Revue des Energies Renouvelables Vol. 11 N°1 (2008) 35 – 40

Study and modelling of a heating system aimed for the site of Tlemcen

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(reçu le 22 Décembre 2007 – accepté le 30 Mars 2008)

Abstract - *The building thermal function is one of the significant functions of this one: it is necessary that within the building an environment should be maintained in order to satisfy in habitant from the thermal comfort point of view. This is to provide air-conditioning in hot countries or hot seasons or heating in cold countries or cold seasons. The aim of this work is the study and modelling of a new design of thermal photo sensor with reduced losses and high efficiency aimed for the site of Tlemcen.*

Résumé – *La fonction thermique du bâtiment est l'une des principales fonctions de celui-ci: il est nécessaire que l'environnement de la construction devrait être maintenu pour satisfaire un confort thermique de l'habitant. Cette mesure vise à assurer la climatisation dans les pays chauds ou dans les saisons chaudes et le chauffage dans les pays froids ou dans les saisons froides. Le but de ce travail est l'étude et la modélisation d'une nouvelle conception du capteur photo thermique avec des réductions des pertes thermiques et qui vise un rendement élevé pour le site de Tlemcen.*

Keywords: Conception - Simulation - Solar energy - Heating of the sanitary water.

1. INTRODUCTION

The use of solar energy enabled a large availability in the photo thermal applications. The cost of produced energy remains hence limited and the development at industrial scale is thus slowed down by the low density of solar flow and by the losses of heat transport. To solve this problem, we transport a concentrated solar energy to the place of conversion. The transport of heat under electromagnetic wave is carried out with a considerable reduction of losses than the transport of heat with coolant.

The idea to transport concentrated solar energy was launched in 1980 by a group of French researchers [1]. Now, the technology of optical fibres available for this transmission offers a high quality of production with a large diameter of these fibers core [2]. In this work, we use light drivers which have the advantage of weak attenuations and tiny losses in conversion.

A plane sensor consists of a metallic plate blackened, covered with one or more panes or transparent sheets. Solar radiations which cross the glazing are absorbed by the blackened metal which re-emits energy in the form of big wavelength radiations. As these radiations cannot cross the pane, the temperature of the blackened plate rises. One makes pass a coolant (air or water) on this one, where it is heated, and, as long as the sun is shining, the temperature of the fluid leaving the collector is maintained [3], (Fig. 1).

The supplied thermal energy rising from such a solar collector is equivalent to the decreased incidental energy of the losses. The losses of thermal energy are due to radiation reflexion, reemission, convection and conduction.

We note, according to figure 2, that for a flow of 1000 W/m^2 on the level of the pane almost 14 % of this radiation is lost by reflexion from the front and back faces of the pane. And arriving to the absorber almost 21 % is lost and finally the recovered power is about 60 %, i.e. 40 % of the

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incident total radiation is lost. The losses can't be reduced significantly, but owing to a new design of the photo thermal sensor, we can even though reduce the losses and enhance the output.

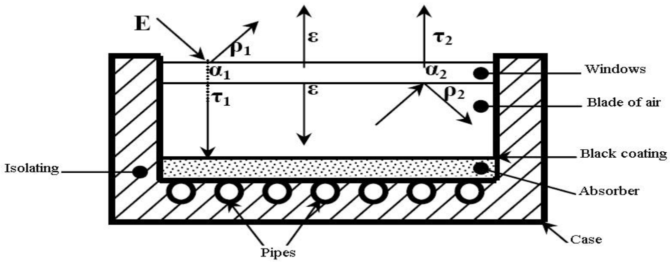

Fig. 1: Longitudinal cut of a plane solar sensor

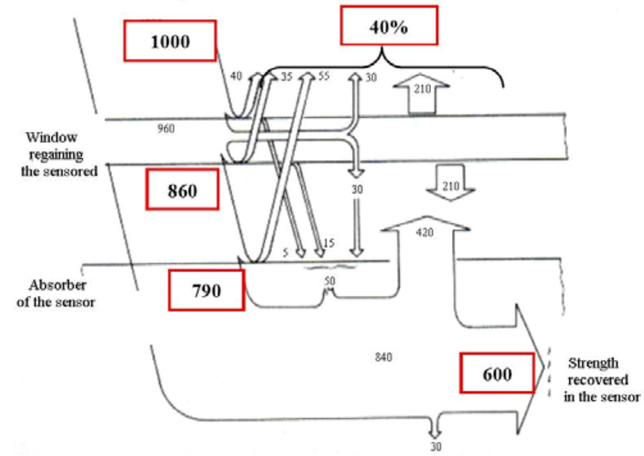

Fig. 2: Distribution of the incidental energy on a classic sensor

The device is made up:

* Of a concentrator which is a parabolic mirror having the following geometrical characteristics: $R = 366$ mm , the focal distance $f = R/2$.

* An optical fiber QSF 1000 with a length of $L = 5$ m made up of a core of quartz and silica, with 1 mm diameter, manufactured with silica of synthesis, average attenuation τ equal to 2×10^{-2} dB/m on the whole of the solar spectrum, a numerical opening of $\theta_F = 20°$, surrounded by a water pipeline in order to allow a good cooling.

* A cone with a $R_1 = 25$ cm ray and a height $H = 2$ R . Selective surface surrounding all surface of the cone made up of a black painting on copper with the following coefficients: Absorption $\alpha = 0.95$ and of emission $\varepsilon = 0.18$.

The whole of the cone + fiber is isolated with glass wool.

2. ESTIMATION OF ENERGY TRANSPORTED BY AN OPTICAL FIBER

Solar energy is concentrated on a spot which size is equal to the surface of the fiber entry [4, 5].

2.1 Input and output fiber energy

To estimate the input and output thermal energy of solar fiber, we modelled the solar radiation then we developed a simulation program for sun race. Lastly, to follow the attenuation of the radiation to various lengths of fiber [6], whose results are shown in the figures, here after.

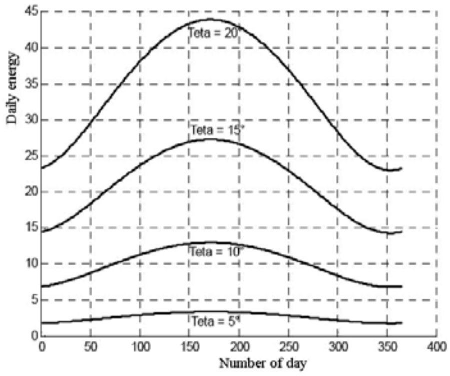

Fig. 3: Input daily energy of fiber for different openings

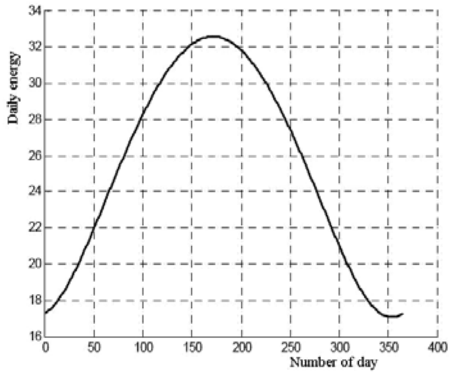

Fig. 4: Daily solar energy in the output of the fiber, Tlemcen site

For a good adaptation of the concentrator, the opening of this last should be equal to the numerical opening fiber [7]. A fiber adapted to the opening concentrator transports a maximum of solar energy of 44 Wh/mm^2 to the summer solstice, and a minimum of 24 Wh/mm^2 to the winter solstice with a clear blue sky in Tlemcen city (Fig. 3).

2.2 Solar energy in the optical fiber output

The output energy noted after crossing the optical fiber with 5 m of length in figure 4, to the winter solstice does not exceed the 18 Wh/mm^2. It is maximum, for a value of 32.59 Wh/mm^2 at summer solstice.

a) Water heat transport

The energy stored inside the cone can be transferred to a coolant. The water used as coolant, allows also the cooling of fibre transporting concentrated energy (Fig. 5).

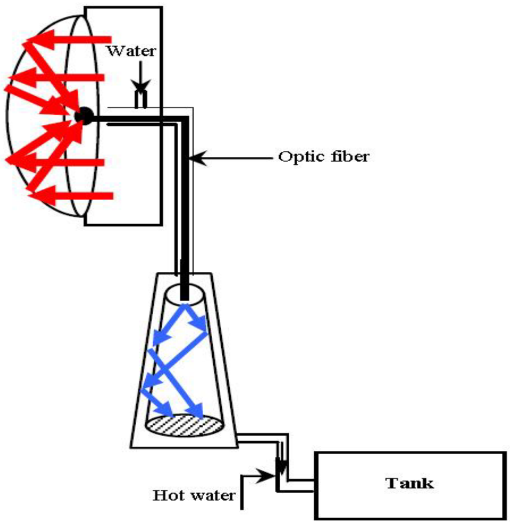

Fig. 5: Water conic photo thermal sensor

The incidental radiations are concentrated within the core of the concentrator then transported with an optical fiber until the top of the cone and then disperse inside the cone.

The temperature difference (ΔT) in input-output of water is determined by knowing the outside fiber power and represented in the following figure.

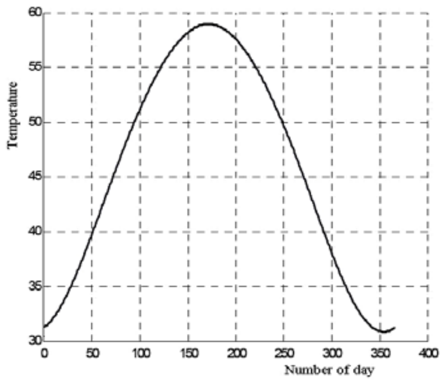

Fig. 6: Evolution of the daily temperature difference transported by water Tlemcen site

According to these results we noticed that there is a great temperature difference between the inlet and outlet, it is about 32 °C in winter and 58 °C in summer.

The heat transfer can be increased while operating on the speed of water circulation, or the heat-transferring surface of the cone.

The disadvantage of this type of heat transfer is the layer of fur sediment when the temperature of water exit exceeds 60 °C. To remedy, one can use a closed loop (with special oil) with an exchanger in the tank.

b) Air heat transport

The heat concentrated inside the conical sensor can be also transported by the air, for that we turn off the water tap (Fig. 7).

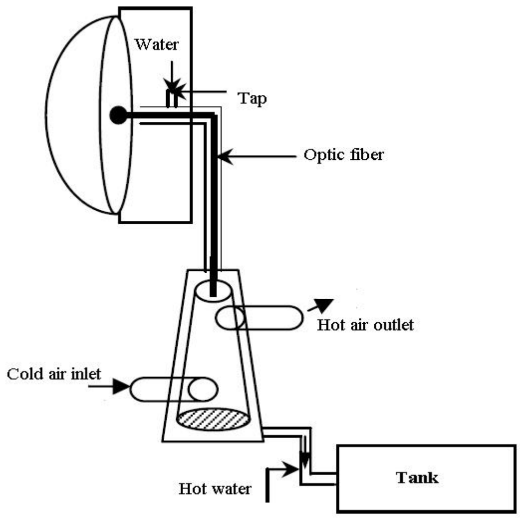

Fig. 7: Air conic photo thermal sensor

We noticed that the air temperature difference in input-output is about 36 °C in winter and it can reach 70 °C in summer.

Here, one can exploit the speed air circulation and the heat-transferring surface of the cone to increase the heat transfer.

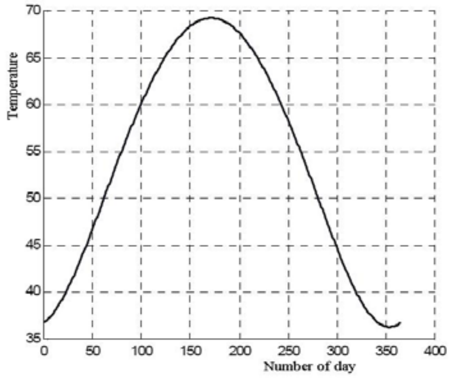

Fig. 8: Evolution of the daily temperature difference transported by air in Tlemcen

c) Mixed Transport

We use a mixed heating where calories transport is carried out as well as by air or water. For this purpose we fixed the water temperature difference in input-output at 20 °C and we tried to determine the air temperature difference for winter period, (Fig. 9).

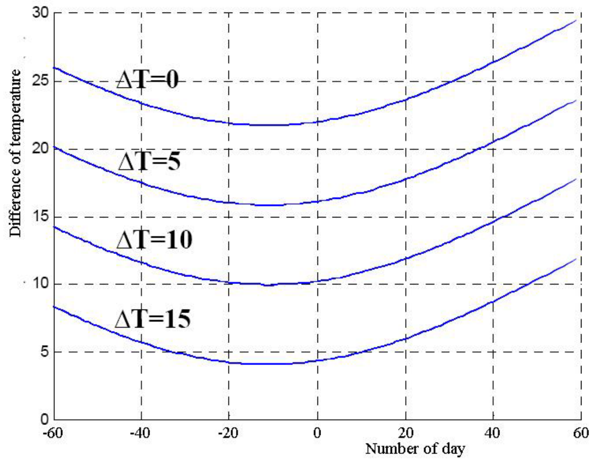

Fig. 9: Evolution of the difference in temperature transported by air during winter period

Water and air flow rate, fixed by the regulation system allows domestic hot water supply and the adequate heating of dwelling.

3. CONCLUSION

Concentrated solar energy can be transported with light drivers; this technique proves very promising for thermal applications. It should allow a use of the solar energy concentrated with power efficiencies which can exceed the 50 %.

Our work consists to elaborate a program which makes it possible to consider energy incidental with the wire of the sun, on a parabolic concentrator. Concentrated energy is transferred then transported by an optical fiber towards a photo sensor thermal conical with double coolant (water and air).

The simulation program carried out determines the output power of an optical fiber, as well as the differences in water and air temperatures input-output on the outlet of the sensor used for the heating of a dwelling and the heating of domestic water.

Energy supply and temperatures are then estimated during all the year for different length of optical fibers.

Thus, our contribution consists of a new design of thermal photo sensor with reduced losses and high output.

NOMENCLATURE

E	Solar radiation	θ_C	Concentrator opening
P_{in}	Incident power of the concentrator	θ_F	Numeric opening of fiber
α_1	Absorption coefficient of glass	R_1	Cone radius
τ_1	Transmission coefficient of glass	U_1	Air flow rate
S	Internal surface of the cone	Q	Quantity of heat introduced by optical fiber
ε	Emission coefficient of glass	H	Height of cone
R	Radius of concentrator	α	Absorption coefficient of selective surface
f	Focal length of concentrator	Q_1	Quantity of heat transported by water
U	Water flow rate	Q_2	Losses heat through the system
l	Length of the fiber	Q_3	Quantity of heat transported by air
D	Internal diameter of the pipe	ε	Transmission coefficient of selective surface
r	Fiber diameter	$P(1)$	Outside fiber power
τ	Middle attenuation on the whole of spectre	$P(2)$	Entry fiber power

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