Editorial: organic rankine cycle for efficiency improvement of industrial process...

Health & Medicine

Editorial on the Research Topic

Organic Rankine Cycle for Efficiency Improvement of Industrial Processes and Urban Systems

Background

The organic Rankine cycle (ORC) is a particularly promising and mature technology for the utilization of low- and medium-grade thermal sources such as solar (Quoilin et al., 2011 ; Freeman et al., 2015 ; Markides, 2015), geothermal (Quoilin et al., 2013), or waste heat from industrial processes and internal combustion engines (Wang et al., 2011 ; Lu et al., 2017). ORCs are thermal power cycles that employ organic working fluids in order to convert low/medium-temperature thermal energy into either mechanical or electrical power. One advantage of ORCs is that the best working fluid can be chosen according to different heat sources and applications. For example, there exists a significant amount of surplus energy across industrial processes, and ORC systems can be integrated with these processes for the efficient utilization of this otherwise wasted energy. The estimated global waste heat energy in 2012 is 245 PJ, about 51. 8% of the overall consumed primary energy (Forman et al., 2016). ORC technology has progressed significantly in recent years, with applications of the technology being a key component of sustainable development of a high-efficiency, low-carbon society.

This collection for Frontiers in Energy Research seeks to present the latest progress, technological development and application of ORC technology. The Research Topic covers research on systematic system design, strategies for performance optimization, design of new organic working fluids, system integration in real applications and experimental investigation on demonstrators using both simulation and experimental studies. This Frontiers Research Topic has attracted a total of six research articles from countries including China, United Kingdom, Belgium, and Iraq. The editorial team would like to thank the authors and reviewers for their excellent contributions in making this Research Topic a success.

Summary

Papers in this collection highlight different aspects of ORC technology from fluid selection, innovative system design and application, to expander development. In terms of working fluid selection, the research considers the integration of system design and parameter optimization simultaneously with the identification of the best working fluid. White and Sayma propose an optimization framework that can optimize the working fluid and cycle parameters simultaneously, and identify whether a subcritical or transcritical cycle, with or without a recuperator, is most suitable for a specific application based on a non-linear turbine model and Peng-Robinson equation of state. The optimal cycles if a performance map is used for the expander efficiency are quite different from that assuming a constant turbine efficiency. Castelli et al. employ a cycle optimization approach to identify the most promising working fluid from 102 candidates including both pure fluids and zeotropic mixtures. The cycle variables are optimized for maximum thermodynamic performance. For waste-heat recovery in an aluminum production plant as a case study, HFE-347mcc and isobutane-isopentane are found to be two particularly suitable working fluids with a high exergy efficiency. Multi-objective optimization is also adopted in both studies to evaluate thermodynamic as well as economic performance comprehensively.

Three contributions in this Research Topic focus on system design and innovative applications of ORC technology. Al-Tameemi et al. design a gas-powered heating system, integrating an ORC system with a heat pump. The performance and operation of the combined ORC and heat pump system are discussed, and optimal control strategies are considered using Aspen Plus in response to variations in the ambient conditions. The cold water first flows into the heat pump system and then to the ORC system is a better design. Zhang et al. put forward a power and ejector-refrigeration system using zeotropic mixture R134a/R123 as the working fluid. The relationship between the input heat of the ejector, the net power changes and the power saved by ejector is analyzed. The power saved by the ejector is larger than the net power reduction. Song et al. investigate the thermo-economic performance of subcritical and transcritical geothermal ORC power-plants with or without superheating and recuperation. Non-recuperated transcritical cycle systems using working fluids whose critical temperature are close to the heat source temperature are reported as being favorable in this large-scale application. These studies suggest that ORC technology has a great potential in various industrial and renewable-heat processes. A high exergy efficiency can be achieved as around 60% with a profitable economic performance.

In ORC systems, especially in small-scale systems, the expander is a key component that can strongly determine thermodynamic performance and affect the overall cost. The development of new, high-efficiency expanders is a critical element of the mass deployment of small-scale ORC systems.

Oudkerk and Lemort present an experimental study of a swash-plate piston expander. The influences of the rotational speed and levels of pressure on the power output and the expander isentropic efficiency are investigated. The importance of different sources of losses is analyzed based on a detailed mathematical model. The results show that the maximal power output and isentropic efficiency of the expander are 2. 8 kW and 53%, respectively.

Outlook

ORC technology shows great potential for the effective utilization of low-to-medium temperature waste heat in industrial applications. The thermal efficiency of an ORC system can be a few percentages to over 20% according to the temperature of the heat source. Huge amount of additional power can be generated by ORC systems if global waste heat is utilized comprehensively. However, significant challenges exist, and further progress is needed before successful, widespread ORC system deployment. An issue of increasing importance and urgency in this regard concerns the development of new and efficient working fluids with environmentally friendly properties. New working fluids such as HFOs and HFEs appear poised to become the next-generation working fluids for ORC systems, whereas more novel working fluids need to be developed in further research. Meanwhile, research and development into even more innovative ORC systems remain crucial to improving performance and economic viability. Designing suitable ORC systems tailored to various industrial applications is key, as is the requirement to optimize these systems while considering the full details of their integration within wider energy systems.

Author Contributions

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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