Cement's green power source

With a significant electricity requirements, cement producers are looking to minimise power costs. The source of cheaper power can be found in their plants in the form of waste heat. Recent case studies in Turkey and India provide further examples of successful waste heat-based power generation.

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Cement production currently has a thermal energy intensity of 3.6GJ/t of clinker and an electricity intensity of 100kWh/t of cement, according to the IEA Cement Outlook. To align with a Net Zero Emissions (NZE) 2050 scenario, both thermal and electrical energy intensities must be reduced by 2030 to 3.4GJ/t of clinker and 95kWh/t of cement, with an additional 5kWh/t required for carbon capture, utilisation and storage (CCUS).

While there is an increasing shift towards biomass and refuse-derived fuels (RDF) or solid-derived fuels (SDF) for combustion in rotary kilns in regions such as Europe and the USA, fossil fuels continue to dominate as the primary energy source for cement production in emerging economies. According to the 2023 Energy Report by the International Council of Academies of Engineering and Technological Sciences (CAETS), cement production in China and India still depends on fossil fuels for over 95 per cent of its energy requirements. This reliance on fossil fuels for heat and electricity contributes to the industry's carbon footprint.

The use of waste heat recovery in the cement industry

To reduce the use of fossil fuels and lower its carbon footprint, the cement industry has made significant progress in energy efficiency through the adoption of waste heat recovery (WHR) systems, and in the switch from wet to dry rotary kiln processes. According to a report by the Institute for Industrial Productivity and the International Finance Corporation, China leads the world with 739 WHR installations, far outpacing India (26) and the rest of the world (100). As the largest cement producer in the world, China has recognised the potential of WHR and implemented it across many of its cement plants. In contrast, India and other emerging economies still have considerable untapped potential for WHR deployment. In India, the current installed WHR capacity is 520MW, while the total assessed potential is 1100MW, as detailed in the "Best Practice Manual for Waste Heat Recovery in the Cement Sector in India" released by PwC India.

Steam turbine generator (STG) installed in a cement plant in India for generating power by sourcing waste heat from the process

Encouragingly, major cement producers in India have made strides toward greater WHR use in recent years, installing several WHR plants and adding around 250MW of capacity. However, barriers to wider adoption of WHR in the country's cement sector persist, including high capital expenditure (INR100-120m/MW or US$1.18m-1.42m/MW) compared to fossil fuel-based captive power plants (INR40m-50m/MW), a policy environment that does not classify power generated through WHR as renewable under local Renewable Purchase Obligation (RPO) guidelines, and limited awareness among smaller cement producers and operators of brownfield plants.

However, power generation from WHR applications generally ranges between 25-45kWh/t of clinker, highlighting the substantial potential for power generation, depending on the clinker capacity of the plant. Typically, preheater exhaust temperatures in cement plants range between 280-450 °C, while air quenching cooler (AQC) exhaust temperatures range between 250-330 °C. Therefore, a 10,000tpd cement plant with typical parameters can generate around 15MW of power from waste heat.

Injection condensing steam turbine generators

India-based Triveni Turbines Ltd (TTL) has a strong reference list for injection condensing steam turbine generators (STGs) sought after by the cement industry for its WHR applications. These steam turbines have been custom designed to suit low inlet parameters and high flows, corresponding to flue gas conditions from preheater exhaust and allow admission of low pressure injection steam from air quench cooler boilers. Low pressure condensing modules are suited to handle

"The implementation of waste heat recovery systems to produce clean electricity in cement plants globally aids cement producers in reducing their reliance on fossil fuels and lowers the plant's carbon footprint,..."

Triveni Turbines' 22 MW Injection Condensing Steam Turbine Generator (STG) for a WHR-based power plant in a cement plant located in Satna, Madhya Pradesh, India

variability in operation, yet yield best in class steam path efficiencies.

TTL's expertise in replacement solutions is matched only by a few market players. The company has installed multiple turbines in WHR applications for cement industry, replacing an earlier installed turbine module with higher capacity. These steam turbines offer benchmark heat rates to customers and contribute to the industry's shift towards increased captive power capacity and energy efficiency.

The in-house installation and commissioning teams have expertise in providing a plug-and-play experience to the customer's plant operators. Installation and commissioning is supported by a strong after-market team, available 24/7 to assist customers.

Case studies in the Turkish and Indian cement industry

TTL's steam turbines are operating successfully in cement plants worldwide, generating power from waste heat in greenfield and brownfield cement plants.

Türkiye

A cement customer based in Türkiye wanted to install an STG to optimise the WHR boiler operation due to low pressure and temperature. After assessing the scope requirements, the team at Triveni Turbines recommended the installation of injection condensing steam turbines. The supplier managed the entire installation and commissioning process, which was executed by its qualified in-house team of engineers.

The highly efficient STG set was designed, assembled, tested and dispatched from TTL's state-of-the-art manufacturing facility in Bangalore, India. It is designed to operate at low pressure and temperature levels. The inlet steam pressure was 13bar and inlet steam temperature 360˚C. The injection steam pressure was 3bar and the temperature was 166˚C.

The turbine internals, including blades and rotors, were designed to meet the specified pressure and temperature requirements while achieving optimal efficiency levels. Utilising the waste heat generated from the processes is expected to reduce power generation costs and coal requirements, as well as lower the carbon footprint of the cement plant operations.

India

Since August 2020 TTL has been supporting a major Indian cement company operating its plant in Satna, Madhya Pradesh at the full 7Mta capacity. TTL has helped it reduce the cement producer's reliance on the grid for power while enhancing the plant's returns and efficiency.

The customer sought to increase WHR power generation following an expansion of its cement capacity. The existing 3000rpm turbine, supplied by an overseas OEM, was operating with low efficiency. After assessing the on-site conditions, TTL replaced the existing 14MW STG set with a high-efficiency, higher rpm 22MW injection condensing turbine set, designed for 10.50ata and 295˚C high-pressure steam and 2ata and 190˚C medium-pressure injection steam.

The STG set was installed on the same foundations and within the same housing as the existing STG, utilising the same hardware components, including the lubrication oil system, control oil system, motor control centre panel, various electrical panels, distributed control system, cables, gearbox and alternator. The entire installation and commissioning process, including the dismantling and removal of the existing STG set, was handled by TTL's engineering team.

The customer was immensely satisfied with the 7MW increase in WHR power generation. The load on the cement producer's captive power plant has been reduced by 7MW, leading to lower power generation costs, reduced coal requirements and a decreased carbon footprint. The modification was achieved with minimal capital expenditure and will lower operational expenditure costs while generating power, indirectly reducing cement manufacturing input costs.

Conclusion

The implementation of waste heat recovery systems to produce clean electricity in cement plants globally supports cement producers in reducing their reliance on fossil fuels and lowers the plant's carbon footprint, contributing to the industry's goal of achieving net-zero emissions.

The installation of condensing steam turbine generators is not only increasing the power generating capacity of WHR systems installed in cement plants but is also accelerating the adoption of green power sources in the global cement industry. ■