BAMBOO

TECHNICAL INFO-PACK



ORGANIC RANKINE CYCLE



ORGANIC RANKINE CYCLE

Organic Rankine Cycle technology uses organic compound to transform thermal energy

DESCRIPTION

Organic Rankine Cycle (ORC) technology is a power generation plant based on a Rankine cycle where the working fluid is an organic compound rather than water steam. An ORC turbogenerator largely operates to **convert thermal energy into mechanical energy and eventually into electricity.** The main components of the ORC unit are an evaporator, a turbine, a condenser, and a feed pump. Instead of steam, the ORC system vaporises an organic fluid, characterised by a molecular mass higher than water. This leads to the slower rotation of the turbine (3,000 rpm), a completely dry expansion of the fluid in the turbine and it avoids erosion of the metallic parts and blades.

The process is based on the following steps:

- A single or multiple waste heat sources provide the necessary thermal power to feed the ORC thermodynamic cycle. The heat is transferred between the heat sources and the ORC turbogenerator either indirectly, through an intermediate heat carrier fluid, or directly, with the heat source stream heating and evaporating the ORC working fluid.

- The heat carrier fluid (or the heat source stream) is drawn to and from the ORC module. Within the ORC unit, the organic working fluid is evaporated in dedicated heat exchangers (pre-heater and evaporator).

- The organic vapour expands in the turbine, producing mechanical energy, which is then transformed into electricity through an alternator.

- The vapour leaving the turbine is then cooled and condensed by a cooling media. This cooling fluid can be either water (in an open or closed cycle) or air.

- The condensed organic fluid is pumped back into the regenerator before recirculating as a cool liquid for heat exchange once again with the waste heat source.

In the BAMBOO project **the innovative idea consists of the replacement of traditional coolers** (air coolers and trim coolers) **with newly developed heat exchangers that cool the refining product** to the target temperature while heating and vaporising the ORC working fluid directly. In such a way, a double benefit is obtained:

1. the refining product is cooled without electricity and/or water consumption.
2. Electricity is produced by the ORC without any fuel consumption.

POTENTIAL MARKETS AND END-USERS

The ORC technology has proven to be valid in different sectors and to enable the recovery of the excess waste heat produced by industrial proces-ses. The solution could be replicated also in other

oil & gas facilities, in power stations operating open-cycle gas turbines or in reciprocating engines, and in any other energy-intensive sectors.

The potential end-users are:

- The **cement industry.** In Europe, the potential of waste heat recovery using ORC technology is estimated at 550+ MW; a quantity of around 3 to 4.5 TWh could be generated from waste heat recovery per year.[1]
- The **steel sector.** The ORC application is considered suitable for recovering exhaust gasses.Around 750 MW could be generated in Europe with the use of ORC technology and potential recovery varies between 3.5 and 6 TWh every year.[2]
- **Gas compressors.** Around 1,300 MW ORC gross power could potentially be installed in gas plants and gas compressor facilities, with electricity generation up to 10.5 TWh per year.
- The **flat glass plants sector.** The analysis suggests a potential of 80 MW gross ORC power with around 50 installations in Europe.[3]
- The **petrochemical industry.** Between 25% and 35% of the prime mover nominal power output could be recovered through ORC technology.

RESULTS

While ORC as an energy efficiency tool was introduced several years ago in the cement, steel, and glass industries, this has not been the case in the petrochemical sector. Only recently has this sector started looking into waste heat recovery.

The BAMBOO project was able to identify the potential benefits and difficulties of integrating an ORC waste heat recovery unit into a complex facility when it assessed ORC possibilities at the Tupras refinery in Aliaga (Turkey).



Figure 1. An ORC unit installed in a steel factory



Figure 2. EAF in the steel-making industry is a source of waste heat that can be recovered and used to produce power through ORC technology

Based on the calculation carried out, **an ORC installed in Tupras refinery would be capable of producing approx. 31,000 MWh of clean electricity over two-years.** If we compare this result with the European (EU 27) and Turkish energy mix and related CO2 emissions intensity, we find that this 15.500 MWh of green energy per year corresponds to:

- 8,300 tons of CO2 avoided every year in Turkey, where carbon intensity is 0.54 tonCO2 per MWh el. produced (source: European Energy Agency, 2017 data).
- 4,600 tons of CO2 avoided every year in EU, where carbon intensity is 0.30 tonCO2 per MWh el. produced (source: European Energy Agency, 2017 data).

1,2, 3 According to estimates from the H-REII project



Figure 3. A cement plant

Despite these positive environmental results, **the project will remain on the paper due to the hurdles encountered in aligning**, from a technical and economic point of view, **the ORC solution to the requirements typical of the O&G industry:**

1. the ORC technology is a simple system where the design aims to guarantee simplicity and cost-effectiveness while maintaining reliability and safety.

2. O&G companies are used to very high-profile specifications and top-of-the-class components.

If applied to the ORC, such requirements imply high extra costs that undermine the project itself. This suggests that a change in the approach is necessary from both sides to find a solution that meets the minimum requirements of an O&G company and the need to be economically feasible.

This project has received funding from the European Union's Horizon 2020 research and Innovation programme under grant agreement N°820771