MODELLING AND SIMULATION OF A BOX-TYPE SOLAR FURNACE UNDER MADAGASCAR METEOROLOGICAL CONDITIONS

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ABSTRACT

Our work focuses on the theoretical study of a box-type solar cooker with an inclined receiving surface fitted with double glazing and an internal reflector. We have attempted to model and simulate its operating parameters. Sensitivity analysis was carried out for certain parameters such as the thickness of the insulation, the thickness of the glass, the quantity of food to be cooked and the construction material. The results show that this box-type solar cooker has exploitable temperature levels for cooking. An insulation thickness of 4 cm and a glass thickness of 3 mm are appropriate for good thermal insulation of the cooker. Finally, the results show that the type of construction material has an almost negligible influence on this type of cooker.

Keyword: *Solar cooker, Temperature, Double glazing, Solar flux, Modelling, Weather conditions*

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1. INTRODUCTION

In Madagascar, firewood and charcoal are the main sources of fuel in rural and urban areas. This contributes to heavy deforestation on the island. That's why solar energy could prove to be the most ecological and economical solution for cooking food, through the use of solar cookers. What's more, solar cookers will help prevent the release of large quantities of greenhouse gases caused by the above-mentioned fuels [1].

There are solutions to the energy shortage almost everywhere in the developing world, such as the solar cooker, because our country has a great deal of solar potential, especially in coastal areas. All the regions of our country have more than 2,800 hours of sunshine a year; for example, Tuléar has 3,600 hours a year, Tananarive 186 days a year, and Tamatave has 25 days of sunshine.%.

The sun's rays are reflected on the cooker mirrors and concentrated on the container, gradually increasing the heat and heating the preparation. The gradual increase in temperature means that cooking is gentle and unattended. The advantages of solar cookers are: firstly, the technology is simple and inexpensive, and the appliance requires virtually no maintenance. Secondly, it uses free energy from the sun, creating jobs and preserving the vitamins and trace elements in the food [2].

They cook food using the energy contained in the sun's rays. This energy is transformed into heat by the greenhouse effect and by concentrating the radiation. It's a simple, effective solution to a number of health and environmental problems: lung and eye diseases caused by smoke from wood fires are avoided. The system also helps to reduce deforestation, as the energy that can be used in Madagascar from wood is 92% of the total energy.% of total energy.

2. SYSTEM PARAMETERS

2.1. Description

It's an insulated wooden box, inside which is an aluminium box that is vertically fitted with a black sheet placed at the bottom to produce the greenhouse effect, and the whole thing is covered by a double-glazed frame. This transparent cover isolates the inside of the cooker from the outside and traps the radiation to achieve maximum heat. By fitting a reflector, more rays are directed towards the container (Fig-1). Other models of box-type solar cooker are fitted with several aluminium reflectors on the outside of the wooden box to produce more radiation towards the double glazing. The box-type solar cooker is the strongest and most efficient model, easy to build from locally available materials: wood, plywood, household aluminium, glass and sheep's wool.

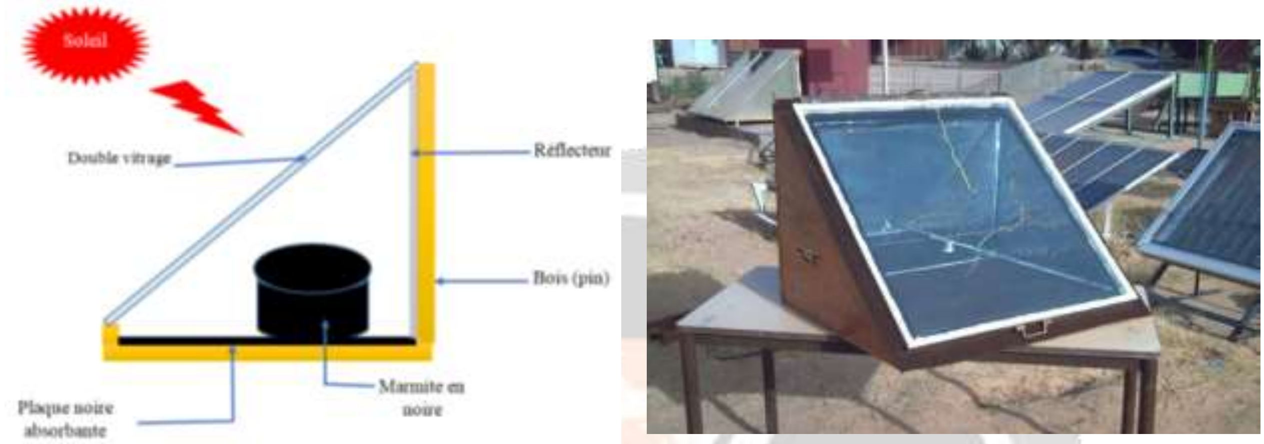

Fig- 1: Diagram of a solar box cooker

The cooking time depends on the angle of the double glazing, the dish to be cooked, the quantity and also the intensity of the sun (between 2 and 4 hours), i.e. it depends on the average temperature of each region, for example in Tuléar the average temperature is 25°C. It also depends on the thickness of the double glazing, because if, for example, the glass is very thick, the heat is obviously difficult to transfer to the inside of the cooker. In general, the temperatures reached by box-type cookers range from 100°C to 200°C and depend primarily on the number and size of panels used [3].

2.2 . Installing the cooker

The solar cooker only works with direct sunlight: clouds, fog and dust reduce the amount of radiation and extend the cooking time. Similarly, to capture the maximum amount of radiation, the cooker needs to be correctly oriented in relation to the sun. All you have to do is reorientate it once an hour.

The transparent cover is angled to allow good exposure of the absorbent plate and better penetration of the sun's rays, while leaving enough space for the cooking utensils to be inserted. To minimise heat build-up, avoid opening the cooker too much during cooking, i.e. putting in all the ingredients you need right from the start. The new cooker should first be heated empty to allow the black paint to dry completely, i.e. only start cooking once there are no more odours. To increase the fraction of solar radiation absorbed by the hotplate, a flat reflector is placed vertically on the inner surface opposite the opening.

2.3. Instructions for use

The containers should be dark in colour or painted black (on the outside only). Shorter cooking times are achieved with thin-walled aluminium pots, by dividing the food between several pots. The best results are obtained with dishes cooked in water, such as cereals, beans or vegetables. The usual amount of water should be reduced by a third.

3. MODELLING AND SIMULATION

3.1. Equation for no-load cooker

The simulation of the thermal behaviour of our cooker is carried out with no load, in other words the system is exposed to solar radiation with no load. No pots are placed inside the cooker. This study has therefore enabled us to estimate the maximum temperatures that can be reached in the black absorber plate and the air inside after a certain period of exposure to solar radiation. This temperature level enables us to make a preliminary statement about the capacity of our cooker to prepare food dishes (Fig-2).

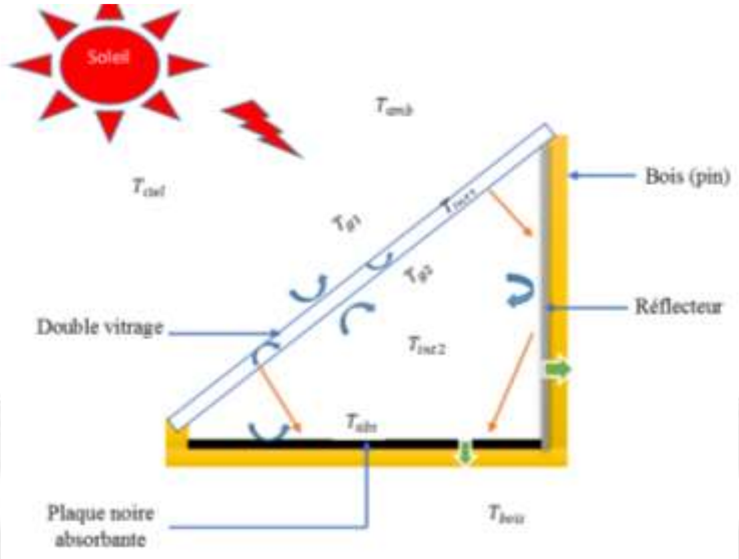

Fig-2: Representative diagram of the different heat transfers for the cooker with no load

with ↷ : heat transfer by convection

→: heat transfer by radiation

➡. heat transfer by conduction

The law of nodes tells us that the sum of incoming flows is equal to the sum of outgoing flows.

Writing the energy balances gives us the following mathematical models [4]:

$$(mC_p)_{g_1}\frac{dT_{g1}}{dt} = Q_1 + Q_2 + Q_3 - Q_4 - Q_5 \qquad (1)$$

$$(mC_p)_{g_2}\frac{dT_{g2}}{dt} = \tau_{g1}Q_1 - Q_2 - Q_6 + Q_7 + Q_8 \qquad (2)$$

$$(mC_p)_{int2}\frac{dT_{int2}}{dt} = Q_9 - Q_7 \qquad (3)$$

$$(mC_p)_{abs}\frac{dT_{abs}}{dt} = Q_{10} - Q_{11} - Q_{12} - Q_{13} \qquad (4)$$

$$(mC_p)_{bois}\frac{dT_{bois}}{dt} = Q_{13} - Q_{14} \qquad (5)$$

With :

$Q_1 = S_{g1}G\alpha_{g1};\ Q_2 = S_{g1}\sigma\varepsilon_{g1}\left(T_{g2}{}^4 - T_{g1}{}^4\right);\ \ Q_3 = S_{g1}h_{g1-int1}\left(T_{int1} - T_{g1}\right);$

$$Q_4 = S_{g1}\sigma\varepsilon_{g1}\left(T_{g1}{}^4 - T_{ciel}{}^4\right);\ Q_5 = S_{g1}h_{g1-amb}\left(T_{g1} - T_{amb}\right);$$

$$Q_6 = S_{g2}h_{g2-int1}\left(T_{g2} - T_{int1}\right); Q_7 = S_{g2}h_{int2-g2}\left(T_{int2} - T_{g2}\right);$$

$$Q_8 = S_{g2}h_{abs-g2}\left(T_{abs} - T_{g2}\right);\ Q_9 = S_{abs}h_{abs-int2}\left(T_{abs} - T_{int2}\right);$$

$$Q_{10} = S_{abs}\alpha_{abs}\tau_{g1}\tau_{g2}G;\ Q_{11} = S_{abs}h_{abs-int2}\left(T_{abs} - T_{int2}\right);$$

$$Q_{12} = S_{g2}h_{abs-g2}\left(T_{abs} - T_{g2}\right);\ Q_{13} = S_{abs}\frac{K_{abs}}{e_{abs}}\left(T_{abs} - T_{bois}\right);$$

$$Q_{14} = S_{bois}h_{bois-amb}\left(T_{bois} - T_{amb}\right);\ T_{int1} = \frac{T_{g1} + T_{g2}}{2};$$

$T_{g1}\ and\ T_{g2}$ are the temperatures of pane 1 and pane 2

T_{int1} : temperature of the air space between pane 1 and pane 2;;

T_{int2} : temperature of the air inside the cooker;

T_{abs} : absorber temperature;

T_{bois} : temperature of the bottom of the wooden cooker;

S : surface area ;

G : Illuminance (global solar flux);

τ : thermal transmittance;

α : absorption coefficient;

ρ : reflection coefficient;

σ : Stephan-Boltzmann constant

réf : reflector ;

h : convective heat exchange coefficient

K : thermal conductivity;

e : thickness;

m : mass ;

C_p : heat capacity by mass;

Q : heat flow

3.2. Equation of the various heat transfers in the loaded cooker

A black pot with food to be cooked is placed inside the cooker shown in Fig-3.

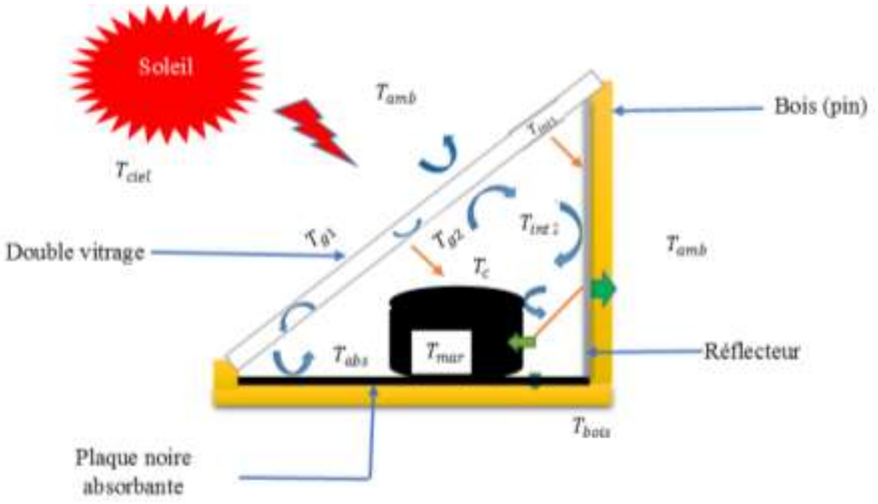

Fig-3: Representative diagram of the different heat transfers in the presence of a boiler

with ↻ : heat transfer by convection

→ : heat transfer by radiation

➡ : heat transfer by conduction

By applying the energy balances to our system, we obtain the following equations [5] :

$$(mC_p)_{g_1}\frac{dT_{g1}}{dt} = Q_1 + Q_2 + Q_3 - Q_4 - Q_5 \tag{6}$$

$$(mC_p)_{g_2}\frac{dT_{g2}}{dt} = \tau_{g1}Q_1 - Q_2 - Q_6 + Q_7 + Q_8 + Q_9 + Q_{21} \tag{7}$$

$$(mC_p)_C\frac{dT_C}{dt} = -Q_7 - Q_{10} + Q_{11} - Q_{12} - Q_{13} \tag{8}$$

$$(mC_p)_f\frac{dT_f}{dt} = Q_{12} + Q_{13} + Q_{14} + Q_{15} \tag{9}$$

$$(mC_p)_{mar}\frac{dT_{mar}}{dt} = Q_{16} + Q_{17} - Q_9 - Q_{14} - Q_{15} + Q_{22} \tag{10}$$

$$(mC_p)_{int2}\frac{dT_{int2}}{dt} = Q_{18} + Q_{19} + Q_{20} - Q_8 \tag{11}$$

$$(mC_p)_{abs}\frac{dT_{abs}}{dt} = Q_{23} - Q_{24} - Q_{25} - Q_{26} - Q_{27} \tag{12}$$

$$(mC_p)_{bois}\frac{dT_{bois}}{dt} = Q_{26} - Q_{28} \tag{13}$$

with :

$Q_1 = S_{g1}G\alpha_{g1}$; $Q_2 = S_{g1}\sigma\varepsilon_{g1}\left(T_{g2}{}^4 - T_{g1}{}^4\right)$; $Q_3 = S_{g1}h_{g1-int1}\left(T_{int1} - T_{g1}\right)$;

$Q_4 = S_{g1}\sigma\varepsilon_{g1}\left(T_{g1}{}^4 - T_{ciel}{}^4\right)$; $Q_5 = S_{g1}h_{g1-amb}\left(T_{g1} - T_{amb}\right)$;

$Q_6 = S_{g2}h_{g2-int1}\left(T_{g2} - T_{int1}\right)$; $Q_7 = S_c\sigma\varepsilon_c\left(T_c{}^4 - T_{g2}{}^4\right)$; $Q_8 = S_{g2}h_{int2-g2}\left(T_{int2} - T_{g2}\right)$;

$Q_9 = S_{mar}\sigma\varepsilon_{mar}\left(T_{mar}{}^4 - T_{g2}{}^4\right)$; $Q_{10} = S_c h_{c-int2}(T_c - T_{int2})$; $Q_{11} = S_c G\tau_{g1}\tau_{g2}\alpha_c$;

$Q_{12} = S_c h_{c-int3}(T_c - T_{int3})$; $Q_{13} = S_c\sigma\varepsilon_c\left(T_c{}^4 - T_f{}^4\right)$; $Q_{14} = S_{mar}\sigma\varepsilon_{mar}\left(T_{mar}{}^4 - T_f{}^4\right)$;

$Q_{15} = S_m h_{mar-f}\left(T_{mar} - T_f\right)$; $Q_{16} = S_{mar}h_{mar-int2}(T_{int2} - T_{mar})$; $Q_{17} = \rho G S_{ref}\tau_{g1}\tau_{g2}$;

$Q_{18} = (S_{abs} - S_c)h_{abs-int2}(T_{abs} - T_{int2})$; $Q_{19} = S_{mar}h_{mar-int2}(T_{mar} - T_{int2})$;

$Q_{20} = S_c h_{c-int2}(T_c - T_{int2})$; $Q_{21} = S_{g2}h_{abs-g2}\left(T_{abs} - T_{g2}\right)$;

$Q_{22} = S_{mar}\dfrac{K_{mar}}{e_{mar}}(T_{abs} - T_{mar})$; $Q_{23} = (S_{abs} - S_c)\alpha_{abs}\tau_{g1}\tau_{g2}G$;

$Q_{24} = (S_{abs} - S_c)h_{abs-int2}(T_{abs} - T_{int2})$; $Q_{25} = S_{g2}h_{abs-g2}\left(T_{abs} - T_{g2}\right)$;

$Q_{26} = S_{abs}\dfrac{K_{abs}}{e_{abs}}(T_{abs} - T_{bois})$; $Q_{27} = S_{bmar}\dfrac{K_{mar}}{e_{mar}}(T_{abs} - T_{mar})$;

$Q_{28} = S_{bois}h_{bois-amb}(T_{bois} - T_{amb})$; $T_{int1} = \dfrac{T_{g1} + T_{g2}}{2}$; $T_{int3} = \dfrac{T_c + T_f + T_{mar}}{3}$;

$\alpha_{g1} = \alpha_{g2}$; $\tau_{g1} = \tau_{g2}$; $\tau_{g1}Q_1 = S_{g2}\alpha_{g2}\tau_{g1}G$;

$T_{g1}\ and\ T_{g2}$ are the temperatures of pane 1 and pane 2;

T_c : temperature of the pot lid;

T_f : temperature of the fluid in the pot;

T_{int1} : temperature of the air space between pane 1 and pane 2;;

T_{int2} : temperature of the air inside the cooker;

T_{int3} : temperature of the air between the surface of the fluid and the lid of the pot;

T_{mar} : temperature of the pot;

T_{abs} : absorber temperature;

T_{bois} : temperature of the bottom of the wooden cooker;

S : surface area ;

S_m: surface wetted by the fluid;

G : Illuminance (global solar flux);

τ : thermal transmittance;

α : absorption coefficient;

ρ : reflection coefficient;

σ : Stephan-Boltzmann constant;

réf : reflector ;

h : convective heat exchange coefficient

K : thermal conductivity;

e : thickness ;

m : mass ;

C_p : heat capacity by mass;

Q : heat flow

3.3. Simulation of the system of equations

The aim is to determine the temperature inside the cooker before and after the kettle is installed. Once the conceptual model of the solar cooker has been defined, the heat exchanges expressed and the energy flows calculated, the energy balance equations give us a system of coupled, non-linear differential equations. Solving the resulting system of equations requires the development of a calculation programme with an analysis methodology capable of guaranteeing the reliability of the model and ensuring its flexibility. To solve the systems of differential equations, we used MATLAB software using the classic Runge Kutta method of order 5 for the cooker without load and order 8 for the cooker with pot, in order to obtain the different temperatures of each part of the cooker (Fig-4).

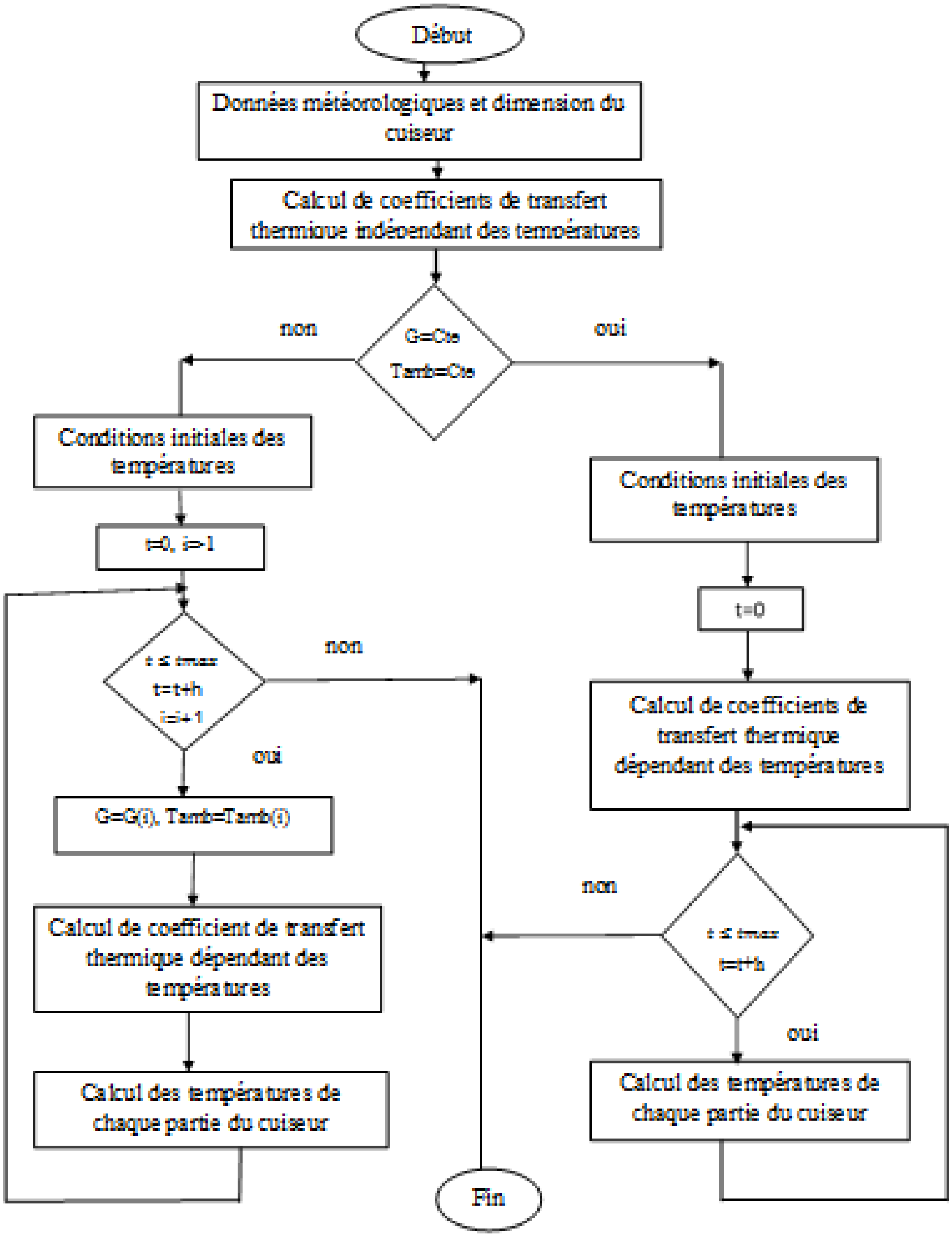

Fig-4: General calculation flow chart

4. RESULTS AND INTERPRETATION

4.1. Variation of temperatures in the kettleless cooker as a function of time

The solar cooker is exposed to solar radiation without any load (black absorber plate with no load). The temporal evolution of the temperatures of the various elements during a day from 06:00 in the morning to 18:00 in the evening is shown in Fig-5.

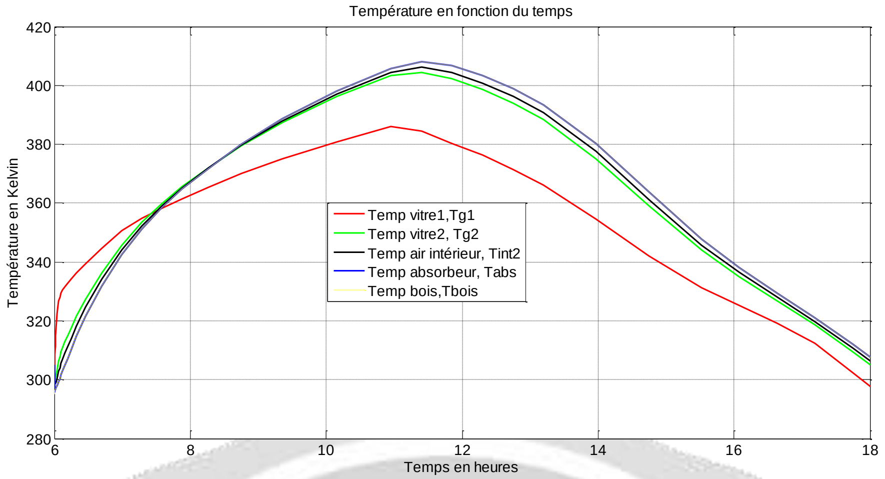

Fig-5: Temperature variation curve for the kettleless cooker as a function of time

For one day, with the double glazing tilted every hour as the sun moves, we get a lot of solar radiation. Analysis of the results obtained leads to the following conclusions:

The initial temperature of the first pane outside is 25°C, rising to 113°C at 11 o'clock, i.e. an increase of 88°C in 5 hours, and then dropping to 25°C when the sun goes down. This temperature is the lowest because the radiation reaching the first pane is distributed as follows: some of it is reflected by the ambient air; some is transmitted to the double glazing, the reflector and the black absorber plate.

While the cooker is in the sun, the temperature of the inner pane rises to 131°C at midday and then drops to 32°C at 6pm. The temperature of the second pane is higher than that of the first pane because heat is transferred by convection through the air between the two panes and the inner pane, the inner air and the inner pane, the black absorber plate and the inner pane, and the radiation between the outer pane and the second pane.

4.2. Variation of the temperatures of each part of the cooker in the presence of the kettle as a function of time

With load, we obtain a system of differential equations with eight equations. The simulation results obtained with an aluminium pot filled with cooking fluid are represented by the curves in Fig- 6.

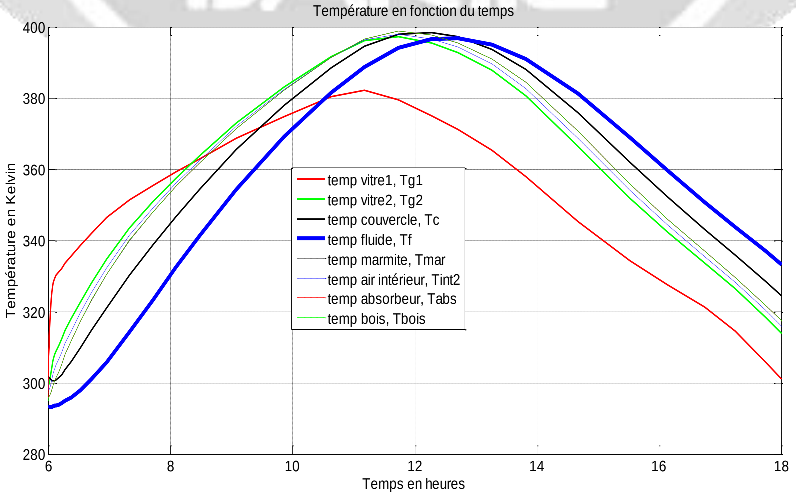

Fig-6: Temperature variation curve for each part of the cooker in the presence of a pot as a function of time

These results show that :

The temperature of the outer pane rises to 109°C at 11 o'clock, then drops to 28°C at 6 o'clock in the evening. The temperature of the inner pane is 27°C at the initial moment and becomes 124°C after 05 hours. It gradually decreased to 28°C at 6pm. The temperature of the lid of the kettle at the start of exposure to the sun is 29°C, rising gradually to 125°C at 12 o'clock and then falling to 51°C at 6 o'clock. If we put food at 20°C inside our pot from the start of exposure to the sun, it will reach a temperature of 122°C at 12 hours, but after 10 hours it will scald.

In a practical situation, once the fluid reaches a temperature of 100℃, while cooking this temperature remains constant because of the latent heat of vaporisation. The pot reaches a temperature of 126°C at 12 hours and it gradually decreases to 44°C when the simulation is stopped. The air inside the cooker takes on a temperature value of 28°C at the initial moment, rising to 125°C at 12 hours and then falling to 43°C at 18 hours. The black absorbent plate reaches a temperature of 126°C at midday, and gradually decreases to 44°C. The wood outside our appliance reaches a temperature of 125°C at 12 o'clock and it drops to 44°C at 6 o'clock in the evening.

4.3. Fluid temperature variation as a function of pane thickness

When the thickness of the pane is increased, the variation in fluid temperature is shown in Fig-7.

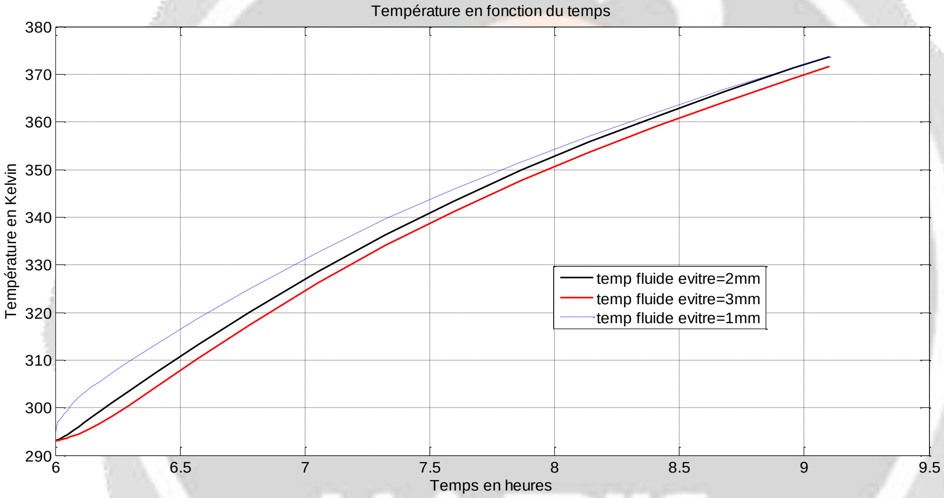

Fig-7: Fluid temperature variation as a function of pane thickness

When boiling 1 litre of water, for a 1 mm thick glass the boiling time is 3 hours. If you use 2 mm glass, the boiling time is 3 hours 15 minutes and for 3 mm it becomes 3 hours 30 minutes.

4.4. Variation of parameters to find the optimum insulation thickness

If we increase the thickness of the wooden insulation (pine), since the quantity of cooking fluid in the pot remains constant, the variation curves of the various elements making up the cooker are shown in the following figures (Fig-8).

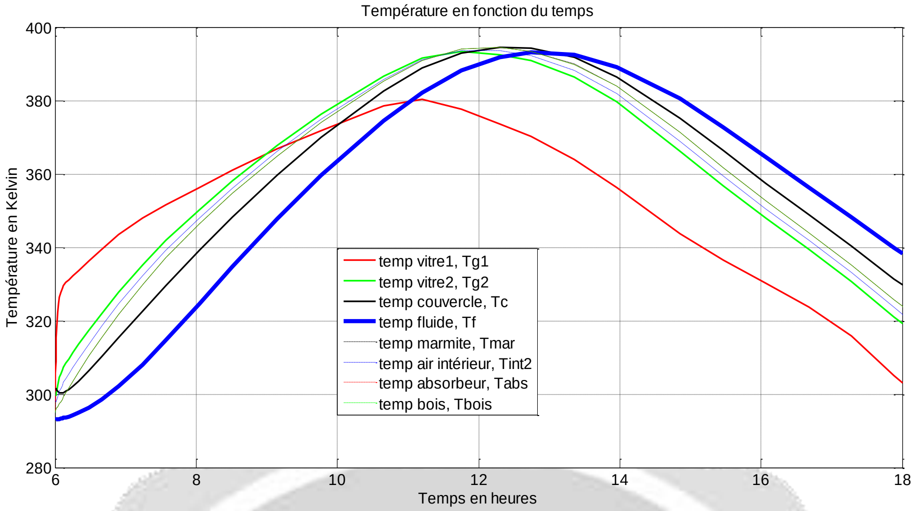

Fig- 8: Temperature variation for insulation thickness

We can see that if we increase the thickness of the wooden insulation, the temperatures in each part of the cooker also increase because the heat arriving inside the cooker is trapped by the insulation and the double glazing. In this case, heat transfer by conduction to the outside of the box is low compared to the radiation from the double glazing. Heat transfer by convection to the inside of the pot is obviously stronger.

4.5. Maximum temperatures for each variation in insulation thickness

From a thickness of 4 cm, the temperatures of each element of the cooker remain constant. The variation in the thickness of the wood is therefore a parameter to be considered in order to improve the performance of a box-type solar cooker. Thus, a thickness of 4 cm of wood is sufficient to minimise heat loss in the box-type solar cooker (Table -1).

Table- 1: Summary of maximum temperatures for each variation in insulation thickness

Insulation thickness in cm Temperature maximum in °C	1	2	3	4	5
Window 1	107	108	111	111	111
Window 2	118	124	127	129	129
Lid	121	125	128	130	130
Feed	120	125	127	128	128
Marmite	121	126	129	131	131
Indoor air	120	125	128	130	130
Absorber	121	126	130	131	131

Wood	119	124	126	127	127

4.6. Maximum temperatures for variations in pane thickness

From the results, we can see that if the thickness of the glass increases by 1mm, the maximum temperature of each part of the cooker decreases by 1°C. This means that the heat entering the cooker is reduced. Heat transfer by radiation, conduction and convection is therefore slow through the air inside the cooker, and some of the heat reaching the glass is reflected back to the ambient air. The thickness of the double glazing is a necessary parameter for the performance of our cooker. In practice, the thickness of the glass should not exceed 3 mm.

Table- 2: Summary of maximum temperatures for variations in pane thickness

Glass thickness in mm Maximum temperature in °C	1	2	3
Window 1	110	109	108
Window 2	127	126	125
Lid	128	127	126
Feed	126	125	124
Marmite	129	128	127
Indoor air	128	127	126
Absorber	129	128	127
Wood	129	128	127

4.7. Heat flow in the cooker

4.7.1. *Heat flow for the cooker without load*

Table -3 shows the heat flux for the cooker exposed to the sun with no load.

Table -3: Heat flux for the cooker exposed to the sun without load

Heat flow	Minimum (in W)	Maximum (in W)
Q1	0.6316	26.8998
Q2	-7.7431	155210
Q3	-203.9857	0.4497
Q4	3.0657	3.9359
Q5	-57.2891	54.7871

Q6	4.1418	246.9619
Q7	-9.1757	5.6852
Q8	-18.7101	11.9967
Q9	-10.0409	7.8400
Q10	0.6741	28.7139
Q11	-10.0409	7.8400
Q12	-18.7101	11.9967
Q13	-7.7129	284 200
Q14	-7.10	16.7093

From these results, we can say that :

The outer pane receives heat from the sun by radiation. The inner pane receives heat from the outer pane by convection; the black absorber plate absorbs heat by radiation using the double glazing and the reflector, after which this heat is received by the air inside the cooker .

The insulator receives heat from the black absorber plate by conduction and convection; some of the heat reaching the first pane is reflected back to the ambient air by radiation and convection, so it's a heat loss; the absorber transfers heat to the wooden insulation by conduction and convection, then this heat is lost to the ambient air by conduction and convection too. Heat entering the cooker is transmitted by radiation and heat lost is transmitted by conduction.

4.7.2. *Heat flow for the kettle cooker*

We have calculated the heat flow in each part of the cooker. Table -4 shows the minimum and maximum flow in the cooker.

Table- 4: Minimum and maximum heat flow for the cooker with load

Heat flow	Minimum (in W)	Maximum (in W)
Q1	0 .6316	26.8162
Q2	-8.24	14.2879
Q3	-195.3449	0.00060565
Q4	3.2741	43.0683
Q5	-187	-12.4120
Q6	3.7218	230.0933
Q7	-3.2209	3.0824
Q8	-9.0851	5.4324
Q9	-3.6478	3.6814

Q10	-1.2582	0.9548
Q11	0.0495	2.1030
Q12	0.2771	11.2364
Q13	-2.1790	3.5578
Q14	-10.7894	161523
Q15	-2.5471	4.1177
Q16	-0.5853	1.5820
Q17	0.3420	14.5210
Q18	-10.0874	7.3920
Q19	-1.5820	0.5853
Q20	-1.2582	0.9548
Q21	-17.2621	11.6000
Q22	-1435.3594	4335.8
Q23	0.6356	26.9889
Q24	-10.0874	7.3920
Q25	-17.2621	11.6000
Q26	-5.488	284 200
Q27	-528 .8166	1597.4
Q28	-6.6800	19.3639

We can see :

The first pane receives heat from the sun by radiation; the second pane receives heat from the first pane by convection; the lid receives heat by radiation and convection; the reflector receives heat by radiation and reflects towards the black absorber plate and the pot;

The pot receives heat from the absorber by conduction and convection; the absorber receives heat from the outside by radiation; the wooden insulation absorbs heat from the absorber by conduction and convection, so the black absorber plate receives and transfers heat; the first pane of glass transfers heat to the surrounding environment by convection and radiation; the pot transfers heat to the fluid by natural convection; the absorber transfers heat to the outside environment by conduction and convection. Light energy, which is absorbed by the dark kettles and the dark trivet under the kettle, is converted into heat energy of a longer wavelength and radiated from the materials inside.

5. DISCUSSION

The maximum temperatures in each part of the cooker are as follows: Glass 1 temperature Tg1=113°C; Glass 2 temperature Tg2=131°C; Internal air temperature Tint2=133°C; Absorber temperature Tabs=135°C; Wood temperature Tbois=135°C.

The temperatures of the various elements making up the cooker are at their highest around 12 o'clock, which means that the overall solar flux, the ambient temperature and then the temperature of the sky are at their highest, and the temperatures rise gradually from the beginning. If food is cooked from 6 a.m. onwards, it is ready from 10 a.m. onwards, i.e. 04 hours are needed to prepare the food. In general, cooking time depends on the dish to be cooked, the quantity and intensity of the sun. It varies from 02 to 04 hours, as cooking is not very fast and dishes can be left unattended.

The hot elements (pot, absorber and food) in a box-type solar cooker give off heat waves or radiant heat to the surrounding area. These heat waves are radiated by hot objects through air or space. Most of the radiant heat given off by the hot pot in a solar cooker is reflected by the aluminium foil and the glass inside the pot and on the bottom tray. Although transparent glass captures most of the radiant heat, some escapes directly through the pane. The glass traps the radiant heat. Air molecules move in and out of the cracks or slits in the box. In a solar cooker, the hot air molecules are convected, escaping first through the cracks around the lid, through an open side (cooker door) or because of manufacturing faults. The cooler air around the can also enters through these openings.

The majority of heat gain comes from the double glazing, which is inclined towards the interior of the cooker by radiation. Heat is lost through the outer pane by convection and radiation, and through the insulation to the ambient air by conduction. Most heat loss occurs through conduction in the insulation.

6. CONCLUSION

In this work, we studied a box-type solar cooker. To study the operating parameters of this cooker, modelling and simulations were carried out in Matlab in two stages: without load and with load. The input variables consisted of meteorological data, ambient temperature, sky temperature, global solar flux and the characteristics of the cooker, i.e. its dimensions, construction materials and the size of the pot. The output variables are the temperatures of each part of the cooker. Numerical simulation of the no-load system enabled us to predict the temperature reached by the air inside the cooker. The results show that this box-type solar cooker will be able to achieve temperatures that can be used for cooking. The simulations carried out revealed that the water will boil for 2 hours and the temperature of the absorber can reach up to 135°C. This research work has given us a more in-depth knowledge base on solar cookers.

7. REFERENCES:

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