Multi-objective optimization to enhance the performance of thermo-electric generator combined with heat pipe-heat sink under forced convection

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ABSTRACT

The performance of Thermo-Electric Generator (TEG) is negatively affected by heat sink lack of design. The heat pipe heat sink (HP-HS) has the best performance compared to other conventional cooling systems which uses TEG. In medium temperature range below 300 °C, HP-HS is the most appropriate heat exchanger of the TEG. However, the effect of some parameters of fin space, fin length, fin height, fin materials and optimum geometry of the cold side of the TEG HP-HS under forced convection (FC) has not been fully studied. The objective of this paper is to conduct an analytical and statistical study on these parameters effect on the performance of the TEG. In addition, this paper determines the optimum geometry of HP-HS and materials of aluminum (AL) and copper (CO) at 250 °C of heat source temperatures. Central composite design model (CCD) has been used to design the experiments using response surface methodology (RSM). The multi-objective optimization using RSM is applied to determine the optimum geometry of HP-HS in terms of maximising the TEG power output (P), TEG efficiency (η), and minimising HP-HS cost ($\$$). Compared with the literature, the results showed an improvement in TEG performance. The maximum P and η after optimization were 9.6 W and 3.3%, respectively. The percentage difference of TEG efficiency (η) compared with best previous results were, 18.78%. In addition, the CO HP-HS was found to be preferred over AL, because of its lower $\$/P$, at 7.57 USD/W, as compared to AL, at 8.74 USD. Finally, this study shows an improvement in HP-HS cost; a reduction of 29% was achieved compared with the estimated HP-HS cost in literature.

KEYWORDS

Central composite designs; Heat source temperatures; Medium temperature; Optimum geometry; Parameters effects; Power out put; Response surface methodology; Statistical study

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