THERMAL MODELLING OF NONCONVECTIVE SOLAR POND COLLECTOR/STORAGE SYSTEMS

by

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TO MY PARENTS

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ABSTRACT

This thesis presents author's work on mathematical modelling of nonconvective ponds as solar energy collector and storage systems. A self consistent time dependent (periodic) heat transfer model of a salt gradient solar pond as a solar energy collector and long term storage system has been developed. The model is envisaged to be rigorous with regard to the account of thermophysical processes operative in a salt gradient solar pond which normally consists of three zones: a convective zone at the surface, a nonconvective zone which acts as a translucent medium of low thermal conductivity and another convective zone at the bottom. The model explicitly takes into account the convective heat and mass flux through the pond surface and properly considers the transient thermal storage in the ground and the two convective zones of the pond. Explicit expressions for the transient rate at which heat is extracted and the temperature of heat extraction are derived. Extensive numerical results for the optimum thermal performance of the pond during its year round operation are presented for two modes of operations viz. (i) heat extraction at constant flow rate of heat retrieval fluid and (ii) heat extraction at constant temperature of the heat extraction zone. Heat retrieval effeciencies of 32.1%, 27.9%, 25.1% and 23% are predicted at collection temperatures 40^0, 60^0, 80^0 and 100^0C, respectively in a pond with 0.2 m deep upper

convective zone. The criteria for the size and heat transfer characteristics of the in-pond heat exchangers for heat extraction has also been investigated.

An innovative concept of rendering a pond nonconvective by viscous additives has been investigated and the characteristics of viscosity stabilized pond have been identified. In view of these characteristics an interesting application of viscosity stabilized solar pond as passive solar collector/ storage roof is advanced. An analysis of heat transfer processes in the system comprising a nonconvective pond placed on the roof of an airconditioned building for its passive heating has been carried out. It is found that the thermal storage behaviour of such a system is better than the conventional skytherm system consisting of a convective type pond. Subsequently, the thermal performance of a nonconvective roof pond system with movable insulation has also been investigated to evaluate its suitability to heat houses in colder climates. A comparative study of the thermal performance of this system with the one without movable insulation and the other with a movable insulation and convective pond system has been made to assess the effectiveness of the system components. It is found that the nonconvective pond greatly governs the solar thermal collection and storage characteristics of the system.

Finally, a thermal model for predicting the performance of nonairconditioned building with a nonconvective roof pond and variable indoor conditions has been developed. Indoor comfort conditions corresponding to a tropical winter outdoor climate have been studied.

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