ORC Applications from Low Grade Heat Sources

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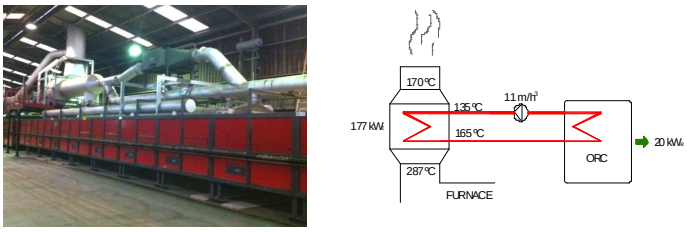
Abstract

This work deals about three different applications implemented in Spain. The first application consists of a power only system for industrial waste heat recovery, taking advantage from the exhaust air of a ceramic furnace to produce a rated electrical power of 20 kW. The second application is a Combined Heat and Power (CHP) system integrated as a bottoming power cycle of an Internal Combustion Engine (ICE), with the purpose to recover waste heat from exhaust gases. This system is installed in a hospital to increase the ICE electrical production and generate hot water up to 90 ºC. The third application can operate producing power only or heat and power. In this last case, the ORC module is used to profit thermal energy from a biomass supported solar thermal system, producing a maximum electrical power about 6 kW and hot water above 80 ºC.

Applications

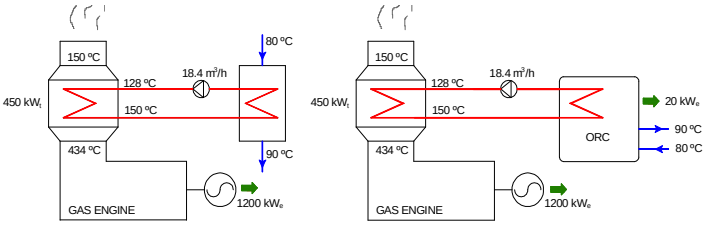
1. POWER ONLY SYSTEM FOR INDUSTRIAL WASTE HEAT RECOVERY



(a) (b)

Figure 1: Industrial furnace of Keros Ceramica and heat recovery facility: (a) heat transfer loop, (b) facility scheme.

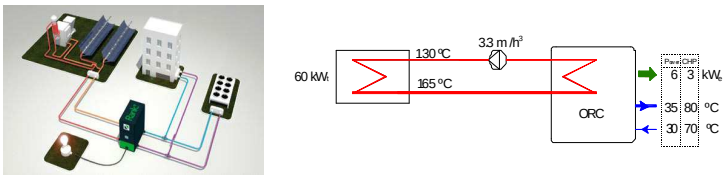
2. COMBINED HEAT AND POWER (CHP) SYSTEM AS BOTTOMING CYCLE OF AN ICE



(a) (b)

Figure 2: Heat source of the ORC system: (a) scheme of the original facility with heat exchanger, (b) scheme of the improved facility through ORC.

3. POWER ONLY AND CHP SYSTEM FOR A BIOMASS SUPPORTED SOLAR THERMAL SYSTEM



(a) (b)

Figure 3: Power and CHP applications: (a) typical architecture, (b) facility scheme.

Expanders Comparison

	Max. expander efficiency $\varepsilon_{el,ise}$ (%)	*Pressure ratio* r_p
Power Only application	64.89	7.93
CHP application	68.54	2.61
Power and CHP application	63.77	4.10

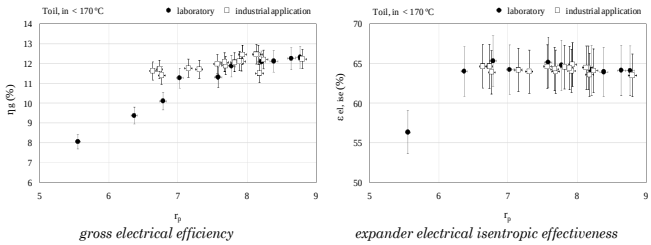
ORC Modules

(a) (b) (c)

Figure 4: ORC modules: (a) Power generation system integrated in the industrial application, (b) CHP system during tests, (c) Power only and CHP system during tests.

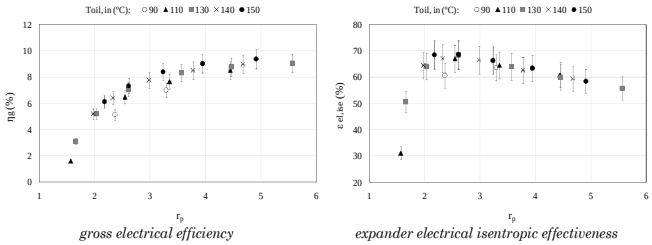
Experimental Results

Power Only



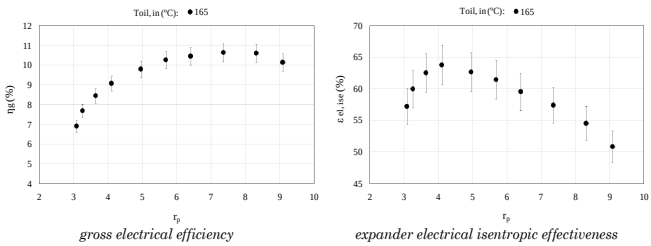
gross electrical efficiency *expander electrical isentropic effectiveness*

Combined Heat and Power



gross electrical efficiency *expander electrical isentropic effectiveness*

Power and CHP



gross electrical efficiency *expander electrical isentropic effectiveness*

CONCLUSIONS

The results show that the expander plays a key role in the optimization of a system for a specific application. So, a large Vi is recommended to operate in power applications, demonstrating a gross electrical efficiency of 12.47% with activation temperatures about 165ºC. A small Vi is preferable for CHP applications, being able to provide hot water up to 90 ºC with an acceptable gross electrical efficiency of 9.40%, with activation temperatures about 150ºC. However, if the system requires operating in both modes, power and CHP, an intermediate Vi results a suitable solution. So, the experimental data show a maximum gross electrical efficiency of 10.64% with activation temperature about 165ºC.