Exploring the ORC solution

Organic Rankine Cycle (ORC) technology is a is a proven solution for waste heat recovery (WHR) in cement plants. Italy-based Turboden explains the benefits of ORC systems, using a number of cement industry reference projects with capacities ranging from 1.4MWe to more than 7MWe.

■ *by **Turboden**, Italy*

Waste heat recovery (WHR) from cement production process exhaust gas is one of the technologies that can improve the energy efficiency of a plant, aiming to increase process sustainability and reduce production costs. Even though the efficiency of the cement production process has been improving over recent decades, there is still a significant amount of hot gas containing useful heat that is vented into the atmosphere. This useful heat can be recovered and transformed into electricity thanks to Organic Rankine Cycle (ORC) technology. The electricity produced can be used inside the cement plant, reducing costs related to energy purchased by the grid.

Since 2010 Turboden has installed 10 ORCs in cement plants in seven countries. Pictured is the ORC system at CRH Slovakia

Influences on output potential

In a cement plant there are two heat sources: the preheater tower (PH) exhaust gas and clinker cooler (CC) air. There are several variables that influence the waste heat available from these two sources as well as the electricity generation potential.

When analysing heat recovery potential in a cement plant, it should be considered that the higher the temperature of the heat source, the higher the thermal power available and the ORC electrical efficiency. In the CC the spraying of water decreases the available temperature for heat recovery. Therefore it is recommended to check whether it is possible eliminate water spraying and enable a higher hot air temperature, which leads to more electric power output.

On the PH side, a higher number of preheater stages increases kiln efficiency while decreasing gas temperature. In cement plants where there is a higher share of alternative fuels usage, the exhaust gas temperature and recoverable thermal power are higher.

One of the main parameters that influences the available thermal power is the humidity of raw materials and the further drying needs related to the type of fuel used. In cement plants where the raw material has a medium/low humidity, WHR is an optimum option to further increase plant efficiency and sustainability.

Furthermore, ORC technology has the capability to adapt to different thermal power load conditions, so it can maximise the production of electricity even when there is a seasonal variation on the heat needed for drying.

ORC electric power output is also highly influenced by cold source temperature, typically ambient air or cooling water. In this case, the lower the temperature, the higher the electric power output. Therefore, cement plants located in colder places can benefit from higher efficiency.

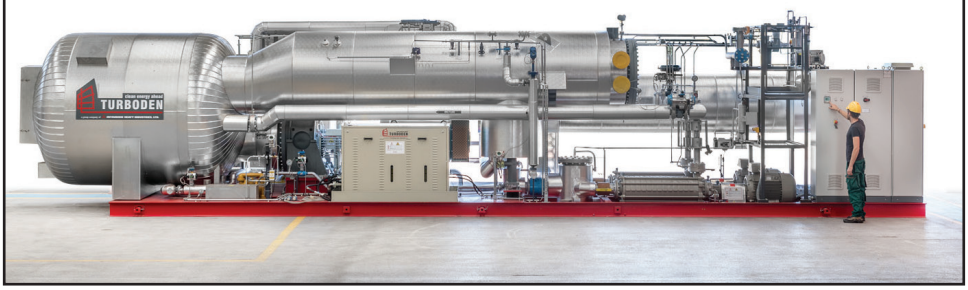
Several parameters influence electric power output, which is why the amount of electric power produced by WHR systems can vary widely from plant to plant. A WHR system can account for 10-30 per cent of a cement plant's electric consumption and with monthly electricity expendture reducing by the same percentage. In addition to the lower cost of electricity, in most of the cases studied there are other benefits. In fact, in many cement plants, the gas from both the preheater and clinker cooler has to be cooled before entering the filtration system. Nowadays gas is cooled using quenching towers in the PH side and an air-to-air heat exchanger in the CC gas. Cooling the gas temperature in heat exchangers instead of these systems allows for a further reduction in electric consumption of air-to-air exchanger fans, while not spraying water in the quenching tower saves a significant amount of water.

Cement plants with their own power plant based on engines or gas turbines can consider recovering the heat from the power plant and from cement production, feeding a single ORC unit. In this way power plant fuel consumption is reduced, leading to lower CO_2 emissions, as well as a lower cost of self-generated electricity.

Table 1: Turboden cement industry references, 2010-present day

Plant	Country	Start-up	Kiln capacity (tpd)	Heat source	Heat carrier	ORC gross electric power (kW)
Ciments du Maroc (HeidelbergCement – formerly Italcementi)	Morocco	2010	5000	PH	Thermal oil	2000
Holcim Romania	Romania	2012	4000	PH + CC	Thermal oil + superheated water	4000
CRH Slovakia (formerly Holcim)	Slovakia	2014	3600	PH + CC	Thermal oil	5000
Carpatcement (HeidelbergCement)	Romania	2015	3500	PH + CC	Thermal oil	3800
Jura Cement Fabriken (CRH)	Switzerland	2016	3000	PH	Superheated water	2300
Cementi Rossi	Italy	2018	3500	PH + CC	None – direct exchange	2000
Çimko (Sanko Group)	Italy	2019	9500	CC	Thermal oil	6500
Holcim Suisse (Eclépens)	Switzerland	2019	2300	PH + CC	Superheated water	1300
Sönmez Çimento	Turkey	2019	6000	PH + CC	Thermal oil	7500
Secil	Portugal	Under construction	3800	PH + CC + concentrated solar power	Thermal oil	7200

Turboden's ORC turbogenerator



Cement industry references

Turboden, part of the MHI group, has 40 years of experience in ORC technology. This technology is recognised to be a competitive alternative to steam technology, especially in plants ranging from 5-15MWe, thanks to several advantages such as no water consumption, low operation and maintenance (O&M) needs, and no need for supervision. ORC technology can exploit low-temperature sources better than steam technology and with a high electrical efficiency.

Today, there are around 400 Turboden ORC plants, 35 of which are used in WHR plants. Turboden has a long and reliable history in medium-high temperature projects. The average availability of the operating fleet exceeds 98 per cent and more than 18,000,000 operating hours have been reached.

Since 2010, Turboden has installed 10 ORCs in cement plants in seven countries. Among the range of ORCs already in operation, the smallest produces 1.4MWe at Holcim Eclépens (Switzerland) and the largest produces more than 7MWe at Sönmez Çimento (Turkey). Another 7MWe ORC is under construction for Secil in Portugal, which is due to start up in the first quarter of 2022. Turboden's complete cement industry reference list is shown in Table 1.

Turboden ORC clients recognise several advantages of ORC-based waste heat recovery systems compared to steam turbines. Firstly, the system can operate in fully-automatic mode without risk, and there is no requirement for supervision personnel, thus reducing operational costs and allowing operators to focus on cement production. In addition, the ORC system has a flexible operation with a wide range of thermal power loads with high efficiency even at partial load. It can be operated quickly and automatically at partial loads, following the cement plant's production programme without interrupting electric production and thus increasing the power plant reliability.

As previously mentioned, ORC needs minimum maintenance requirements. In particular, no partial condensation occurs at the level of the turbine. The blades are not exposed to wear or corrosion due to the properties of the working fluid, and this is a key factor in long-term O&M costs. The long life without the need for major overhauls completes the beneficial maintenance features.

Finally, possible configuration with no water consumption and consequently no need for water treatment leads the ORC to be a winning technology in countries where there is shortage of water.

A proven solution

All these references confirm that ORC technology is a proven solution in terms of WHR for cement plants, helping to increase sustainability of cement production thanks to its ability to recover heat even at low temperatures and with good efficiency. ORC can adapt very well to variable heat sources, maximising the electricity produced all year round to the benefit for the cement plant. ■