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Theoretical Analysis and Design Consideration of Screened Heat Pipes for Low-Medium Concentration Solar Receivers

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Abstract : This paper summarizes the results of an investigation into the heat pipe heat transfer for solar collector applications. The study aims to show the feasibility of a concentrating solar collector, which is coupled with a heat pipe. Particular emphasis is placed on the capillary and boiling limits in capillary porous structures, with different mesh numbers and wick thicknesses. A mathematical model of a cylindrical heat pipe is applied to study its behaviour when it is exposed to higher heat input at the evaporator. The steady state analytical model includes two-dimensional heat conduction in the HP's wall, the liquid flow in the wick and vapor hydrodynamics. A sensitivity analysis was conducted by considering different design criteria and working conditions. Different wicks (mesh 50, 100, 150, 200, 250, and, 300), different porosities (0.5, 0.6, 0.7, 0.8, and 0.9) with different wick thicknesses (0.25, 0.5, 1, 1.5, and 2 mm) are analyzed with water as a working fluid. Results show that it is possible to improve heat transfer capability (HTC) of a HP by selecting the appropriate wick thickness, the effective pore radius, and lengths for a given HP configuration, and there exist optimal design criteria (optimal thick, evaporator adiabatic and condenser sections). It is shown that the boiling and wicking limits are connected and occurs in dependence on each other. As different parts of the HP external surface collect different fractions of the total incoming insolation, the analysis of non-uniform heat flux distribution indicates that peak heat flux is not affecting parameter. The parametric investigations are aimed to determine working limits and thermal performance of HP for medium temperature SC application.

Keywords : screened heat pipes, analytical model, boiling and capillary limits, concentrating collector
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