Study of Simulation of a Water Sensor Steady Applied for Membrane Distillation

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Abstract: ***The sun provides the earth with huge amounts of energy that can be exploited in various ways. In this work, the use of solar energy by heat using a solar water plan has been studied. Before designing such a device, it is very important to pay particular attention to the effect of internal and external operational parameters on the thermal performance of this device. To meet this need, we have studied the thermal behavior of a solar plan in permanent water regimes, developing a computer program in the laboratory. Solving the system of equations obtained is addressed by two numerical approaches, the Gauss-Seidel and the Runge Kutta [4]. The results have been validated by an experimental work was conducted in the Center for Development of Renewable Energies. The results we have obtained have clarified the effect of internal and external parameters of a sensor, and highlight the predominant effect of the irradiance.***

Keywords: solar plane, steady state, simulation.

1. Introduction

The solar collector is a device designed to capture the energy carried by the solar radiation, convert it into heat energy and transmit it to a heat transfer fluid, it combines two physical principles: the greenhouse effect and the black body. The heat generated by the sensors can then be used for [1]:

- Heat the premises and provide hot water.
- Membrane distillation.
- Dry beans and forages.
- Operate combustion engines.
- Supply of refrigeration machines.

Flat plate collectors can handle temperatures ranging from 30 °C to 150 °C and do not require concentration of the incident radiation or track the sun. [1] The relatively low temperature of the sensor plane is due to the retransmission of the radiation receiver, and heat loss periphery of the sensor [2], [3].

A flat detector consists essentially of a transparent cover, an absorber, a heat transfer fluid, a thermal insulation and a safe (Figure.1).

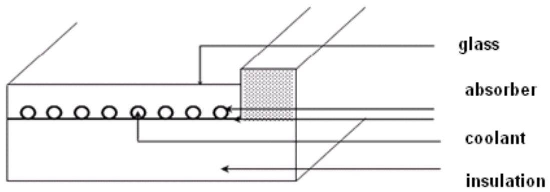

Figure 1: Components of a solar plane.

The principle of operation of a solar plan is very simple [4]. A solar collector involves simultaneously three modes of heat transfer, conduction, convection and radiation (Fig. 2).

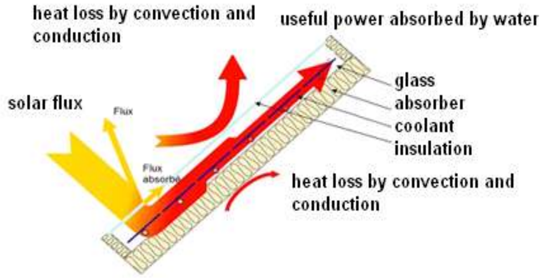

Figure 2: The different heat transfer in a plane sensor.

A solar plan is influenced by different parameters [3], [1], [4], [5].

2. The parameters of the solar

2.1 The External Parameters

- Irradiance due to global radiation.
- Position of the sun and sunshine duration.
- The time of day and season.
- The geographical location of the place in question (latitude).
- Ambient temperature.
- Speed.

2.2 The Internal Parameters

- Orientation, tilt sensor location.
- Fixed sensor or follower of the sun.

3. Study of Solar Collectors for Water

N.Bellel et al [4] studied theoretically a solar plan for a single water to compare two configurations of the coolant system; there is a network in the form of a coil and another in series. The authors validated the results obtained theoretically by experimental work, and found a 10% difference found satisfactory. After a comparative study between the two configurations, the authors concluded that the sensor network with a coil is more efficient than with a network of tubes in series.

H.Abdi and Al [6] conducted experimental and theoretical work to study the effect of the geometric shape of fluid flow on the effectiveness of sensors in the case of a direct contact water-absorbent plate. The authors used two configurations [6] of the absorber plate (Figure.3) one concave and the other convex. The dimensions of the passage of the fluid are selected to have the same hydraulic diameter for the two configurations.

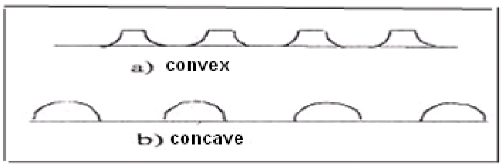

Figure 3: Geometric shapes of absorber plates

This work concluded that the sensor depends more usual parameterized (external conditions, thermal characteristics), geometric shapes absorbing plates. The sensor with an absorbent plate convex shape gives better performance. In what follows; we will express the power absorbed by the components of a solar plan single glazing to draw the energy balance of the system in steady state and transient.

3.1 Power absorbed by a solar plane with single glazing

The power absorbed by the glass:

$Pv = \alpha v \times G \times Av$ (1)

Where:

Pv: power absorbed by the glass.
αv: absorptivity of glass.

Front: glass surface.

3.1.2 Power absorbed by the absorber

$Pab = \alpha ab\ \tau v \times \times G \times Aab$ (2)

Where:

Pab: power absorbed by the absorber.
Aab: absorber area.
αab: absorptivity of the absorber.
τv: transmissivity of the glass.

3.2 Overall heat balance of the sensor plane permanent schemes.

The equations that characterize the operation of a solar collector, which is in continuous operation data respectively by [7]:

$Pa = Pu + P'$ (3)

Where:

Pa: incident radiant power absorbed per unit area.
P ': heat loss.
Pu: useful power recovered by the coolant.

3.3 Energy balance of the solar plane

We propose in the following to determine the heat balance of the solar collector steady. For this we assume that each sensor is part of a node, on which we will build a thermal balance (Figure.4).

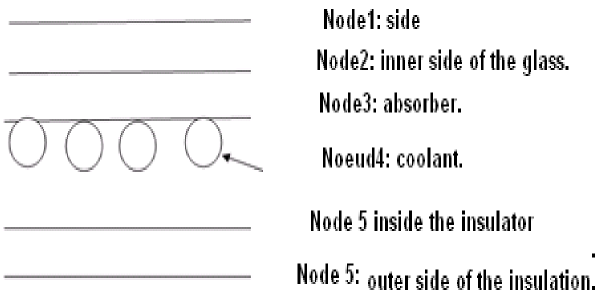

Figure 4: Mapping of different sensor nodes

Or any section of the system at time t, i is a sector represented in this section, half its mass, cpi its specific heat and its temperature Ti.

The balance sheet at node i give:

$mi \times cpi \times \frac{dTi}{dt} = \sum_{i=1}^{n} qij + pi$ (4)

Pi term source or sink.

N: set of nodes j for which Tj is connected to a potential Ti.

It may:

$mi \times cpi \times \frac{dTi}{dt} = 0$ (5)

3.4 Heat balance of the solar collector steady

It is necessary to advance some hypotheses to be a simulation of the system studied approached steady state:

- The sun is considered a black body.
- The flow regime is permanent.
- The material properties are assumed constant.
- The temperature of the soil is taken to the temperature of the atmosphere.
- The wind is supposed to blow parallel to the faces of the system.
- The heat exchange surfaces are assumed gray and scattering.
- The atmospheric diffuse radiation is assumed isotropic.
- The temperature of the absorber plate is assumed to be that of the tubes.
- The different solid media have a uniform temperature in a plane normal to the direction of flow.
- The heat flow is one-dimensional.
- The transparent cover is clean.
- The side walls are assumed at constant temperatures.
- The coolant used is pure water.
- Thermal balance in the outer surface of the window

$pv / 2 + kv / ev = qcva + qrvc$ (6)

kv: thermal conductivity of the glass
ev: thickness of the glass.

• Heat balance at the inner side of the glass

pv / 2 + qrav + qcav = kv / ev (7)

• Heat balance at the absorber

Pab = qcaf + qcav + qrav+ qcdai (8)

• Heat balance in the coolant

qcaf = qcfi (9)

• Heat balance at the inner surface of the insulation

ki / ei = qcfi + qcdai (10)

ki: thermal conductivity of the insulation.
ei: insulation thickness.

• Thermal balance in the outer face of the insulation

ki / ei = qris+ qcia (11)

After establishment of the thermal balance of the solar plane steady, we obtained a system of six algebraic equations to be solved by the iterative Gauss-Seidel, where it will be transformed into a matrix form a
AXT = B.

4. Principle of Solar Simulation Steady

We will use the method followed by Hottel, Whillier and Bliss which assumes steady state, the mean temperature of each sensor element are uniform and constant over the entire element neglecting the transient effects, this method is a convenient tool for design calculation, although it should, again iterate [8].

4.1 The main program steady

- The first step: data entry and calculation constants.
- The second step: calculation of the different thermal exchange independent of Temperatures, which are: the coefficients of exchange by conduction between the two faces of the window, both surfaces of the insulation between the insulation and the absorber and that the convective heats transfer between the sensor and the wind ratio.

  The third step:

- Room temperature is calculated, and initially assumes temperatures of the various components of the sensor are at ambient temperature except the temperature of the absorber and the heat transfer fluid which is at slightly higher temperatures, and calculating for initial temperatures
- Thermophysical properties of the coolant are:
  - The density.
  - Thermal conductivity.
  - The kinematic viscosity.
  - Specific heat.
  - The Prandtl number.

The heat transfer coefficients, namely:

- The coefficient of exchange by radiation between the glass and the celestial sphere.
- The coefficient of exchange by radiation between the glass and the absorber.
- The convective heat transfer coefficient between the glass and the absorber.
- The convective heat transfer coefficient between the absorber and the heat transfer fluid.
- The convective heat transfer coefficient between the coolant and insulation.
- The coefficient of exchange by radiation between the insulation and the floor.
- Resolution of the equation system by the Gauss-Seidel method.
- The fourth step: calculation of the instantaneous efficiency of the collector.

All these steps are shown in the following charts. The main program was developed language C++.

5. Results

Solving the system of equations of heat balance at each of the sensor by two numerical methods, the iterative Gauss-Seidel method and the Runge-Kutta 4, allowed us to obtain a set of numerical results that we validated by experimental work conducted at the Center for Renewable Energy Development in Bouzareah [6]. The solar plane studied has the following characteristics: [6]

Dimension(M)	1.2*1.95*0.105
Envelope	Aluminium Thickness=0.35
Radiator	copper Total tuble=10 L=18
Absorber	Aluminium Area=2.07m^2
Insulation	Copper F=50mm C=20mm
Glazing	Thickness=4mm Transmativity=0.83

Table 1: Characteristics of the sensor plane studied [6]

In this section, we study the effect of internal and external operational parameters on the instantaneous efficiency of the collector steady regimes.

5.1 Study of the effect of operating parameters on the instantaneous efficiency of the solar collector water plan steady

5.1.1 Overall effect of radiation on the temperature of various components of the sensor

The analysis of the curves in Fig .5 can be noted that the temperature of the absorber is higher, which is easily explained by its high solar absorption factor. Then, in descending order, we have the temperature of the coolant resulting from convection coefficient between the absorber and the heat transfer medium, then the temperature of the inner face of the insulator which is located directly underneath the absorber whose conductivity heat is high, then the temperature of the inner surface of the glass due to absorption of the incident radiation on the one hand, and the heat released by the absorber in the form of IR radiation and convection other. Note that the outer surface of the glass generally subjected to the action of the wind is slightly lower than the inside temperature. The lower temperature is that of the outer face of the insulator resulting from a low thermal conductivity and also the effect of the wind.

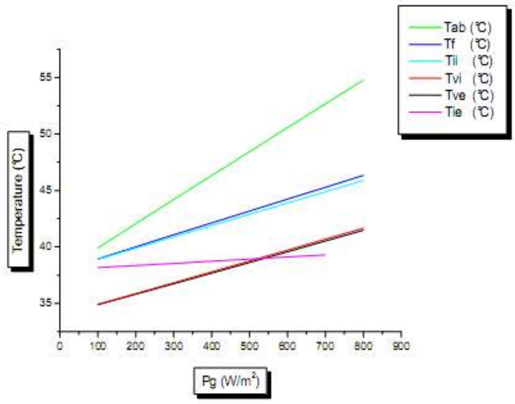

Figure 5: Temperature variation of the components of the sensor according to the overall radiation

5.1.2 Effect of Global Radiation

Shows that the instantaneous efficiency of the collector is an increasing function of global solar radiation; this is explained by the relationship between the useful energy recovered by the working fluid and the global solar radiation.

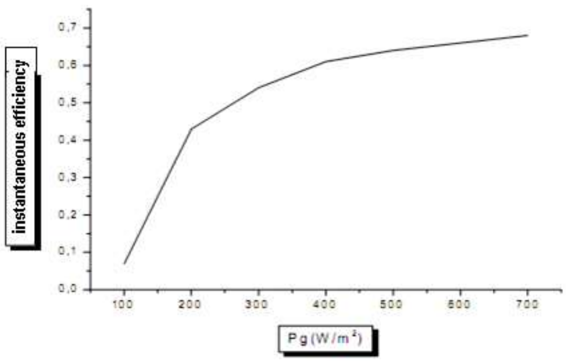

Figure 6: Change the flash output based on the global radiation

5.1.3 Effect of Variation in Ambient Temperature

It is easy to notice the growing Figure.7 the shape of the curve of variation of the instantaneous efficiency of the sensor according to the ambient temperature. Indeed, a lower ambient temperature leads to a decrease in temperature of the sensor components and hence lower returns.

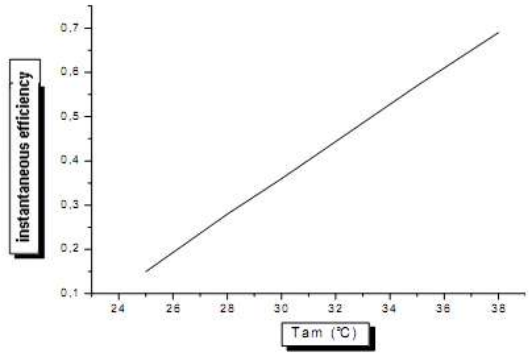

Figure 7: Change the flash output with the ambient temperature

5.1.4 Effect of the Specific Heat

Specific heat is the amount of heat that must be supplied to the unit mass of coolant to increase the temperature of 1 degree, therefore, the higher the temperature of the fluid increases (due to the increase in solar power), plus the amount of thermal agitation which the increase of the specific heat, which fact explains the relationship of proportionality between the specific heat of the coolant and the heat transfer efficiency of the sensor (Figure.8).

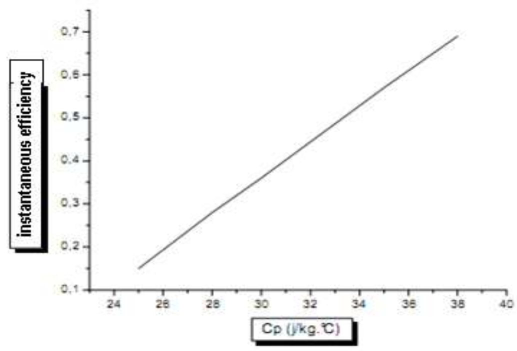

Figure 8: Change the flash output depending on the specific heat

5.1.5 Effect of the inlet temperature of the coolant

The effect of the inlet temperature of the coolant on the instantaneous efficiency of the solar collector is highlighted on Figure.9 which allows observing that, for a given outlet temperature, increasing the inlet temperature fluid leads to a decrease of the instantaneous output.

Indeed, the useful energy recovered by the heat transfer fluid is closely related to the temperature difference between the outlet and the inlet of the fluid, it follows a drop of it and therefore the instantaneous efficiency.

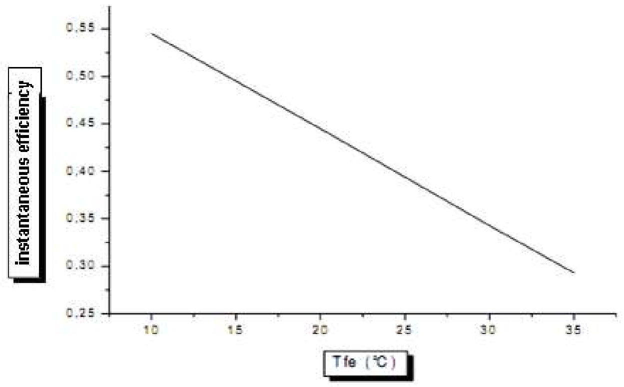

Figure 9: Variation of the instantaneous performance against the inlet temperature of the coolant

5.1.6 Rate effect

The figure 10 clearly shows that the instantaneous efficiency of the solar collector is an increasing linear function of the fluid flow.

In fact, the increased flow of fluid flow leads to turbulence which will promote the convective heat transfer between the absorber and the heat transfer fluid.

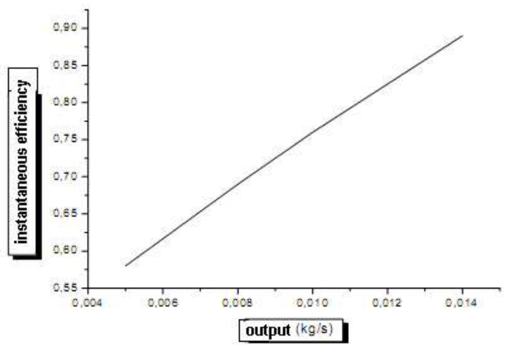

Figure 10: Change the flash output level sensor according to the flow

6. Conclusion

As part of this work we have undertaken a theoretical and numerical study of a solar plan in permanent water regimes will apply for coupling membrane distillation. After a brief presentation of some astronomical data, we have developed a state of the art solar collector. Our focus has been subsequently on the different heat exchange brought into play within a sensor to determine the equations governing the thermal behavior of the device in continuous systems.

The resolution of the discretized equations by the finite difference method system has been addressed by a numerical approach based on methods of Gauss-Seidel and Runge-Kutta 4. The results highlight the influence of internal and external parameters of the sensor plane. It is clear that the flash output is proportional to the global solar radiation plays a major role function. In addition, increasing the temperature of the atmosphere promotes improved flash output of the sensor in the two systems studied. The results also show the influence of optical and thermophysical properties of the various components of the sensor on the flash output. Note as well that:

- The use of an absorber with a specific heat, thermal conductivity and high absorbency improves the instantaneous efficiency.
- The transparent cover should have good transmissivity of visible light and thin to minimize its thermal inertia.
- The insulator must have a thickness and a high specific heat and a low thermal conductivity to improve heat transfer efficiency of the sensor.
- The coolant must have firstly a specific heat and high thermal conductivity and a second, a dynamic viscosity and reduced density.

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