**Experimental analysis of partial evaporation micro-ORC for low-temperature heat recovery**

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Abstract

In this paper, we present an experimental assessment of the performance of a partial evaporating organic Rankine cycle (PE-ORC) power system. The system converts low‑temperature heat into electrical energy, with a power size around one kW, thus suitable for micro-generation in the residential sector. Although the test bench was designed for operating with superheated vapour at the expander inlet, it has demonstrated to be able to work with the expansion occurring entirely in two-phase condition.

Since the direct measurement of the vapour quality is not possible using the sensors installed in the test rig, the state of the fluid in the two-phase condition is estimated by means of the thermal balance at the heat exchangers, so the thermodynamic cycle can be evaluated. Temperatures of the heat source in the range between 40 °C and 75 °C have been tested, and for each temperature value the vapour quality at the expander inlet has been varied by regulating the feed-pump rotating speed. Experimental data are provided regarding the performance of the overall cycle, of the heat exchangers, of the expander and of the feed-pump. It was observed that the effectiveness of the evaporator and the efficiency of the pump are improved with respect to the operation with superheated vapour at the expander inlet. However, the overall performance are lower, especially due to the high ratio of the pump consumption over the expander produced power, commonly called *back work ratio* (BWR). The latter, under some boundary conditions, resulted higher than the unit, meaning that the system was not able to produce net electrical power.

The aim of the paper is to identify the design characteristics required by a micro-ORC energy system in order to enhance its performance in the PE operating mode.

RESULTS and DISCUSSION

Figure 1 shows how the electrical power produced by the expander varies with the vapor quality of the working fluid at the expander inlet, and with the temperature of the heat source. The expander power mainly depends on the heat source temperature, with a value close to 1200 W registered with a temperature of 75 °C and quality approximately equal to one. At constant heat source temperature, the electrical power decreases with the reduction of the vapor quality, which is the result of the increment of the flow rate of the working fluid. The power reduction is more evident at high temperature of the heat source. This behavior is in contrast with the regular operation of the micro-ORC with dry expansion, in which the increment of the flow rate leads to an increment of the pressure difference across the expander, and therefore to the rise of the expander power.

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| **Figure 1. Expander electrical power versus vapor quality at the expander inlet, at different heat source temperature.** |