Títle: Production of compressed air from residual waste heat. A new concept developed by TASIO.

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Introduction: TASIO is a collaborative Project funded by the European Commission (H2020-EE-2014-1-PPP. GA: 637189). The main objective is to develop innovative concepts for the recovery of waste heat of Energy Intensive Industries (EII). The project begun in December 2014 and will finish in May 2018 with the installation and validation of a demonstrator in the industrial facilities of Cementi Giovanni Rossi SpA located in Piacenza (Italy). The Project will develop and validate the direct heat exchanger (DHE) Organic Rankine Cycle (ORC) concept for Energy Intensive Industries, new materials that may better resist corrosion and elevated temperatures and new control and monitoring systems that may be used with waste gases coming from the production of cement, glass and steel processes. Nowadays, and once the design phase is finished, a DHE demonstrator is being built that will be installed in the second half of 2017. Validation phase will encompass the period comprising September 2017 up to May 2018 when the project is to be finished with an open workshop to show the developed technology.

In December 2016 a technical milestone was reached successfully in a parallel activity. The concept of compressed air generation from hot gases created in a postcombustor using the ORC technology was validated in Tecnalia´s installations in San Sebastian. Figure 1 shows the transmission module that had been developed to couple the ORC to the compressor.

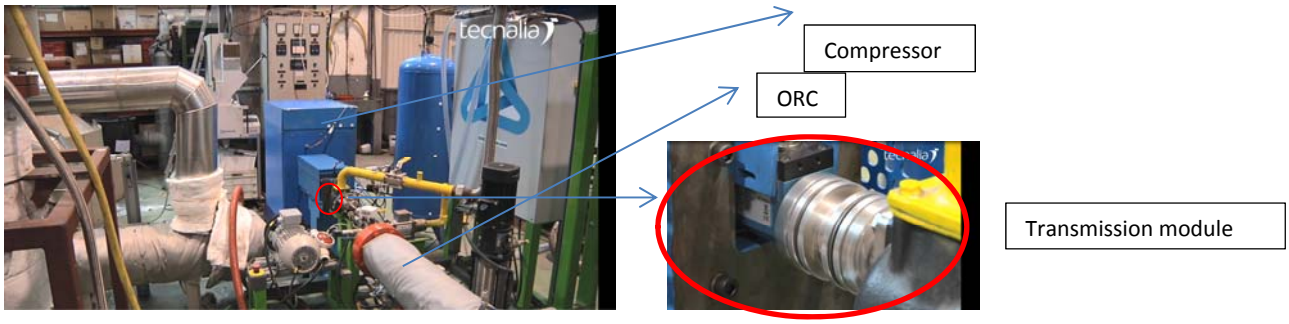

Figure 1: Pilot installation for the generation of compressed air from hot gases. Detail of de transmission module developed in the project.

Most relevant activities:

TASIO is based on the ORC (organic Rankine Cycle) technology. The consortium is composed of industrial partners representing steelmaking (SIDENOR), glassmaking (VIDRALA)) and cement (CEMENTI ROSSI) sectors. The Italian companies Turboden SpA, that is a worldwide leader in the ORC field, D´Appolonia, company develops and offers engineering services and CSM, focused on the design of materials and products and reduction of environmental impact of industrial processes participate also in the project together with the Hungarian environmental service specialist GEONARDO.

ORC is a technology to transform heat into electrical energy. It is similar to the more conventional Rankine Cycle (RC) technology, the main difference being that ORC uses organic fluids instead of water as the thermal fluid. RC usually consists in a thermal fluid that is heated by an external energy. The energy is subsequently transmitted by means of a heat exchanger to

another cycle that uses either water (RC) or organic fluids (ORC) that get vaporised in the evaporator and get expanded in a turbine before getting condensed and reused. The turbine is connected to a generator that produces electricity. TASIO aims at developing innovative concepts that may increase the efficiency of the recovery of energy coming from waste heat of Energy Intensive Industries.

In the first 30 months of the Project the consortium has overcome with success several challenging technical milestones and nowadays it is focused on the construction of the industrial demonstrator that will be installed in Piacenza (CEMENTIO ROSSI) in summer 2017. The main innovative aspect of the demonstrator will be the direct heat exchanger unit. It will make it possible that waste heat enters in direct contact with the organic fluid of the ORC eliminating the thermal oil and the intermediate exchanger used in conventional equipment.

The development of materials and coatings that may withstand the contact with waste heat gases generated in the industrial processes to produce glass, cement and Steel and the production of compressed air are two other milestones that have been reached in these months. In the first case TECNALIA selected and produced 3 structures or testers containing 12 different samples of different material/coating combinations. Three different Steel grades and 4 different coating materials and technologies. These samples remained within the chimneys of plants producing cement, glass and Steel during 3-5 months to check their performance in contact with those waste gases.

Figura 3: Metallic frame containing samples obtained by the combination of 3 steels and 4 coating materials recovered from the interior of the chimney in SIDENOR´s plant after the 4 month long test.

The milestone related to the generation of compressed air was achieved in December 2016. TECNALIA designed and produced a transmission module to join their pilot 30 Kw ORC´s turbine to the axis of a compressor (see scheme in figure 3) and validated the concept in their plant in San Sebastian (Spain).

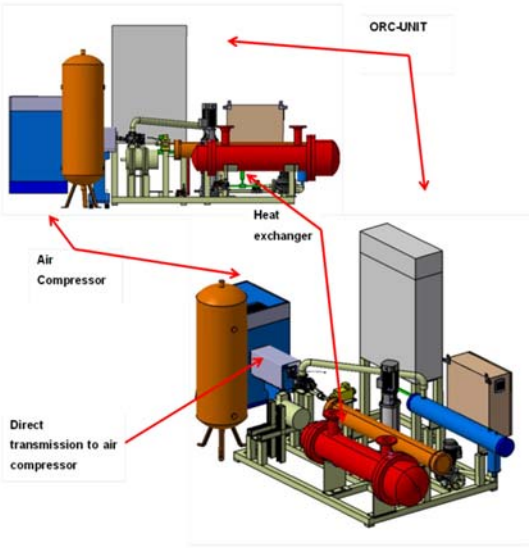

Figure 3: Layout of the pilot demonstrator designed to validate the concept for the generation of compresed air with the use of combustion gases.

Trials were carried out in three phases. In the first phase the ORC was connected to a hot water thermal unit with a thermal capacity of 36 kW and able to supply water with a temperature of up to 115 ºC. This water was used as thermal energy source to start the Rankine cycle and validate the concept. Compressed air was created and all the systems developed to control and collect data were checked. Once this phase was finished successfully the ORC module was translated to the pilot plant where it was connected to a postcombustor working with natural gas and able to produce combustion gases that, after getting refrigerated in a refrigerating tower, are available with a temperature of up to 360-400ºC. These gases enter in the heat exchanger connected with the ORC that is connected to the compressor. This system was kept working during 3 hours in continuous mode and generated 2 kW of mechanical energy and 180 l/min of compressed air.

In the third phase solid particles supplied by VIDRALA were introduced in the gas stream into the direct heat exchanger. The objective was to simulate the features of the gas produced in the glassmaking process. The system was kept working during 4 hours with the incorporation of the particles starting after the second working hour. The average efficiency of the ORC was around 6.5% and the incorporation of the particles generated a slight increase of the pressure drop in the heat exchanger from 145mm H_2O down to 158 mm H_2O.

Trials were carried out in December 2016. In the following months TASIO will continue working in the pending tasks related to the production and installation of the new ORC demonstrator based on the direct heat exchange concept. Parallel studies on the replicability and adaptability of the technology for further sectors will be also approached. It is foreseen that the demonstrator will be working from October 2017 onwards, up to May 2017. An open workshop will be organized to demonstrate the technology to all the sectors and companies interested in the recovery of waste heat in Energy Intensive Industries.