Low-temperature heat valorization toward electricity production (LOVE)

http://love.epfl.ch/

Second reporting period (Oct 2011 – Sept 2012)

Project context and Objectives

In the EU 27, the industry sector represents nearly one quarter of the final energy consumption and one fifth of the GHG emissions. One means to enhance the efficient use of energy in industrial processes is a more effective use of the waste heat generated in the process. This is the aim of the LOVE project, which focuses on the identification of low-temperature (T<120°C) waste heat sources in industrial operations, and in the development and demonstration of cost efficient innovative technologies for the use of these sources for electricity production.

Overall, the project consists of four parallel research activities organized in several work packages:

1. development of a methodology for the identification of waste heat sources in an industrial process and for the optimal integration of thermodynamic cycles (WP1),
2. definition of key performance indicators (economic, sustainability and technical) for the proposed technologies and the evaluation of their market potential (WP3),
3. manufacturing of two demonstration units to be installed in two cement factories, one of Holcim and one of Cemex (WP2 and WP4),
4. research on innovative heat exchangers and thermodynamic cycles (WP1, WP2 and WP5).

WP6 regulates management and dissemination activities.

The LOVE project started in October 2010 and will run for 3 years. This report provides an overview of the goals and progress achieved during the second year period.

Work performed since the beginning of the project and main results achieved

During the 2nd year, laboratory characterizations of the demonstrators' main components have been realized, as well as planning for the installation at the two cement plants. The analysis of available waste heat sources in different industrial processes, the identification

of alternative power cycles and the assessment of economic indicators have been deepened. Prototypes of polymeric heat exchangers have been manufactured and tested.

WP1: System integration, methodology and optimization

The methodology for characterization of waste heat sources in industrial processes, based on process integration techniques and pinch analysis, has been further developed and described in Deliverable 1.2. The method has been adapted for the application to the cement process. In parallel, flow sheeting models of LTHV cycles have been developed. Optimal integration of LTHV cycles has been assessed for a specific case study, with a process integrating a district heating system.

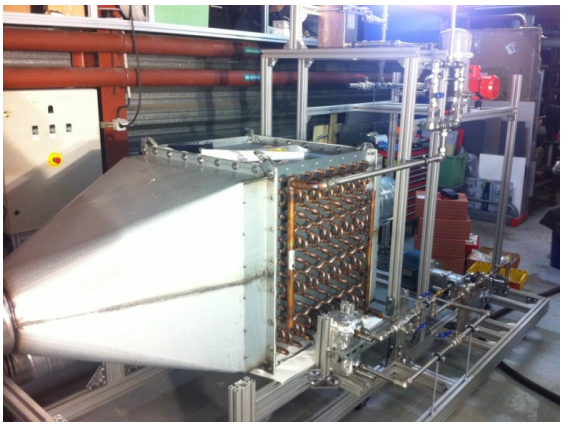
WP2: Waste heat recovery and advanced energy conversion towards implementation on demonstration power units by Rankine cycle

The different components of the two pilots to be installed at the cement plants have been designed: a finned tube heat and a packed column heat exchanger. Using the heat sources parameters, the optimal operating parameters of each component of the two ORC prototypes have been evaluated. Test benches for laboratory characterization of the heat exchangers have been realized. Design, construction, testing and characterization of the heat exchangers have been presented in Deliverables 2.1 and 2.2.

The radial inflow turbine that will be shared between the two prototypes has been designed, manufactured and transported to the test facility.

All other components of the prototypes have been designed and sized The realization and the assembly of the two prototypes has been launched in September 2012.

The following figures show the laboratory prototype of the heat exchangers to be used for the two demonstrators.



(1)

(2)

Figure 1: Finned tube (1) and packed column (2) heat exchangers mounted on the laboratory test benches.

WP3: Key indicators, impact study and transfer opportunities for selected industrial sectors

An overall economic analysis of the profitability of the plant based on the available cost and technical performance was performed and summed in Deliverables 3.5 and 3.6. The calculations set provided profitability criteria of the ORC investment in the cement plant considered. The case studies showed in most of the cases longer payback time than those generally accepted by industrial for off-production investments. Indeed, the turbine chosen in the LOVE project had to be relatively simple, with high efficiency and with the possibility to be scaled up to 1 MW. However, because of the constraint of use the same equipment on two different waste heat sources, no overall optimization is reachable. The cost of the turbine could be dramatically different, as there are other options for ORC in this scale but with lowered efficiencies. Larger scale deployment might influence the cost significantly, and this opportunity will be investigated at the end of the project.

WP4: Application and validation, electricity production in the cement sector

Following the detail design of the components carried, a list of drawings and materials has been prepared gathering the and the equipment and installation works required for the integration of the demonstrators unit at sites.

The cement partners have asked offers from local contractors. Thereafter, the detail engineering and the installation of the interfaces in the plants has started.

The measurement strategy and protocol of tests have defined between the cement partners, taking into account the technical limitations. A comprehensive list of sensors (over 250) will be installed on the demonstrators.

WP5: Exploratory research for low-temperature heat recovery and alternative conversion cycles

Several prototypes of polymeric gas-liquid heat exchanger have been manufactured and tested at laboratory scale during the reporting period. The main efforts in the reporting period are related to the minimisation of the pressure drop on the gas side. This is a key requirement before any further scale up and test in a real plant. Two prototypes have been prepared for tests in future activities. A specifically designed laboratory test bench has been constructed for this purpose.

WP6 - Project management and results dissemination

To facilitate efficient decision making and knowledge sharing, the LOVE consortium meets in regular cybermeetings. In addition, two semi-annual physical meetings have been held in March and September 2012. The project website is regularly updated both to exchange internal documents and to enhance external dissemination of results.

In March 2012 the 1st Industrial Advisory Committee meeting was held. It saw the participation of a dozen of large and small companies. Goal of this meeting was to present the project to a panel of industrial representatives in order to share knowledge and increase the application potential.

Expected final results and their potential impact and use

The LOVE project aims at developing innovative solutions to generate electricity from low-temperature (< 120°C) waste heat sources identified within various industrial sectors and specifically in the cement industry. This project will result in several technological developments:

- innovative heat exchangers, able to operate in hostile environmental conditions,
- a scalable and economically viable radial inflow turbine,
- adaptation and use of the energy integration methodology, and development of multi-criteria decision-making tool for valorisation of low temperature heat sources,
- exploration of high efficiency conversion cycles and low impact working fluids.

Two transportable demonstration power units will be built and operated at two cement plants. This will increase the perspectives of exploiting the R&D results generated by the project. It has been estimated that the valorisation of the two sources selected for demonstration in 20% of the EU cement plants could yield 430 GWh p.a.

The total volume of the project is estimated to be 5 Million Euro, more than 60% funded by the European Commission.

In the third reporting year the LOVE project will face several challenges, in particular with the installation and on site test of the two demonstrators within WP2 and WP4.

The methodology developed in WP1 and the criteria assessed in WP3 will give clear indications on the application potential of the developed technologies, while heat exchangers and conversion cycles developed in WP5 will open further waste heat recovery paths.

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