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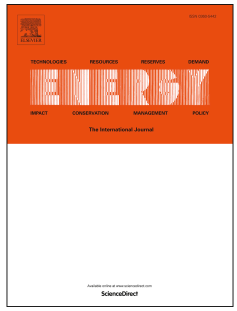

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Abstract

The organic Rankine cycle (ORC) is a promising method of generating power that utilizes low-enthalpy renewable energy and industrial waste heat. Given that the exergy loss and capital investment cost of heat exchangers account for a large proportion of the components in the ORC, research on the development of novel heat exchangers and configuration optimization coupling with other components and cycle parameters is essential to improve the ORC performance. In this study, an innovative liquid separation condenser (LSC) is incorporated into a waste heat-driven ORC system. A non-convex mixed integer non-linear programming model is formulated to simultaneously optimize the component configurations and system parameters of the LSC-based ORC. The objective is to minimize the electricity production cost of the ORC. The pressure drops of the heat exchangers are directly incorporated into the cycle model instead of ignoring them or constraining them by upper bounds. The physical property parameters of the working fluid are regressed using the Refprop9.0 database to ensure the optimization of cycle operating variables. A case study is presented to test the proposed methodology and the formulated model. The results achieved using the simultaneous optimization method are compared with the results achieved using the sequential optimization method. The optimization results of the LSC-based ORC are also compared with those of the parallel flow condenser-based ORC. Then the influences of the key structure variables on the optimization results are studied. Finally, a sensitivity analysis of heat source parameters and environmental parameters on the optimization results are conducted.

Keywords: simultaneous optimization, component configuration, liquid separation condenser, electricity generation cost

1. Introduction

The decrease in fossil energy reserves and the increase in energy prices have resulted in a strong interest in utilizing renewable heat sources or waste heat for power generation. The organic Rankine cycle (ORC) is a promising heat-to-power conversion technology due to its simplicity, flexibility, low maintenance requirements, and favorable operating pressures. Given the nature of low-temperature energy sources, the thermal efficiency of the ORC is relatively low and its investment cost is higher than that of traditional power generation technologies that use high-grade energy. Therefore, improving conversion efficiency and reducing electricity production costs are popular topics in ORC research.

During the past decades, the ORC has been extensively investigated in terms of fluid selection [1–6], thermodynamic analysis and thermodynamic optimization [7–10], cycle structure improvement [11–13], and integration with other energy systems [14–17]. In addition, many ORC plants have been installed worldwide to convert waste heat [18], geothermal energy [19], solar thermal energy [20], and biomass energy [21] into power. However, several important research issues still require extensive research. These issues include the investigation of high-performance components (e.g., evaporators and condensers) for low-temperature heat-driven ORCs, the coupling and optimization of component configurations and cycle parameters, and the optimum integration of the ORC with available heat sources and environmental parameters.

Given that thermodynamic analysis and optimization focus on the improvement of the thermodynamic performance of the ORC, the results obtained may not be optimal in economic point of view. The economic cost of the ORC comprises

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