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Design and Simulation of Thermal Comfort in a Dry zone Region of Bechar

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The research articles and the development must be original and contribute innovative, helping in the development of new and advanced technologies, like the studies that have concrete ideas which are of primary interest in mastering a contemporary scientific concepts. These articles can be written in Arabic, French or English. They will not be published in another journal or under review elsewhere. The target readership is composed especially of engineers and technicians, teachers, researchers, scholars, consultants, companies, university lab, teaching techniques and literary ... The journal is obtainable in electronic form, which is available worldwide on the Internet and can be accessed at the journal URL:

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Abstract – This work concerns the study of an office comfort thermal situated in the region of Bechar (Algeria). The studied building has oriented South-North; whose vertical East, West walls and ceiling are subject to a solar flux calculated by the ASHRAE model; This latter has been validated with experimental results obtained from ENERGARID Research Laboratory meteorological station, the floor is considered adiabatic. The ambient air characteristics was performed using a CFD code where the solar flux boundary conditions are introduced as a user defined function using C++ language. Initial conditions are a basic climate conditions; the density was treated according to the perfect gas laws. The results are presented as velocity fields, isotherms, iso-humidity and streamlines. The temperature and stream displayed on the moist air diagram brought using a program that we developed using Delphi programming language. Our results are in agreement with literature.

Keywords: Thermal comfort, Energy simulation, Building, temperature, Humidity, Air, Solar flux;

I. Introduction

With the current needs of energy-saving and controlling the environmental impact of the building, some doubts arise about the definition of thermal comfort and how to create and maintain comfort conditions. In situ studies of thermal comfort have found an overestimation of perceived discomfort level compared to that provided by these standards, especially in air-conditioned buildings during hot weather. These studies were used to put the bases of an adaptive approach, which characterizes the thermal comfort through adaptive interactions between the occupant and the environment. The use of standards can lead to systemic use of air conditioning, while the adaptive approach ensures thermal comfort with energy consumption more modest. What differentiates the situation where modern architecture at the energy problem, the architecture of any epoch is not only the reduction in the availability of energy resources but rather the requirement for thermal comfort become mass only since the nineteenth (19th) century [1]. Recent years is an important period for the development of thermal comfort in buildings, during which some brakes and other obstacles to the extension of comfort will be removed, allowing it to become a real challenge, both economically and socially. The development of technology has played a very important role to improve comfort. This period is characterized by the growth and development of machinery thermal [2].

Currently, thermal comfort is a request acknowledged and justified in buildings because of its impact on the quality of indoor environments, the health and productivity of the occupant through three quarters of their time indoors. This request is supported by standards and regulations (DTR) that ensure the compliance of the indoor thermal comfort requirements. However, research environments uniform internal heat and comfortable to standards, throughout the year, without taking into account the peculiarities of climate, site, building is accompanied by an increase in climate systems, resulting in high energy consumption, fossil essentially exhaustible and polluting. We focus in this work the analytical aspect of thermal comfort in addition to the simulated appearance which together provides a holistic view of thermal comfort in buildings. Since the problem under consideration is still valid and saw the work presented by Xiaoshu read, 2001 [3], those carried out by Chien Hung Chi Nan Lin and Liao [4] M. Bensafi et al [5] the work is the study of the thermal comfort of an office in the region of Bechar and as the study by N. fezzoui et al [6] a comparative study between two regions in southern Algeria (quantitative study), Bechar and Tamanrasset, and that presented by N. el Gharbi and A. Benzaoui [7], their goal is to provide optimal conditions (temperature distribution, humidity and air flow mode), for an operating room. We proposed to develop a simulation of thermal comfort in a local region of Bechar subject to actual conditions (solar radiation, outside temperature).

II. Description of The problem

Urban development of South was made like the northern cities, thus marginalizing the harsh climatic characteristics of these regions. For many years, following a crisis due to a strong demand for housing, the State is the victim of this technology which does not reflect the socio-cultural aspirations of the Algerian citizen and does not meet the requirements of these climatic and economic regions: buildings with arbitrary orientations, including facades and windows no matter how unsuitable choice of the use of building materials, exhibition buildings to solar constraints (not use sun breezes), the majority of people build their own homes in their own way.

The objective is to calculate the heat balance of a local oriented North-South, as well as determine the flow speed and air temperature.

II.1. External conditions

According to the regulatory technical document (RTD 3-4), the basic external conditions are:

- Temperature outside is: $T_{es} = 44\text{ }^{\circ}\text{C}$
- Relative humidity is: $\varphi = 14\%$

II.2. Conditions inner base

To ensure thermal comfort in this room, you will realize the basic conditions in indoor summer:

- Temperature inside is: $T_{es} = 27\text{ }^{\circ}\text{C}$
- Relative humidity is: $\varphi = 50\%$

II.3. Description studied local

The local study is integrated in a building whose function is to provide administrative services. This room has an area of 15m^2 . Its height is 3m, a width of 3m and 5m long. As shown in Figure.

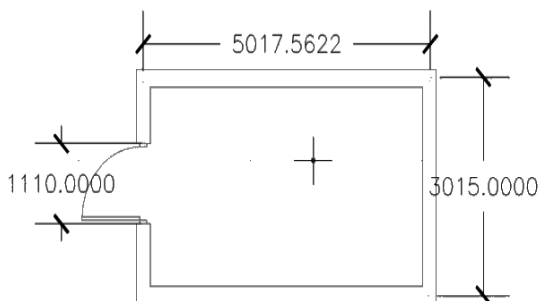


Figure 1. The Ground plane.

II.4. Estimated loads

For the evaluation of thermal balance sheets we used the method of DTR 3-4 Bechar region ($31^{\circ}38'N$ $2^{\circ}13'$ West). The results of calculations of heat gains can calculate the total power installed: $P = 2630.42\text{ (W)}$

Airflow blown represents the quantity of air must be blown into the conditioned space per unit time can be written as follows: $qsouf = P / Cp \cdot |T_{int} - T_S|$.

Where the supply flow rate: $qsouf = 0.2\text{ Kg/s}$.

III. Equations

III.1. The equations of Continuity

The continuity Equations is given by :

$$\text{div}(\rho u) = 0 \quad (1)$$

III.2. The equations of momentum

The momentum Equations is given by :

$$\begin{aligned} \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} &= -\frac{1}{\rho} \frac{\partial p}{\partial x} + \nu \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right) + S_i \\ \frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} &= -\frac{1}{\rho} \frac{\partial p}{\partial y} + \nu \left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} \right) + S_j \end{aligned} \quad (2)$$

III.3. The equations of Energy

The Energy Equations is given by:

$$\frac{\partial T}{\partial t} + u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} = \left(\frac{k}{\rho \cdot Cp} \right) \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right) \quad (3)$$

$$k \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right) + f(t, i, \delta, a, \psi) = \frac{\partial T}{\partial t} \rho \cdot Cp \quad (4)$$

III.4. The equations of mass transfer

The mass transfer Equations is given by:

$$\frac{\partial C}{\partial t} + u \frac{\partial C}{\partial x} + v \frac{\partial C}{\partial y} = \left(\frac{h}{\rho \cdot Cp} \right) \left(\frac{\partial^2 C}{\partial x^2} + \frac{\partial^2 C}{\partial y^2} \right) \quad (5)$$

III.5. The Source term

We have developed a program written in C, and then it was introduced as a User Defined Function.

- The density of dry air: $\rho_{as} = p_{as} \cdot m / (R \cdot T)$
- The density of steam: $\rho_v = p_v \cdot m / (R \cdot T)$

Another program in C language has been programmed for ASHRAE radiation model and inserted as User Defined Function. The total irradiance E_t reaching a receiving surface with a sky Claire is the sum of three components: $E_{t,b}$ direct illumination from the sun, the diffuse component $E_{t,d}$, from the sky, and the component $E_{t,r}$, reflected from the ground of the ground in front of the receiving surface. As follows:

$$E_t = E_{t,b} + E_{t,d} + E_{t,r} \quad (6)$$

$$E_{t,b} = E_b \cos \theta \quad (7)$$

$$E_{t,d} = E_d Y$$

$$E_{t,r} = (E_b \sin \beta + E_d) \rho_s (1 - \cos i) / 2 \quad (7)$$

With:

$$E_0 = E_{SC} \cdot \left[1 + 0.033 \cdot \cos(360(n-3)/365) \right] \quad (8)$$

$$Y = \max(0.45, 0.55 + 0.437 \cos \theta + 0.313 \cos^2 \theta) \quad (9)$$

III.6. The initial conditions and boundary conditions

At the moment $t=0$, the temperature of outer (external conditions for the basic area Bechar D1 (DTR 3-4)). The temperature of the interior $T=44^\circ\text{C}$ (the difference in outdoor temperature and indoor temperature base for local DTR). For moisture to the interior and the exterior is $H=14\%$.

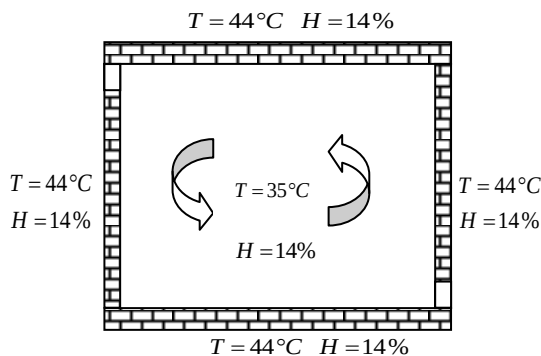


Figure 2. The local presentation.

At the moment $t > 0$, the east wall (90° compared to the south (0°)), vertical (90° with the horizontal plane)

subject to a solar flux calculated numerically with ASHRAE's method.

The west wall (-90° compared to the south (0°)), vertical (90° with the horizontal plane) subject to a solar flux calculated numerically using the ASHRAE method. The floor, Horizontal (0° with the horizontal plane) submitted a solar flux calculated numerically using the method of ASHRAE.



Figure 3. Solar flux to a vertical East wall.

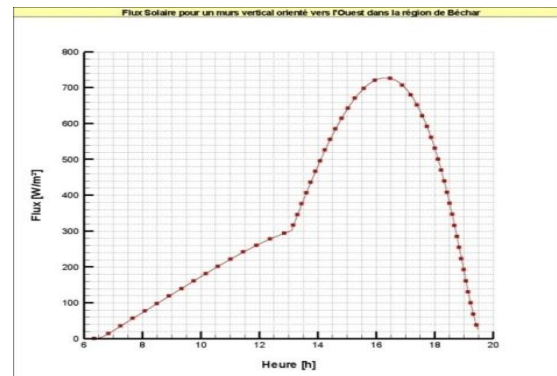


Figure 4. Solar flux to a vertical West wall.

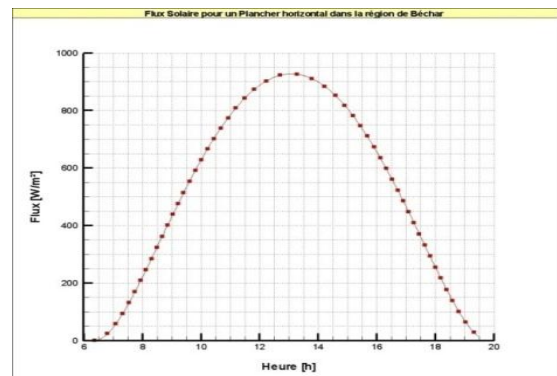


Figure 5. Solar flux for horizontal floor.

The figures show the solar flux for the three walls. Air is blown for a mass flow rate of $q_{sout,m} = 0.22 \text{ [kg/s]}$, the specific volume of air is $v_s = 0.8651 \text{ [m}^3 / \text{Kg}_{as}]$, The

volume flow of the air is $q_{\text{soif},v} = 0.19 \text{ [m}^3/\text{s]}$, the moisture is $H = 50\%$ or $r = 0.0112 \text{ [m}^3/\text{Kg}_{\text{as}}]$.

IV. Results

The results are presented as isotherms, iso-moisture for:

- The first case, the maximum solar flux is on the east wall (FSME).
- The second, the maximum solar flux is on the wall Horizontal (FSMH).

The third, the maximum solar flux is on the west wall (FSMO).

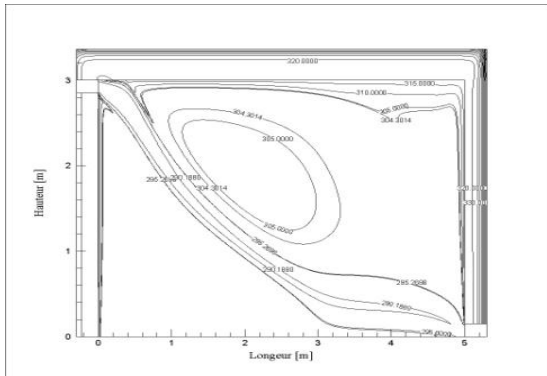


Figure 6. Isotherms for F.S.M.E.

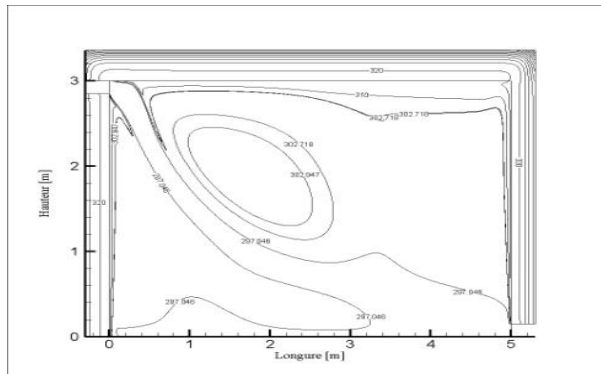


Figure 7. Isotherms for F.S.M.H.

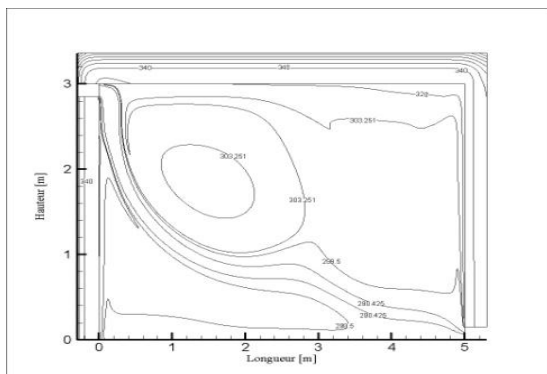


Figure 8. Isotherms for F.S.M.O.

Figures above show the existence of a temperature stratification near the Horizontal wall. This latter is due to the temperature gradient.

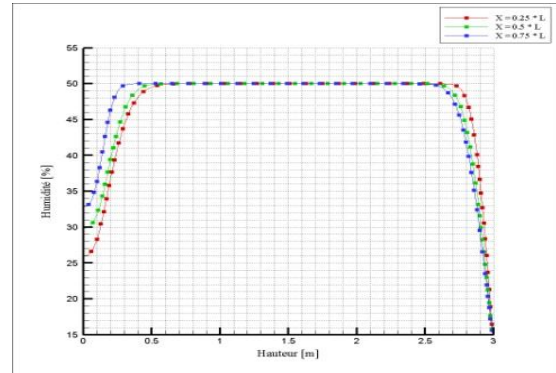
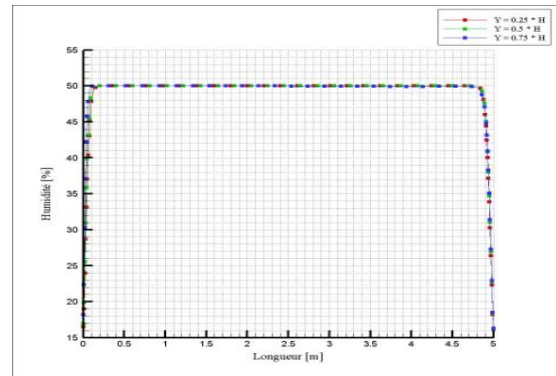


Figure 9. Iso-humidity for F.S.M.E.



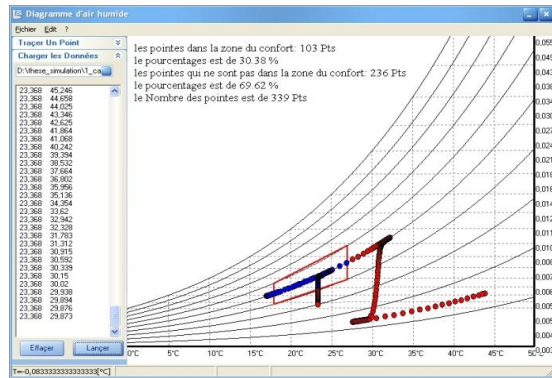


Figure 12. Temperature and humidity in the diagram of humid air F.S.M.E

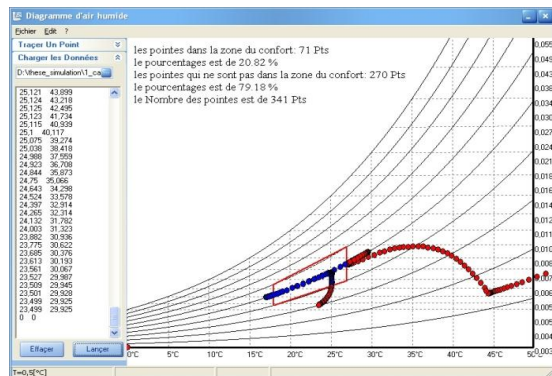


Figure 13. Temperature and humidity in the diagram of humid air F.S.M.O.

After performing simulations, while specifying the conditions mentioned above, first, we obtained temperature fields and secondly humidity field. These results were displayed in the diagram of humid air.

However, Figures 12 & 13. shows these points, namely the temperature and humidity in the middle of the room studied, we note that the percentage of points that are in the comfort zone is less than they are outside the comfort zone.

V. Conclusion

This study has allowed us to take a maximum of work in the context of thermal comfort where we could highlight the concept of thermal comfort. In this study we undertook a study of an office in the town of Bechar, where we studied the thermal comfort through a CFD. In this study we took into account the solar radiation where the ASHRAE model has been integrated. In the case of the study of local convection in the Boussinesq approximation has not been considered and replaced by a program written in C is introduced as a User Defined Function in CFD. We found that the studied configuration cannot satisfy the human being in terms of comfort.

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