Performance Analysis of a Novel Photovoltaic Thermal PVT Double Pass Solar Air Heater with Cylindrical PCM Capsules using CFD

ABSTRACT

Photovoltaic Thermal Double Pass Solar Air Heater (PVT-DPSAH) with Phase Change Material (PCM) capsules in the bottom channel is a promising design for enhancing the system performance. The PVT-DPSAH comprises a glass cover, absorber plate photovoltaic (PV), PCM capsules, and back plate. The current study uses COMSOL Multiphysics software to perform a Computational Fluid Dynamics (CFD) analysis of a novel PVT-DPSAH with vertical cylindrical PCM capsules in the second channel. To solve the differential equations in the 3D computational domain, the Finite Element Method (FEM) is employed. This study uses the high Reynolds (Re) number and κ-ε turbulent flow model with enhanced wall functions. The impact of varying solar irradiance levels (500-800 W/m2) on the performance of PVT-DPSAH, with mass flow rate (ṁ) ranging from 0.011 kg/s to 0.065 kg/s, is investigated. The optimum mass flow rate was found to be 0.037 kg/s at solar irradiances ranging from 500 W/m2 to 800 W/m2 , with average thermal efficiencies, electrical efficiencies, and fluid output temperatures of 60.7% to 63.4%, 11.25% to 11.02% and 42.96 ºC to 49.54 ºC, respectively. PVT collector's maximum combined efficiency was 84.12% at solar irradiance of 800 W/m2 with the mass flow rate, ṁ of 0.065 kg/s. This study identified RT-47 paraffin-waxPCM as the best option for the PVT-DPSAH based on the PCM's thermal distribution and melting temperature.