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Analyses of entropy generation and pressure drop for a conventional flat plate solar collector using different types of metal oxide nanofluids

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ABSTRACT

This paper theoretically analyzes entropy generation, heat transfer enhancement capabilities and pressure drop of an absorbing medium with suspended nanoparticles (Al_2O_3, CuO, SiO_2, TiO_2 dispersed in water) inside a flat plate solar collector. Steady, laminar axial flow of a nanofluid is considered. These nanofluids considered have different nanoparticles volume fractions and volume flow rates in the range of 1–4% and 1–4 L/min, respectively. Based on the analytical results, the CuO nanofluid could reduce the entropy generation by 4.34% and enhance the heat transfer coefficient by 22.15% theoretically compared to water as an absorbing fluid. It also has a small penalty in the pumping power by 1.58%.

1. Introduction

Nowadays science and technology have dramatically improved, and hence, requirement for energy is rushing at a fancy speed. Bearing in mind the breeding consumption of formal primary energy (coal, petroleum, natural gas) and environment-related concerns, improving low temperature heat resources has developed an expected choice to resolve problems associated with energy and environment.

Flat plate solar collectors as an assuring energy adaptation technology in the ground of low rank heat employment have been investigated by many researchers for years (i.e., [1,2]). In current ages, some researchers have given additional concentration to engaging nanofluids as an absorbing medium to employ solar energy for its enormous and sustainable reserve. In this context, Lu et al. [3] examined the thermal performance of an open thermosyphon using water-based CuO nanofluids as the functioning liquid. Replacing water-based CuO nanofluids for water as the working fluid could suggestively improve the thermal performance of the evaporator and evaporating heat transfer coefficients could increase by about 30% compared to those of deionized water. The CuO nanoparticles mass concentration had amazing effect on the heat transfer coefficient. Yousefi et al. [4] considered the consequence of Al_2O_3 water nanofluid, as functioning fluid, on the efficiency of a flat-plate solar collector. Outcomes indicated that, in contrast with water as working medium by means of the nanofluids as functioning fluid improved the efficiency by 28.3% with 0.2 wt% nanoparticles in base fluid. Natarajan and Sathish [5] investigated the thermal conductivity improvement of base fluids employing carbon nanotube (CNT) and recommended if these fluids were used as a heat transport medium, it could rise the efficiency of the traditional solar water heater. Tyagi et al. [6] examined the competence of utilizing a non-concentrating direct absorption solar collector (DAC) and paralleled its performance with that of a conventional flat-plate collector. A nanofluid, a combination of water and aluminum nanoparticles, was used as the absorbing medium. Agreeing to the consequences of Tyagi's study, the efficiency of the DAC employing nanofluid as the working fluid was up to 10% sophisticated than that of a flat-plate collector.

Typically flat-plate solar collectors have been comprehensively exercised in low temperature energy technology. A number of projects of solar collectors have been established over the years with the intention of developing their performances. Thermal performance of a solar collector is considerably low due to the low value of the convective heat transfer coefficient between the absorber plate and heat transfer medium, foremost to high absorber plate temperature and more heat losses to the environments [7]. Low heat loss coefficients direct to improve in the net flow of exergy, which therefore reduces pressure drop.

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