INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Due to the rise in greenhouse gas in earth atmosphere and global climate change, attention has been focused on harvesting energy from renewable resources such as solar, wind, hydro, biomass, geothermal tidal, wave, and ocean thermal energy. The global potential of solar energy is higher than the potential of all other renewable energy sources together. Solar energy is primarily harvested using two prominent conversion methods viz. solar thermal and solar photovoltaic (PV). In practice, solar PV conversion is quite common for power generation due to its inbuilt advantages like no moving parts, easy installation, availability of raw material and life of operation. However, PV system suffers from its lower conversion efficiency as well as a decrease in efficiency with the rise in cell temperature. PV cell converts only a small fraction (less than 20%) of irradiance into electrical energy. Infra-red radiation absorbed by the PV reduces the electrical efficiency of the cell. The influence of temperature on the electrical output is significant at higher cell temperature (>42 °C). To address this difficulty, solar photovoltaic-thermal (PV/T) collectors are proposed. PV/T is a promising technology where both electrical and thermal energy generation can be possible. Cooling uniformity and efficiency of the PV/T system are major challenges for its applicability. The present study is formulated to address the current challenges associated with the existing PV/T collectors. A novel thermal model of a PV/T system (tube and sheet type collector) by considering thermal contact resistance between the layers of a PV/T system, individual resistance of each layer and Ohmic heat generation in the PV layer has been carried out. The Root Mean Square Errors (RMSE) of 3.75 K, 1.36 K and 2.71 K were found for the water outlet temperature, glass surface temperature and cell temperature, respectively. The results illustrated that consideration of thermal contact resistance and Ohmic loss at the PV layer increases the accuracy of the model significantly. Based on the numerical investigation, initially two PV/T collectors viz. only tube absorber (M1) and sheet-tube (M2) configurations were developed. The cells in the PV/T collectors are made of Si-multicrystalline. Both the collectors have vertical oscillating tube assembly pattern. The performance of collectors are extensively studied under outdoor conditions. Higher thermal efficiency has been reported for the collector without absorber sheet. This is due to less resistance to the thermal energy transfer from the top surface of the PV/T collector to the flowing fluid in the tubes as compared to the module with sheet-tube configuration. Two more PV/T collectors namely rectangular spiral (M3) and horizontal oscillating (M4) transparent PV/T collectors without absorber sheet were developed and a comparative experimental investigation has been carried out. The performance of the M3 collector is found to be superior and hence considered for further investigation. Finally, a form-stable phase change biocomposite has been developed using water hyacinth biochar as matrix. The developed material is applied in the M3 collector for investigation of cooling uniformity. The results of the experiments demonstrate that the use of PCM- biocomposite improves the cooling uniformity, which further results in the enhancement of electrical output by 18.4%. Furthermore, this arrangement improves the thermal efficiency by 15.7% as compared to the M3 without the PCM- biocomposite. Based on the study M3 collector with PCM-biocomposite is found to be the best amongst all the developed collectors in terms of cooling uniformity, performance and cost.