

A FIRST

Introduction

Waste heat recovery in Turkish cement production is a very dynamic and promising market; many cement plants have already implemented waste heat recovery (WHR) systems. Since 2011, a total of 12 WHR plants have been commissioned, with an overall installed capacity of about 120 MW.¹ At the beginning of 2018, Çimko (a Sanko Group company) selected CTP Team as its EPC contractor, and Turboden as its Organic Rankine Cycle (ORC) and air-cooled condenser supplier. This is all for its site in Narlı, Karamara, which will be the first project in Turkey based on ORC technology, and will include a thermal oil loop for heat recovery.

Why WHR?

The advantages of a heat recovery system include lowering electricity bills, an increase in competition, and no additional fuel consumption. WHR is a

profitable, low carbon footprint way to produce electricity and present a greener image.

Furthermore, the flexibility of WHR plants based on ORC technology reduces the need for water. This avoids the expenses of a water-based steam solution, such as water chemical treatment, water re-integration, and continuous chemical-physical water monitoring. The installation of a water-free plant also means protection from issues such as erosion and corrosion of components, and water-loss risks, for which Turkey presents one of the highest rates.² Turkey's water consumption should be taken into account in the project evaluation, particularly considering the 25 year life time of the WHR system and that of the cement plant.

ORC is a proven technology, available on the commercial market since the 1970s and originally used for the exploitation of geothermal sources. Since then, it has been used for power production from biomass

FOR TURKEY



Sabrina Santarossa, Turboden,
discusses the development of
the first waste heat recovery
plant in Turkey.

combustion, converted waste to energy, and aided heat recovery from industrial processes.

Over the past 10 years, increasing numbers of heat recovery projects have adopted ORC technology. Turboden is an Italian firm with more than 35 years of experience in this sector and close to 360 ORC plants worldwide. The average availability of the operating fleet exceeds 98% and more than 15 million operating hours have been reached.

The project partners

Turboden has been active in Turkey since 2012, when the first 1 MW co-generation unit was delivered to Kastamonu Entegre, a leader in the particle board industry. Turboden has subsequently put seven units in operation (26.5 MW total capacity) and there are five more under construction (21.7 MW), for customers in heat recovery, biomass, waste to energy, and geothermal applications.

In 2015, Turboden established a local company, Turboden Turkey. Located in Ankara, it manufactures ORC turbines, as well as other components, and has developed a Turkish supply chain. A local after-sales team was also created to assist the increasing number of Turboden plants, reduce response time, and easily provide support in Turkish.

CTP Team is an engineering and manufacturing company with 50 years of experience in environmental systems and heat recovery in cement plants. It is a global supplier of turnkey solutions, completing civil works and the mechanical and electrical balancing of plants. Through its sister company, CTN, CTP Team provides manufacturing of heat exchangers and building activities in Turkey. Local staff provide assistance during emergencies and planned maintenance, to fulfill any customer needs.

The combination of Turboden and CTP Team ensures that customers can rely on proven expertise in the design and manufacturing of components in cement

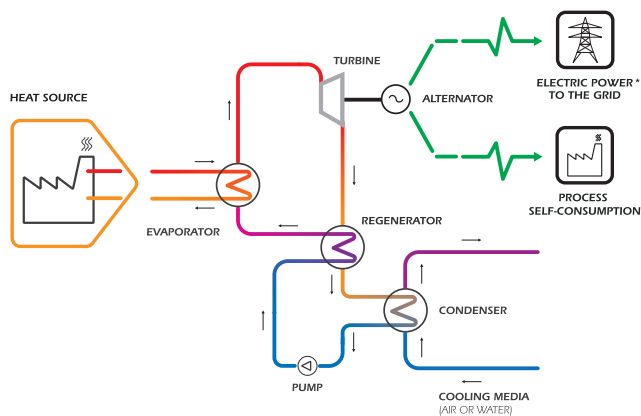
plants and power islands, as well as state-of-the-art technology for the cement market.

WHR systems with ORC in cement

Turboden has developed numerous projects to aid heat recovery from the cement production process, including the following:



2 MWe Turboden ORC system at an Italcementi cement plant.



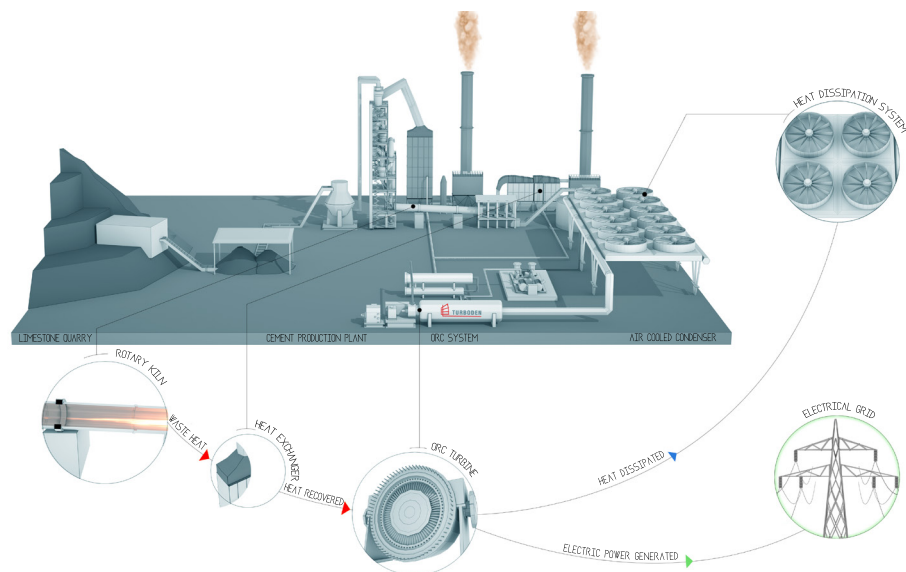
* ORC units can produce electric and/or mechanical power

Waste heat recovery process.

- 2 MW ORC unit installed in Ait Baha, Morocco, for Ciments Du Maroc (now HeidelbergCement), in operation since 2010. In 2014, this power plant was hybridised by the integration of thermal input, produced by solar power through a concentrated solar system.
- 4 MW ORC unit installed in the Holcim Romania factory (LafargeHolcim) in Alesd, started up in 2012.
- 5 MW ORC unit installed for CRH Slovakia's plant in Rohožník, which has been in operation since 2014.
- 4 MW ORC unit for Carpatcement (HeidelbergCement), which was installed in Fieni, Romania, in 2015.
- 2 MW ORC unit for Jura cement (CRH Group) in Switzerland, in operation since 2016.
- An innovative 2 MW direct exchange ORC unit recently installed at Cementi Rossi in Piacenza, Italy.
- 1.4 MW ORC unit, which is currently under construction for Cadcime in Switzerland, at the Holcim Eclepens plant.
- 7 MW ORC unit is currently being constructed at Çimko Narli (Sanko Group), in Turkey.

Çimko Narli project

The Çimko Narli plant is the first Turboden project in the Turkish cement market. The Çimko Narli kiln was installed in 2007, producing about 7500 tpd of clinker. The heat recovery project will increase the efficiency of the cement plant, already one of the most capable in Turkey. Turboden's WHR system will recover heat from the clinker cooler air at 340°C. A heat recovery exchanger will be installed after the clinker cooler and before the ESP filter because exhaust gases from the preheater tower are used in the raw mill and no thermal power can be exploited as waste heat. The WHR plant will bypass the main gas duct, decoupling from the main process when needed. Thus there will be no negative impact on clinker production. This is the typical configuration in industrial process



Layout of a cement plant with ORC.

heat recovery, which preserves the core business, while producing electricity.

In Çimko Narlı, as in several other WHR plants, the heat carrier used in the heat exchanger is thermal oil. Hot thermal oil will feed the ORC, in which cyclopentane will vaporise and expand in the high-efficiency axial turbine, which is coupled up to an electrical generator. After the turbine, the cyclopentane will go through an air-condenser, in which no water is used. The produced electric power will cover part of the captive consumption of the plant, decreasing the electricity demand from the grid.

During peak conditions, the ORC will produce up to 7 MW electricity, while in normal conditions the power production would be closer to 5 MW. The annual energy production will be higher than 30 GWh, all of which will be entirely consumed by the cement plant. From an environmental point of view, this will avoid 15 000 tpy of CO₂ emissions and no water will be consumed in the WHR plant.

Turboden will supply the ORC unit to CTP Team, appointed as EPC contractors by the Sanko group. Some components of both the ORC system and the heat recovery exchanger are manufactured in Turkey, decreasing transport costs and promoting the local supply chain. Civil works started in the summer of 2018 and the completion and start-up of the WHR plant is foreseen to take place in 1Q19.

During the tender phase, the customer evaluated both traditional Rankine Cycle and ORC. The latter was considered more competitive in terms of electric power production, water consumption, and operation costs.

This new reference plant confirms that the ORC has become a competitive alternative to steam technology, especially between 5 and 15 MWe, several features and advantages also having been confirmed by customers.

Benefits of ORC

Totally automatic system

The ORC module has a high level of automation and is designed to automatically adjust itself to the actual operating conditions. Variations on exhaust gas temperatures and flows will only affect the power output of the system, not the functionality.

ORC does not need supervision personnel in normal operating conditions, nor in the shutdown procedure. Comparatively, a steam-based heat recovery plant needs more than 10 dedicated operators.

ORCs are remotely monitored and require minimal maintenance every year, allowing the cement plant technicians to focus their time on cement production processes.

Highly efficient

ORC can reduce the designed thermal load to 10%, while maintaining high electrical efficiency down to 50% of the thermal load. If there are multiple kilns or a variable heat source load, ORC can maximise the energy produced per year.

Minimal maintenance and long life

Maintenance activities and costs are minimal compared to steam turbines. This is due to several characteristics of ORC technology, including organic fluid dry expansion in the turbine (meaning no erosion of blades), non-aggressive and non-corrosive organic fluid, low rpm of the turbine and feed pump, etc.

No water consumption

The main advantage of ORC technology, compared to steam, is the possibility of configuring the system without using water. Therefore, in remote and desert areas, where water consumption is an issue, ORC can be designed to fit.

High availability

Statistically, availability is higher than 98%.

Flexibility


ORC can be optimised to fit specific cement plants, selecting the type of heat carriers, the proper organic fluid, and the cooling technology.

The typical size of the ORC system is from 1 MWe to 18 MWe. Previous successful projects were achieved in different fields, such as a 8 MWe ORC biomass plant, a 10 MWe ORC in a steel factory, and a 16 MWe ORC geothermal project.

Conclusion

The first ORC-based heat recovery plant in a Turkish cement factory is an important milestone, which will develop heat recovery projects in this field.

Saving water is an important topic worldwide, particularly in Turkey, as there are several dry areas. ORC technology is a water-free solution that satisfies this requirement. Furthermore, when employing air-cooled condensers, the physical properties of organic fluids allow them to condense at a pressure greater than steam, but at a lower temperature. Thus, the efficiency of the thermodynamic cycle is increased and the electric power output has an acceptable cost increase.

ORC technology is able to recover heat at low temperatures, has good electrical efficiency, high flexibility, and minimum operation and maintenance costs. It is a good technological solution for effective and profitable implementation of heat recovery systems from cement processes. 

References

1. 'Waste Heat Recovery in Turkish Cement Industry: Review of Existing Installations and Assessment of Remaining Potential', (International Finance Corporation; 2018).
2. MADDOCKS, A., SAMUEL, R., REIG, P., 'Ranking the World's Most Water-Stressed Countries in 2040' (Water Resource Institute; 26 August 2015).

About the author

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