Cleaner, smaller, simpler

As cement companies strive to achieve their net zero target to avert far-reaching global climate change, the benefits of electrically-powered kilns have become increasingly clear. Finland-based Coolbrook has developed a game-changing heating technology that enables kilns to run on electrical power rather than fossil fuels.

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Cement production is responsible for a third of industrial CO_2 emissions and accounts for eight per cent of all man-made CO_2 emissions worldwide, according to the International Energy Agency. While no-one could seriously contest the fact that cement is vital to global economic development, its current manufacturing methods produce emissions that, if ignored, would put the 1.5˚C climate target out of reach, with catastrophic consequences for the planet. However, recent technological innovations provide plenty of reasons to be optimistic about the cement industry's future.

Fossil fuel-free cement production is within reach thanks to innovative RotoDynamic Technology. In development for a decade, RotoDynamic Technology is capable of producing the high temperatures – up to 1700˚C – required for industrial processes using only electric power. If used at scale across all its potential industrial applications, this ground-breaking technology could cut over 2bnta of CO_2 emissions.

For cement manufacturers, this means that the fossil fuels currently burned to heat kilns can be phased out in favour of 100 per cent electric-powered heaters that are compact, more efficient and more reliable, thereby significantly accelerating the much-needed cuts to CO_2 emissions. With development support from ABB, academic partnerships with Oxford and Cambridge Universities, and partnerships from various industrial leaders, RotoDynamic Technology is set to deliver sustainable cement to the world.

RotoDynamic Technology uses a highly-efficient electric motor to generate energy in a gas, which can generate temperatures in excess of the 1500˚C needed to heat cement kilns

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Turbomachinery: the science behind RotoDynamic Technology

RotoDynamic Technology is novel in its application, but the underlying design is effectively a gas turbine in reverse. Instead of heating gas to spin turbine blades and generate electricity, as in a conventional turbine, a highly-efficient electric motor spins blades to generate energy in the gas, which is expressed through heat.

Two processes are used to heat the gas – whether air, nitrogen, CO_2 or hydrogen – to the desired temperature. First, by accelerating the gas to supersonic velocities and then using a diffuser to rapidly decelerate to subsonic velocities to create a shockwave that converts the kinetic energy of the gas into heat. Secondly, the spinning blades create a highly turbulent flow with intense mixing and therefore, heating the gas further.

This combination of rotating blades and diffuser can then feed into a second stage where the process is repeated, further heating the gas. Multiple stages can be chained in succession to achieve the target heat – depending on inlet and outlet temperatures, gas volumes, and other parameters – up to around 1700˚C.

A single stage takes just milliseconds to heat the gas before passing it to the next, allowing very high volumes of gas to be heated, which is vital for RotoDynamic Technology to be viable in an industrial setting. By current calculations, a full-scale RotoDynamic set-up would be able to treat hundreds of thousands of cubic metres per

If used at scale across all its potential industrial applications, RotoDynamic Technology could reduce global CO_2 emissions by 2bnta

hour to high temperatures.

The blades are spun using high-efficiency, industrial-scale electric motors with total efficiency from electricity to heat exceeding 90 per cent and expected to reach 95 per cent in future iterations. In a typical electric heater, a heating element is used to transfer heat to the surrounding gas, which requires large resistive elements that need to be heated to very high temperatures to achieve the heat transfer to the gas. Due to this, traditional heaters have not been able to respond to the challenge of heating gases to the temperatures required by the most energy-intensive industrial processes. RotoDynamic Technology skips the heating element and heats the gas directly, effectively using the gas itself as the heat transfer agent, which is how such high efficiency has been achieved.

Flexible and seamless fit

The RotoDynamic Heater (RDH) can generate temperatures in excess of the 1500˚C needed to heat cement kilns, and its ability to process very high volumes of gas means it can keep up with industrial demand. This would allow a cement plant fully equipped with RDH units to stop burning fossil fuels and run entirely on electric power. Plants connected to renewable electricity supply will be able to generate heat emissions-free, while those that still depend on electricity from non-renewable sources will be future-proofed for when the supply switches to clean energy.

Although significant investment will be required for renewable power production to fully electrify cement production worldwide, this transition is already happening and worldwide electricity production mix is forecast to reach nearly zero emissions within two decades. In Europe the transition will occur even sooner, perhaps by 2030, as renewable technology continues to fall in price and increase in availability – not to mention the energy security benefits of dropping volatile fossil fuels for wind and solar in the current geopolitical environment.

Switching to renewable-powered equipment is just one part of the transition to clean industry. Though RDH can eliminate emissions from heating, there

The simplicity of the RotoDynamic Heater results in low maintenance requirements

Clean cement will enable humanity to continue building at the scale required to serve an expanding global population

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"RotoDynamic Technology hit a major milestone in December 2022 with its first real-world, live industrial demonstration at Coolbrook's pilot site at the Brightlands Chemelot Campus in Geleen, The Netherlands."

are other parts of cement production that would remain a significant source of emissions, such as the CO_2 released through the calcination process.

This is where other solutions, such as carbon capture and storage, will come in to achieve full net-zero cement production, along with considerations for how cement is transported throughout the supply chain. A holistic view of industrial processes can spur exponential progress towards decarbonisation through the mutual benefits of complementary technologies. For example, RDH makes carbon capture more efficient by concentrating the CO_2 in the off-gas from the cement kiln.

The timeline for renewable energy and complementary technologies to become available gives cement plants a generous window in which manufacturers can begin incorporating RDH equipment. RDH has been designed to accommodate for the fact that every plant is unique, with its own combination of fuels, energy fuels, and maintenance schedules. It can be easily retrofitted into existing set-ups, and has a footprint of just a few metres, allowing cement producers to save space while reducing their emissions.

The flexibility of RDH means that a cement plant might opt to phase in the technology, for example, using RDH for preheating while maintaining a conventional main burner. This enables the creation of hybrid plants that can gradually work towards completely fossil fuel-free operations in the future.

Moving towards a hybrid set-up helps cement producers eliminate the complex logistical and infrastructure requirements that can be entirely eliminated through the switch to electricity, from managing the delivery and storage of fuels to maintaining the complex feeding systems that distribute them.

The simplicity of the RDH feeds into its reliability. In addition to the above benefits, gas turbines are incredibly reliable, with a single annual endoscopic inspection likely to suffice for many years, significantly reducing downtime.

Commercial deployment

RotoDynamic Technology hit a major milestone in December 2022 with its first real-world, live industrial demonstration at Coolbrook's pilot site at the Brightlands Chemelot Campus in Geleen, The Netherlands. The pilot confirms the technology is on track for full commercial availability to cement producers around 2025.

CEMEX – a key partner in the Brightlands pilot – will help Coolbrook achieve another milestone with the first industrial deployment of RotoDynamic Technology as the company begins integrating RDH Technology into its plants. Coolbrook is also working with UltraTech, which plans to use RDH to reduce CO_2 emissions from cement production in India, as part of the company's wider decarbonisation goals.

Going forward

The global distribution of Coolbrook's partnerships demonstrate the global scale of the decarbonisation effort, and it is reassuring to see these critical industries recognise and respond to the urgency of climate action.

Coolbrook will continue to seek new partnerships and complementary solutions that can help RotoDynamic Technology usher in a new era of net-zero cement production that is more efficient, reliable, and cost-effective than ever. Clean cement will allow humanity to continue building at the scale needed to serve a growing global population, without endangering the world we are building on. ■