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Response Surface Methodology to Optimize the Performance of a Co2 Geothermal Thermosyphon

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Abstract : Geothermal thermosyphons (GTs) are increasingly used in many heating and cooling geothermal applications owing to their high heat transfer performance. This paper proposes a response surface methodology (RSM) to investigate and optimize the performance of a CO2 geothermal thermosyphon. The filling ratio (FR), temperature, and flow rate of the heat transfer fluid are selected as the designing parameters, and heat transfer rate and effectiveness are adopted as response parameters (objective functions). First, a dedicated experimental GT test bench filled with CO2 was built and subjected to different test conditions. An RSM was used to establish corresponding models between the input parameters and responses. Various diagnostic tests were used to assess evaluate the quality and validity of the best-fit models, which explain respectively 98.9% and 99.2% of the output result's variability. Overall, it is concluded from the RSM analysis that the heat transfer fluid inlet temperatures and the flow rate are the factors that have the greatest impact on heat transfer (Q) rate and effectiveness (εff), while the FR has only a slight effect on Q and no effect on εff. The maximal heat transfer rate and effectiveness achieved are 1.86 kW and 47.81%, respectively. Moreover, these optimal values are associated with different flow rate levels (mc level = 1 for Q and -1 for εff), indicating distinct operating regions for maximizing Q and εff within the GT system. Therefore, a multilevel optimization approach is necessary to optimize both the heat transfer rate and effectiveness simultaneously.

Keywords : geothermal thermosiphon, co2, Response surface methodology, heat transfer performance
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