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Dynamic control strategies for distributed microgeneration and waste heat recovery power plants

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Abstract

In this paper the modeling activity on a waste heat recovery microgeneration ORC plant is presented together with the results of the application of two different load diagrams and three different control strategies. The overall energy production and the average efficiency were compared and a proper control strategy was evaluated to optimize the energy recovery process as well as the dynamic response of the plant.

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Keywords: low carbon city; urban energy system; renewable energy; sustainable development.

1. Introduction

In the last years the interest towards the low-enthalpy heat conversion into electrical energy has largely grown up, and this was due to the claim for pollutant emissions and fossil energy dependence reduction.

Organic Rankine cycles (ORC) are among the most studied solutions not only from the point of view of the overall efficiency but also for their operational flexibility and capability of following the energy input, which may be quite unpredictable especially when dealing with unprogrammable energy sources.

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Up to now, many systems are available with a minimum power output of about 0.5 MW, while in the lower range only few plants have been built so far. However, the minimum size of 500 kW might be oversized for many applications.

In the lower range of power output (up to 100 kW), several research paper about the use of volumetric expansion devices were published, due to the lower sensitivity to the moisture content of the operating fluid at the end of the expansion than turbines [1] and for their higher intrinsical flexibility of use [2-11].

This paper focuses on the improvement of the plant flexibility with respect to the variations of the energy input and a waste heat recovery system was taken as a case study. To the authors' knowledge, it is the first time that a working conditions dependent control strategy was evaluated.

2. Material and Methods

The work described in this paper was carried out through numerical analyses performed with the AMESim code and the volumetric expansion device employed was of the Wankel type, whose simulation model was presented in a previous paper [1]. This type of device proved to be suited for the power output range of 10-50 kW depending on the working fluid, which in this case is R-600a, based on previous published work [10]. The energy input diagram was also derived from literature and is representative of a typical application of waste heat recovery (from the exhaust of an internal combustion engine). The plant scheme is depicted in fig. 1 while the load diagrams considered are traced in fig. 2.

The differences between the two load cycles were in the amplitude of temperature variations, while mass flow rate was the same.

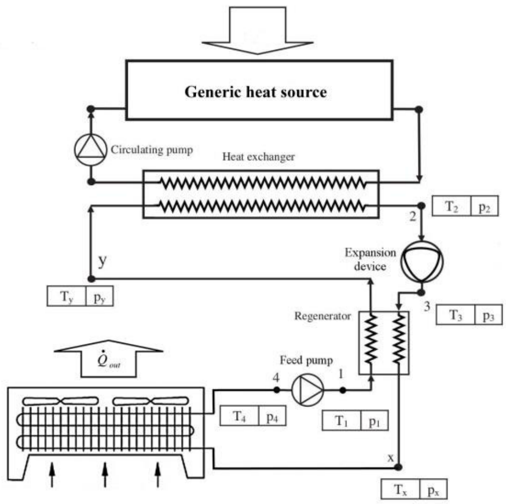

Fig. 1. Plant sketch