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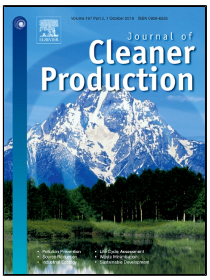

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Model development and performance analysis of the nanofluid-based direct absorption parabolic trough collectors

Hongbo Liang[a,†], Man Fan[a,†], Shijun You[a], Huan Zhang[a,*], Wandong Zheng[a]

a *School of Environmental Science and Engineering, Tianjin University, Tianjin 300350, China*

Abstract

In this paper, a simple one-dimensional heat transfer model for the nanofluid-based direct absorption parabolic trough collector (NDAPTC) was developed, which was quick to solve, easy to understand, and unnecessary to solve the complicated differential equations. In an actual system, the vacuum condition between the inner tube and glass cover may be changed gradually over time. Therefore, a continuous function for calculating the convective heat transfer in the annulus from near vacuum to atmospheric pressure was established. Combined with it, the derived heat transfer model was suited to evaluating the long-running thermal performance of a NDAPTC quickly. The heat transfer model for a conventional indirect absorption parabolic trough collector (CIAPTC) was also constructed, aiming at comparing the heat transfer processes of this two kinds of collectors. Both the heat transfer models were validated by the test data from the reference. Additionally, the effects of physical parameters, operational and weather conditions on the collector thermal performance were analyzed. It was shown that improvement of the glass transmittance and emittance was crucial to raise the collector efficiency, especially at a higher inlet temperature. The pressure change in the annulus affected the collector thermal performance greatly, thus it tried to avoid the vacuum damage. The collector efficiency was raised with the solar irradiance and ambient temperature increasing and wind velocity reducing, which was more sensible to these weather conditions at a higher inlet temperature and pressure in the annulus. The results in this paper were useful for guiding the collector improvements and engineering designs theoretically, and were beneficial for cleaner production in civil and industrial heat utilization further.

Keywords:

Nanofluid; Direct and indirect absorption; Parabolic trough collector; Heat transfer model; Convection in the annulus; Performance evaluation

1. Introduction

The parabolic trough collector (PTC) is one of the most widely used solar applications, which can be applied to concentrating solar power[1-2], solar water disinfection [3] and so on. Its energetic and exergetic performance has been investigated in detail [4] and some improvements have been made in use, such as increasing a flat transparent cover on the aperture plane [5].

The traditional PTC is the conventional indirect absorption parabolic trough collector (CIAPTC). Its absorber is a metal tube with a selective absorption coating generally. In contrast, due to the better thermophysical properties of the nanofluid, the novel nanofluid-based direct absorption parabolic trough collector (NDAPTC) has been presented and paid more attention gradually, whose absorber is the nanofluid itself. Khullar et al. [6] studied the thermal performance of a NDAPTC with an established mathematical model. The efficiency of the NDAPTC (Aluminium/Therminol VP-1

* Corresponding author. Tel./fax: +86 22 2789 2626.
E-mail address: lianghb@tju.edu.cn (H. Liang), fanman@tju.edu.cn (M. Fan), yousj@tju.edu.cn (S. You), zhhuan@tju.edu.cn / Zhanghuantju@163.com (H. Zhang), wdzheng@tju.edu.cn (W. Zheng).
†These authors contributed equally to this work.