

Performance and Design Optimization of Solar Collectors

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Abstract: The objective of the present work was to conduct a comparative analysis of solar collectors. The experimental set-up consists of two flat plate solar collectors, the first collector was with a fixed surface tilted at 30° towards the South, and the second one was equipped with dual-axis rotation system. A programmable chronological tracker was used to control the motion of the moving collector. An experimental programme was performed to investigate the effect of the sun tracking system usage on the collector efficiency. The study includes development of a 3-D mathematical model of the system and extensive numerical simulation, based on the computational fluid dynamics (CFD) approach. The main aim of the modelling is to provide information on heat transfer, and to numerically simulate the heat transfer performances and the energy capture capabilities of the fixed and moving collectors in various operating modes. The comparative analysis shows that there is a good agreement between the experimental and numerically predicted results for different running conditions, and the presented modelling approach can be used for further investigations, including more complex problems.

Keywords: Solar collector, Solar energy, Heat transfer

Introduction

One of the simplest and most direct applications of the solar energy, which is cost effective, is its conversion into heat. It is also one of the ways the residential and other sectors can lessen their share in electricity consumption and impact on the environment. The cost effectiveness of solar thermal collectors depends on the cost of collector components, the efficiency and the thermal losses associated with the collector at the local operating conditions. Flat plate solar water heaters are traditionally in use in domestic hot water systems because of the low temperature requirement and low equipment cost (Sumathy, 1999). Conventional solar water heater systems and solar assisted heat pump systems for hot water production in specific local conditions are presented in (Li & Yang, 2009).

A 3-D numerical model for flat-plate solar collector that considers the multidimensional and transient character of the problem, the effect of the non-uniform flow on the collector efficiency was quantified and the degree of deterioration of collector efficiency was defined by Molero - Villar et al.(2009). Their analysis showed that this deterioration increases with the increase of the flow non-uniformity, although this effect is very limited. The model was verified with a steady-state conditions.

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