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Abstract

Parabolic Trough Collectors (PTCs) are commonly employed in both industrial and residential settings for the purpose of harnessing solar energy. Several techniques have been implemented to improve performance, such as altering the geometry of the absorber tube, enhancing the selective coatings of the receiver envelope, and utilizing nanofluids. This study proposes a new method for enhancing the thermal-hydraulic efficiency of PTCs through the utilization of non-uniform heat flux distribution on conical solar receiver. The effectiveness of this approach is evaluated through numerical simulations conducted using Ansys Fluent with the aid of optical simulation performed using TracePro. The geometry under consideration is assessed at various diameter ratios (DR) spanning from 1.25 to 2 and Reynolds number (Re) ranging from 20000 to 100000, with increments of 20000. This evaluation is conducted at three distinct inlet temperatures: 150 °C, 250 °C, and 350 °C. The studied parameters include- the Nusselt number (Nu), friction coefficient (f), thermal efficiency (η_{th}), exergetic efficiency (η_{ex}), and thermal enhancement factor (TEF). Furthermore, a comparative analysis is conducted between the newly proposed geometric design and a traditional straight absorber and glass structure. The findings indicated that a conical receiver generally enhances system heat transfer by a minimum of 7% and up to 65%, resulting in improved thermal and exergetic efficiencies. Decreasing the pipe outlet diameter from DR=1.25 to DR=2 led to a significant exponential rise in the friction coefficient. The TEF demonstrated that a diameter ratio of 1.25 and 1.5 resulted in maximum values of 1.19 and 1.11, respectively, at high Re and an inlet temperature of 350 °C. The results suggested that incorporating conical receivers in PTCs can greatly improve their performance. To minimize the friction coefficient and associated pumping power, it is crucial to carefully evaluate the reduction of the diameter of the absorber outlet. The results offered valuable insights for the development and improvement of PTCs in both industrial and power generation settings, promoting the adoption of renewable energy and supporting long-term sustainability.