Mechanical and Industrial Engineering-College of Engineering-Sultan Qaboos University

Modeling and Optimization of Organic Rankine Cycle (ORC) Using Generalized Property Correlations

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Abstract

Organic Rankine Cycle has no difference in principle component with conventional Rankine Cycle except the working fluid. In recent year, ORC has been significantly used in low-grade heat applications. The fluid that circulates in the ORC are organic fluids which due to their specific characteristics are suitable for low grade heat applications like solar heat source, geothermal and etc. selection of working fluid for ORC plays an determining role while designing Organic Rankine Cycle. The specification of the Organic fluids effect the results on the thermal and exergy efficiency of the cycle as well as the work output and Exergy destructions. In this study, first correlations were developed using six different regressions namely linear, Quadratic, Power, Exponential, Growth and Multiple. For thermodynamic properties of 19 different organic fluids all the aforementioned correlations were investigated, these 19 fluids were selected according to the criteria of theirs thermodynamic features, frequency of usage in industry and environmental point of view. The database for the thermodynamic properties is REFPROP 9.1 represented by NIST (National Institute of Standards and Technology). All the thermodynamic properties were investigated and correlations were developed according to the type of the fluid. As there are three different type of working fluid for ORC applications (Dry, Wet, Isentropic) each calculations and regression procedure were done accordingly. In the second phase of this project, the selected correlations with least error were implemented to do the optimization process by using matlab programming. Having these correlations give the option of studying and investigating a wide range of temperature range in a continuous manner instead of defining specific intervals. In optimization section, two different scenarios were taken; first, the optimum working condition for each of the fluids were found. In addition, the correlations were implemented to find the maximum temperature limit for evaporation. The criteria to find the highest applicable temperature was to set the maximum quality of 0.99 in all stages of expansion process in Turbine. Second scenario for optimizing while using correlations was to fix a specific temperature for condensation and evaporation then finding the optimum working fluid for that range. Two objective functions were defined to do the comparison correspondingly and base on them choose the optimum fluid and working condition. The first objective function F1 was defined as the ratio of the efficiency to total irreversiblities, second objective function F2 was defined to be the ratio of work output to the overall exergy destruction rate. The corresponding values for thermal efficiency, exergy efficiency, work output, F1, F2 and total irreversiblities were surfed versus lowest and highest temperature limits of the cycle.

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