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Numerical study of air behaviour in a greenhouse Equipped with a thermal storage system

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Abstract—**The object of this study is to predict by a numerical simulation the behaviour inside of a tunnel greenhouse with a thermal storage system located in the climate of the Ghardaia. The study focuses on determining the temporal distribution of the stream lines and the isotherms of temperature .The obtained results give us a general view of air circulation within the greenhouse and according with that in literature.**

Keywords **: greenhouse, isothermes, Isolines, naturel convection**

I. INTRODUCTION:

A greenhouse is a production tool to artificially create a microclimate for growth and development of culture. By his presence, it protects vegetation blows due to changes in climate factors [1] .A greenhouse is both a highly complex biological and energy system in which all the different modes of exchanges are involved [2]. The main climate factors of the internal environment in a greenhouse are temperature and humidity. Each of these factors is conditioning in the greenhouse, with its level on the outside, by the properties of roofing material and the characteristics of this greenhouse.

Many physical models to understand the energetic phenomena in greenhouses have been developed. Almost the majority of these models revolve around the formulation of instant energy balances of the various components of the greenhouse (indoor air, soil, plant cover and heating systems) [3]. Such a model globally optimizes climate greenhouses from the quantitative prediction of exchanges between the inside and outside, but nothing about the details of the internal temperature exchanges, humidity and CO_2 in the greenhouse [4].

With recent advances in computing power and commercial codes solving the equations of fluid mechanics, these models have become indispensable complements experimental work and powerful tools in the study of the internal climate of greenhouses. The numerical simulation using the software of fluid mechanics has been widely used in the analysis of climatic heterogeneity in closed greenhouses and ventilated greenhouses [5]. Most works on the study of convection and the general circulation of the air inside the greenhouses in the literature, concerned mainly greenhouses cathedrals (mono or multi chapels chapel), widespread in the North of 'Europe [6-7].

The aim of our work is to give a general air distribution has seen inside of greenhouse tunnel due to convective heat transfer is located research unit heated the ground by a roller system using a commercial code of fluent.

II. EXPERIMENTAL INVESTIGATION

In this part we are interested in the description of an experimental installation of two greenhouses, one unheated (green light) and one heated by a thermal storage device.

The latter is composed of four 200mm diameter PVC pipes that have tubes in H. This format is filled with pre-washed and dried pebbles. The bed of the rollers is positioned inside a greenhouse buried deep 0,70m [2] .The tunnel greenhouse dimensions, width: 8m, length 25 m and a height of 3m. The acquisition system is provided by a microcomputer connected to acquisition one of two LINSEIS type and the other HYDRA FLUKE for the survey of solar flux, temperature and relative humidity.

Fig.1 : Two greenhouse in URAER

II. MATHEMATICAL FORMULATION

The simulations were obtained by solving the Navier–Stokes equations which, for a steady flow, are written as:

$$\rho=\rho_0(1-\beta(T-T_0)) \quad (1)$$

$$\frac{\partial U}{\partial x}+\frac{\partial U}{\partial z}=0 \quad (2)$$

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+w\frac{\partial u}{\partial z}=-\frac{\partial P}{\partial x_i}+\nu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial z^2}\right) \quad (3)$$

$$\frac{\partial w}{\partial t}+u\frac{\partial w}{\partial x}+w\frac{\partial w}{\partial z}=-\frac{\partial P}{\partial x_i}+\nu\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial z^2}\right)+g\beta(T-T_0)$$

(4)

$$u\frac{\partial T}{\partial x}+w\frac{\partial T}{\partial z}=\alpha\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial z^2}\right) \quad (5)$$

The flow flowing inside the greenhouse is laminar air ,incompressible and two - dimensional in constant physical properties except the density ρ is given by the assumption of e Boussinesq .This equations formed the Boussinesq equations and modeled the natural convection in the low temperatures .

III.2. GEOMETRICAL CONFIGURATION

Te geometrical of the greenhouse considerate i this study was presented in the fig.3. The bottom we supposed that the green house was heated by a high temperature and the top was cooled, were we didn't considerate the radiation.

The proprieties of the air used in this case we given the values of Rayleigh number and Prandetl 10^5 and 0.71.in our study we varied the Rayleigh number between 10^5 and 10^7. Solving equations is performed by the commercial code Fluent Version 6.3.26 in configuration Cited in Fig. 2.the transport equations for all popular sizes are resolved by the second order scheme coupled with the SIMPLE algorithm for determining the pressure field. The latter is estimated on the faces by the PRESTO. To accelerate convergence, the calculated values are under relaxed in each iteration. Two types of boundary conditions are essential for closing the system is cited above this paragraph.

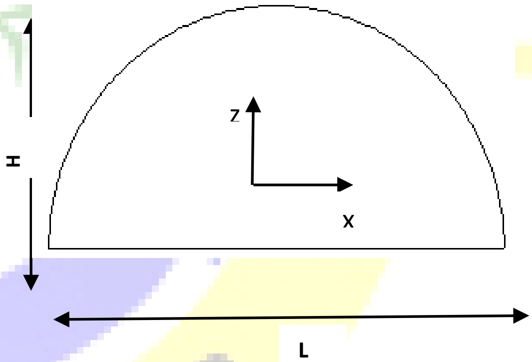

Fig. 2 : Geometrical configuration

IV. RESULTAT:

In the Fig.3 and 4, we presented lines and isotherms corresponding currents in case of natural convection with not radiation. In this case, air circulation is characterized by two cells recirculation located symmetrically to the vertical median of the greenhouse. This structure is explained by the fact that the cold air is heated up to the top of the greenhouse and flows along the roof, where it cools. Therefore, a portion down along the left wall and the other along the right wall. Thus, the symmetrical structure the roof and the central position is responsible for the bi-cell structure current lines. It's found that the air flow increases with the number of Rayleigh. About isotherms indeed, the pure natural convection isothermal adiabatic walls are perpendicular.. Indeed, the more Rayleigh big plus the fluid velocity accelerates and enables the extraction of a greater amount of heat. Therefore isotherms are denser near the bottom when the Rayleigh Number is large.

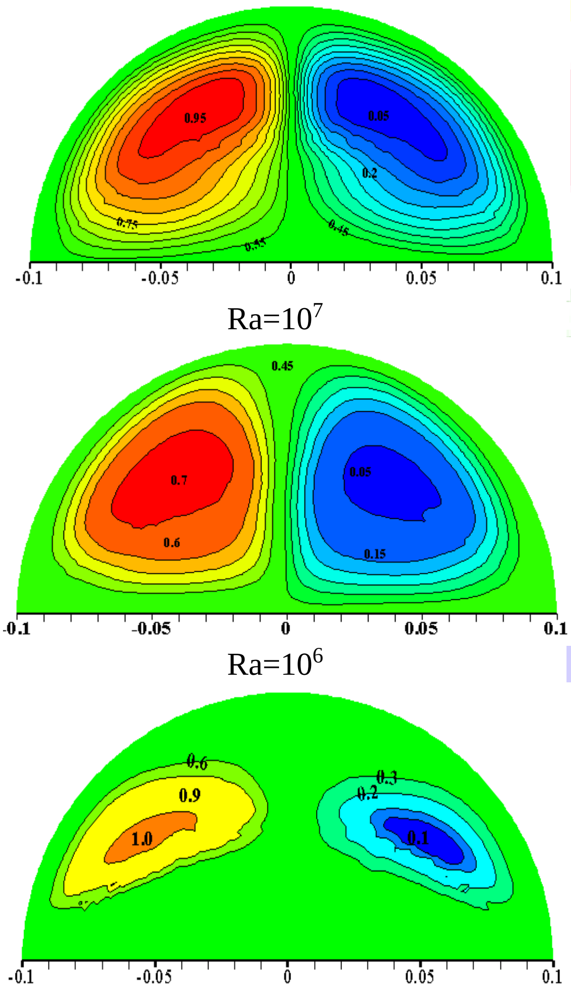

Fig. 3: Isolines of curant fonction

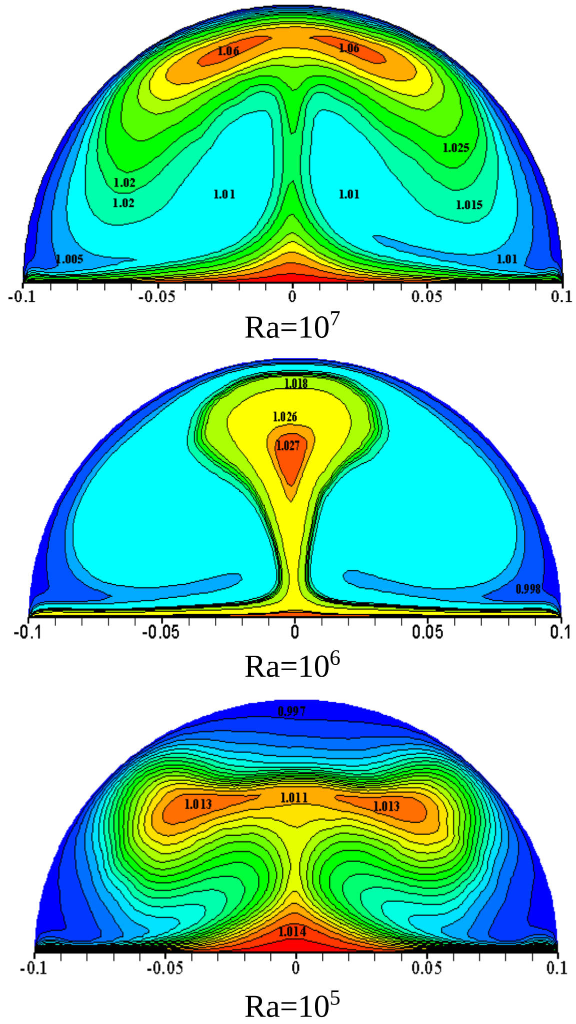

Fig. 4: isothermes of temperature

In the Fig.5 we presented the saturation pressure were is depended with the temperature , it's see that near the bottom the pressure is more greater than the top , were we see in the Fig.6 the relative humidity is independent with temperature , it's very important in the top , that' logically , that's when the temperature increases the humidity goes down.

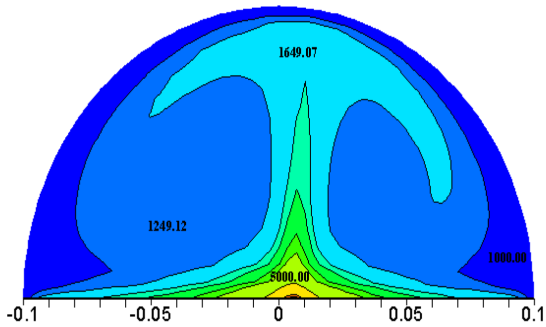

Fig.5. Saturation pressure

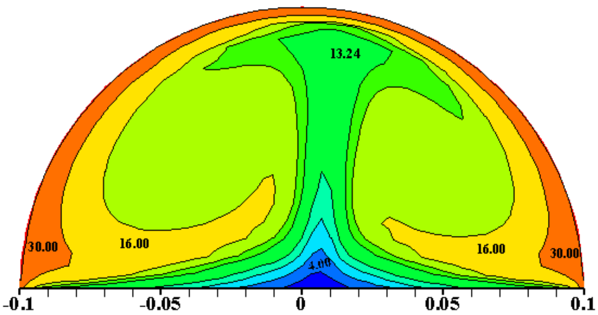

Fig.6. Relative humidity

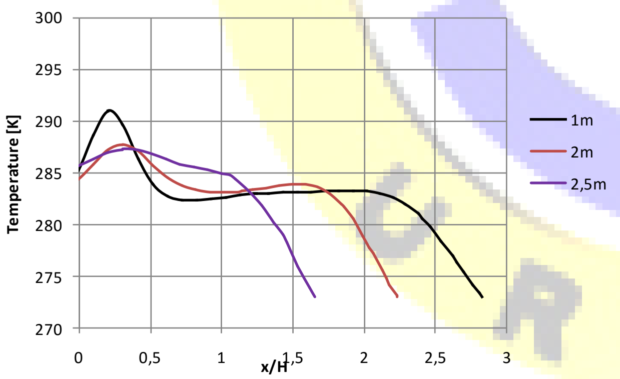

Fig.7.Profils of temperature at different sections

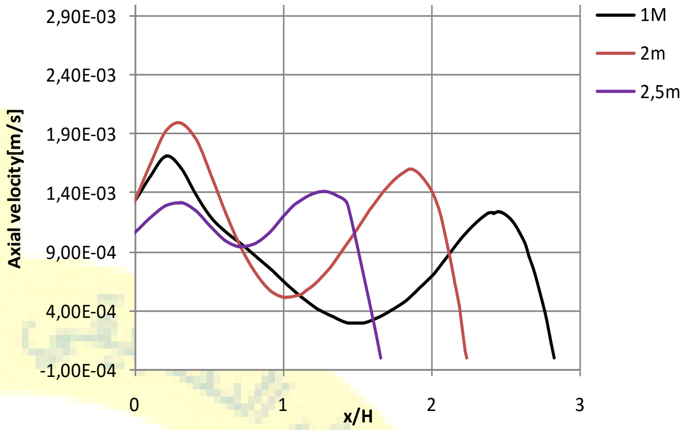

Fig.8. Radial profils of axial velocity at different sections

V. CONCLUSION

We have studied numerically the air behavior inside a greenhouse with a thermal system, we view the description makes sense with respect to the evolution of isotherms and isolines, remains to introduce other parameters such as radiation with a three-dimensional configuration.

REFERENCES

[1] T. Boulard, Caractérisation et modélisation du climat des serres : application à la Climatisation estivale, *Thèse de Doctorat, Ecole Nationale Supérieure d'Agronomie de Montpellier, France*, 1996.

[2] S. Bezari, A. Bouhdjar, Réalisation d'un dispositif de stockage thermique. Premier Séminaire International sur les Energies Nouvelles et Renouvelables, Ghardaïa (2010).

[3] J. C. Roy, T. Boulard, Y. Bailly, étude expérimentale de la convection naturelle dans une serre chauffée, *Congrès Français de Thermique, SFT. (Lyon, France, 15-17 mai. 2000)*, pp. 11-17, 2000.

[4] A. Mezrhab and M. Bouzidi, Computation of view factors for surfaces of complex shape including screening effects and using a boundary element approximation. *Engineering Computations. International Journal for Computer-Aided Engineering and Software*, vol. 22, N°2, pp. 132-148, 2005

[5]Hicham BOUALI(a), Ahmed MEZRHAB(a), Larbi ELFARH(a), Cherifa ABID, simulation numérique des transferts thermiques dans une serre agricole chauffée par un bloc solide isotherme, *13èmes Journées Internationales de Thermique*

[6] Belgacem DRAOUI, Mebirika. BENYAMINE et Thierry. BOULARD, influence du facteur de forme sur la convection naturelle en regime transitoire dans une serre monochapelle chauffée par le bas (flux), *12èmes Journées Internationales de Thermique* .

[7] B. Draoui, M. Benyamine, Y. Touhami et B. Tahri, Simulation Numérique de la Convection Naturelle en Régime Laminaire Transitoire dans une Serre Tunnel Chauffée par le Bas (Flux), *Rev. Energ. Ren. : Valorisation (1999) 141-145*