TRANSIENT HEAT AND MASS TRANSFER WITHIN A SALT-GRADIENT SOLAR POND UNDER REAL EXTERNAL CONDITIONS

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INTRODUCTION

The salt-gradient solar pond has received in the past a particular attention from researchers due to its wide and interesting applications such as heating and desalination[1]. Most of the previous works considered however the problem of a one-dimensional heat diffusion and/or constant properties of the saline solution [2-5]. Only a few works have considered the problem of the pond stability [6,7,8] using the linear stability theory. Although some interesting results were obtained, they cannot reflect a real pond situation where the external perturbations are often drastic. Recent authors' work[12] have shown that the solar radiation as well as the heat losses may have drastic influence on the stability of the pond itself. In the present work, the problem of a transient diffusion of heat and mass within a three-dimensional salt-gradient solar pond subject to real external conditions has been numerically investigated. We are particularly interested to study not only the time evolution of the temperature and salinity fields, but also the pond stability under the influence of various external factors during a long period of operation.

MATHEMATICAL FORMULATION AND NUMERICAL METHOD

In the present work, the problem of heat and mass transfer inside a Salt-Gradient Solar Pond has been studied, with a particular attention on the stability within the pond while subjected to real external perturbations. The study consists of a 3D-transient Cartesian model of a 10mX10mX 5m-depth salt water basin which is heated by absorption of the solar radiation from the sun and loses its heat into the surrounding environment (the heat loss through the lateral walls, the convection and evaporative heat losses to the ambient air including wind effect and the radiation heat loss towards the sky). Beside the influence of several operating and meteorological parameters, we are particularly interested to evaluate the stability of pond during a long period of operation time. The set of the governing equations, which are non-linear and strongly coupled each other, were obtained from the principle of conservation of mass and energy. We consider the saline solution as an incompressible fluid for which the transport properties are dependent on both the local temperature and the salt concentration. The transient internal temperature and salinity fields must be determined at every time step submitted to real meteorological conditions taking from a particular Tunisian test site. The system of governing equations has been successfully solved by employing the control-volume-based method where the Power-Law scheme is used throughout to compute the heat and mass fluxes, while a temporal second-order scheme was used for the treatment of the transient terms. The study of the influence of the grid on results has been thoroughly carried out and the non-uniform 50X50X60 (60 nodes along the pond depth) has been adopted with grid points highly packed near all the boundaries of the pond. As initial conditions, we assume a stratified temperature and salinity profiles corresponding to an 'artificially-stabilized conditions' of the pond. A typical time step varies from ½ hour to 3hours. The convergence solution has been reached with residues as low as 10^{-5} and 10^{-6} respectively for the salinity and temperature.

SUMMARY OF RESULTS

The results expected from this study will show the transient behaviors of the solar pond that is submitted to real external meteorological conditions. The stability of the pond itself will be determined and scrutinized during a long period of operation. Preliminary results have shown that the solar radiation has a great influence on the internal temperature field of the pond especially in the region near the bottom. The heat losses, in particular those through the water free surface have important effect on the stability in that area which may become unstable.

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