<u>Title:</u> **Contribution to the numerical study of convection in closed and open greenhouses.**

Abstract

The author proposes in this work, the numerical study of the natural convection phenomenon, in a closed and open greenhouse, also a numerical study of the phenomenon of mixed convection, in an open double-chapel greenhouse, crossed laterally by a forced flow in steady and laminar regime. These two types of greenhouse are filled with a Newtonian and incompressible fluid. The number of Prandtl is fixed at 0.702 (case of air).

For the tunnel greenhouse, using the Boussinesq approximation and the vorticity-stream function formulation, the flow is modelled by partial differential equations: the continuity and the momentum equations expressed in a system of coordinates known as "Bicylindric». We took conditions of heating and ventilation as:

- Isothermal walls for our greenhouse (T_H for tubes, T_M near heating tubes and T_C for the roof, with $T_H > T_M > T_C$).the convect4e flow is governed by different control parameters, namely Rayleigh number (Ra), $10^3 \leq Ra \leq 10^3$, tubes number (N_t), $1 \leq N_t \leq 7$ and the form factor (f), $0 < f \leq 1$.
- Three positions of natural openings (P_s) are taken into consideration as well as their opening dimensions (D_m).

The guideline equations written in bicylindrical coordinates were discretized using the finite volume method and the vorticity-stream function formulation; the resultant algebraic equations were solved using the successive over relaxations method. Concerning the calculation code validation, our results and those of the literature are in very good agreement. The influences of physical and geometric parameters were examined. In the first case of the closed greenhouse with heating tubes, the Rayleigh number effect on the heat transfer was examined for a fixed number of tubes as a reference (Nt=3), the number of tubes was subsequently modified, to see its influence on the heat transfer in the greenhouse, this on the one hand, on the other hand, the geometry system effect on the natural convection phenomenon on the greenhouse was also taken into account. On the other hand, in the second case, where we studied numerically the natural convection in an open greenhouse, containing two openings in the roof, we examined the opening position effect with three different positions, as well as the opening size effect on the heat transfer and the climate inside the greenhouse tunnel.

For the open double-chapel greenhouse, we took as heating conditions for our greenhouse (T_H for the ground and T_C for the roof, with $T_H > T_C$).

The equations governing this phenomenon, discretized by the finite volume method, were solved numerically with a commercial code Fluent. We examined the effect of the parameters that characterize the heat transfer, and the flow structure. Several situations have been considered by varying the Rayleigh number ($10^3 \leq Ra \leq 10^5$) and the Reynolds number ($10 \leq Re \leq 500$).

Keywords: Heat transfer, natural convection, mixed convection, bicylindrical coordinates, heating tunnel greenhouse, double chapel greenhouse, natural ventilation, opening position and size, vorticity-stream function formulation, finite volume method.