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Optimization of Solar Rankine Cycle by Exergy Analysis and Genetic Algorithm

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Abstract : Nowadays, solar energy is used for energy purposes such as the use of thermal energy for domestic, industrial and power applications, as well as the conversion of the sunlight into electricity by photovoltaic cells. In this study, the thermodynamic simulation of the solar Rankin cycle with phase change material (paraffin) was first studied. Then energy and exergy analyses were performed. For optimization, a single and multi-objective genetic optimization algorithm to maximize thermal and exergy efficiency was used. The parameters discussed in this paper included the effects of input pressure on turbines, input mass flow to turbines, the surface of converters and collector angles on thermal and exergy efficiency. In the organic Rankin cycle, where solar energy is used as input energy, the fluid selection is considered as a necessary factor to achieve reliable and efficient operation. Therefore, silicon oil is selected for a high-temperature cycle and water for a low-temperature cycle as an operating fluid. The results showed that increasing the mass flow to turbines 1 and 2 would increase thermal efficiency, while it reduces and increases the exergy efficiency in turbines 1 and 2, respectively. Increasing the inlet pressure to the turbine 1 decreases the thermal and exergy efficiency, and increasing the inlet pressure to the turbine 2 increases the thermal efficiency and exergy efficiency. Also, increasing the angle of the collector increased thermal efficiency and exergy. The thermal efficiency of the system was 22.3% which improves to 33.2 and 27.2% in single-objective and multi-objective optimization, respectively. Also, the exergy efficiency of the system was 1.33% which has been improved to 1.719 and 1.529% in single-objective and multi-objective optimization, respectively. These results showed that the thermal and exergy efficiency in a single-objective optimization is greater than the multi-objective optimization.

Keywords : exergy analysis, genetic algorithm, rankine cycle, single and multi-objective function
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