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THERMAL CONFORT ENHANCEMENT IN A HABITAT ISOLATED FROM THE ROOF BY A POROUS MEDIA

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ABSTRACT

The large share of energy consumed for the heating or cooling of buildings has led researchers to address the issue of heat exchange between premises and the environment.

Since Much of the heat loss occurs through the roof, insulating materials slow down heat Transfer through the building envelope. The quality of the insulation required depends on the climate, the exposure of the roofs and also the materials used for the construction. The choice of a material used as insulation depends naturally on its availability and cost. In this study, we propose to analyze the heat Transfer in a ceiling-insulated building by a porous medium (glass wool), based on the effect of the Rayleigh number on the heat exchange between the Building and the outside environment. For this purpose, a Comsol multiphysics software based on the finiteelementmethodis used to solve the equationsgoverning heat transfer in the fluid medium as well as the porous medium. The resultswillbe in the form of currentlines, isotherms, temperature profiles and Nuseltnumbers..

KEYWORDS: Darcy-Brinkman, finite elements, porous media, pitched roof, thermal insulation.

INTRODUCTION

Most building materials have a porous structure insidewhich water in liquid or vaporformcanbestored or returned to the surrounding environment. Computer simulations makeit possible to study the thermal performance of buildings offering the possibility of improving the design by integrating insulation of different type. The researchcarried out in this work also aims to use modelingtools to predict the thermal behavior of a building to the presence of an insulator in a porous medium. In this study, we propose to analyze the effect of the number of rayleigh on heat transfer in a ceiling-insulated building by a porous medium (glass wool).

PHYSICAL MODEL

The physical model studiedisrepresented in FIG. 1. It is a habitat with an inclined roof simulated by an enclosure with a height H and a lengthL'on the roof of a porous layer of thicknessEp and saturated by a fluid the air). The vertical walls are keptadiabatic and impermeable (Neuman conditions), the leftwallbelongs to a window through which a heat flow passes, while the floorissubjected to a Dirichlet condition (temperature) and the roof has a heat flux q.

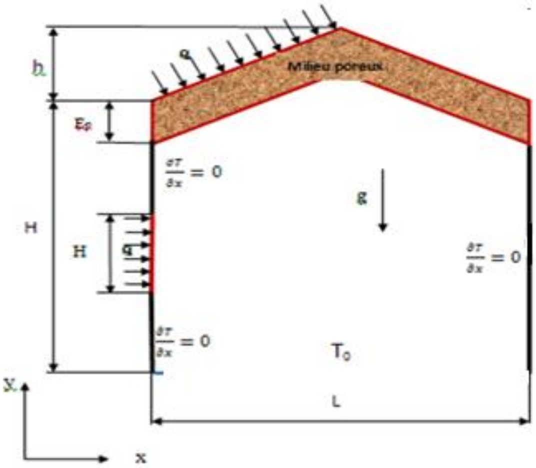


Figure 1 :Problem Geometry

THE INFLUENCE OF POROSITY

To describe the effect of the Rayleigh Ra number on the flow structure and heat transfer, the following parameters:(h, H, L, Ep)

Mathematical Formulation

Fluid area

$$\frac{\partial u^*}{\partial x^*} + \frac{\partial v^*}{\partial y^*} = 0. \ (1)$$

$$\frac{\partial u^*}{\partial t^*} + u^* \frac{\partial u^*}{\partial x^*} + v^* \frac{\partial u^*}{\partial y^*} = -\frac{\partial p^*}{\partial x^*} + \Pr\left(\frac{\partial^2 u^*}{\partial x^{*2}} + \frac{\partial^2 u^*}{\partial y^{*2}}\right)(2)$$

$$\frac{\partial v^*}{\partial t^*} + u^* \frac{\partial v^*}{\partial x^*} + v^* \frac{\partial v^*}{\partial y^*} = -\frac{\partial p^*}{\partial y^*} + \Pr\left(\frac{\partial^2 v^*}{\partial x^{*2}} + \frac{\partial^2 v^*}{\partial y^{*2}}\right) + \Pr \mathrm{Ra}\, T^*(3)$$

$$\frac{\partial T^*}{\partial t^*} + u^* \frac{\partial T^*}{\partial x^*} + v^* \frac{\partial T^*}{\partial y^*} = \left(\frac{\partial^2 T^*}{\partial x^{*2}} + \frac{\partial^2 T^*}{\partial y^{*2}}\right)(4)$$

Porous area

$$\frac{\partial u^*}{\partial x^*} + \frac{\partial v^*}{\partial y^*} = 0(5)$$

$$\frac{1}{\varepsilon}\frac{\partial u^*}{\partial t^*} = -\frac{\partial p^*}{\partial x^*} - \frac{\Pr}{\mathrm{Da}} u^* + \frac{\Pr R_V}{\varepsilon}\left(\frac{\partial^2 u^*}{\partial x^{*2}} + \frac{\partial^2 u^*}{\partial y^{*2}}\right)(6)$$

$$\frac{1}{\varepsilon}\frac{\partial v^*}{\partial t^*} = -\frac{\partial p^*}{\partial x^*} - \frac{\Pr}{\mathrm{Da}} v^* + \frac{\Pr R_V}{\varepsilon}\left(\frac{\partial^2 v^*}{\partial x^{*2}} + \frac{\partial^2 v^*}{\partial y^{*2}}\right) + \Pr \mathrm{Ra}\, T^*(7)$$

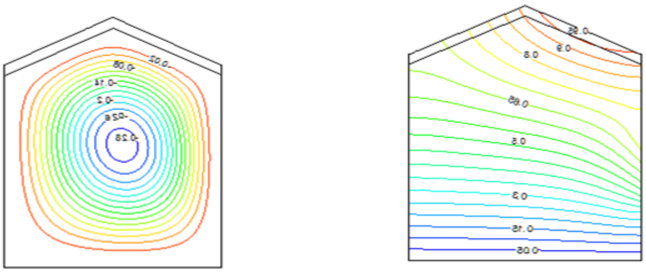
$$\sigma\frac{\partial T^*}{\partial t^*} + u^* \frac{\partial T^*}{\partial x^*} + v^* \frac{\partial T^*}{\partial y^*} = K_r\left(\frac{\partial^2 T^*}{\partial x^{*2}} + \frac{\partial^2 T^*}{\partial y^{*2}}\right)(8)$$

RESULTS AND DISCUSSIONS

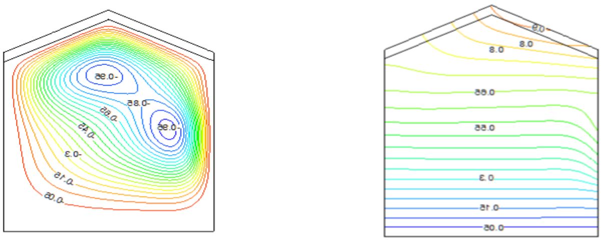
Current Lines and Isotherms

The lines of currents shown in (FIG. 2) Show that for the small values of Ra, a single celloccupies the entire enclosure, the direction of rotation of whichishourly. We note that for Ra = 10^5 the self-defense and begins to decompose in two zones. For Ra = 10^7 the lines of current are in two large cells in the form of rollers of opposite directions, one large cell next to the left vertical wall and anothersmallat the top. Beyond = 10^8 the flow structure becomes more complex, indicating the passage to the turbulent regime. The effect of the Rayleigh number also appears on the intensity of the values of the currentfunctionswhich are accentuated with the increase of Ra.

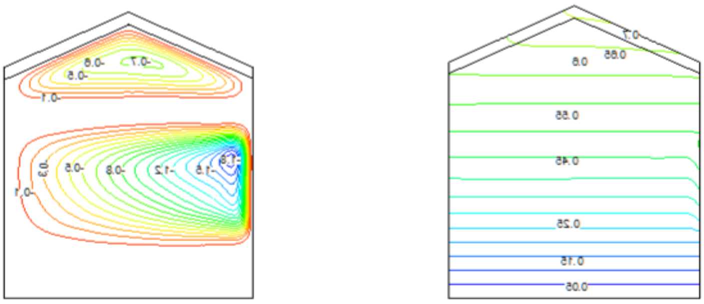
For low Rayleigh numbers (Ra = 10^3, Ra = 10^4) the structure of the isothermsisalmostparallel of the inclined wall of the enclosure means that the heat transferisperpendicular to this wall. The pace of its lines begins to move towards the horizontal for Ra = 10^5. For a Ra> 10^7 the isotherms are almost parallel to the lower wall, the thermal flux is perpendicular to the gravity field. The influence of the Rayleigh number also appears on the temperature values



Ra = 10^3



Ra = 10^5



Ra = 10^7

Figure 2: Isotherms and Current Lines for Different Values Of the Rayleigh Number

TEMPERATURE PROFILE

From FIG. 3. We note for Ra = 10^3 a decrease of these temperature values of an exponential form and the insulation has no almost influence on these profiles. For Ra = 10^5 the temperature drops to X * <0.2 and becomes constant for all the other part of the enclosure, it is also observed that the insulation helped decrease the profile of the temperature. We find for Ra = 10^7that the profile keeps the same pace, but with a big difference between the isolated case and the other not isolated.

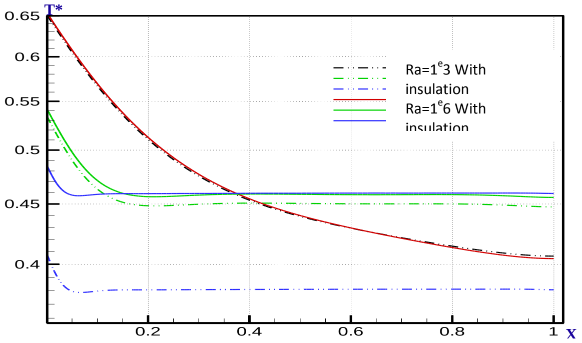


Figure :: Les Profile De Température A La Mi-Hauteur De L'enceint Pour Des Différentes Valeurs Ra

NUSSELT AVERAGE

From Table 1, it is noted that the average Nusselt grows with the growth of the Rayleigh number, and the insulation has decreased in number for each Rayleigh.

Table 1: Change in Average Nusselt Number as a Function of Ra

Ra	Ra= 10^3	Ra= 10^5	Ra= 10^7
N_{UM}	1.637	1.993	2.572

CONCLUSIONS

We have a presentedanumerical study of the transfer of heat by natural convection in an isolated habitat on the roof of a porous medium. The geometric configuration of the physical model is an inclined roof enclosure with thermal boundary conditions of Dirichlet and Neuman types.

We studied the effect of the Rayleigh number which characterizes the intensity of natural convection. Heat transfersincreasewith the Rayleigh number. Beyond Rayleigh, the flow becomesverycomplicated, so we move on to a transitional regime.

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