A NEW MODEL FOR THE ANALYSIS OF PERFORMANCE IN EVACUATED TUBE SOLAR COLLECTORS

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ABSTRACT

This paper describes a new model for the performance analysis of evacuated tube solar collectors. The analyzed collector is equipped with truncated compound parabolic reflectors, but the analysis is also extended to the case of collectors without reflectors. An original software is developed under MATLAB environment for the simulation purpose. A novel numerical procedure is implemented to obtain the solution for the nonlinear set of equations representing the mathematical model. In the model, the variation of important parameters is considered in the circumferential, longitudinal and radial directions. The length of the tube, where the heat transfer fluid flows, can be divided into a specified number of segments and the energy analysis is performed for each segment along the tube length in order to obtain the variation of different parameters in the longitudinal direction. The model analyzes separately the optics and the heat transfer in the evacuated tubes and this approach allows to extend the analysis to new configurations. The model can simulate the efficiency curve under steady-state conditions, according to the standard EN 12975-2 (EN 12975-2. Thermal solar systems and components - solar collectors - part 2: test methods. Brussels: CEN; 2006). A comparison with experimental data shows the accuracy of the present model.

1. INTRODUCTION

Solar collectors can provide a useful response to the heat demand in buildings, such as heating of domestic water and spaces. Beside the heating application, there is also need to meet the increasing energy consumption due to the summer air conditioning. In the latter application, solar collectors can supply heat to absorption machines, where the temperature levels required for the input heat are higher than 80 °C. In the work of Zambolin and Del Col (2010), an experimental comparison of thermal performance of flat plate and evacuated tube solar collectors was performed. The efficiency of the evacuated tube collector is higher when the reduced temperature difference exceeds 0.035 m^2 K/W. For instance, for a global solar irradiance of 1000 W/m^2, the performance of the evacuated tube collector is higher than that for the flat plate one when the temperature difference between heat transfer fluid and ambient air is higher than 35 K. If ambient air temperature is 5 °C (winter case), such value of reduced temperature difference occurs when the solar collector produces heat at 40 °C, which is suitable for space heating with radiant panel systems. If ambient air temperature is 25 °C (summer case), such value of reduced temperature difference occurs when the solar collector produces heat at a temperature higher than 60 °C, so evacuated tube collectors can be more suitable for solar cooling. The evacuated tube collectors are subdivided in two main types. The first type is the direct flow collector where the heat transfer liquid is pumped in the tubes. The second type consists of heat pipes inside vacuum sealed glass tubes. In most of cases, both types of collector are equipped with a CPC (Compound Parabolic Concentrator) to optimize the collection of solar radiation. Among the direct through flow types, the U-tube evacuated tube solar collector appears to be a well-developed type of collector. Installations of evacuated tube collectors without CPC are also possible in case of specific requirements in building designs. Theoretical and experimental research works are done on the optical and thermal performance of the evacuated tube solar collector