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Theoretical Model of a Flat Plate Solar Collector Integrated with Phase Change Material

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Abstract : The objective of this work was to develop a theoretical model to study the dynamic thermal behavior of a flat plate solar collector integrated with a phase change material (PCM). The PCM acted as a heat source for the solar system during low intensity solar radiation and night. The energy balance equations for the various components of the collector as well as for the PCM were formulated and numerically solved using MATLAB computational program. The effect of natural convection on heat during the melting process was taken into account by using an effective thermal conductivity. The model was used to investigate the effect of inlet water temperature, water mass flow rate, and PCM thickness on the outlet water temperature and the melt fraction during charging and discharging modes. A comparison with a collector without PCM was made. Results showed that charging and discharging processes of PCM have six stages. The adding of PCM caused a decrease in temperature during charge and an increase during discharge. The rise was most enhanced for higher inlet water temperature, PCM thickness and for lower mass flow rate. Analysis indicated that the complete melting time was shorter than the solidification time due to the high heat transfer coefficient during melting. The increases in PCM height and mass flow rate were not linear with the melting and solidification times.

Keywords : thermal energy storage, phase change material, melting, solidification
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