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

Modeling and Optimization of a solar Organic Rankine Cycle

Ahmed AL Hajri

Abstract

Organic Rankine Cycle is one of the imperative techniques in generating electricity using the thermodynamic properties of the refrigerants. It doesn't differ from the steam Rankine cycle in principle except in the working fluid. It comes to overcome some of the disadvantages of using the steam Rankine cycle, such as operating the cycle in low-grade heat sources like solar energy and industrial heat waste. The type of fluids that circulate in the ORCs are organic fluids which due to their specific characteristics are suitable for low grade heat applications.

This work investigates the optimal working fluid for the ORC by concentrating on the thermodynamic properties and safety and environmental aspects. A solar radiation was utilized as the heat source using vacuum tube solar collector. The collector was modeled mathematically and the governing equation was used to obtain the average temperature in the cities of study. Eighteen working fluids were studied using a MatLab code. Non-linear correlations were used using the thermodynamic properties database provided by REFPROP9.1 using the dimensionless factor =1-T_sat/T_C . The maximum error in using these correlations is not exceeding 4%. In this study, three simulation scenarios were investigated for the three types of fluids. Two cases were considered in each scenario: inspecting the properties at 1000 kPa as an evaporator pressure and finding the optimal pressure for the fluids using the pinch temperature. The Pinch temperature should not exceed 10 K. Wet fluids have lower NBP than dry and isentropic fluids. The heat source is enough to vaporize the wet fluids due to the low NBP. Whereas, some of the dry and isentropic fluids may require more heat source to operate an ORC . That can be explained by, their saturation temperature is higher than the heat source, so the pinch temperature limitation cannot be achieved. The best working fluids in each scenario were nominated to a safety and environment comparison. The simulation were carried out for a range of an evaporator pressure and for four different condensing pressures. Lowering the condenser pressure will results in increasing the work output, consequently the thermal efficiency. Determining the optimal working fluids is not an easy process, since there are many criteria to deal with. These criteria has to be checked thermodynamically in one side and environmentally from the other side .A high evaporator pressure needs a high cost and complicated equipment, therefore increasing the cost of the system. On the other hand, decreasing the condensing pressure involves an air infiltration, which will require a special vacuum equipment to reject air from the cycle.