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Analyses of exergy efficiency and pumping power for a conventional flat plate solar collector using SWCNTs based nanofluid

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ABSTRACT

This paper theoretically analyses entropy generation, heat transfer enhancement capabilities and pressure drop for a flat-plate solar collector operated with single wall carbon nanotubes (SWCNTs) based nanofluids as an absorbing medium. Specific heat (*Cp*) of the nanofluid was measured using a PerkinElmer DSC 4000, and a density meter was used to measure the density of the nanofluid. Second law based exergy analysis was carried out to evaluate the efficiency of the flat plate collector. It is observed that the SWCNTs nanofluid reduced the entropy generation by 4.34% and enhance the heat transfer coefficient by 15.33% theoretically compared to water as an absorbing fluid. Pumping power penalty of nanofluid operated solar collector found to be 1.20% higher than the water as a working fluid.

1. Introduction

Solar energy has become one of the top priorities because it is environmental friendly, clean and freely available. Solar energy therefore has an important role to play in the building energy system for heating and cooling purposes. Optimal combination of evacuated and flat plate collectors and PV panels in building can provide 100% of its net energy use and thus the integration of solar collectors are widely accepted for thermal utilization into building [1]. Nearly zero energy buildings should have solar thermal collector systems for heating and hot water production and for cooling in combination with a thermally driven chiller system and photovoltaic systems which are used to operate a reversible heat pump [2]. By installing a solar heating system, it is possible to reduce and even bringing the energy consumption close to zero of a building [3]. An innovative and economical system to reduce energy consumptions is to use solar energy for heating of fresh air for ventilation purpose in the buildings [4]. Solar radiant floor cooling is preferable for improvement of energy efficiency and to provide better thermal comfort in large buildings with high intensity solar radiation. It lowers the demand of total energy 20–30% than the conventional all-air system [5]. In order to have environment friendly buildings, the newer solar buildings usually combine several solar-related technologies such as integrated system of heating, air-conditioning, natural ventilation and hot water supply based on solar energy [6]. A cooling system can be installed in buildings using solar energy which will effectively reduce the cooling load of main air conditioners under hot and humid climatic conditions [7].

Solar thermal energy is a very suitable source of heating technology that does not rely on the limited energy resources. Solar collectors are used to transform solar radiation into heat and transfer the heat to an absorbing medium. Cooling and heating of the systems can be carried out using solar energy. A flat plate solar collector is commonly used to heat water but unfortunately, the efficiency of this type of solar collector is still low. Water is frequently used as an energy carrier in solar collectors since it is easy to transport through the pumping system. However, heat transfer coefficient of water is low due to poor thermo-physical properties of water. The efficiency of SWH has been found to be low because of the low convective heat transfer coefficients between absorber plate and the flowing water which increases the absorber plate temperature. This consequently raises the heat losses to the environment resulting in low thermal efficiency of such collectors. Therefore, to improve the thermal efficiency of such collectors, new heat transfer fluids known as nanofluids have been applied by many researchers as found in the literatures [8–17].

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