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Heat recovery and electric energy production trough ORC technology

In a typical heat recovery application, the heat contained in exhaust gas is transferred indirectly - through an intermediate thermal oil, water or steam loop - to the ORC plant.

The ORC plant produces electricity and low-temperature heat through a closed thermodynamic cycle which follows the principle of the Organic Rankine Cycle (ORC). The low-temperature heat is normally either delivered to thermal users (i.e. district heating networks) or discharged to the atmosphere through cooling towers or air cooled radiators within a closed loop cooling water circuit. The system is fully automatic and is controlled by the actual heat contained in the exhaust gas and the ambient temperature.

In a typical ORC process, designed as a closed cycle, the organic working fluid is pre-heated in a regenerator, then vaporized through heat exchange with the thermal oil loop. The generated vapour expands in a turbine, which drives an asynchronous generator. After leaving the turbine, the organic fluid (still in the vapour phase) passes through the regenerator in order to pre-heat the organic liquid before vaporizing, therefore, increasing the electric efficiency through internal heat recovery.

The organic vapour then condenses and delivers heat to the cooling water circuit. After the condenser, the working fluid is brought back to the pressure level required (for turbine operation) by the working fluid pump.

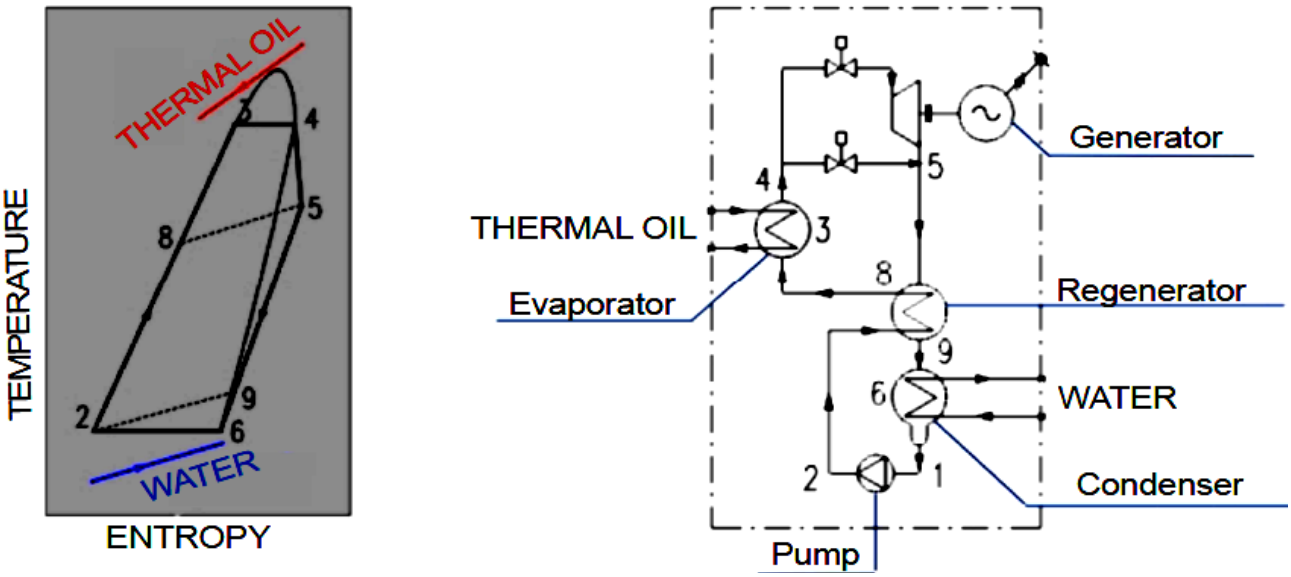

Figure 1 Thermodynamic cycle of the ORC plant.

With reference to fig. 1 the turbogenerator uses the hot temperature thermal oil to pre-heat and vaporize a suitable organic working fluid in the evaporator (8→3→4). The organic fluid vapour

powers the turbine (4→5), which is directly coupled to the electric generator through an elastic coupling. The exhaust vapour flows through the regenerator (5→9) where it heats the organic liquid (2→8). The vapour is then condensed in the condenser (cooled by the water flow) (9→6→1). The organic fluid liquid is finally pumped (1→2) to the regenerator and then to the evaporator, thus completing the sequence of operations in the closed-loop circuit.

The working fluid of the ORC module is a high molecular weight silicone fluid, which allows optimization of the thermodynamic cycle taking into account the boundary conditions for the specific case considered.

When compared to alternative technologies (steam turbine), the ORC plants demonstrate several advantages:

- High cycle efficiency;
- Very high turbine efficiency (up to 85%);
- Low mechanical stress of the turbine due to the low peripheral speed;
- Low RPM of the turbine allowing the direct drive of the electric generator without reduction gear;
- No erosion of blades, thanks to the absence of moisture in the vapour nozzles.

These technical advantages are translated in operational advantages, such as:

- Simple start-stop procedures;
- Minimum maintenance requirements (the time required to operate our modules is estimated between 3 to 5 hours per week);
- No extra technical competences needed for ORC operations (differently from steam boilers and turbines);
- Good performances at partial load (ORC can easily operate down to 10% of the nominal load);
- Low O&M requirements: about 3-5 hours / week (generally ORC plants are not guarded);
- Quiet operations.

Furthermore, the heat recovery system is designed to automatically adjust itself to the actual operating conditions: variations amount of heat available (in reasonable span times) will not affect the functionality of the system (but the power output).

Figure 2 shows a schematic representation of the ORC based heat recovery system, which is essential composed of:

- ORC unit;
- Primary heat exchanger - exhaust gas /heat carrier;
- Heat carrier circuit;
- Cooling water circuit and air-coolers (or cooling towers)

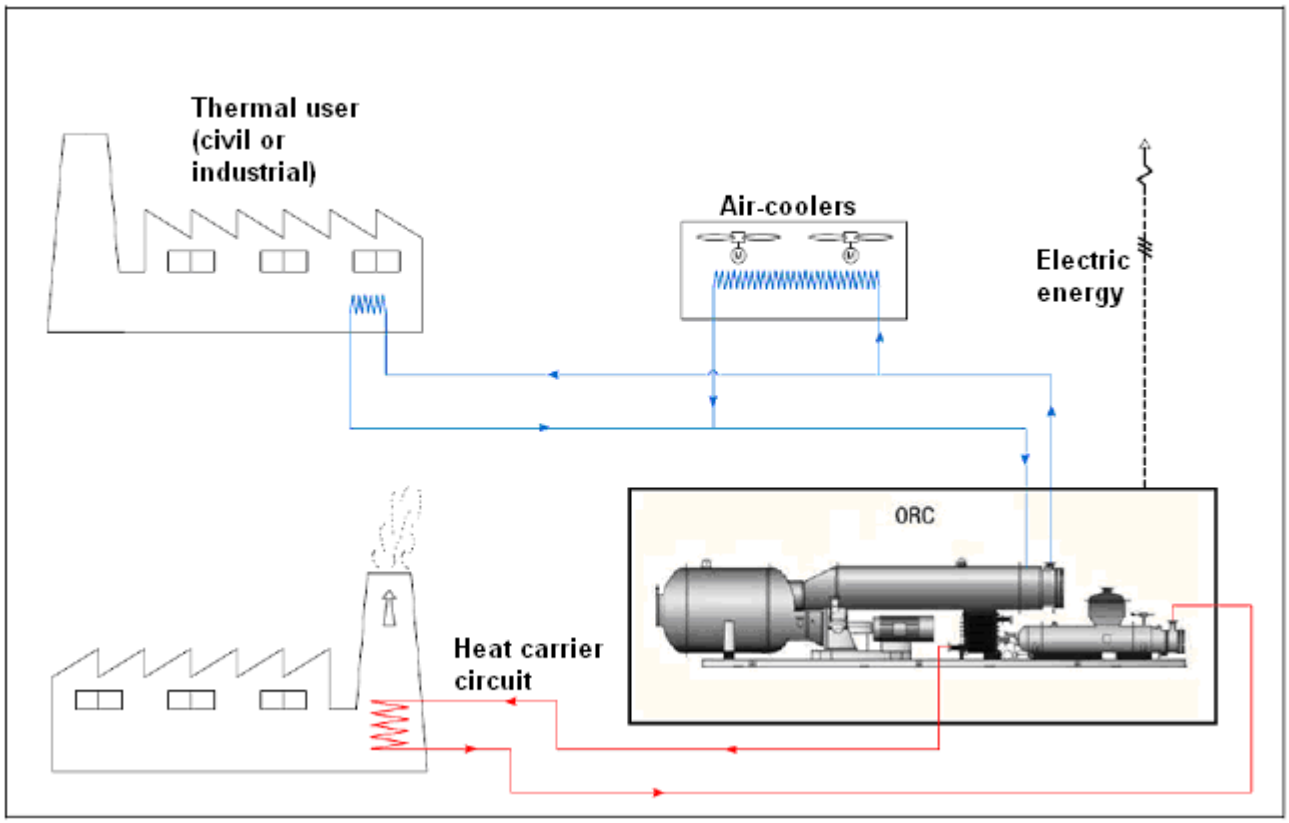

Figure 2 Schematic representation of an ORC based heat recovery system.