Association pour la Promotion Scientifique de l'Afrique

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Title

Method for Determining the Optimum Insulation Thickness of the Plaster Tow Material: Influence of the Heat Exchange Coefficient in Transient Regime

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Outline presentation

I- Context

II- Presentation of local materials

III- Materials and methods

IV- Numerical resolution

I- Resultats and discussions

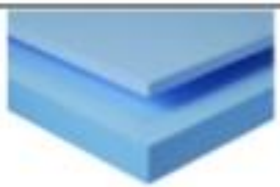
I- Conclusion

Context

The high energy consumption was caused by air conditioning in buildings and prompted researchers to focus on the characterization of high performance local insulating materials to improve thermal comfort of buildings and save energy and money it is important to use local materials that are available and easy to use, hence the interest of insulating the hearths with an insulating material with a small thickness to amortize the cost of investment. In this work, we determined the optimum insulation thickness of the plaster tow material. The proposed method is based on the determination of the thermal resistance in the depth of the material for a different value of heat exchange coefficient. We also used the relative thermal resistance that shows how the optimum insulation thickness of the material changes when the heat exchange coefficients change values .

I- Presentation of Materials

a- Synthetic insulation materials

Materials	Picture	Manufacturing	Thermal conductivity (W/m.K)	Properties	Conditions of use
Expanded Polystyrene (EPS)		Crude oil - balls compression-bonded during molding	0,029-0,038	- Fragile in the face of fire: requires associating it with plaster, for example - Releases CO_2, H_2O and CO in case of fire - Unstable over time - Sensitive to the action of corrosives and rodents	Recommended on regular surfaces for roof, wall and floor insulation In the form of plates
Extruded Polystyrene (XPS)		Crude oil - balls compression-bonded during molding	0,029-0,037	- Compression-resistant - Waterproof, cold, heat resistant - Fragile in the face of fire (combine it with plaster)	Basements, flat roofs, floors, heated underfloor, double walls Panels with smooth or flush edges
Polyurethane (PUR)		Polyurethanes are produced by the reaction of an isocyanate and a polyol of various types.	0,022-0,030	- Good compression support - Moisture does not alter it - Micro-porosity of its structure: allows water vapour to migrate from the inside to the outside => no need for a vapour barrier - Dangerous in case of fire: releases toxic gases	Roofs, flat roofs, floors, wall lining Suitable for renovation and construction Foam or panels
Phenolic foam		Phenol-formaldehyde resin	0,018-0,035	- Fireproof and low smoke emission during combustion - Sensitive to moisture: requires water repellent	Roofs, walls, floors Panels

I- Presentation Materials

B-local Materials

Cannabis (South of senegal)

Kapok Fibers (many locations)

Typha many locations

Tow

Typha Fibers

II-Material and Method

A brick of Tow –plaster mixture of 5cm tick

The average diffusivity of the tow-plaster mixture is 2.07.10-7m2 s -1

The average conductivity of the order of 0.15W.m 1 .°C-1

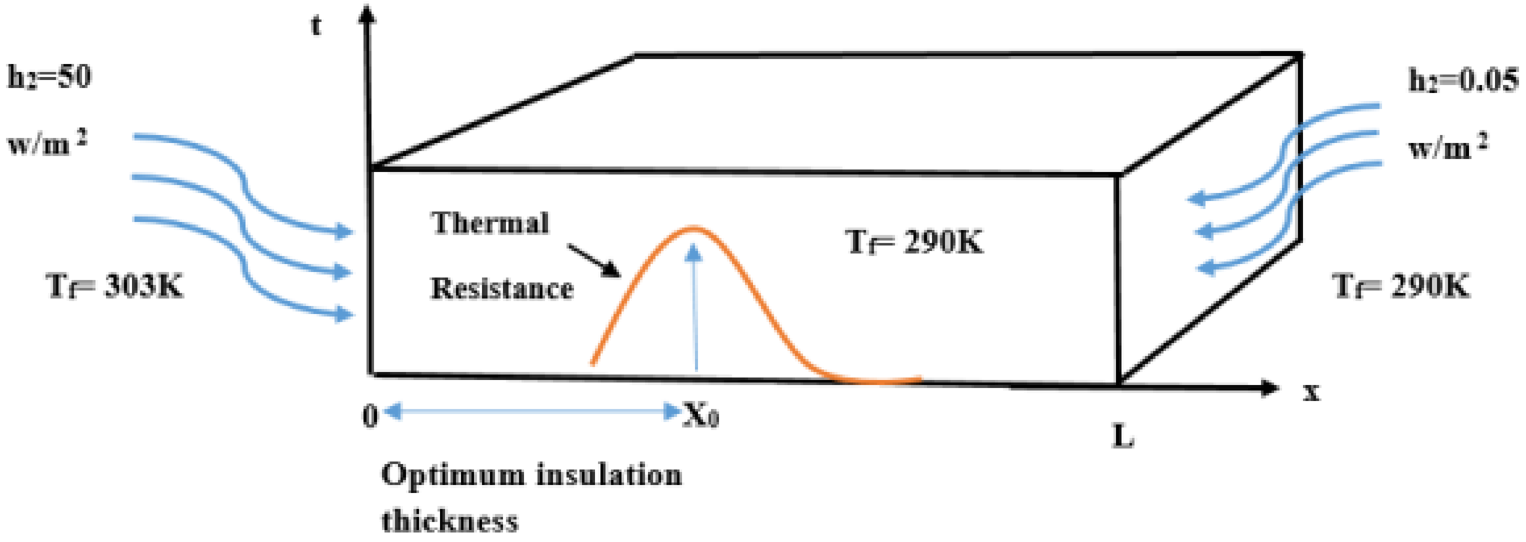


Fig. 1: Tow plaster plane material

II-Material and Method

The equation for heat without a heat sink is given by the following expression

$$\frac{\partial^2 T(x,t)}{\partial^2 x} - \frac{1}{\alpha}\frac{\partial T(x,t)}{\partial x} \quad (1)$$

Where $\alpha = \frac{\lambda}{\rho c}$ (2)

α is the thermal diffusivity of the material assumed to be uniform.

λ is the thermal conductivity of the material

c the specific heat

Equations (2) and (3) reflect the conservation of heat flux at the surface of the material and equation (4) represents the initial condition.

$$\begin{cases} h_1\left(T(0,t) - T_{f1}\right) = \lambda \frac{\partial T(x,t)}{\partial t} |x = 0 & (3) \\ h_1\left(T(L,t) - T_{f2}\right) = \lambda \frac{\partial T(x,t)}{\partial t} |x = L & (4) \\ T(x,0) = T^0 & (5) \end{cases}$$

III- Numerical resolution

The finite-difference discretization method applied to the equations allows us to obtain; the temperatures expressions on the two faces

$$\begin{cases} T_i^{j+1} = AT_i^j + 2PT_2^j + CT_{f1} & (7) \\ T_i^{j+1} = BT_i^j + 2PT_{M-1}^j + DT_{f2} & (8) \\ T_i^1 = T^0 & (9) \end{cases}$$

Where,

i locate the variable space

j is the locates the variable temp

$\boldsymbol{T_i^j}$ is the temperature at node i at date j

M represents the number of nodes along the space x

N the number of nodes along time t

The expression of the flux density

$$\phi_j^i = -\lambda \frac{[T_{i+1}^j(h_1, h_2, \alpha) - T_i^j(h_1, h_2, \alpha)]}{\Delta x} \qquad (10)$$

The expression of the resistance in the discrete form:

$$R_i^j(\alpha, h_1, h_2) = \frac{T_1^j(\alpha, h_1, h_2) - T_M^j(\alpha, h_1, h_2)}{\phi_i^j(\alpha, h_1, h_2)} \qquad (11)$$

Where $1 \leq i \leq M-1$ et $1 \leq j \leq N$

The relative constant of thermal resistance is defined by the following expression:

$$R_r = \frac{R_{th}}{R_{max}} \qquad (9)$$

IV-Results and discusion

We have studied the influence of the heat exchange coefficient of the front face h1 on the evolution of the thermal resistance of the material at depth.

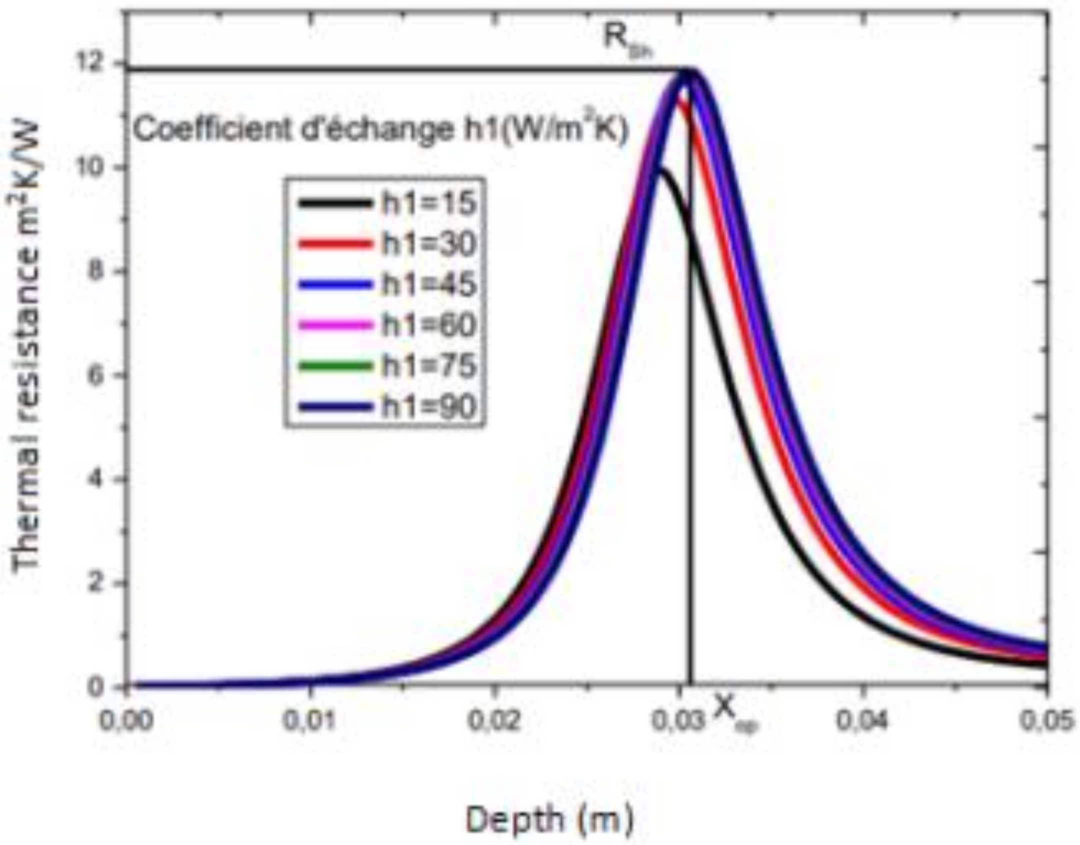


Fig 2: Evolution of thermal resistance as a function of depth - influences of heat exchange coefficient h1 W/m^{2}K; h2 = 5 W/m^{2}K; N = 100,000; M = 100; x = 5cm

IV-Results and discusion

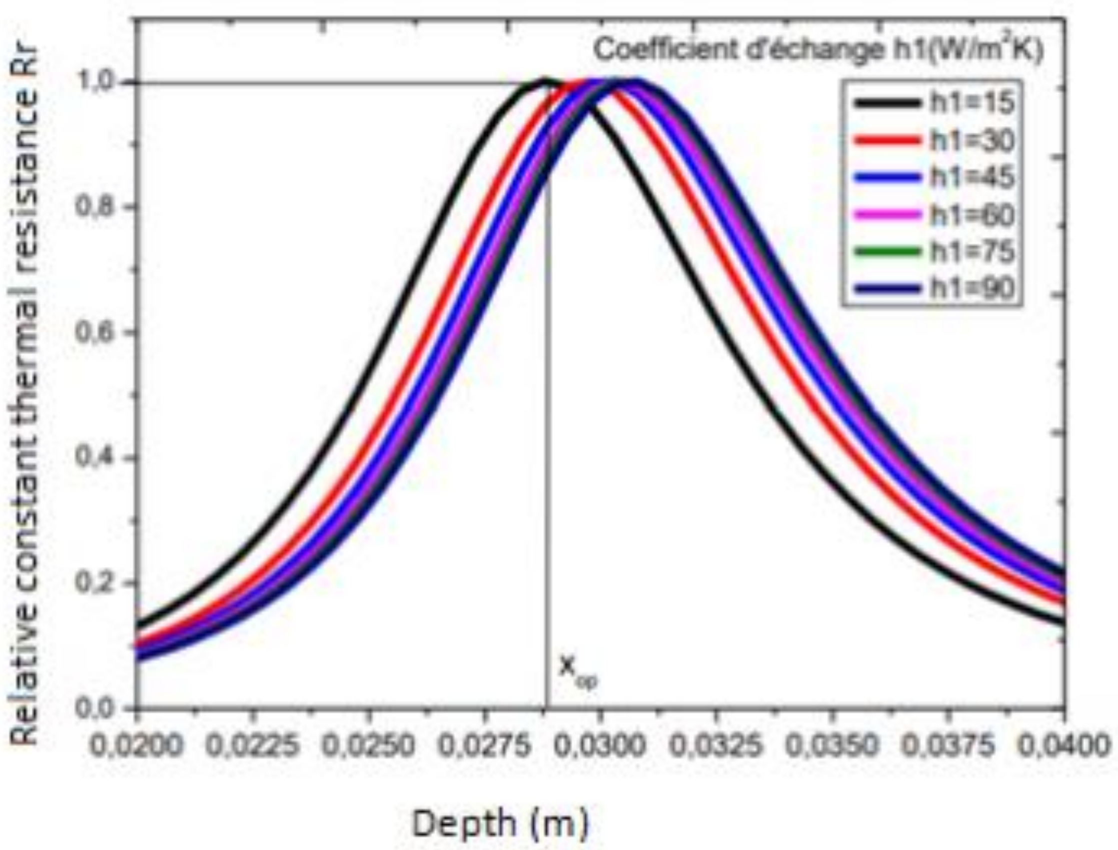


Fig 3: Evolution of the relative constant of resistance as a function of depth -influences of heat exchange coefficient h1 = 50 W / m2K; h2 = 5 W / m2K; N = 100,000; M = 100

IV-Results and discusion

Table 1 influence of the heat exchange coefficient h_1 on the thermal shunt resistance and insulation thickness

Heat exchange coefficient h_1(W/m2K)	15	30	45	60	75	90
Maximum resistance R_{max} (m^2K/W)	11.32	12.40	12.64	12.75	12.71	12.63
Optimal insulation thickness Xop (m)	0.028	0.029	0.029	0.029	0.030	0.030

IV-Results and discusion

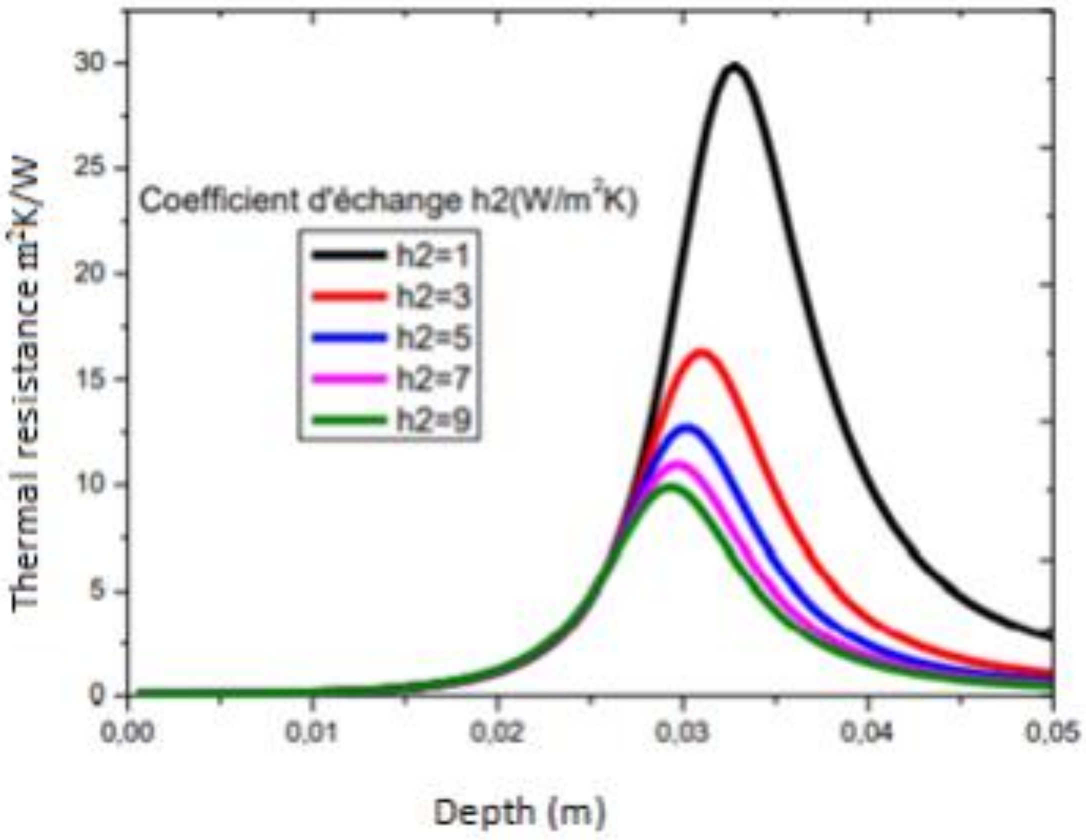
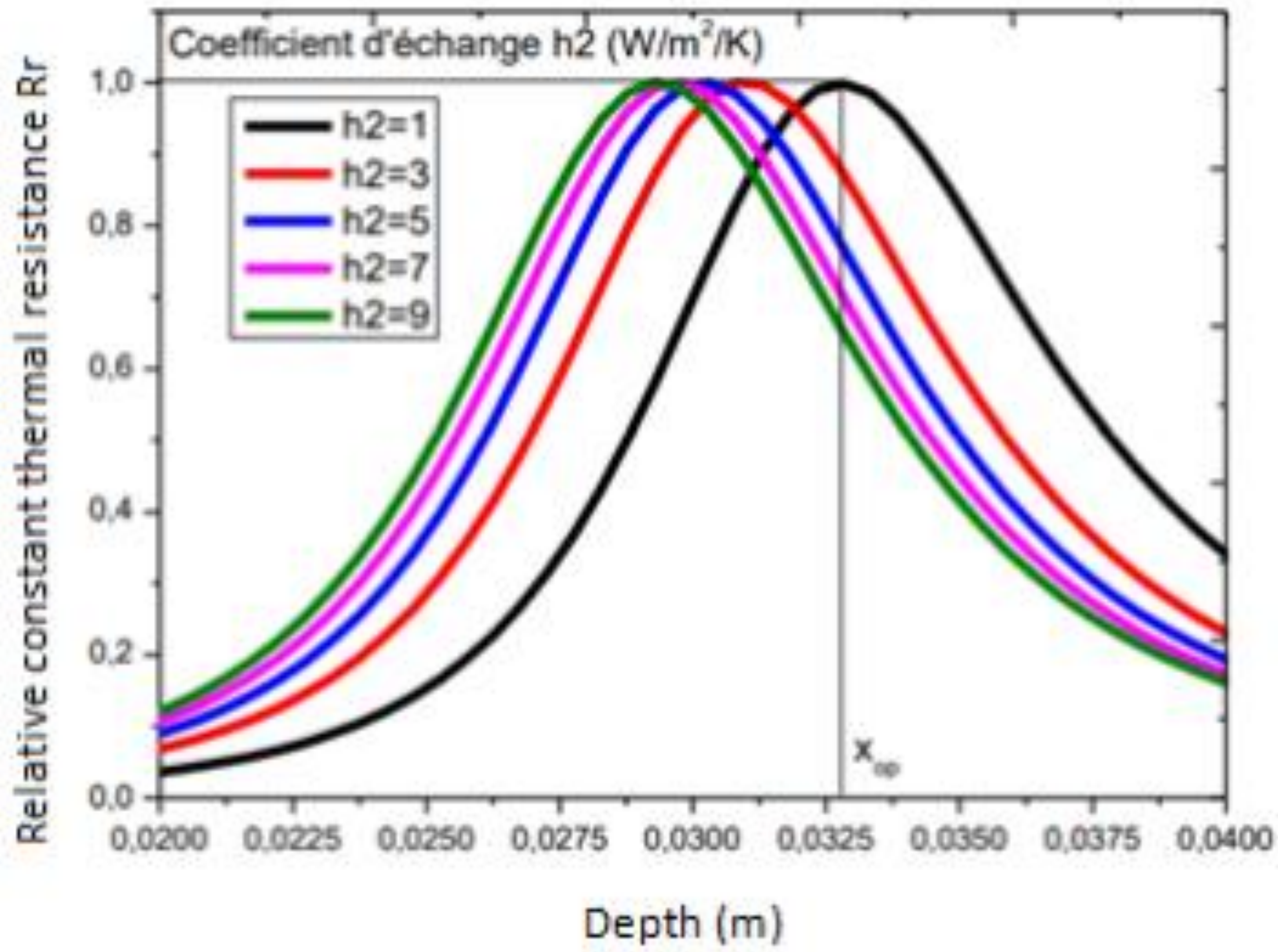


Fig 4: Evolution of thermal resistance as a function of depth – influence of heat exchange coefficient h1 W/m²K; h2 = 5 W/m²K; N = 100,000; M = 100; x = 5cm.

IV-Results and discusion



IV-Results and discusion

Table 2: influence of the heat exchange coefficient h_2 on the thermal shunt resistance and insulation thickness

Heat exchange coefficient h_2 (W/m^2K)	1	3	5	7	9
Maximum resistance R_{max} (m^2K/W)	29.85	16.25	12.65	10.94	9.92
Optimal insulation thickness Xop (m)	0.032	0.031	0.030	0.029	0.029

Conclusion

In this work, we determined

- The optimum thermal insulation thickness of the tow material.

- The influence of heat exchange coefficients on the front and rear sides of the material to be put. The latter has little influence on the variation of the optimum insulation thickness.

- And the value of maximum optimum insulation thickness is approximately 3cm. With 3cm of plaster tow material, we can make good thermal insulation.

Thank You For Listenning