ELECTRIC POWER GENERATION FROM KILN OFF-GASES IN CEMENT AND LIME PLANTS

Waste Heat Recovery based power generation projects (WHR) in cement and lime plants are designed to capture the heat from the pyroprocess off-gases to drive a thermodynamic cycle that operates a turbine and a generator. The thermodynamic cycle can utilize steam (Steam Rankine Cycle) or an organic fluid (Organic Rankine Cycle) as the operating medium.

Waste Heat available for power generation

The most important task in designing the WHR system is to make the correct assessment of waste heat available for power generation. To this end, our consultants obtain the gas quantities and temperatures from the plant operating data and this information is then validated by comparing reported values and calculated values.

The heat required for other sections of the manufacturing process, such as drying of raw materials and coal, is carefully evaluated. ONLY the residual available heat is considered for power generation.

The moisture level of raw materials may not be constant throughout the year according to the season. The moisture's monthly cycle and the corresponding heat requirement are evaluated to determine the optimum heat availability for sizing the WHR equipment. Choosing the maximum heat for sizing WHR equipment may render the entire project unviable economically, if for instance, the maximum quantity is available only for one month in a year.

Steam Rankine Cycle

The Steam Rankine Cycle (SRC) utilizes water as the thermodynamic fluid. The heat exchanger directly uses water and the heat is used for converting the water into high-pressure steam, which drives the turbine and the generator.

Organic Rankine Cycle

The Organic Rankine Cycle (ORC) uses an organic fluid to convert liquid to high pressure vapor which runs the turbine and the generator. However, due to the higher cost of the organic fluid and risk of exposing it directly to the hot gases, there is an intermediate thermal oil loop that collects the heat from the hot gases through a heat exchanger and delivers it to the thermodynamic fluid at the power plant.

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Brief comparison between SRC and ORC

The following table gives a broad comparison of the two systems:

S. No	SRC	ORC
1	More suitable for high temperature applications.	Can be used for low temperature gases. Typically, not suitable for gas temperature > 400^0C
2	Lower efficiency	Conversion efficiency is higher – higher power potential for the same waste heat
3	Use of water makes it cheaper, though a water treatment plant will be necessary	Both thermal oil and the organic fluid are very expensive
4	Relatively safer	Organic fluid is flammable. The thermal oil has a flash point of around 300^0C
5	Spillage risks are not an environmental threat	Though both loops are sealed, there is some risk of spillage of hydrocarbon fluids
6	Higher maintenance due to potential corrosion of turbine	Less maintenance. The organic fluid does not corrode the turbine.
7	Lower initial investment	Higher investment costs

Most plants expect a payback period of 5 years, which can happen only with high power tariffs (>0.10 $/kWh) and very favorable configurations (large kiln with high temperature gases) and much lower CapEx (~3-4 M $/MWe power). WHR projects are many times financially feasible if the Government provides a good incentive for waste heat utilization and for reducing the carbon footprint.

It is to be emphasized that the Owner requires an experienced consulting company having expertise in cement/lime process as well as WHR systems to truly evaluate opportunities and integrate designs with the existing plant operations.

PEC Consulting provides the crucial role of due diligence, choice of appropriate capacity and system, and engineering for integrating with the plant.

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