An Experimental Study of Parabolic Solar Water Heater Performance located in Basra city

دراسة عملية لاداء مسخن ماء شمسي قطع مكافئ في مدينة البصرة

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Abstract: -

In this paper the effect of focus and tilted angle of parabola solar water heart are studied, the result show that, the optimum focus is 25 cm, where the tilted angle of parabola cannot be adopted because it has different value from time to time, also the study focus on heating pipe glassing with different tube diameter, and show the glassing heating pipe with 1-inch tube diameter give good performance from other size and that without glassing.

الملخص

في هذا البحث تم دراسة تأثير البعد البؤري وزاوية الميلان لمسخن ماء شمسي ذو قطع مكافئ، ومن خلال هذه الدراسة بينت ان البعد البؤري الأمثل هو 25 سم، بينما الدراسة لم تتمكن من التنبوء بافضل زاوية ميلان للقطع المكافئ لأنها تختلف من وقت لآخر، وكذلك تم التركيز في الدراسة على تأثير استخدام الانابيب المغلفة بالزجاج مع اقطار انابيب مختلفة، وقد بينت الدراسة ان أنابيب التدفئة المغلفة بالزجاج مع أنبوب قطره 1 بوصة تعطي أداء أفضل من اقطار الانابيب الاخرى والانابيب الغير مغلفة بالزجاج.

1. Introduction: -

Parabolic-trough solar water heating is a well proven renewable energy technology with considerable potential for application at southern Iraq city. Parabolic trough water heating systems are most cost effective in the South of Iraq where direct solar radiation is high. As with any renewable energy efficiency technology, Parabolic-trough solar water heating requiring significant initial capital investment.

The energy consumption in residential sector is substantial as it accounts for approximately one-third of overall delivered-energy use and carbon dioxide emissions of this delivered-energy use, approximately a quarter is for water heating. Water heating is generally provided by using electrical source that from burning fuels, the energy from the sun can be used for both heating purposes (of water and buildings) and for electricity generation. In combination with absorption cooling systems, parabolic-trough collectors can also be used for air-conditioning [1]. In order to utilize the heat, thermal solar collectors are used, and in order to generate electricity, solar cells (or PV-modules) are used. Solar energy is an environmentally friendly energy source that does not cause unwanted emissions of CO2, other pollution or noise disturbance. The fuel, i.e. the sun's rays, is also abundant and free of charge.

Why is the energy from the sun not utilized to a greater extent? One of the major reasons is the high cost associated with the solar energy technology. The problem here is that the production volume of solar collectors is not large enough to motivate investments in automatic manufacturing techniques. This results in expensive collectors, few customers and a continued low production. Many studies are focused on using parabolic water heater. Dr. Subhi et al [2] perform the theoretical study using FORTRAN 90 program depend on simple iteration technique, they found that the increase in the solar radiation leads to increase in the useful energy and the increased of the mass flow rate leads to a decrease in the useful energy. Also the heating water mass flow rate of 0.02-0.03 kg/s give the highest thermal efficiency. Tadahmun [3] did an experimental a theoretical study

to show the effect of heating water mass flow rate on thermal efficiency of the parabolic water heater, she found that the actual thermal efficiency of concentrator is less than the theoretical thermal efficiency in (7-15) %. So the thermal efficiency of collector in winter is more than the thermal efficiency in summer by (2-5) %. Mayur et al [4] study the performance of parabolic water heater over the time of day, they found that the heating water temperature is the maximum value at 12:30 P.M of all-day of year. F. Jamadi [5] did an experimental study to cheek the effect of heating fluid mass flow rate on collected heat. He concludes that as the heating oil mass flow rate decrease the outlet heating oil temperature will increase, on the other hand the thermal efficiency will increase as oil mass flow rate increased.

2. Experimental Setup and Test Procedure

This section provides a description of the facilities developed for conducting experimental work on parabolic water heater.

Experimental test rig

As shown in fig (1), fig (2) the test rig consist from:

1. **Cold water tank and Hot water tank:** a galvanized steel sheet tank (25L) with multi layer of glass wool as insulator it is used for storage the cooled and hot water.
2. **Parabolic Reflector Steel Structure:** a steel structure is used to carry the parabolic, which consist from many connecting hollow shaft to perform the steel structure. The parabolic attached on structure in such way that can be moved around a central shaft.
3. **Parabolic Reflector**: it used to reflect the sun rays falling on the parabolic and focuses it at the focus point, which is the hot water pipe (black copper tube). The angle of the parabolic trough can be chosen at the required angle.
4. **Pump**: which is used for pumping and circulating the water through the system at a rate of (3L/min).
5. **Flow meter:** it used to measure the water flow rate.
6. **Thermometers**: T type thermocouple sensors to measure water temperature which fitted at inlet and outlet of hot pipe at a range (-50 to 300) C^0.

Test Procedure: -

After complete the connections of test rig components and measuring devices, the test procedure takes this fallowing steps:

1- To reduce the error of experimental work that due to variation of focus and tilted angle with time (sun ray intensity different from time to time), all three tubes are tested at the same time by installed to one parabola as shown in fig (1) and (2).
2- After 25 mints of running the inlet and outlet water temperature of heating tube will be measured by the thermometer, while water flow rate measured by flow meter.
3- In this study the amount of collected heat is taken as the guide for the best selection. To perform the best test the equation below is used

$$Q= m_w \times Cp \times (T_{w(out)} - T_{w(in)}) \quad [8]$$

Where:
Q = is the collected heat in kW
m_w = water mass flow rate kg/s
$T_{w(out)}$, $Tw_{(in)}$ =temperature of inlet and outlet of water respectively in kelvin .
Cp = specific heat of water kJ/kg.k

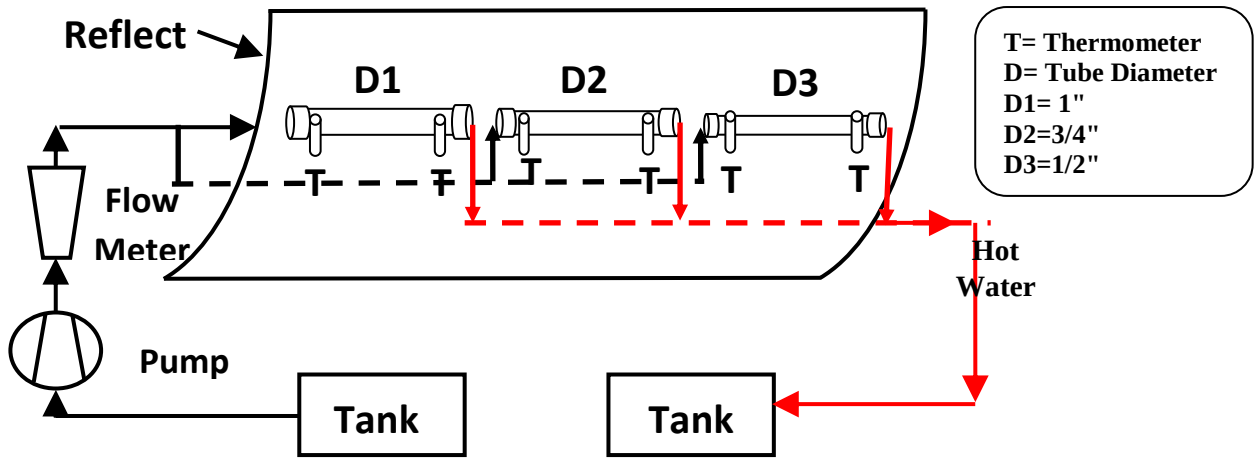

Fig. (1) The schematic diagram of the test rig

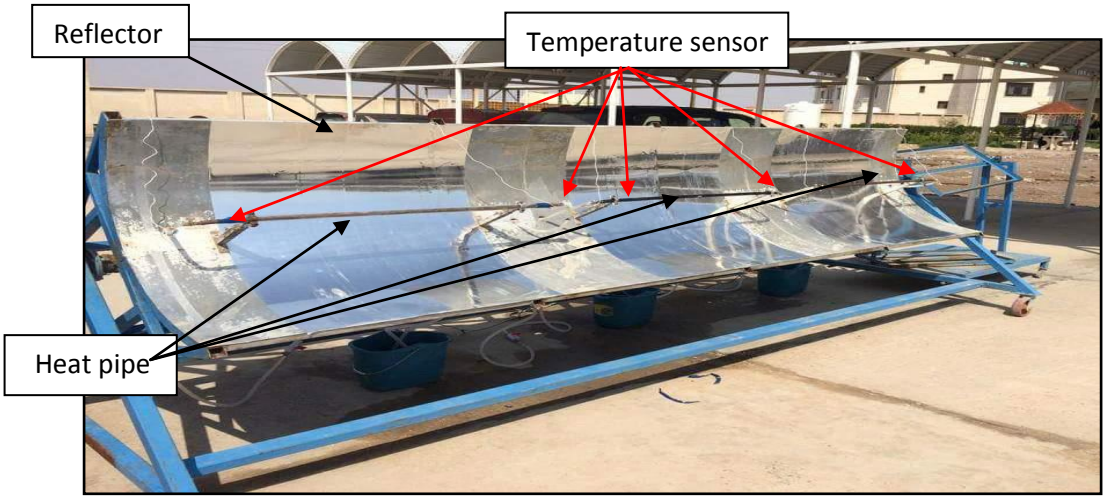

Fig. (2) Test Rig

3. Result and discussion: -

3.1. Effect of Focus Changing: -

In this study the parabola focus was varied from 25 to 40 cm in order to show the effect of focus variation and find the optimum focus selection also. Figure (3) showed the collected heat decreased as the focus length increased due to the decreasing in the concentrated sun ray to the heating pipe. The focus of 25 mm length can be taken as optimum focus.

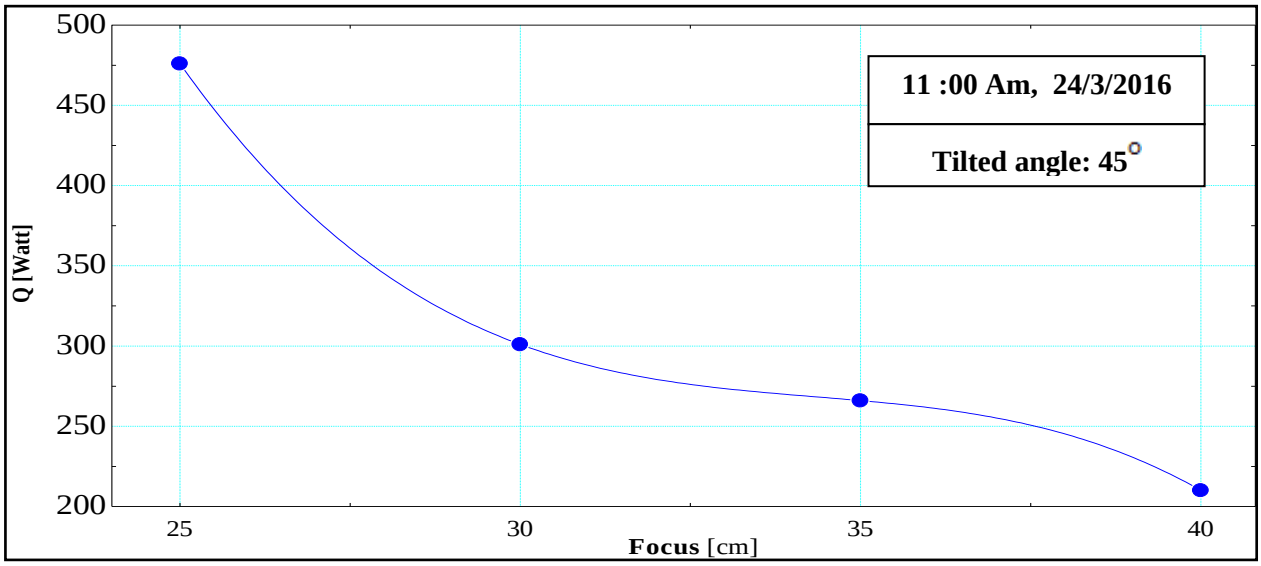

Fig (3) Effect of Focus Varying on collected solar energy

3.2. Effect of parabola tilted angle on collected solar energy: -

To study the effect of parabola tilted angle on collected heat, the tilted angle is varied over the range from 25° to 60 ° with step of 5° ,and for two days at same month and parabola location , as the tilted angle increased the collected solar energy increased also ,due to reduce the shaded area that made by parabola and reducing the diffusion ray, the optimum tilted angle for this day is 40°,as shown in figures (4)

There for to maximize the collected solar energy the parabola should be tilted with known angle this angle is different from time to time, day to day and month. The use of tracking system give's a good performance.

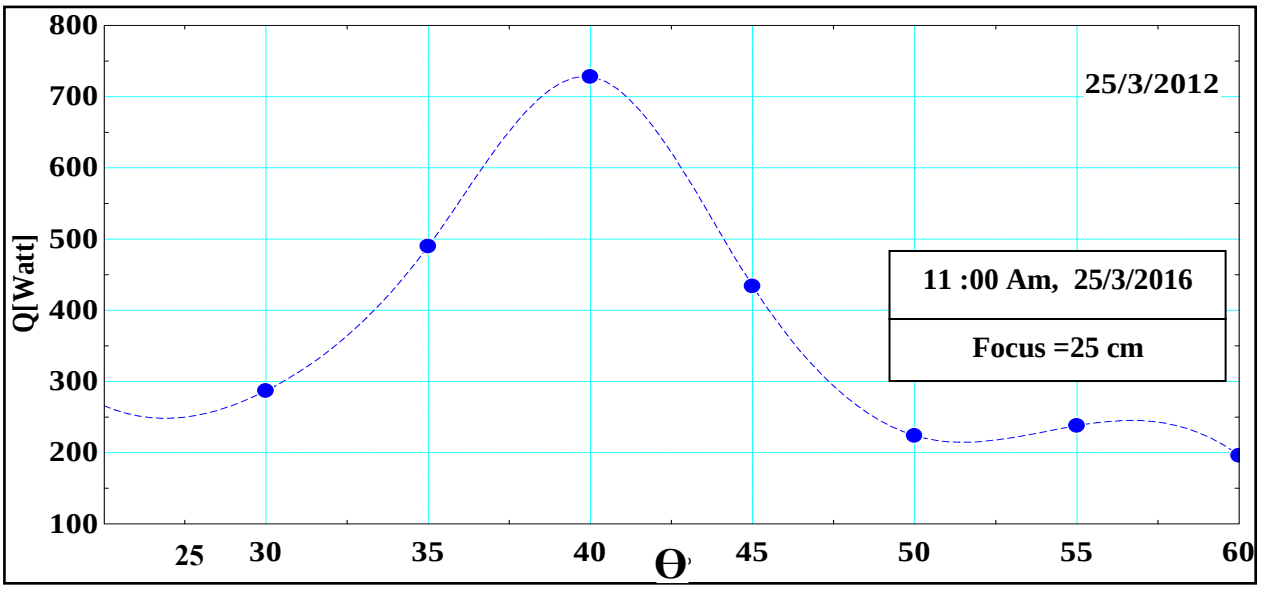

Fig (4) Effect of tilted angle on collected solar energy

3.3. Effect of Heating Pipe Surrounded with Glassing: -

To study the effect of heating pipe glassing, two pipe with same diameter of 1 inch and same mass flow rate are adopted. From Fig. (5) the major point show that the heating pipe with glassing give the best performance than other tested tube, because of the glassing reduce the effect of heat losses from the pipe to the surrounding air by convection and radiation. Where the stagnated film of air work as insulation.

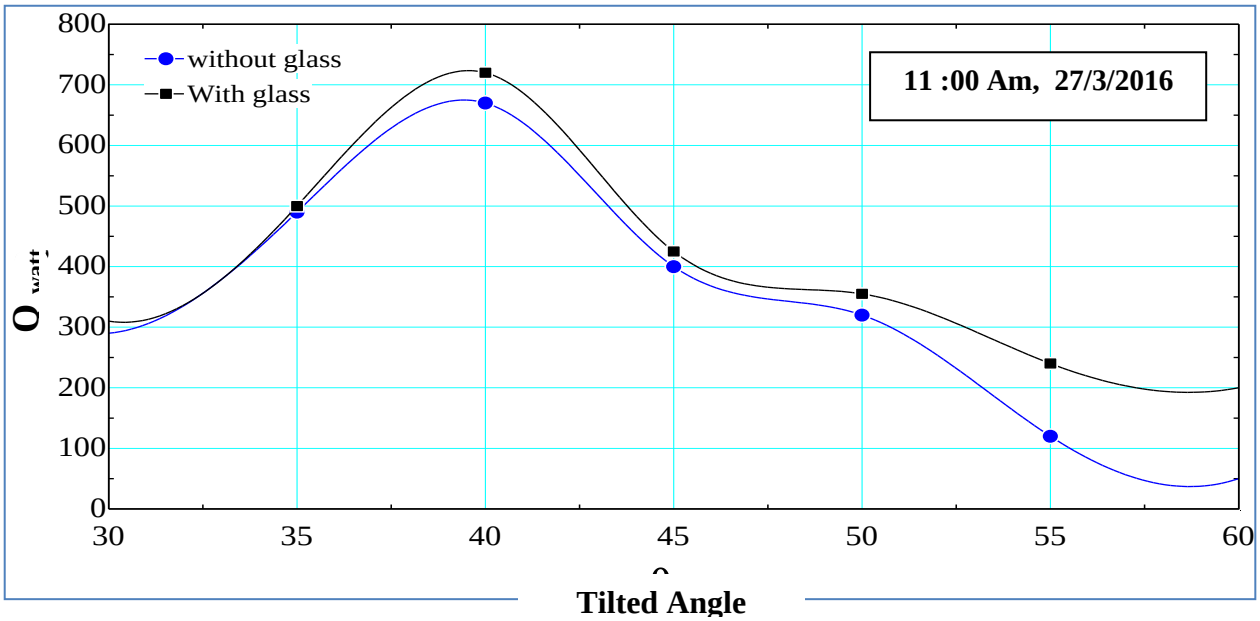

Fig (5) Effect of Heating pipe glassing on collected solar energy

3.4. Effect of tube diameter: -

To study the effect of parabola heating tube diameter with tilted angle on collected heat energy, the tube diameter is varied over the range from ½" ,3/4" and 1" with variation of tilted angle step of 15° ,and for the same day at same month and parabola location ,from the figure (6) as the tube diameter increased the collected solar energy increased also ,due to increase in tube area that will reduce the ray diffusion, the optimum tube diameter is 1" with tilted angle for this day is 45°.

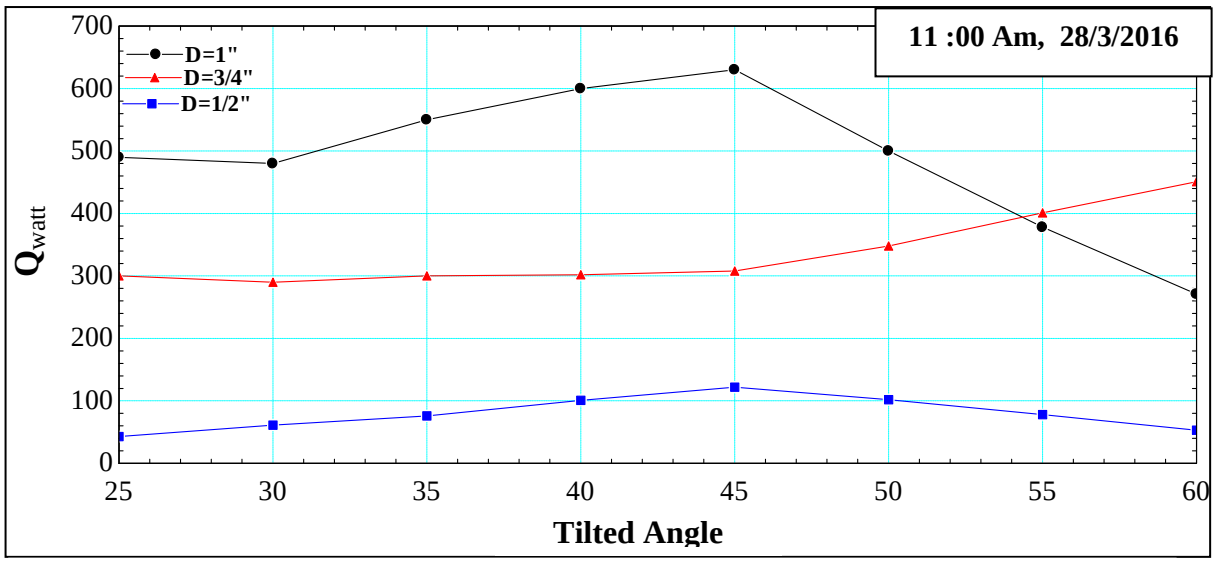

Fig (6) Effect of tube diameter on collected solar energy

4. Conclusions:

In the light of the preceding results, the following conclusions can be drawn: -

1. The optimum parabola focus is 25 cm.
2. The tube glassing gives good insulation and good performance.
3. Parabola water heater should be tilted with tilt angle that different from time to time.
4. The tube diameter with 1" give the beast heat collected for the diameters range used in this research.

5. References

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