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Optymalizacja parametrów konstrukcyjnych i eksploatacyjnych siłowni ORC zasilanej ciepłem odpadowym z procesów przemysłowych

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Abstract

Waste heat, which is an unavoidable by-product of many industrial processes, represents a loss that can be usefully managed with appropriate technologies.

It is common practice to utilise this energy still in the same process through regenerative and recuperative heat exchangers, or as heat for heating purposes. However, these solutions are organically confronted with the distribution of heat demand over the course of the year or the limited possibilities of transporting it over long distances, hence the growing interest in technologies that enable waste heat to be converted into electricity.

One such technology is the Organic Rankine Cycle, which is a variation of the classical steam Clausius-Rankine Cycle. The main difference lies in the use of working fluids other than water, typically characterised by a lower boiling point and/or enthalpy of vaporisation.

This makes ORC technology ideally suited for harvesting heat with low thermal parameters, such as geothermal, biomass, solar energy or industrial waste energy.

On the other hand, the great diversity of waste heat carriers in terms of temperature level, flow rate and nature of the load makes it difficult to design standardised series of units and, in many cases, may require individual approach to design the optimum unit.

This paper presents the specifics of the market niche of industrial waste heat, identifying the theoretical potential of waste heat in Poland and estimating the possibility of implementing ORC units with a total capacity of almost 340 MW in various industry branches.

Well established, as well as emerging technologies competing with ORC technology, such as the classic steam cycle, the Kalina cycle or the Inverted Baryton Cycle (IBC), are discussed. The specifics of the ORC technology, the types of working medium used, the technological structures, the types of expanders used, are presented.

A description is given of the ORC units built to date by Marani and their main design principles and parameters.

A description is given of the calculation procedure used to evaluate waste heat sources,, selection of rated design parameters, the calculation of the heat exchange surface area, the ecological effects, the payback time and the off-design parameters of designed units.

A case study is presented, with comparison of results as well as verifications of the results obtained with the developed tools with the results obtained by the Robert Szewalski Institute of Fluid-Flow Machinery obtaining convergent results for independent analyses. As part of the study, an acceptable range of variation in the waste heat carrier parameters was determined to allow the operation of an ORC system with the selected parameters.

Based on the measurements of the Marani ORC30 system, the results obtained with the developed model for the analysis of ORC systems at partial load conditions were verified.