INVESTIGATION OF A TOPPING/BOTTOMING ORC BASED CHP CONFIGURATION INTEGRATING A NEW EVAPORATOR CONCEPT FOR RESIDENTIAL APPLICATIONS

João S. Pereira*, José B. Ribeiro, Ricardo Mendes and Jorge C. André.

* Corresponding author: joao.pereira@dem.uc.pt.

University of Coimbra,
Rua Luís Reis Santos, Pólo II, 3030-788 Coimbra,
Portugal.

ABSTRACT

The development of ORC based micro-CHP systems to retrofit the current combi-boilers is receiving noticeable attention from research centers and companies due to the huge dimension of the potential market. One of the key components of these systems is the ORC-evaporator that, due to its specificities, cannot be adapted from parts of mass production devices and demands specific design. Taking the requirements related with dimension, efficiency and turn down ratio in consideration, the following design principles arisen: i) use of combustion gases for direct vaporization of the ORC working fluid; ii) a counter-flow arrangement and iii) use of a pre-mixed gas-burner. Moreover, to avoid problems of overheating, the existence of a cold surrounding to the gas-burner head arise as a fourth principle. This last specification, provided by a sleeve through which the CHP water flows, leads to an original (hybrid – topping/ bottoming) configuration in which the thermal energy is produced stepwise: first in the ORC-condenser and then in the gas-burner head sleeve of the ORC-evaporator. A model of this configuration was developed to determine the optimal fraction of the CHP water heating process that is performed in the gas-burner head sleeve. Furthermore, an efficiency analysis was performed for a wide range of the CHP operating conditions to study the effect of i) the reduction of the ORC average condensing temperature, ii) the increase of the expander pressure ratio and, iii) the reduction in the ORC working fluid mass flow rate. When compared to a standard CHP configuration, this solution show benefits for the greater part of those conditions. Besides of solving the safety issues posed by the ORC-evaporator requirements without significant penalties, and even with benefits in a significant part of the CHP operating conditions, this configuration also reduces the combustion gases' temperature before they reach the organic working fluid heat-exchanger section in the ORC-evaporator that can be crucial to mitigate the risk of its (working fluid) thermal degradation.