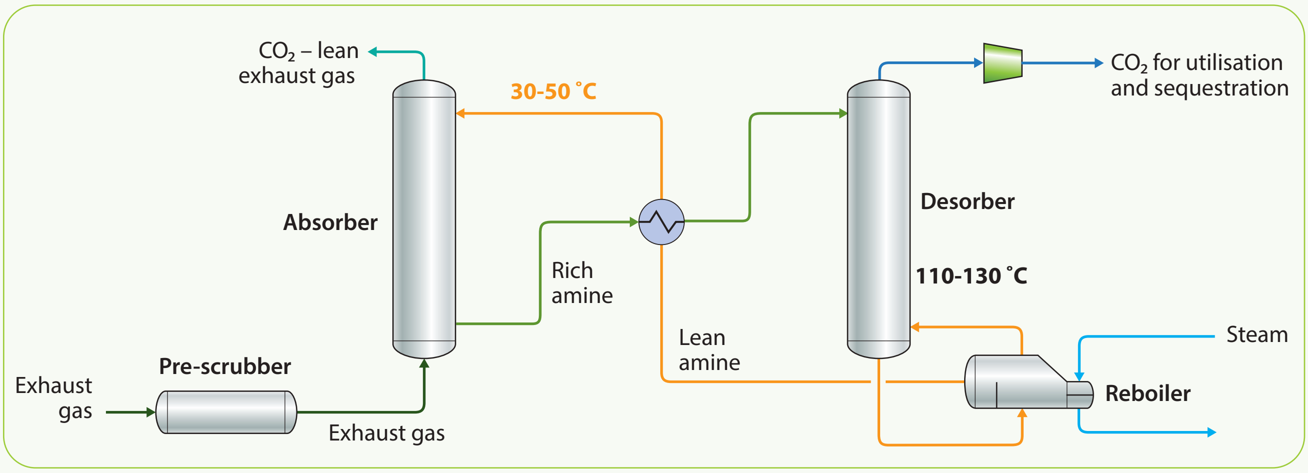

Figure 4 Diagram of typical carbon capture process

for optimal CO_2 absorption by solvents or membranes.

Furthermore, heat tracing is essential in maintaining the temperature and pressure conditions required for the transportation and storage of captured CO_2. By preventing temperature fluctuations in pipelines and storage vessels, heat tracing helps maintain the integrity of the carbon capture process, ensuring that CO_2 is safely and efficiently transported to storage sites or utilisation facilities.

④ Enhancing process control and stability

In cement production, process stability is critical to maintaining product quality and reducing energy consumption. Heat tracing solutions provide precise temperature control, which enhances the stability of key processes, such as kiln operation and fuel combustion. By maintaining consistent temperatures, heat tracing minimises the risk of process disruptions, which can lead to energy inefficiencies and increased emissions.

For example, in oxy-fuel combustion systems, maintaining the correct temperature is vital for efficient combustion and CO_2 capture. Heat tracing ensures that the oxygen supply, fuel lines, and other critical components remain at the optimal temperature, preventing issues such as condensation, freezing, or incomplete combustion.

Conclusion

The journey to decarbonising the cement industry is challenging, particularly given the high-temperature processes and carbon-intensive nature of cement production. However, heat tracing solutions offer a powerful tool to address these challenges. By enhancing energy efficiency, supporting the use of alternative fuels, optimising carbon capture processes, and improving process stability, heat tracing can play a pivotal role in reducing the cement industry's carbon footprint. Through innovative applications of heat tracing, the industry can move closer to its goal of reducing emissions while maintaining the high standards of quality and efficiency that are crucial to its operations.

VIEW REFERENCES

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