Fabrication of Parabolic-trough concentration for solar water heating

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Abstract
This paper presents the design fabrication Parabolic-trough solar water heating is a well-proven technology that directly substitutes renewable energy for conventional energy in water heating. In Two meters parabolic solar concentration has been fabricated to produce boiled water up to 100^{o}C for the purpose of central heating services. The concentration is toward the sun light during the day time; by using a control circuit, The amount of the portable water was much dependent on the accurate focusing of the system which increases according to preheating. This system could therefore be used for heating water at home via increasing the temperature in hot tank by covering the hot water and isolating the tank from the surroundings.
Keyword: Solar concentration, solar hot water, heat transfer, solar thermal, parabolic reflector, solar trough . Parabolic trough concentrator, Fixed focus concentrator, Standing reflectors .

Introduction
the best example of successful application of solar trough collector can be seen in the nine commercial Solar Electric Generating Systems (SEGS) located in the Mojave Desert of California, USA [1] . The DISS test-loop is consisted of nine 50-m and two 25-m LS-3 collectors connected in series, giving a total length of 550 m. The DISS collectors are capable of direct steam generation and can achieve an overall solar-to-net electric efficiency of up to 23% [2].They presented the advantages, disadvantages, and design considerations of a steam cycle operated with saturated steam. A simulation study of solar lithium bromide–water absorption cooling system with a parabolic trough collector is carried out by Mazloumi et al. [3] A detailed heat transfer analysis and modeling of a parabolic trough solar receiver were carried out by Foristall [4]. One and two dimensional energy balances were used for short and long receivers, respectively. A model was used to determine the thermal performance of parabolic trough collectors under different operating conditions. Jones et al. [5] in parabolic trough solar thermal generation system. It is used to convert solar radiation to thermal energy. Optimizing its performance and improving its efficiency has important effects on the thermal-electricity conversion efficiency. Kalogirou et al. [6] studied the performance of parabolic trough collectors using a theoretical model. They predicted the quantity of steam generated by the system. The optimum flash vessel diameter and inventory obtained from this analysis are 65 mm and 0.71, respectively. Current state of the art of parabolic trough solar power technology is reviewed by Price et al. [7]. the results showed that the high nickel alloys had excellent thermo-mechanical properties compared to the austenitic stainless steel. Almanza and Flores [8,9].Research involving inexpensive and fresh sources of energy such as solar energy, recently the use with solar energy for electricity generation, air conditioning and water heating has grown-up. [10] In the domestic applications, households consume energy by using air conditioning, heating, water heating, lighting and other uses. Solar water heating (SWH) or solar hot water (SHW) systems comprise several improvements and many established renewable-energy technologies that have been well recognized until many years. SWH has been widely used in Australia, Austria, China, Cyprus, Greece, India, Israel, Japan and Turkey **[11]**.

Theory:-
The "concentration ratio" is used to describe the amount of light energy concentration achieved by a given collector. Optical Concentration Ratio (CR_o). The averaged irradiance (radiant flux) (I_r) integrated over the receiver area (A_r), divided by the insulation incident on the collector aperture. [12]

$$CR_o = \frac{\frac{1}{A_r}\int I_r dA_r}{I_a} \quad \text{-------------------} \quad (1)$$

Geometric Concentration Ratio (CR_g). The area of the collector Aperture A_a divided by the surface area of the receiver A_r

$$CR_g = \frac{A_a}{A_r} \quad \text{----------------} \quad (2)$$

Optical concentration ratio relates directly to lens or reflector quality; If the origin is taken at the vertex V and the x-axis along the axis of the parabola, the equation of the parabola is

$$y^2 = 4fx \text{-------} \quad (3)$$

where f, the focal length, is the distance VF from the vertex to the focus. When the origin is shifted to the focus F as is often done in optical studies, with the vertex to the left of the origin, the equation of a parabola becomes

$$y^2 = 4f(x+f) \text{----------} \quad (4)$$

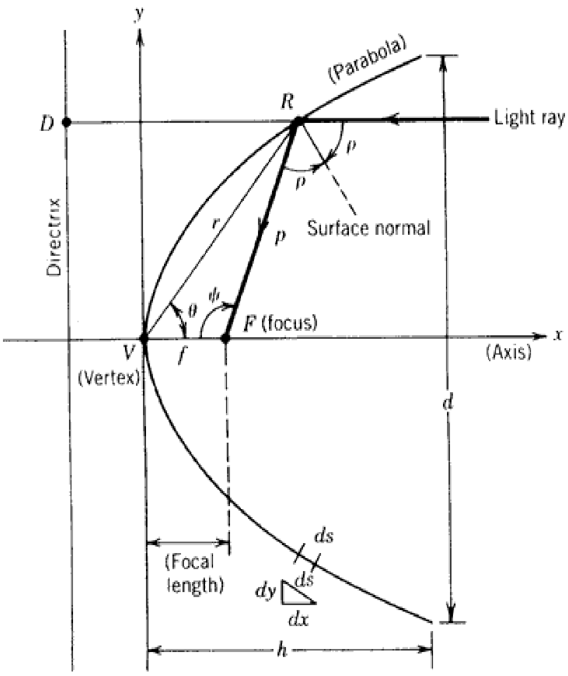


Fig (1) The parabola [12]

In polar coordinates, using the usual definition of (r) as the distance from the origin and (Θ) the angle from the x-axis to r, we have for a parabola with its vertex at the origin and symmetrical about the x-axis . The general expressions given so far for the parabola define a curve infinite in extent. Solar concentrators use a truncated portion of this curve. The extent of this truncation is usually defined in terms of the rim angle (ψ_{rim}) or the ratio of the focal length to aperture

$$h = \frac{d^2}{16f} \text{------------------- (5)}$$

In a like manner, the rim angle (ψ_{rim}) may be found in terms of the parabola dimensions:

$$\tan \psi_{rim} = \frac{1}{(d/8h) - (2h/d)} \text{--------- (6)}$$

Another property of the parabola that may be of use in understanding solar concentrator design is the arc lengths. This may be found for a particular parabola from Equation (3) by integrating a differential segment of this curve and applying the limits x = h and y = d/2 as pictured in Figure (1). this area should not be confused with the reflecting surface area of a parabolic trough or dish or their aperture areas [13]

$$\tan\left(\frac{\psi_{rim}}{2}\right) = \frac{1}{4(f/d)} \text{------------ (7)}$$

$$\frac{f}{d} = \frac{1}{4\tan(\psi_{rim}/2)} \text{------------- (8)}$$

Collector Efficiency

The solar energy collection efficiency, η_{col} of both thermal collectors and is defined as the ratio of the rate of useful thermal energy leaving the collector, to the useable solar irradiance falling on the aperture area.:

$$\eta_{col} = \frac{\dot{Q}_{useful}}{A_a I_a} \text{----------- (9)}$$

where:

$\dot{Q}_{useful}$ = rate of (useful) energy output (W)
A_a = aperture area of the collector (m^2)
I_a = solar irradiance falling on collector aperture (W/m^2)

This general definition of collector efficiency differs depending on the type of collector. The rate of useful energy output from thermal collectors is the heat addition to a heat transfer fluid as defined by collector absorber or receiver can be written as; The 'useful' energy for a solar thermal collector is the rate of thermal energy leaving the collector, usually described in terms of the rate of energy being added to a heat transfer fluid passing through the receiver or absorber , [14 ,15] :

$$\dot{Q}_{useful} = \dot{m} c_p (T_{out} - T_{in}) \quad (W) \text{-------(10)}$$

where:

$\dot{m}$ - mass flow rate of heat transfer fluid (kg/s)
c_p - specific heat of heat transfer fluid (J/kg·K)
T_{out} - temperature of heat transfer fluid leaving the absorber (K)
T_{in} - temperature of heat transfer fluid entering the absorber (K)

Experimental setup

Collector design:-

Parabolic Trough

The trough collector consists of low-cost iron sheet of 1.5 mm thickness covert by silver miler sheet , which has undergone a careful deformation process that was necessary to bring it to parabolic shape as shown in **Fig.(2)**

Fig(2) Parabolic trough collector;

the aperture width of the trough is taken 1m and its focal length is 0.2 m. The aperture area of the reflecting surface is 2 m^2. To maintain the parabolic shape intact, cross-ribs made of cast iron are provided on the back surface. For reflective surface of the collector, locally available silvery polymer mirror film for reflectivity76% and used on the collector. The trough collector is then mounted on wheeled stand made of slotted iron .

Receiver

By using copper pipe with length 2.25 m, diameter 2.5mm fixed on the trough its around 20 cm away from the vertex it's a focus we install 2 valve on both sides of the pipe then we paint the pipe black .

Sun-Tracking

By using single motor to move the trough . The tracking mechanism was developed to rotate the collector about axes. Because the trough in design can be rotated 180° around the axis and use a control with two CdS detector

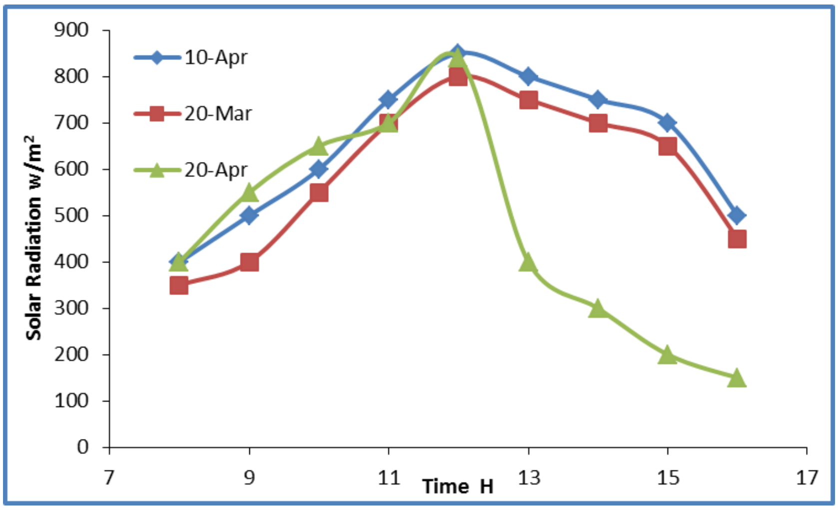
Storage tank :-

we used one tanks which are made from steel that is used to storage Freon gas and we made modifications by making two holes for water inlet , outlet and place for installation thermocouple Fig(3).

Fig (3) show storage tank

Testing and Result

In this work I studied solar radiation with time in Iraq Tikrit experimental for altitude (34.59) and longitude (43.68) 10- 20- April, 10- May2014 Fig (4), because Iraq in the middle of solar radiation I notice increasing in the solar radiation with time between 9:00 AM to 1:00 PM and decreasing between 1:00AM to sun set and notice decrease in the solar radiation (20/4/2014) at 10.14 o'clock this result due to the pass of the partial clouds.

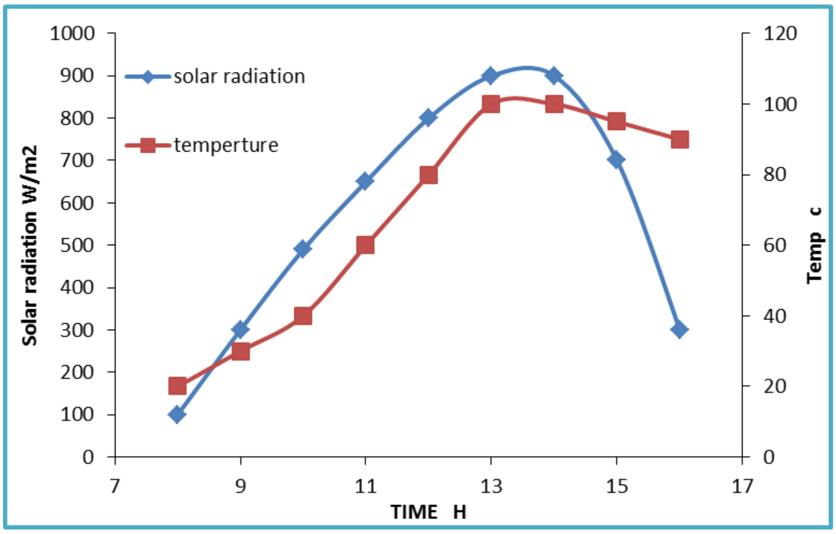


Fig(4) Relation between solar radiation with time.

(Table-1): Details of the solar concentrator:

Surface collecting of the parabola	2.0 m^2
Depth of the parabola	0.9m
Focal distance f	0.2 m
Rim angle	45 °
Efficiency of parabola	50%

In this figure (5) we notice increasing in the water temperature with time comparing with the increasing of solar radiation is because Iraq is in a suitable place for solar thermal application[16].



Fig(5) Show relation between Solar radiation and temperature with time

In Fig (7,6) notice efficiency decreasing with work temperature The efficiency is to high when start operation and decrease with time and operation temperature the system the radiation losing energy proportional to 4th power of receiver and indicator receiver is suitable [12] .

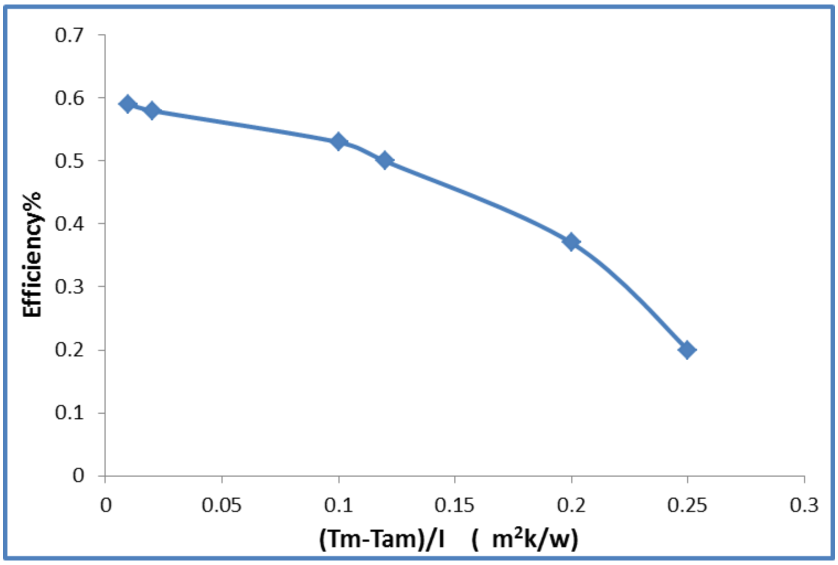


Fig (6) Relation between Efficiency and work temperature (16)

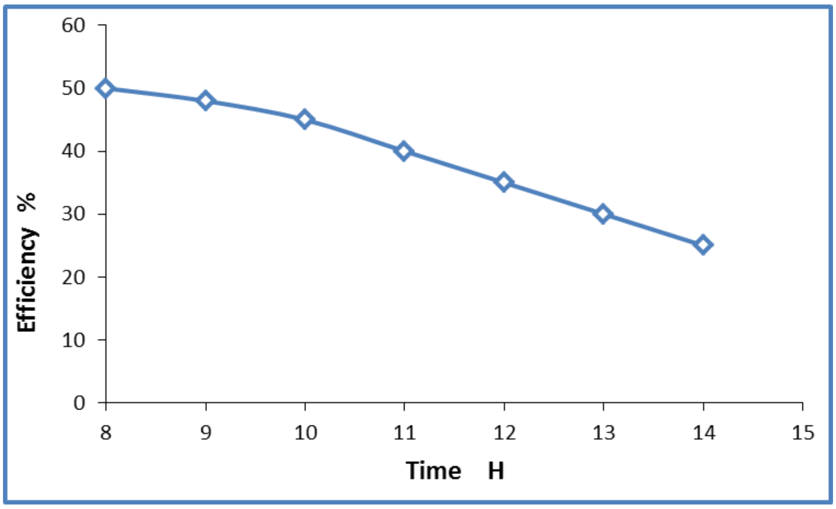


Fig (7) Relation between Efficiency and Time.

We tested the system for 2 hours and 30 minutes we found out during this period of time that the temperature of the tank is more than 100 °C we can increase this temperature and saving it for long time by isolating the system pipes and the tank from surrounding environment by using thermal isolated sheet Fig(8).

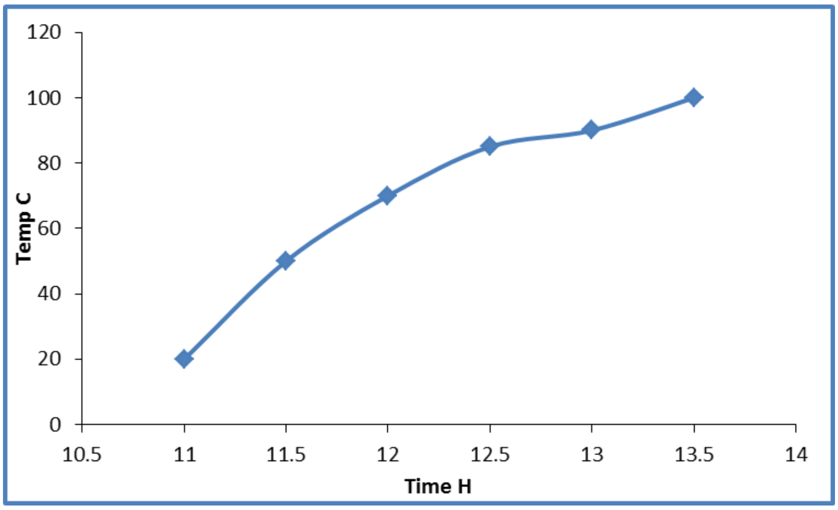


Fig (8) Show relation of temperature of the tank with time.

Conclusion

Parabolic trough solar thermal is a good example for solar thermal and there are many applications for this trough .one of this application, In this paper is design and fabrication of low cost of solar trough concentration and study parameter in home also study the solar radiation in this location we find out that the solar radiation is enough for all application of solar thermal and designing sample solar water heater ,I found out this is a suitable to heat water and increasing the temperature with increasing solar radiation and used a solar tracking and increasing the active area for solar trough and when used many stage the temperature increasing faster to super temperature .

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تصنيع المركز الحوضي لأغراض تسخين المياه

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قسم الفيزياء ،كلية العلوم ، جامعة تكريت ، تكريت ، العراق

الملخص

في هذا البحث تم تصميم مركز الشمسي الحوضي لتسخين المياه بالطاقة الشمسية المباشرة وهي تكنولوجيا جيدة ضمن مشاريع الطاقة المتجددة. تم استخدام مركز طوله2 متر من نوع الحوضي على شكل قطع مكافئ للوصول الى تسخين ماء بدرجة حرارة $100\ ^{o}C$ لأغراض الاستخدامات المنزلية. يوجه المركز نحو الشمس خلال النهار باستخدام دائرة التحكم (تتبع شمسي)، كما ان كمية المياه المسخنة تعتمد على درجة تركيز الاشعاع الشمسي على المسخن. وبالتالي يمكن أن يستخدم هذا النظام لتسخين المياه في المنزل عن طريق زيادة درجة الحرارة في خزان السخان من خلال تغطية وعزل الخزان عن المحيط .