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Research Paper :

Performance evaluation of an earth to air heat exchanger integrated greenhouse during winter period

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ABSTRACT

This article describes the analytical approach and experimental findings for utilization of stored thermal energy of ground in space heating by an earth air heat exchanger system. The appropriate thermal model has been developed for solar greenhouse combined with earth air heat exchanger. The same concepts can be applied for the feasibility of using earth air heat exchanger not only for greenhouse heating but also for thermal heating of a residential building, poultry farming, goat rearing, aquaculture pond etc. by exploring the immense thermal energy of ground. A complete numerical model has been developed to investigate the potential of using the stored thermal energy of ground for space heating with the help of an earth to air heat exchanger (EAHE) system integrated with the greenhouse located in the premises of IIT, Delhi, India. The analysis was based on quasi-steady state condition. Experiments were conducted extensively during winter period from November 2002 to March 2003, but the model, developed, was validated against the clear and sunny days. The performance of the system was evaluated in terms of total heating potential obtained from EAHE, coefficient of performance (COP) and thermal load leveling. The heating potential of the system has also been standardized by the characteristic curve for greenhouse similar to that of flat plate collector. Temperatures of greenhouse air were found to be on an average 7-8^0 C more than the same greenhouse when operating without earth air heat exchanger. The temperature fluctuations of greenhouse air were also less when operated with EAHE as compared to without EAHE. Predicted and measured values of greenhouse air temperature in the model developed, exhibited fair agreement.

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Heating of greenhouse is one of the most energy consuming activities during winter periods. Lack of heating has adverse effects on the yield, cultivation time, quality and quantity of the products in the greenhouse (Santamouris *et al.*, 1994). But studies on greenhouse heating strategies have shown that the cost of heating even exceeds 30% of the overall operational cost of the greenhouse (Coffin, 1985). Due to high relative cost of energy, only a small number of greenhouse owners can afford to the use of auxiliary heating systems. The use of low-cost and alternative heating system is, therefore, of primary importance for a greenhouse to provide optimum indoor conditions during winter months. Efforts to decrease energy consumption have directed the researchers to use alternative energy sources for heating of greenhouse. Several types of passive solar systems and techniques have been proposed and used (Santamouris *et al.*, 1996 and Barral *et al.*, 1999) for exploitation of stored thermal energy of ground for space heating during winter periods and cooling in summer days. As the ground is treated as an easily accessible heat source or heat sink for year round use, the coupling of greenhouse with ground by using buried pipes may be a viable solution for heating during winter and cooling during summer period. In buried pipe systems, the stored thermal energy of earth is usually extracted with the help of an arrangement called earth air heat exchanger (EAHE). An earth air heat exchanger system herein is defined (Puri, 1987) as the study of heat transfer between soil, tubes and air flowing through the tube when the tubes are placed below the ground surface at a certain depth where temperature of soil remains nearly constant throughout the year. As air travels the length of the tube, it gets heated in the winter period and gets cooled during the summer period resulting in the space conditioning due to its entry into the enclosed space. Earth air heat exchanger system has the potential of being used throughout the year. Hence, considering the importance of EAHE as a simple, inexpensive and alternative source of energy, the primary objective of present study is to investigate the performance of EAHES, as an alternative energy source and conservation method for heating of