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# Effect of deposing of oil layers on the surface of the solar collector on its functioning

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*Abstract*—**This paper presents an experimental study of the effect of oil layers depositing on the glass surface of the ET200 solar collector on its performance. It also aims to study the behavior of these commonly used oils (olive oil, salad oil and lavender oil) vis-a-vis of solar radiation and correct false information about their aesthetic use. To accomplish these objectives an active solar energy demonstration system (ET 200), illuminated with a halogen lamp was used. This former consists of water storage tank, a flat plate solar collector, a high-power lamp and a control and command cabinet. The deposition of the cited oils on the collector glass improves its characteristics of transmitting heat which results in an increase of water temperature difference between the inlet and outlet of the solar collector. The glass covered with oil intercepted more energy than that without oil cover. So it is inadvisable to put theses oils 'salad, olive and lavender' on the face to protect it against solar radiation. They are recommended if the opposite effect i.e. tanning effect is desired. Depositing lavender oil on the surface of the collector improves its efficiency by 5.2%. The performance of the solar collector increases by 1.80% when salad oil is deposed on its glass surface. In contrast, olive oil slightly decreases the efficiency of the solar collector by 0.5%.**

***Keywords-component; Solar collector; oil layers; Collector efficiency, Olive oil, Lavender oil, Salad oil***

## I. INTRODUCTION

The quest to minimize environmental effects of the conventional energy resources and especially meeting the increasing energy demand of the global population has steered researchers toward clean and renewable energy sources [1].

Renewable energy technologies generate marketable energy by converting natural phenomena into useful forms of energy. Solar energy is now one of the most promising sources to satisfy global energy demands. It is estimated that 30 min of solar radiation falling on earth is equal to the world energy demand for one year [2].

Solar collectors are generally used for active conversion of solar energy into thermal energy (i.e. heat). They use pumps to move water between the collector and the storage tank. These devices can be utilized to heat water or/air for domestic and industrial applications [3]. Solar water heating technology has significantly enhanced over the past century. Currently, many models of solar collectors are available in the market.

Flat plate collectors (FPC), simple and widely used design, collect solar radiation and transform it into heat transmitted to a transfer medium such as water [4, 5].

These models are largely used for low temperature applications (heating water, space heating…, etc.) [5]. A typical flat plate collector is composed of an absorber with integrated or welded tubes in an insulated box covered by transparent sheets (glazing).

The circulating water from the collector penetrates in the heat exchanger installed inside the storage tank where it gives its brought energy 'i.e. heat' to water storage tank and returns to the solar collector where it is reheated again by sun radiation.

Flat plate collectors have been largely studied (experimentally and theoretically) in order to improve their performances [5,6,7,8,9,10].

This experimental investigation aims to study the effect of covering the glass surface of the ET200 solar collector by common use oils on its functionning. It also aims to study the behavior of these oils (olive oil, salad oil and lavender oil) vis-a-vis of solar radiation and correct the false information for their aesthetic use.

## II. EXPERIMENTAL SETUP

A fully functional demonstrating model (ET 200) of a system for heating domestic water was used in this investigation. This demonstrating model uses light radiation energy of a halogen lamp to simulate the sun energy as illustrated in Fig. 1. It consists of several devices mounted on a metal support.

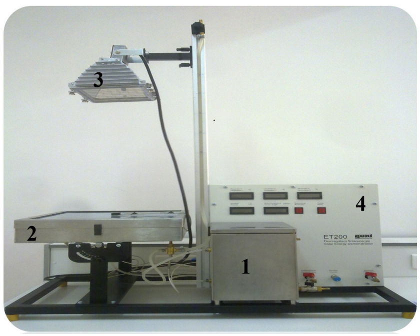



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Fig. 1 Experimental device[10]

The device used in this study consists of water storage tank (1), a flat plate solar collector (2), a high-power lamp (3) and a control and command cabinet (4).

Solar collector is a planar collector with a single glazing pivoting around an axis; it allows an inclination angle from 0° to 60°. The absorber plate consists of three bands of 320x120 mm² each one. It is traversed by a serie of tubes, which absorb the solar radiation. The heat absorbed is transferred to water tank via the circulation of water (a heat transfer medium) inside a serpentine heat exchanger placed in the storage tank (see Fig. 2).

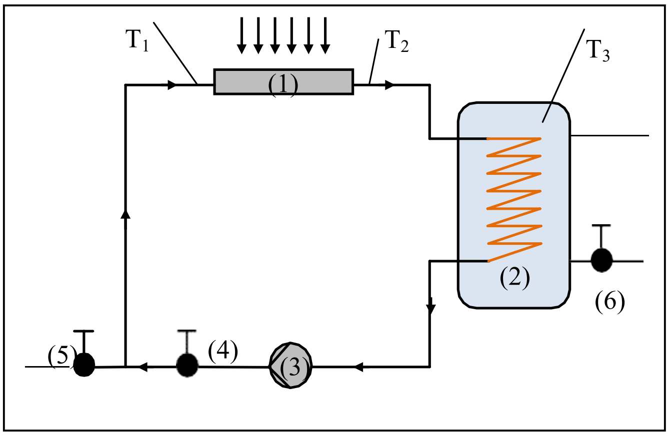


Fig. 2 Schema of the solar demonstration system (1) collector, (2) tank, (3) circulation pump, (4) (5) (6) valves.

Temperature measurements are performed by sensors PT 100 placed at the inlet $T_1$, at the outlet $T_2$ of the absorber and in the storage tank $T_3$ (see again Fig. 2).

A pump for circulating water is used by this active system. Halogen lamp high power simulating natural sunlight is used in our study. Illuminance measurement is carried out with an heliometer placed in the middle of the collector glass under the halogen lamp.

Measures of water flow rate, temperatures and illuminance are shown on the digital displays of the control and command cabinet (see Fig. 1).

## III. Gouverning Equations

In a steady state, the energy balance of the collector area is given by the following equation:

$$E = E_u + P \quad (1)$$

where;

$E$ : Incident solar flux received by the glass surface of the solar collector (W);

$E_u$ : Useful flux, i.e. incident solar flux received by the fluid (water) (W);

$P$ : Fluxes lost by convection and conduction towards the back of the collector and by convection, conduction and radiation forwards of the collector.

### A. Incident solar flux

The power transmitted to the flat plate collector surface is captured directly by the light meter placed exactly in the middle of the collector surface under the lamp to obtain correct measured results [11]. Its value (per meter squared) is read on the control and command cabinet. This value must be multiplied by a correction factor of 2.95 to get the real value [11]. The incident solar flux relation is expressed by:

$$E = G \times S \quad (2)$$

With;

$G$ : Illuminance, i.e. incident solar flux by glass surface (W/m²);

$S$ : Exposed area to radiation (m²).

### B. Useful flux received

The useful flux recovered by water is given by the following equation:

$$E_u = \dot{m} \times C_p \times (T_2 - T_1) \quad (3)$$

With;

$\dot{m}$ : Water mass flow rate (kg/s), which is related to volumetric flow rate by the following relation:

$$\dot{m} = Q_v . \rho \quad (4)$$

$Q_v$: Volumetric flow rate (m$^3$/h);

$\rho$ : Water density (kg/m$^3$);

$C_p$ : Water specific heat;

$T_2$ : Absorber water outlet temperature;

$T_1$ : Absorber water inlet temperature.

### C. Instantaneous solar collector efficiency

The instantaneous efficiency of a solar collector is defined as :

$$\eta = \frac{E_u}{E} \quad (5)$$

It presents the relationship between the useful flux absorbed by water and the solar flux absorbed by the collector surface. It can be simplified by the following equation:

$$\eta = \frac{\dot{m} \times C_p \times (T_2 - T_1)}{G \times S} \quad (6)$$

## IV. Effect of Covering the Collector Glass by Oils

To highlight the effect of covering the glass surface of the ET200 solar collector by commonly used oils on its functioning, experiments were made in this manner:

A same thin layer of the following oils; olive oil, Afia table oil and lavender oil was spread on the glass surface of the


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solar collector. An additional test was performed without filing any oil layer in order to assess their impact.

Experiments were carried out taking the whole surface of the collector (Stotal= 0.13838 m²) maintained at an horizontal position (see again Fig. 1), with a fixed water flow rate of 5.9 l/h.

Each test was carried out for 150 minutes, and the absorber water inlet temperature $T_1$, the absorber water outlet temperature $T_2$ and the tank temperature $T_3$ were recorded every five (05) minutes. All tests were performed in laboratory at an ambient temperature of 19 ± 1°C.

## V. RESULTS AND DISCUSSION

### A. *Effect of Covering the Collector Glass by Oils on temperature evolution*

The first interpretation of the collected temperatures led us to plot the evolution of the temperatures; $T_1$, $T_2$ and $T_3$ over time.

All graphs showing the evolution of the temperatures; $T_1$, $T_2$ and $T_3$ versus time had the same look for all experiments done. Fig. 3 illustrates an illustrative example for olive oil.

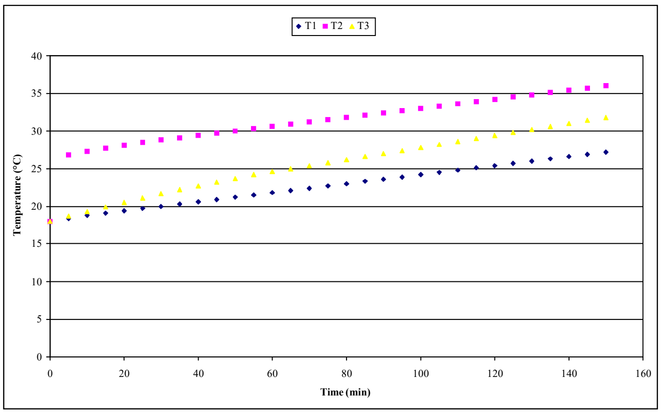


Fig. 3 Temperatures $T_1$, $T_2$ and $T_3$ evolution over time for olive oil.

As illustrated in Fig. 3 all temperatures; $T_1$, $T_2$ and $T_3$, increase with time. Temperature $T_2$ is always higher than the other temperatures ($T_1$ and $T_3$); because it presents water temperature at the outlet of the absorber. Its value is the highest one due to heat water absorption occurred in the absorber. After water heated passage in the tank, heated water gives a quantity of heat to cold water tank, as a consequence, temperature $T_1$ takes the lowest value, and water tank temperature ($T_3$) increases. Thus, storage tank temperature takes an intermediate value between the lowest and highest temperatures (see again Fig. 3).

Once again, all graphs showing the evolution of the temperature difference ($T_2$-$T_1$) depending on time for all experiments done, present the same look (see Fig. 4). As seen, temperature difference evolution can be divided into two phases: the first one called transitional phase from 0 to 30 minutes, is characterized by a non-linear increase of the temperature variation, followed by the stable phase, from 30 minutes until 150 minutes (time of the experiment), where this difference takes almost a constant value.

The time interval when the temperature difference, as a consequence, the efficiency of the collector, are time independent is called also steady state phase.

This investigation was studied during the steady state phase i.e. beyond 30 minutes [10,11,12]. It is observed from Figure 4 that the deposition of oil layers tested on the collector glass affects the temperature difference at the inlet and the outlet ($T_2$-$T_1$) of the latter.

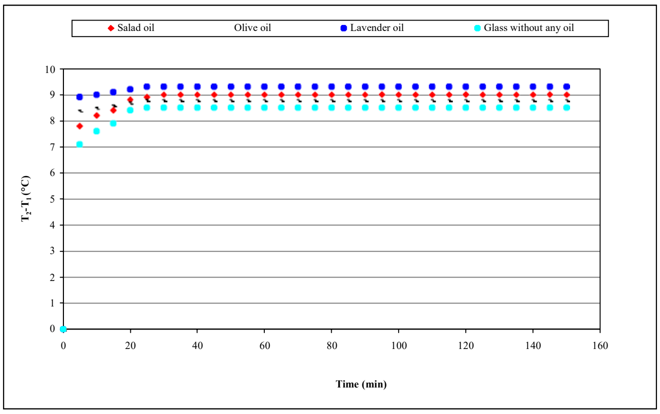


Fig. 4 Temperature difference ($T_2$-$T_1$) evolution over time for all experiments done.

Indeed, the filing of oil on the collector glass improves its characteristics to transmit heat which results in an increase of water temperature difference at the inlet and outlet of the solar collector. It is noteworthy that lavender oil has the best performance than other oils whilst olive oil recorded the weakest performance beyond 30min. This result is in agreement with the evolution of water tank temperature.(see Fig. 5).

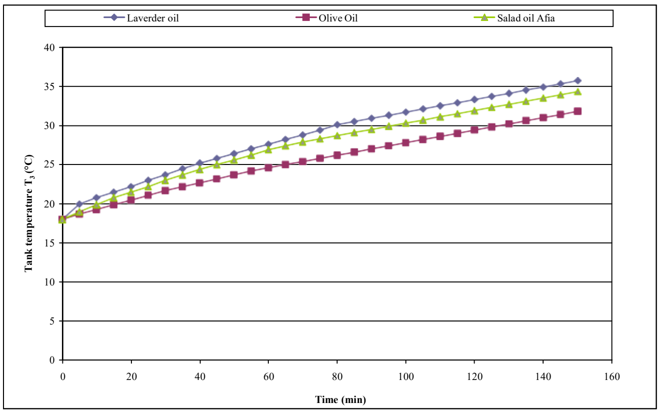


Fig. 5 Water tank temperature evolution over time for oil tested.


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It should be remembered that the glass covered by the tested oils (afia, olive, lavender) leaves more energy from the lamp to penetrate inside the collector resulting thus in a higher temperature difference ($T_1$-$T_2$) than that recorded for the glass without oil , this latter leaves less energy to enter inside the solar collector.

*B. Effect of Covering the Collector Glass by Oils on the evolution of the radiation intensity received by this latter*

The incident solar radiation picked up by the light meter G is influenced by the coverage of the glass surface of the solar collector'deposition of oil layers'. This result is confirmed by Fig. 6, which shows the evolution of the intensity of the radiation received by the glass surface of the solar collector as function of time for all tests carried out.

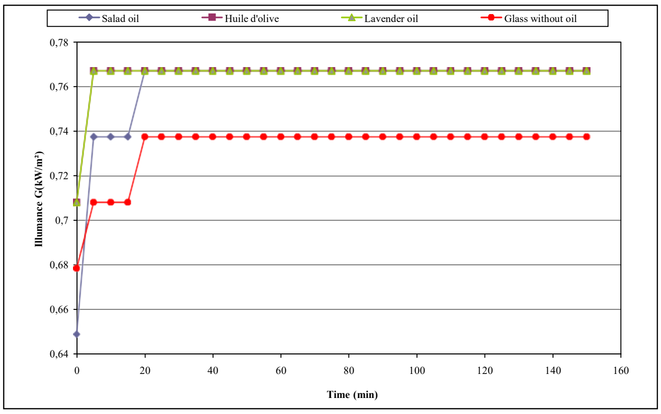


Fig. 6 Evolution of the intensity of radiation received by the glass surface of the solar collector as a function of time for the various oils tested.

As seen the glass covered by oil receives more energy than that without oil. This experience allows us to say that it is inadvisable to cover the skin by these oils if we try to protect it from sunlight. They are advised if you want the opposite effect i.e. tanning effect.

In the Algerian market, it is found on the packing boxes of lavender oil that it is the best natural anti-sun oil what is really wrong.

To take advantage of the virtues of oils such as olive or lavender oils, the ideal time to put them on the face is at night.

It is noted also from Fig. 6 that the incident flux received by the glass covered by oil is independent of the nature of the oil deposited.

*C. Effect of Covering the Collector Glass by Oils on the efficiency of the solar collector*

The efficiency of the solar collector is influenced by the coverage of the glass surface of the solar collector'deposition of oil layers'(see Fig; 7).

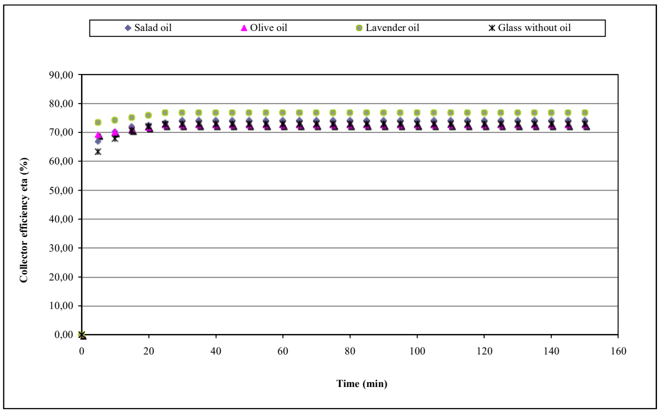


Fig. 7 Effect of Covering the Collector Glass by Oils on its efficiency.

According to Fig. 7, it is found that the cover of the collector glass exerts a distinct effect on the performance of the ET200 solar collector. Indeed, the glass with lavender oil has an efficiency of about 76.7% against 72.6% for the glass with olive oil.

It is also noted that the filing of lavender oil on the surface of the collector improves its efficiency of 5.2%. The efficiency of the solar collector increases also by depositing Afia salad oil on its receiving surface of 1.80%. In contrast, the filing of olive oil on the collector glass slightly decreases its efficiency of 0.5%

## VI. CONCLUSIONS

This study dealing with the effect of covering the Collector Glass by three kinds of oil namely; olive oil, lavender oil and afia salad oil on the functioning of a solar thermal collector using a lamp that simulates sunlight has allowed to remember that:

- The filing of oil on the collector glass improves its characteristics to transmit heat which results in an increase of water temperature difference at the inlet and outlet of the solar collector;
- The glass covered by oil receives more energy than that without oil;
- It is inadvisable to cover the skin by these oils if we try to protect it from sunlight. They are advised if you want the opposite effect i.e. tanning effect;
- To take advantage of the virtues of oils such as olive or lavender oils, the ideal time to put them on the face is at night;
- The deposit of lavender oil or Afia table oil on the surface of the collector improves the performance of the ET200 solar collector;
- It is inadvisable to spread olive oil on the surface of the collector because it slightly degrades the performance of the ET200 solar collector.

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