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Experimental Investigation of a Gasoline-Charged Heat Pipe Solar Water Heater

Ali J. S. Alrafad [1 *], Ali F. Ali Fadiel [2], Karima A. S. Elhabib [3]

[1,3]Mechanical Engineering Department, Higher Institute for Sciences and Technology, Altmimi, Libya

[2]Mechanical Engineering Department, Higher Institute for Sciences and Technology, Tobruk, Libya

[*]*Corresponding author: alidosh85@yahoo.com*

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Abstract:

An experimental investigation was conducted under actual weather conditions at Higher Institute for Sciences and Technology Altmimi in Libya located at 32.24°N latitude and 23.17°E longitude.

The solar complex is designed, manufactured, and assembled with the effect of thermal pipes. The thermal tube is integrated into Flat sucking absorbs heat from solar radiation and this part is considered an evaporator, the other side of the Heat tube is an intense part that is inserted into the water tank, gasoline was selected as a charged work fluid in the copper pipe due to its availability in the local market.

Temperatures were measured in the assembly's absorption board and water temperature in the storage tank and instantaneous efficiency every hour. We noticed that the solar system started heating up the water when it reached a degree.

The flat temperature is 80^{O}C, which is the boiling temperature of the gasoline, and the maximum temperature of water reached Instantaneous efficiency is about 46 ° C 23% respectively.

Keywords: Gasoline-Charged Heat, Pipe Solar Water Heater, Thermal energy storage, Instantaneous efficiency

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Introduction

People are always looking for new sources of energy to cover their growing needs in life applications. Increases Energy consumption day by day as the population increases. The population is expected to double by the middle of the twenty-first century, while global energy demand is expected to increase by 1.5 to 3 times by 2050. Traditional types of energy such as oil and natural gas will not be able to meet this demand in a sustainable way. These energy sources will be depleted, the cost of their exploitation is high and they are the main cause of environmental pollution caused by their burning. These reasons made renewable energy the best option ever. [1] Solar energy is the most abundant of all energy sources and the oldest source used by man over time. Solar energy has become increasingly important as technology advances.

One of the direct uses of solar applications is water heating. These solar assemblies convert solar radiation into heat. A solar water heating system is a technology that harvests energy from solar radiation to increase the temperature of the air or water in a home For commercial or industrial purposes by using solar panels and concentrators. Solar water heating is a renewable energy technology that is freely available and has high application potential worldwide. Solar hot water systems are mainly used on larger scales as they provide environmentally friendly thermal energy for domestic hot water, swimming pool heating, and other various areas that require hot water. The system harvests solar energy to heat air or water. There are two types of solar collectors: vacuum tubes and flat panels. Evacuated tube solar collectors have proven low heat loss coefficient, high performance, and reliability [2]

The objective of the current study

Study the performance of solar water heaters with thermal tubes charged with different working fluids. The aim of this work was to provide a study of this type of solar water heater operating using gravity-assisted thermal tubes, with the requirement that Working fluid and materials used in the manufacture of the solar system are available in the domestic market.

Results and discussion

Solar system used:

For the full experimental preparation of the solar water heater powered by pure Salah pipes, as shown in Figure 1 The entire solar heater was created from materials readily available on the local market.

The thermal pipe used is made of red copper. These pipes are supposed to be shipped 20% of their size by working liquid under atmospheric pressure. It is the best quantity for charged worker fluids in the circular section thermal tube is 20% of the size Tube. But due to the safety and security concerns of our use of a fast explosive fluid, we shipped 15% of the volume Thermal tube with gasoline.

The first part of the thermal tube is integrated under pressure into the absorbent flat grooves absorbing heat from Solar radiation and this part is the evaporator part. Flat panel components are included in the box and are Isolated from both sides and bottom by thermal insulation while the top is covered by a glass plate. The other side of the heat tube is the condenser part that is inserted into the water tank, the tank has been isolated by Thermal insulation to reduce heat energy loss. [3]

Figure 1: Full experimental solar water heater device operated with thermal pipes.

Discussion and results of the experiment

Theoretically identifying fallen solar radiation: -

To determine the efficiency of the solar system, it is necessary to determine the intensity of the fallen solar radiation measured by the watt/m2 unit. Use the ASHRAE model for the purpose of determining the value of the solar beam. Downfall per measurement period (fixed measurement period per hour) Direct downfall beam on the level solar surface with horizontal level and spread around the horizontal solar surface respectively calculated by the following equations:

$Ib = Ibn \cos \theta z$

$Id = IbnCs$

Where Ibn the solar beam falls vertically and determines from the equation: -

$Ibn = As \exp(-Bs/\cos \theta z)$

Where $Cs\ BsAs$ Constants given from the ASHRAE TABLE

The fallen solar beam on the angled solar surface β at the horizontal level determines the following equation: -

$$I_T = I_b \frac{\cos\theta}{\cos\theta_z} + I_d \left(\frac{1+\cos\beta}{2}\right) + (I_b + I_d)\,\rho_g \left(\frac{1-\cos\beta}{2}\right)$$

In addition, some solar corners were used as a solar beam fall angle at the horizontal level θz, italics θ, the angle of the deviation of the solar axis δ, the angle of solar timing ω, Site latitude Φ, Measurement Day N, and the hour for which radiation intensity is to be determined.

Theoretical calculations of the intensity of solar radiation fell on the oblique flat measured in the Watt/m2 unit for each hour shown in Figure 2 below:

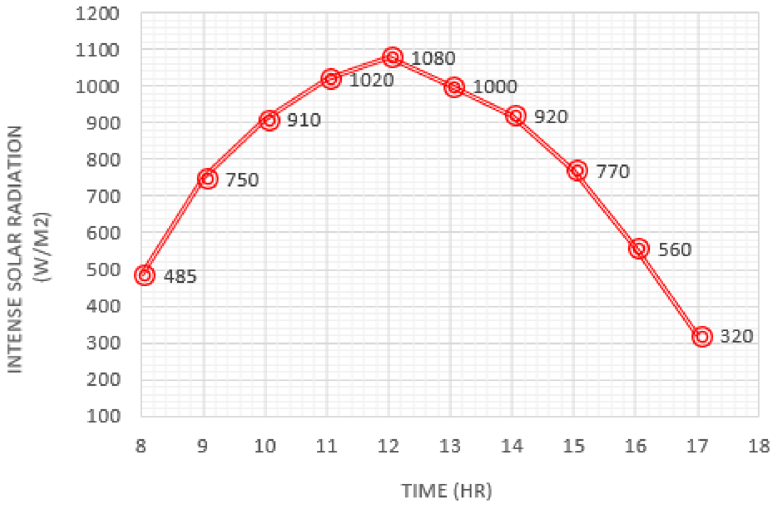

Figure 2: The intensity of theoretical solar radiation**.**

The performance of the solar complex is determined by the energy balance equation as solar rays absorbed by the absorbing flat are distributed into energy stored in the flat and energy used in heating water in the storage tank and thermal loss According to the following formula:

$$I_T\,\tau_g\,\alpha_p\,A_p = \left(mC_p\right)_p \frac{dT_p}{dt} + \dot{Q}_u + Q_{loss}$$

IT :Total beam falling on slash surface (Watt/m2)

τg: the permeability of the glass casing of the fallen solar radiation on it

αp: Absorption of the black metal surface of the solar complex

Ap: Solar Complex Surface Area m2

$(mCp)\ p$: Metal flat mass and specific heat with constant pressure (J/°K).

$\frac{dy_p}{dt}$: Rate of change in internal energy stored in absorbent surface (°C /s).

Qu: Thermal energy storage rate in the water inside the tank (watt/s).

$Qloss$:Total thermal loss from the absorbing surface to the ambient atmosphere (Watt).

Total thermal loss in the flat $Qloss$ is the total loss of the glass cover and the base and sides of the absorbent flat, usually neglecting thermal loss through the base and sides of the complex if the compound is a good thermal insulation of the sides and base.

$Qloss = Qg = Ug(Tgi - Tgo)$

Qg: Thermal loss from above through the glass casing.

Ug: Glass Thermal Loss Coefficient) Watt/m2. °K.

Tgo, Tgi: Temperature grade glass cover inside and outside respectively (°C).

The energy learned in the water reservoir is measured by the increase in temperatures every time, from which we determine the rate of thermal storage from the solar complex.

$Qu^{\cdot} = mw^{\cdot}\,Cp(To - Ti\,)$

$mw^{\cdot}$: The water rate in the reservoir is the mass of water relative to the time period in which the storage rate is measured (kg/s).

Cp: Specific temperature with constant pressure J/kg. °K

$(To - Ti)$: Increase in temperature scores per given period of time (°C). [5,6]

The thermal efficiency of the thermal storage system depends on the energy learned and transferred to the water in the storage tank Solar energy in the solar complex area is known as the following equation:

$$\eta = \frac{\text{Qu}}{\text{IT Ap}}$$

Experimental results:

An experiment was held on Friday 24/6/2022 The temperature of the solar surface, and the temperature of the water tank, from which we determined the momentary efficiency after each hour, note that the heating process within the water tank began when the temperature of the solar surface reached 80°C, As shown in Figure (3), the degree of boiling of gasoline within thermal tubes.

After the gasoline reaches boiling point, it turns into steam that expands inside the tube, the steam reaches the other end of the tube the steam heat travels to the water and condenses inside the tank, then the liquid gasoline comes down with the help of Gravity to the bottom of the tube mounted on the solar surface and the fumigation and condensation process is repeated so that it rises Water inside the tank.

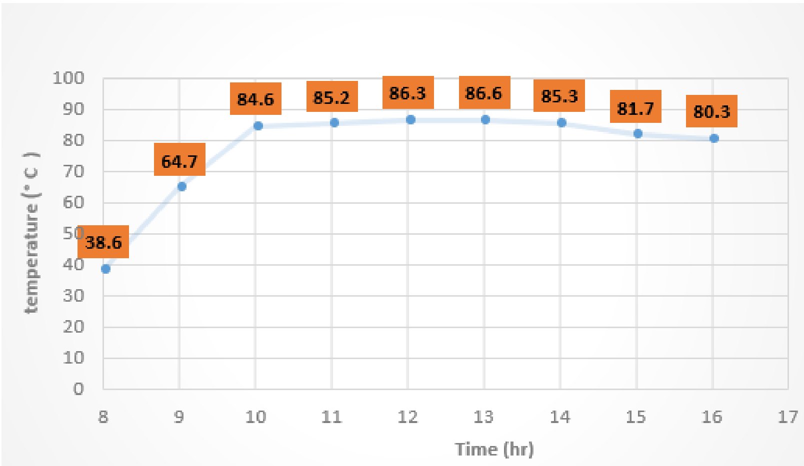

Figure 3: Solar flat temperature**.**

We note the heat transmission process was evident at flat temperature, as the solar flat did not store heat above the boiling degree of gasoline in the flat metal.

But this has not prevented the shortcomings observed in our experience. We noticed that the amount of water in the reservoir was relatively large to the number of thermal pipes, the water temperature in the reservoir reached its maximum value of 46 °C as shown in Figure 4.

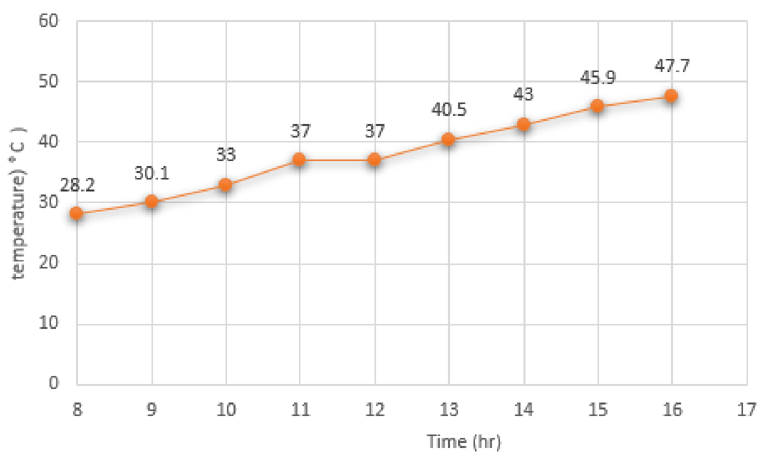

Figure 4: Water temperature in the tank.

Using theoretically calculated solar radiation values, we determined the instantaneous efficiency of each hour according to efficiency equations. Figure 5 also shows that the system's maximum instantaneous efficiency is about 23%... Between 10 ~ 11 hours.

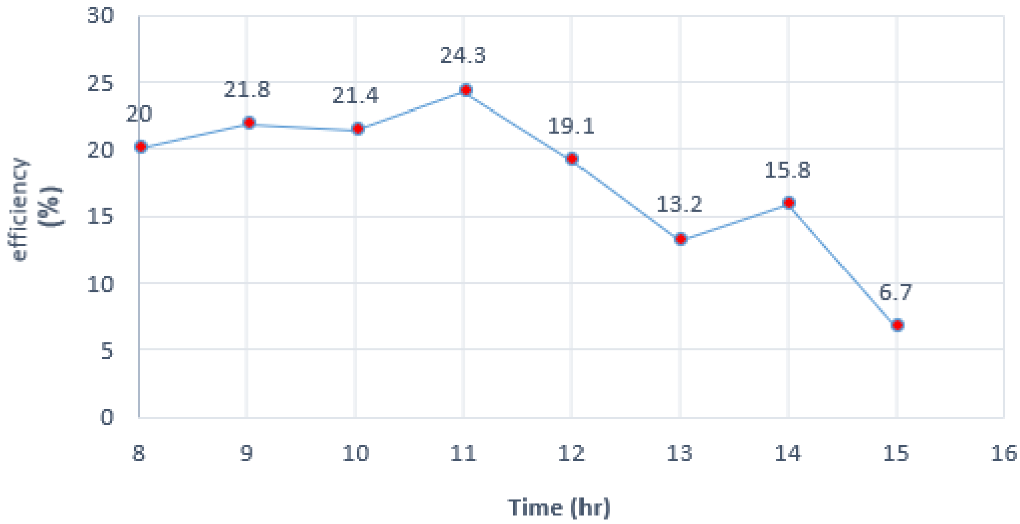

Figure 5: Instantaneous efficiency of the heating system

Conclusion

To find out the efficiency of the solar system, the ASHRAE model was used. To calculate the value of the intensity of the incident solar radiation after conducting the practical experiment and measuring the temperature of the absorbent plate of the collector and the temperature of the water in the tank and the moment. hourly efficiency. We found that when the surface temperature reaches the boiling point of benzene, the solar system starts to heat up. We found that heat transfer is important at surface temperatures because solar panels do not store heat above the boiling point of benzene in the surface metal. Our maximum water temperature is 46°C. There is an increase in efficiency that continues to reach 23% in the middle of the day

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