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Experimental and numerical investigation on the performance of amorphous silicon photovoltaics window in East China

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ABSTRACT

Experiments in a comparable hot-box have been carried out for the study of the thermal performance and power generation of a double-glazing window system integrated with amorphous silicon (a-Si) photovoltaic (PV) cells in Hefei, east region of China. Compared to PV single-glazing window, the indoor heat gain of PV double-glazing window is reduced to 46.5% based on experiment data. The electric efficiencies are both about 3.65% with packing factor 0.8 of PV single-glazing window and PV double-glazing window. The numerical simulation with computational fluid dynamics (CFD) method has been performed for the prediction of air flow and thermal performance of PV double-glass window. The temperature distribution and thermal performance predicted by the CFD model are in good agreement with the experimental data. Compared between the experimental and numerical results, temperature differences of PV modules are only 1.7% and 1.1% for PV double-glazing and PV single-glazing window, respectively. Because of the much lower inner surface temperature of PV double-glazing window compared with that of PV single-glazing window, the predicted mean vote (PMV) of the office work stage area with PV double-glazing window is well improved.

1. Introduction

The application of Photovoltaic technology in buildings has attracted worldwide attention for energy savings and environmental side-effect reductions. Y. Etzion and E. Erell proposed a reversible glazing system that can control transmission of solar radiation into indoor spaces [1]. Brinkworth, B.J. and Cross, B.M. et al. [2] indicated that a ventilated air duct behind a PV panel can decrease temperature of PV cell. CFD package was used to simulate the air flow behind the PV panel and good results were obtained. T.T chow [3] investigated the performance of a PV ventilated window applied to office building of Hong Kong by numerical simulations. With the transmittance of PV window in the range of 0.45–0.55, the electricity consumption was found reduced by 55% compared to the single-glazed window without lighting control. Various numerical investigations of PV ventilated windows with different structures had been carried out to evaluate the thermal loads, daylight contribution and electricity production by Remi C, Geun Y.N [4,5], and so on. Gan and Riffat [6] showed that CFD was a useful tool to optimize ventilation systems for comfortable indoor environment and effective cooling of PV. By studying the factors affecting the local and average heat transfer coefficients along the vertical surfaces of a see-through glazing system with PV cells, Jun Han [7] did some research on the convective flow strength and heat transfer variation in the ventilation duct.

However, there was little report about the performance and PMV analyses of PV window in mainland China. In this paper, the experiment with a comparable hot-box has been carried out in Hefei (N31.8°, E117.3°, east region of China), to study the thermal performance and electrical generation of a double-glazing window system integrated with amorphous silicon cells. Hefei city locates in subtropical climate region, and the annual horizontal solar radiation is about 5000 MJ/m^2. The numerical investigation of the performance of PV window system has also been carried out by computational fluid dynamics (CFD) method.

2. Comparable hot-box and experiments

2.1. Comparable hot-box and a-Si PV windows

The PV single-glazing window, as shown in Fig. 1b, is just a window which consists of single amorphous silicon (a-Si) PV glazing. And the PV double-glazing window system, as shown in Figs. 1a and 4, consists of an amorphous silicon (a-Si) PV panel and a clear backing glazing. There are ventilated openings at the top and bottom of the semi-transparent a-Si PV glazing, and the PV glazing

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