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THE EFFECT OF THE THERMAL INERTIA ON THE TEMPERATURE OF A HEATING SLAB.

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Abstract

The paper presents the influence of the thermal inertia on the temperature of a heated concrete slab. This is a solar sensor provides a solar heating system floor, which the energy input.

The concept of thermal inertia is not easy to grasp. It is defined as the speed that helps a system ((building in our case) reacts to the change in operating conditions. The response of the building facing to the stresses is largely depending on the thermal properties of constituent materials. This feature is related to good performance, good use, and comfort of the thermal machine which is called ‘‘habitat’’. The objective of this work aims to study the influence of the inertia on the surface temperature of the floor, to design the future of homes with high inertia and very low energy consumption with satisfactory comfort conditions.

***Keywords*:** *thermal inertia, solar heating, solar collector, floor, Forte inertia habitat.*

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I. INTRODUCTION:

Today, theconstruction industrygoes into anew era.The energyconsumption of buildingsrepresentingAlgeria,almost 47%of the energy producedand they are responsible forover 25%of greenhousegas emissionsmust be reducedby economic andenergy solutionsrespect to the environment.

For this, improving the building's envelope which is reinforced by insulationand better treatmentof thermal bridgeswhich introduce lower thermal requirementsinair conditioning andheatingshould be taken into consideration. Further research should focus on efficient building heating systems to control the atmosphere of living with a lower energy cost. Certainly, maintenaning the atmosphere is entrusted to the heating system whose quality depends greatly on the design, the design and implementation of the facility. At the same time, technological development in the field ofcurrent heatingneeds to go parallel to the direction ofreducing thenegative environmental impactthrough the use ofrenewable energy sources and toensure also the securityof ourenergy suppliesfacingthe depletion offossil energy resources.

Inthis approach, theheated floorhas a particular placein technology. Itprovides optimalheat distributionvertically and horizontally,perfectly compatible withrenewable energy sources. it is one oflow temperaturesystemswhichreduces theenergy consumption through its use.

Research has been under taken on this heating technology and several designs were studied .A.Mokhtariet al(1992) demonstrated in atheoretical and experimental studyof astorage room witha directsolar flooracaptureratio of 8to 10%ismore than enoughaccordingtothe Algerianclimate.The authorsalso notedthat asensor surfaceequal to 10%ofthe heating floor's surface can be usedwithout fear ofoverheating[1].

For the dimensions that are suitable for our climate, and to avoid the overheating phenomenon and have some thermal comfort. Kharchi A. (2000), used a report in his experimental study, capture area / exchange area (slab) equal to 0.5, for a slab thickness of 10 cm above the grid [2].

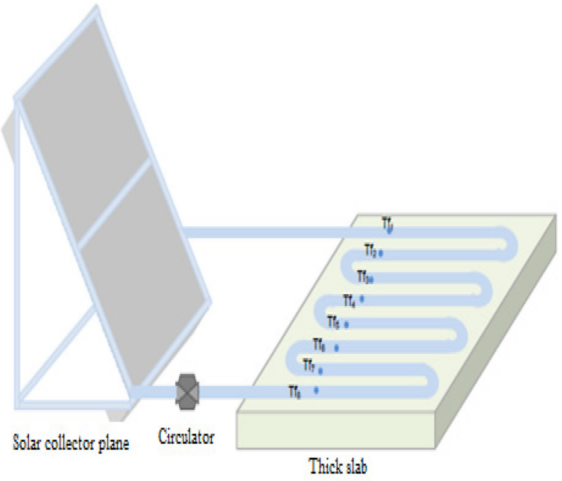
II. THEHEATING SYSTEM

A directsolar floorconsists essentiallyof three elements:

●The solar panel capturesthat convert transformsunlight into heat.

●A slabwherein in whichthe heat transferfluidheatedby the sensors.The lattersimultaneouslyserves to storetheheat generatedby the sensors andtothereturnin the same wayas a conventionallow-temperaturefloor heating, but with a certaintime lag.

●A transfergroup that managesthe heating of thePSD[3].



III. MATHEMATICALFORMULATIONSYSTEM

The systemis modeledaccording tonodalmethod, based ontheheat balancesofeachelement which constitutestheheating system: sensor, coolant, floorconsisting ofa concrete slab.

A. Simplifying assumptions

- The physical properties of materials are assumed to be constant.
- The flow regime is transitional.
- The different solid media have a uniform temperature in a plane normal to the direction of flow.
- The heat flows are of one-dimension.
- The heat transfer fluid used is a pure water.
- the heat losses between the solar collector and the floor are negligible.
- The temperature of the water leaving the solar collector is equal to that of the water at the inlet of the under floor heating.
- We limit ourselves only to study the exchange of heat from the top of the coil (the floor is well isolated from the ground side).
- The heat transfer fluid circulates on the velocity u in the tube.
- The floor temperature isconsidereduniform.

B. Heat balance

1) Usefulpower recoveredby the fluid

The useful power recovered by the heat transfer fluid is governed by the equation [4], [5]:

$$P_u = F_R \cdot \left((\tau\alpha)_{eff} \cdot P_g - U_g \cdot (T_{fe} - T_a)\right) \cdot S_c \quad (1)$$

Or :

$(\tau\alpha)_{eff}$: Effective coefficient ofabsorption.

F_R :Overall efficiency of thethermalexchangeof the sensor.

T_{fe} :Entered temperatureof the coolant.

P_g : Overall power.

U_g :overall heat loss.

2) Heat balanceat thehotslab

By performingaheat balanceat eachnode, we obtain a system of twoequations describingthebehaviorof thefloor.

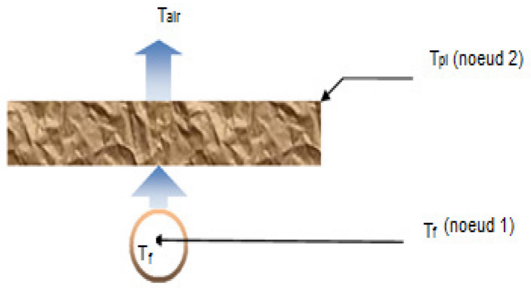


Fig.2.Nœudsconsidered in thefloor

- Nœud1 : (the heat transfer fluid)

$$M_fCp_f\frac{\partial T_f}{\partial t} + U_fCp_f\frac{\partial T_f}{\partial y} = h_{vplf}S_{plf}\left(T_{pl} - T_f\right) + h_{cplf}S_{pl}\left(T_{pl} - T_f\right) \quad (2)$$

Dividing by$M_f.Cp_f$, we obtain:

$$\frac{\partial T_f}{\partial t} + \frac{V_fV_{fmax}}{M_f}\frac{\partial T_f}{\partial y} = \frac{h_{vplf}S_{plf}}{M_fCp_f}\left(T_{pl} - T_f\right) + \frac{h_{cplf}S_{pl}}{M_fCp_f}\left(T_{pl} - T_f\right) \quad (3)$$

- Nœud 2: (the floor)

$$\frac{dT_{pl}}{dt} = \frac{h_{vplf}S_{plf}}{M_{pl}Cp_{pl}}\left(T_f - T_{pl}\right) - \frac{S_{pl}}{M_{pl}Cp_{pl}}\left(\varphi_{vpla} + \varphi_{rpl}\right) \quad (4)$$

With:

φ_{rpl} : Exchangeradiantwith air.

φ_{vpla} : Exchangeconvectionwith air.

Thisequationcompletedby the initial conditionsandsystemboundary, formsasystem of nonlinearequationsandcoupled. The resolutionis performed bythe finite differencemethodusing thedescendingimplicit schemeforthe convectivetermfluidandan explicit schemeforthetransientterm.

IV. RESULTS AND DISCUSSION

The thermal inertiaimposes a certaintime delaybetween the moment whenthe water isintroduced into the tubeand the temperature of thesurface varies.

Thethermalinertia associated with conduction'sphenomenondepends on the thicknessof the slab andthethermo physicalcharacteristics of the materials which consist of (volume, massthermal conductivity, thermal emissivity) [2].

A. Temporal variation inuseful powerof the sensor

It is evident thatthe usefulpower recoveredby the fluidclosely depends on theglobal solar radiation. Thus, andas shown inFigure 3, theusefulpower(heat supplied to the floor) has a bell shape,itis between 120and300watts.

This result has a good agreement withwhat was found inthe literature [2].

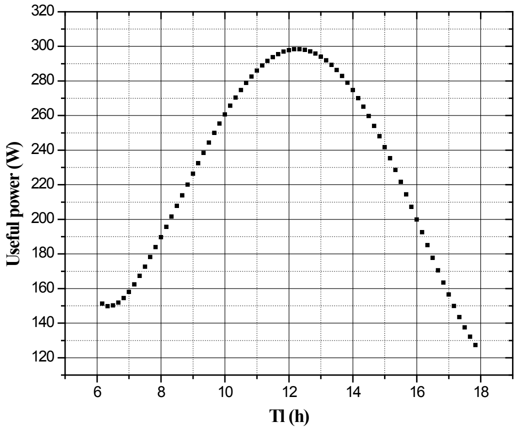


Fig .3. Variationtemporalofthe useful power of the sensor

B. Assessment of the roleof inertiaonthe floortemperature:

1) Influence of the thickness of theconcrete:

a)-Effect ofthe thickness of theconcreteonthe floor temperature:

Figure4.a illustrates the evolution ofthe flour's maximum temperature as a function oftimefordifferent thicknesses of the concrete's layer.It is clear thatthemaximum temperature of thefloordecreases when the thicknessof the layer ofconcrete increases.

Thefloor temperaturewill be evenweaker thanthe concrete massis important.

b) Effect ofthe thickness of theconcreteover the usefulpower:

In Figure4.bwe canfind that theconsumptionof useful powerdecreases when thethickness of the upperconcrete layeris increased (the thermal losses between the sensor andtheslabbeing assumednegligible,theheattransferred totheslabisthusequal to the energycaptured by the"power output" sensor).

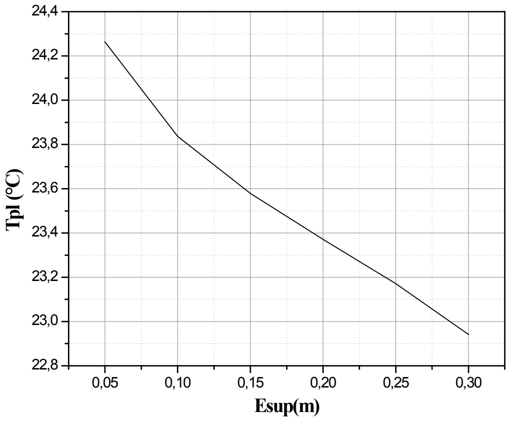


Fig .4 .(a) Influence of the thicknessof the concreteonthe floor temperature.

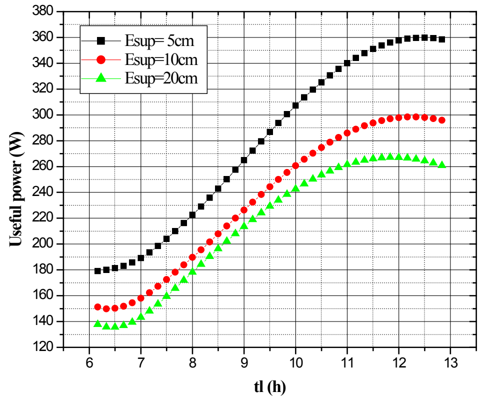


Fig .4.((b) Effectof the thickness ofthe top layer of the useful power .

2) Influence of the thermal resistance of concrete

It is evident thatthefloor's temperatureis highly dependent onthe thermal resistance ofthe top layer ofconcrete.Thus, andasseen in Figure5, the increasing of the thermal's resistance ofconcreteleads to lower of theheat exchange with theatmosphere which directs to areductionofthe floor temperature.

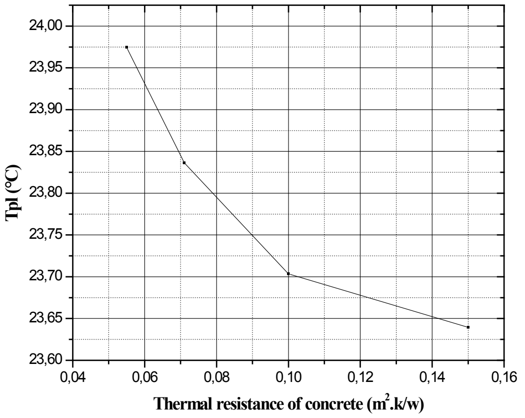


Fig .5. Evolution of thefloor temperatureinfunctionofthe thermal resistance ofthe top layer ofconcrete

3) Influence of emissivity of concrete

The examination of thecurves in Figure6allowssaying thatthefloor temperatureismoreimportant in the casewheretheradiation is nottaken into consideration;in this casethe amount of heattransferred tothe air will beconsiderably larger.

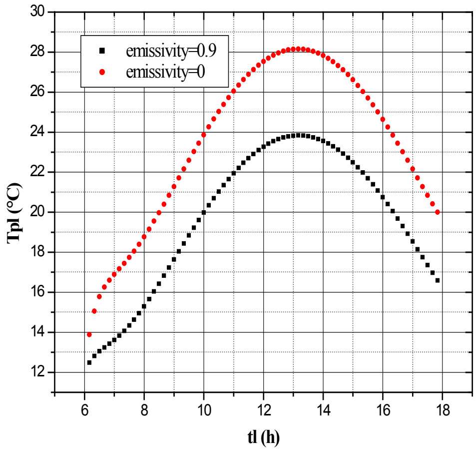


Fig .6. Temporal evolutionofthe temperature of aradiant floorand a nonradiant floor

CONCLUSION

Thermal inertiais thus acomplex phenomenon. Multiple criteriashould be taken into account to forobtaining thesame comfortfor lessconsumption.

The result of the study conducted the following conclusions:

The inertia of thefloorisdirectlyrelated to the thicknessoftheconcretelayer located above heating pipes. With this configuration,it has been shownthatthefloor temperaturewas evenlower thanthe concretemassincreased.

Therefore, it is recommended to increase as much as possible the thickness of the top layer of concrete. Nevertheless, we cannot afford to have too thick floor. Indeed, the "National Building Code" sets the minimum thickness of concrete floors of homes to 75 mm for the slab itself, and the use of a greater thickness is not necessary. A slab 10 cm thick may be a compromise quite interesting.

Furthermore,the natureof the floor coveringaffects the thermalpower emitted by thefloorandonitssurface temperature.

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