

Thermodynamics Analysis of Transcritical HTHP Cycles Using Eco-Friendly Refrigerant and low-Grade Waste Heat Recovery: A Theoretical Evaluation

Authors : Adam Y. Sulaiman, Donal F. Cotter, Ming J. Huang, Neil J. Hewitt

Abstract : Decarbonization of the industrial sector in developed countries has become indispensable for addressing climate change. Industrial processes including drying, distillation, and injection molding require a process heat exceeding 180°C, rendering the subcritical High-Temperature heat pump (HTHP) technique unsuitable. A transcritical HTHP utilizing ecologically friendly working fluids is a highly recommended system that incorporates the features of high-energy efficiency, extended operational range, and decarbonizing the industrial sector. This paper delves into the possibility and feasibility of leveraging the HTHP system to provide up to 200°C of heat using R1233zd(E) as a working fluid. Using a steady-state model, various transcritical HTHP cycle configurations are theoretically compared, analyzed, and evaluated in this study. The heat transfer characteristics for the evaporator and gas cooler are investigated, as well as the cycle's energy, exergetic, and environmental performance. Using the LMTD method, the gas cooler's heat transfer coefficient, overall length, and heat transfer area were calculated. The findings indicate that the heat sink pressure level, as well as the waste heat temperature provided to the evaporator, have a significant impact on overall cycle performance. The investigation revealed the potential challenges and barriers, including the length of the gas cooler and the lubrication of the compression process. The basic transcritical HTHP cycle with additional IHX was demonstrated to be the most efficient cycle across a variety of heat source temperatures ranging from 70 to 90 °C based on theoretical energetic and exergetic performance.

Keywords : high-temperature heat pump, transcritical cycle, refrigerants, gas cooler, energy, exergy

Conference Title : ICHPT 2022 : International Conference on Heat Pump Technology

Conference Location : Ottawa, Canada

Conference Dates : July 12-13, 2022