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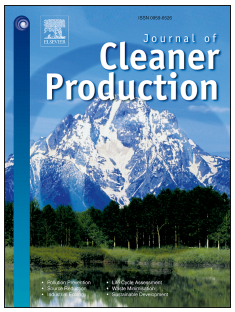

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Thermo-economic-environmental optimization of a liquid separation condensation-based organic Rankine cycle driven by waste heat

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Abstract

Organic Rankine cycle (ORC) is a promising thermal-to-power conversion technology utilizing low enthalpy renewable resources or waste heat energy. The coupling of environmental impact analysis and thermo-economic optimization is effective in evaluating and improving the comprehensive performance of the ORC. In the present study, a thermo-economic-environmental analysis and optimization methodology is proposed for the design of a waste heat driven ORC. A multi-objective mathematical programming model integrating the environmental impact and thermo-economic performance is formulated for the simultaneous optimization of the component configurations and operation parameters for a waste heat driven ORC. The objective functions include the minimization of the environmental impact and the maximization of the net power output. The specific investment cost is used to evaluate the economic performance of the ORC. A previous developed solution strategy is applied to solve the single objective optimization problem and the ε-constrained method is applied to solve the multi-objective optimization model. A case study is elaborated to test the proposed methodology and the formulated model. The single objective optimization results demonstrate the contradiction between the environmental objective and the thermal-economic objective. The trade-off solutions are achieved by multi-objective optimization. The Pareto-frontier is elaborated to show how the material allocation, component configuration, and operation parameters are influenced by the objective functions. Finally, a sensitivity analysis of the life cycle inventory of raw materials on the optimization results is conducted.

Keywords: environmental impact, organic Rankine cycle, life cycle assessment, multi-objective optimization

1. Introduction

Fossil energy depletion and environmental deterioration have become serious issues of current world. The pollutant emission resulting from energy services are the major cause of the climate change. Many countries has been devoting great efforts to cope with the energy and environmental problem. The Chinese government pledges that China's carbon emissions are expected to reach the peak around 2030 (Mi et al., 2016). The European Council promises that the greenhouse gas emissions decrease 40% from 1990 to 2030 (Dogan and Seker, 2016). The recovery of waste energy and effective utilization of renewable energy are two effect means in saving energy, reducing pollutant emission, and replacing fossil energy. Organic Rankine cycle (ORC), a Rankine cycle using low critical temperature organic fluid, is one of the most promising technology that transform these waste energy or renewable energy into power. The ORC has been becoming one of the recent hot topic. In the past few years, many researchers have devoted to improve the performance of the ORC by screening different working fluids (Le et al., 2014; Feng et al., 2015; Vivian et al., 2015; Yu et al., 2015; Heberle et al., 2016; Invernizzi et al., 2016; Stijepovic et al., 2016), investigating novel cycles (Meinel et al., 2014; Galindo et al., 2015; Li et al., 2015; Sadeghi et al., 2016), optimizing the operating parameters and

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