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Comparative study of power generation systems powered by data center waste heat

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Abstract. In this study, a thermodynamic optimization of a subcritical Organic Rankine Cycle (ORC), supercritical ORC, and trilateral Rankine cycle (TLC) power plant from data center waste heat was conducted. The waste heat temperature in a range of 35°C - 75°C was examined. Various working fluids were tested as the working fluid for the power plants studied. A computational code was developed and validated with a result taken from the literature. The golden section method was used to search for an optimum operating condition that provides a highest net power output for the prescribed heat source temperature ($T_{hf,in}$), cooling fluid temperature ($T_{cf,in}$), and pinch point temperature differences. It was found that the supercritical ORC plant is not suitable for generating electricity from the heat source investigated in this study. In addition, the subcritical ORC and TLC cannot generate electricity when $T_{hf,in}$ are at 35°C and 45°C. For the subcritical ORC plant when $T_{hf,in}$ are at 55°C, 65°C, and 75°C, the corresponding highest net power outputs of 416 W, 1.40 kW, and 2.97 kW are obtained respectively. Furthermore, the highest net power outputs of 633.60 W, 2.29 kW, and 4.93 kW are produced from the TLC plant when $T_{hf,in}$ are at 55°C, 65°C, and 75°C, respectively. In the off - design simulations, it was found that the TLC plant provides higher net power output than the subcritical ORC for the whole range of $T_{hf,in}$ and $T_{cf,in}$ investigated.

Keywords: Data center waste heat, low-temperature heat source, subcritical ORC, trilateral Rankine cycle, golden section search