WASTE HEAT RECOVERY SOLUTION:

ORC technology

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Alessandro Zuccato, CEO of Zuccato Energia Srl, explains ORC technology as an efficient and sustainable investment to recover the thermal energy from diesel engines

Companies today are increasingly moving towards a sustainable corporate vision aimed at reducing their environmental impact. Zuccato Energia ORC modules – thanks to their low operating temperatures, represent an excellent choice to recover waste heat from a wide range of engines and gensets, to which they may be interfaced safely and easily through a simple hot- or overheated-water loop that ensures efficiency, safety and simple engineering. This technology permits covering a part or all of the electricity self-consumption of the factory or industrial plant with consequent economic savings on energy consumption, which can be reinvested in the company's core business.

ORGANIC RANKINE CYCLE WORKING PRINCIPLE

The Organic Rankine Cycle has characteristics that make it ideal for heat recovery and the exploitation of low-temperature heat sources in general. Its working principle is simple, as seen in the schematic (Fig.1):

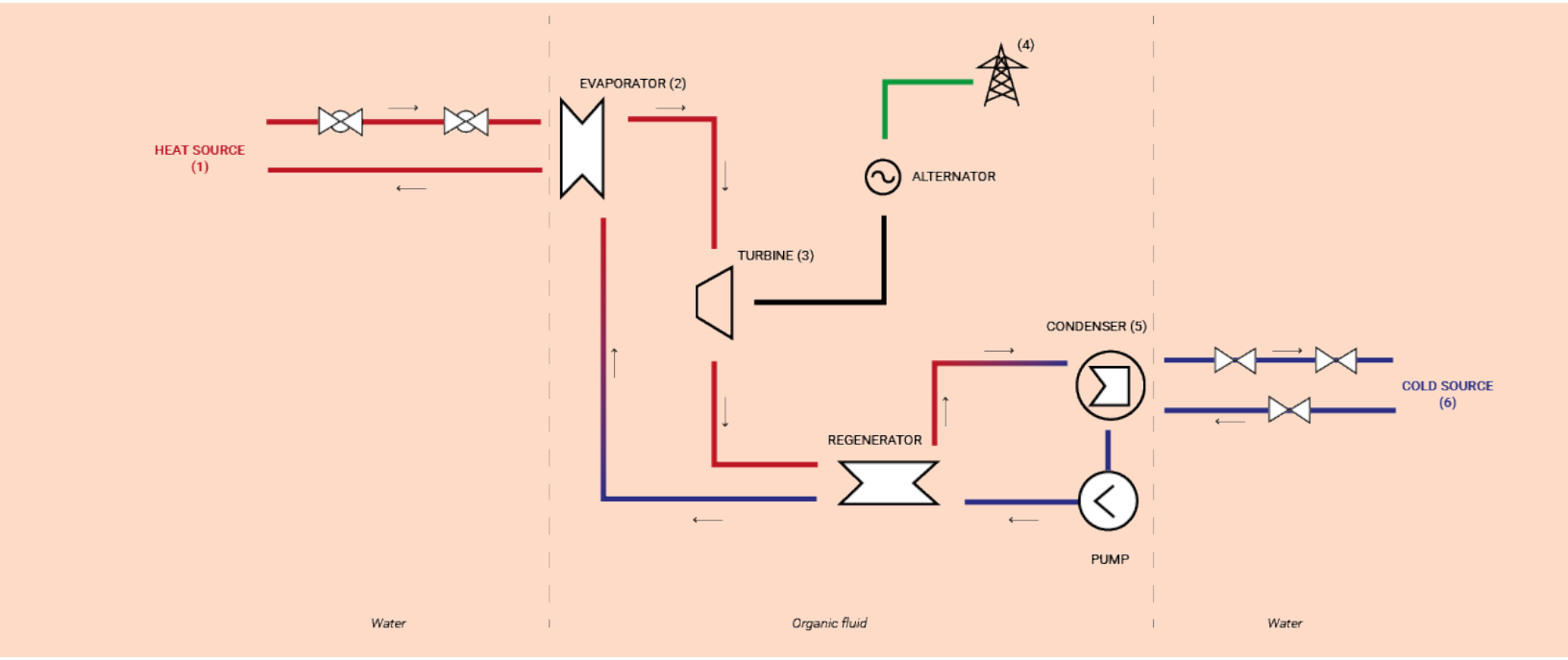

Fig 1 - ORC technology

A heat source (1) generates heat, which is conveyed through a vector fluid circulating into a closed loop to one or more primary heat exchangers, usually a preheater and an evaporator (2), where said heat is transferred from the vector fluid to the working fluid. The working fluid - a low-boiling point, biodegradable, non-toxic liquid when at room temperature - boils in the evaporator at a temperature far lower than that of water. It then becomes a high-pressure dry gas which spins through its expansion impeller of a specifically designed and sized turbine (3). The high-speed rotation (12.000÷18.000 Rpm) of the turbine shaft spins the rotor of a generator which is directly connected to it, thus producing electric power (4) which, after being synchronized in frequency, phase and voltage by a power converter, may be injected into the national power grid or self-consumed, according to local needs and policies. Downstream the turbine, the working fluid - still in the gaseous phase - is conveyed to another heat exchanger, called the condenser (5), where it is cooled, releasing its excess heat and condenses into a liquid which is collected in a condensation tank, to be sent back to the primary heat exchanger by a recirculation pump, thus closing the loop. Excess heat released in the condenser is a low-temperature thermal energy source itself, which may be used for other purposes such as preheating or drying of biomass fuel (thus increasing its heating value), building heating, sanitary hot water production to name a few. If that is not possible, residual heat may be dissipated by using an external cooling system (6) such as an evaporative cooling tower or a dry cooler.

TECHNOLOGICAL AND OPERATIONAL ADVANTAGES:

- **An increase in the overall efficiency of the system plant by recovering waste heat dispersed from the engine in different places:**

exhaust gases, by inserting a fume/water heat exchanger in the exhaust piping; engine cooling jackets, by inserting a water/water exchanger in the cooling water circuit; oil cooling circuit, particularly in larger-size engines (e.g., naval applications).

- **Two series of ORC systems:**

LT Series – for the recovery of high temperatures from exhaust gases and ULH Series – for the recovery of low temperatures from water/oil circuit.

- **Zero Emissions:**

ORC systems are impeccably eco-friendly. The entire process has zero atmospheric emissions. It uses an HFC working fluid and a thermal transfer fluid. Both are completely "ozone-friendly", non-toxic, and fully eco-compatible. Zuccato Energia particularly uses plain tap water for thermal energy transfer instead of environmentally dangerous alternative fluids.

- **Less maintenance and zero supervision:**

the low operational pressures of ORC technology ensure great operational safety. Full-scale automatization removes the need to employ specialized personnel for operation and an integrated remote-control system grants the client full remote monitoring and management capabilities.

- **Long duration (up to 20 years and over):**

ORC systems have different elements that allow a long duration - completely dry working fluid, CNC machined steel body with aluminium alloy impeller and use of ceramic bearings.

Fig. 2 ORC System in a customer plant

CASE STUDY

ZE-50-ULH - Italy

One of the projects we are completing is at a livestock farm specializing in cattle rearing and located in the province of Padua, Italy. It has been decided to acquire a biogas production system on the farm fuelled by the fermented sewage created from the cows. The biogas produced in the fermenting tanks is used as fuel for a micro-power plant based on a 637-kW engine by the German firm Jenbacher. The plant takes advantage of the favourable, all-comprehensive tariff which the Italian government grants to new, small power plants powered by renewable energy sources.

The ORC system supplied, a ZE-50-ULH low temperature Organic Rankine Cycle module - recovers waste heat from flue gases and cooling jackets of the aforementioned Jenbacher engine, and thus contributes significantly to the overall system efficiency and productivity. The ORC module is entirely contained in a custom container, located outdoors, which is both compact (4,2 x 1,5 x h 3,1m) and fully weatherproof. This container hosts the whole ORC system, including turbine, secondary heat exchangers and control panel, as well as a climatization system for the control panels. Cooling for the condensation part of the cycle is ensured by an EvapCo cooling tower located beside the container.

ZE-400-LT – Argentina

This Argentinian customer has decided to valorize his company's waste heat by creating an ORC power plant. The customer, who owns 5 Jenbacher engines (cogenerators) with internal combustion, chose to recover the hot fumes generated by his engines, in order to produce further electricity with ORC technology, increasing in this way, the overall efficiency if his power plant. The ORC module selected at this purpose exploits the heat contained in the engine fumes using a heat recovery heat-exchanger, which transfers the heat of these exhaust gases in clean water, generating superheated water at 160 ° C to feed the ORC module. The selected system can produce up to 420 kW of gross electricity, bringing the current electric production of 6800 kWe of the motors alone to 7220 kWe, with a percentage increase of 6.2%.

Fig. 3 Zuccato Energia ORC System in Area Test

ZE-40-ULH – Korea

This plant – our first installation in the Far East – is found in the main hamlet of a small island, located in the Yellow Sea off the south-eastern shore of South Korea. This small island, occupying less than 20 km2, is home to about 3,000 persons who rely on a local power station based on eight large diesel gensets for their electricity.

The plant owner has given a Korean private firm has been given the task to increase plant efficiency. As such, Zuccato Energia was asked to manufacture a 30 kWE nominal output Low-Temperature ORC Module with a peak output power of 40 kWE and maximum efficiency of 9% designed to operate by recovering the heat from a 1 MW diesel engine operating one of the gensets according to their specifications.

CONCLUSION

"Environmental sustainability" is becoming the watchword of the company vision; and energy consumption is the key element in assessing the environmental impact of an energy-intensive sector.

Waste heat recovery through ORC technology becomes the means to achieving this goal – recovering heat at medium and low temperatures regardless of the fuel burned by the engine to reduce the environmental impact, while at the same time reducing economic impact, allowing the exploitation of waste and conversion into electricity, with high flexibility and minimal maintenance requirements.

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