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ScienceDirect

Energy Procedia 57 (2014) 2416 – 2425

Energy Procedia

2013 ISES Solar World Congress

Numerical Modeling of Solar Ponds

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Abstract

A SGSP is a basin of water where solar energy is trapped due to an artificially imposed salinity gradient. In a SGSP three zones can be identified: the surface and bottom zones that are both convective and an intermediate zone in between which is intended to be non-convective. This zone acts as a transparent insulation and allows the storage of solar energy at the bottom where it is available for use.

A numerical model where the SGSP dynamics is described in terms of velocity u, pressure p, temperature θ and salt concentration σ is presented. It is based on the Navier-Stokes equations for an incompressible fluid coupled to one advection-diffusion equation for θ and one advection-diffusion equation for σ. The fluid density ρ is taken to depend on θ and σ and the Boussinesq hypothesis is adopted: the fluid density appearing in the LHS of the Navier-Stokes equation is supposed constant and equal to some reference value whereas it is assumed to be variable in the RHS.

The space discretization of the governing equations is based on the respective weak formulations and the discretization employs finite elements with a pressure correction method used to decouple velocity and pressure. Integration in time is accomplished by a BDF (Backward Differentiation Formula) method with the above PDEs treated sequentially within each time step. A computer code was developed employing the finite element class library deal.II.

Comparisons with available experimental results are made to validate this numerical model.

Selection and/or peer-review under responsibility of ISES.

Keywords: Solar ponds, numerical modeling, finite elements, double advection-diffusion.

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Selection and/or peer-review under responsibility of ISES.
doi:10.1016/j.egypro.2014.10.250