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Working Fluid Characterization and Performance Assessment of Subcritical Organic Rankine Cycles Based on the Lee–Kesler Approach for Energy Recovery

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In this work, a generalized model using the Lee–Kesler approach based on the corresponding states principle is developed to assess the performance of subcritical Organic Rankine Cycles operating with different working fluids. Each fluid is characterized by five parameters: the acentric factor, critical temperature, critical pressure, molar mass, and the ideal-gas ratio of specific heats at the critical temperature. The model was developed using the compressibility factor modified version of the Benedict–Webb–Rubin equation proposed by Lee and Kesler and the enthalpy and entropy functions to calculate thermodynamic state properties. The model was validated by comparing the results calculated with the model and working fluid thermodynamic properties obtained with the CoolProp database. This comparison was conducted for 91 working fluids, obtaining a relative error below 5% for 88 out of the 91 fluids (~97%). A generalized parametric study was conducted to determine the influence of the pinch point and each fluid parameter on the performance of Organic Rankine Cycle (ORC) systems. It was found that efficiency increases with critical temperature, ideal-gas ratio of specific heats at the critical temperature, and acentric factor, reaching up to 13%. The developed model enables the evaluation of ORC system performance for existing working fluids. It also allows the formulation and evaluation of new fluids to enhance the performance of the ORC while retrieving energy from any kind of source; and likewise, the methodology can be applied to other power generation cycles. [DOI: 10.1115/1.4071671]

Keywords: organic Rankine cycle, Lee–Kesler approach, working fluid characterization, equation of state, performance evaluation, energy conversion, energy systems analysis, power plants