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New Laboratories Design of Solar Collectors Suitable for Basrah City 30.5^0 N

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ABSTRACT: *Since Iraq go through a shortage of electricity production due to numerous factor, so this study aimed to reduce the consumption of electrical energy used for the purpose of obtaining hot water in the winter season where the temperature may be drops below zero degrees Celsius on some days. We design and study a number of solar systems that are fit for work in the atmosphere of the city of Basra, which lies at a latitude of 30.5^{0}N. The study demonstrated the feasibility of obtaining temperatures in these systems may sometimes up to 90 degrees Celsius even in the coldest days. The cost of the manufacture of this solar tank is very low and easy which make every house in the city can be used it.*

KEYWORDS: *Optical efficiency; ICSSWH; Thermal performance; Technological development*

I. INTRODUCTION

There are many types of solar collectors such as glazed, unglazed, and selective surface coated solar collector. A solar thermal collector is a special heat exchanger that transforms solar radiative energy in heat. A solar collector differs in several respects from conventional heat exchangers: it does not accomplish a fluid to fluid exchange, but the energy transfer is from a distant radiant source to a fluid (the most common working fluid is water. During the last two decades a number of researchers have worked on developing new and more efficient solar collector or improving existing ones [1–5]. The integral collector/storage solar water heater (ICSSWH) is quite possibly the most well known and simplest solar water heating system. It's developed from early systems often known as the "bread box" system, it was originally produced in the 1970's but is still in use now. It is simple, efficient and cheap to build. You simply paint a tank black, put it in a big crate, and insulate it all around except one side that needs to be covered by glass or plastic. To be viable economically, the system has evolved to incorporate new and novel methods of maximizing solar radiation collection whilst minimizing thermal loss. All it takes is a tank, insulation and sun. The water is collected, stored and warmed all in one container. Advances in ICS vessel design have included glazing system, methods of insulation, reflector configurations, use of evacuation, internal and external baffles and phase change materials.[6]. To understand the basic theory of the solar collector one should refers to the works of Duffie, Badran and Bando [7-9], Hatfield [10], Bohn [11] , Whilier [12-14], Duffie [15] and Xin-Rong [16]. The advantages to the integral collector/storage system are low cost, no pumps or controls Simple, and Long-lasting. The large size of the tank helps to avoid freezing problems often seen in thermo-siphon units. The disadvantages are water doesn't get really hot, heat loss from the collector, and discontinuity of the optimal use of the hot water produced. In this paper we try to build an integral collector solar heater suitable for Basra city 30.5N south of Iraq. Our model has been tested in winter days where the outside temperature falls below 5^0 C and it seem working wall. To generalized our model, a theoretical analysis has been carried out which allow us to predict the amount of hot water needed ant its temperature. The theoretical model show a good agreement with our experimental data.

II. THEORY

There are a few parts that are basic to most solar water heating systems, collector(s), storage tank, heat transfer medium, and interconnecting plumbing. The collector intercepts the sun's rays and converts it into heat which is transferred to the storage. A cross-section solar collector used in this study is shown schematically in figure (1). consists of number of important functional components fabricated as a ‘sandwich’; is comprised of essentially four major components, the glazing, air gap and insulation layers act to prevent heat loss from the solar collector to the environment, and the absorber tube. The other two components will now be discussed in more detail:

- The glazing layer: This allowed the incoming solar radiation near infrared to pass and blocks the radiation in the far infrared as well as this layer prevents the heat losses from the system to the outside via convection and radiation. One more advantage tho the glazing layer is to prevent mechanical damage to the absorber component and to act as an easy-to- clean surface. In this system is used the normal glazing available in Basra market due to low cost and its solar transmittance can be up to 90%.

- The absorber cylinder: The overall dimensions of the system are 100cm x 60cm x 12cm, the collector cylinder are 5.0 cm in diameter and 80 cm in length, so the volume of this collector is approximately 1.8 liter.

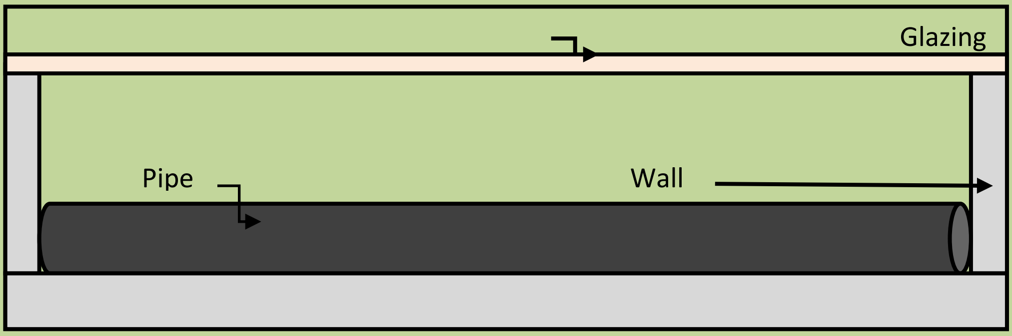


Figure (1) schematic diagram of a cross-section solar collector used in this study

To allow the solar radiation transmitted through the glazing propagates onto the absorber plate. The absorber plate must absorb an optimum amount of solar radiation whilst minimizing thermal re-radiation. Typically, the absorber is painted with black. Based on this experiment set up the general conservation equation of this model can be written as :

$$\rho c \frac{\partial T}{\partial t} = \frac{\partial}{\partial x}\left(k \frac{\partial T}{\partial x}\right) + S \tag{1}$$

This equation is one dimensional unsteady heat equation with source term S, ρ is the density , c is the specific heat, and k stand for conductivity. For convenient we shall assume the terms ρc and k are constant. According to the above set up this equation seem to be one way coordinates in term of spatial and time coordinates, one can obtained the solution by marching in time from a given initial distribution of the temperature. The discretization equation can be derived by integrating equation (1) over a convenient control volume and over the time interval from *t* to *t* + Δ*t* thus:

$$\rho c \int_{x_{i-1}}^{x_{i+1}} \int_{t}^{t+\Delta t} \frac{\partial T}{\partial t} dt dx = \int_{x_{i-1}}^{x_{i+1}} \int_{t}^{t+\Delta t} \frac{\partial}{\partial x}\left(k \frac{\partial T}{\partial x}\right) dt\, dx + \int_{x_{i-1}}^{x_{i+1}} \int_{t}^{t+\Delta t} S dt dx \tag{2}$$

where the order of integrations is chosen according to the nature of the term. By employing the Crank-Nicolson scheme, the result is

$$a_i^k T_i^k = a_{i+1}^{k-1}\left[T_{i+1}^k - T_{i+1}^{k-1}\right] + a_{i-1}^k\left[T_{i-1}^k - T_{i-1}^{k-1}\right] + \left[a_i^{k-1} - a_{i+1}^{k-1} - a_{i-1}^k\right] T_i^{k-1} + S_0 \tag{3}$$

Where for first approximation assume

$$a_{i+1}^{k-1} = a_{i-1}^k = \frac{\rho c}{2\delta x}, \quad a_i^{k-1} = \frac{ps\Delta x}{\Delta t}, \quad a_i^k = 2a_{i-1}^k + a_i^{k-1} \tag{4}$$

The solution shown in Eq. (3) and the linearization used in this solution "the nonlinearity in this set of equations results from the quadratic temperature terms" allowed this problem to formulated as a linear system of algebraic equations, shown in vector form in Eq. (4); the solution to each iteration of this linear system therefore became the solution to a matrix inversion problem:

$$\mathbf{T} = \mathbf{M}^{-1}\mathbf{C} \tag{5}$$

Here M is a square matrix, which contains all the coefficients of the temperature dependencies that result from the energy balance equations. The boundary conditions for the solution domain were specified temperatures at the solar collector inlets and out let only. The initial condition for the temperature field was that all nodes were specified to be a known, and uniform, temperature.

III. RESULT AND DISCUSSION

There is no doubt that we are dealing in our experimental with laboratory models, which can be generalized to become available in commercial form. In this study mainly six types of water solar collectors for domestic heating and hot water production are used. These six very simplest designs of water collector are made and tested. The design are made in a way that every house with simple used material available with him in Basra city can made them, and fitted the collector through the main pipe line of water in his house, these designs are as follows:

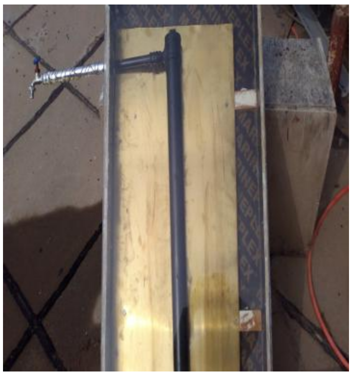
First model: This collector consists of the galvanized iron tube, close at both ends tightly, and have dimensions (length 80 cm, diameter 5 cm, volume 1570 cm^3). This tube is fitted 5 cm away from both bases (upper and

lower). The inlet and outlet pipe are of length 25 cm and diameters 1.25 each, which are fitted in opposite side. The inlet cold water is interred from the bottom of the tube and the outlet of hot water is discharge from top as shown in figure (2). Second model: To benefit from the greenhouse phenomenon, a wood box of dimension (112 cm * 62 cm* 12 cm) is made, the upper base is cover with a glass plate as shown in figure (3).
Second model: The first model now is fitted in this box in a manner that is 5 cm away from each basses (upper and lower).
Third model: Same as second model but the main pipe and all the accessories of the collector now coated with black paint as shown in figure (4). The upper face of the box is cover with glass plate to avoid the heat loss from them.
Fourth model: Same as third model with a copper plate is used underneath the main pipe collector as shown in figure (5). This copper plate work as a good refractor material with dimension (50 cm x 95.5 cm).
Fifth model: Same as fourth model, but now all the side of insulation box are cover with and aluminum sheet to increase the amount of reflected radiations and minimize the heat loses to outside space as shown in figure (6).
Sixth model: Same as fifth model, but in this case the main pipe collector are double in order to increase the amount of production of hot water. The total capacity of water of this model is around 3140 cm^3 as seen in figure (7)**.**
The choice of the optimal collector depends on the temperature level required by the specific application and on the climatic conditions of the site of installation. Therefore, in terms of efficiency, each collector displays features which make it most suitable to a certain application. Sets of results deriving from the collectors in our test methods should be fully comparable between them and allow drawing efficiency curves. However these efficiency curves do not necessarily represent the usual operating conditions and do not describe the global performance of the collector for the entire day under these conditions we will not analysis the performance of the collectors from the efficiency point of view. In straight uses solar collectors can provide energy for domestic hot water with low inlet water temperature systems during winter season in Basrah city (approximately 5-10°C), whereas this heat has to be provided above a minimum temperature of 80-90°C of outlet hot water. Extensive data have also been collected in dynamic conditions to evaluate the performance of the collectors in the whole day (daily tests), at various conditions., where the daily useful collected heat capacity per second is plotted against the day light hours. This approach allows a more comprehensive comparison of the effective performance of the six types of solar thermal collectors considered here. The above mention models are put under test in November 2013, the data are recorded between 8:00 AM and 4:00 PM. Since the heat capacity is an extensive property, meaning it depends on the extent or size of the physical system which means a sample containing twice the amount of substance as another sample requires the transfer of twice the amount of heat (Q) to achieve the same change in temperature (ΔT). In our model except model number (6), the size of the collectors is the same for the other entire five models. Based on this, then the heat capacity per second is calculated for the different collector. Figure (8) shows the relation between heat capacity per second for each collector as a function of day light hours. Figure (8a) represents a comparison between model No. 1 and model No. 2. One can become aware of that there is an increase in the amount of heat absorbed by the collector by model No 2 and reaches the highest amount of heat absorbed between 1:00 PM and 2:00 PM. Figure (8b) to figure (8d) are a comparisons between two adjacent models that are between model No. 2 and model No. 3, and between model No. 3 and model No. 4, and so on. From these figures one can conclude that the better thermal performance is collector (N0.5), and the least thermal performance is collector (No.1) in different condition weather. Figure (8e) represent a comparison between collector No. 5 and collector No. 6, one can see that when the volume is double the outlet water temperature is decreases, but still is suitable for the weather conditions in Basrah, because the amount of hot water gain with collector No. 6 is twice as that for others collectors. Figure (8f) represent a weekly average comparison between all collector, from this figure one can recognize that collector No.5 is the best one among the others collectors. It is worth to say her that the container box of the collector No, 5 is reduce by half its original size in order to minimize the amount of heat losses from the box, and the result is promise which means we have carry on more and more suggestion in future to end up with the best performance collector can do job with the weather condition in Basrah city 30. 5 N. It is worth to say that, there is several key problems involved in adopting this kind of energy. Firstly, using solar energy depends on location of the site. The best site must have no shade on solar collectors. In addition, it is preferable to face the solar collector to the Equator to receive maximum solar radiation. Secondly, the available solar radiation varies with weather conditions. This means that on a cloudy day the system may not heat water sufficiently to meet the requirements of hot water applications. Another problem in using solar water heating is that during midday the availability is high when demands are low. Therefore, substantial thermally insulated hot water storage is needed. As a conclusion one can say that, the location of installation plays a very significant role in the amount of hot water supply by the collectors. The appropriate decision can contribute not only to the amount of hot water generation but also in reduction of greenhouse gases to the atmosphere.


Model No. (2)


Model No. (3)


Model No. (4)


Model No. (5)


Model No. (6)


Model No. (7)

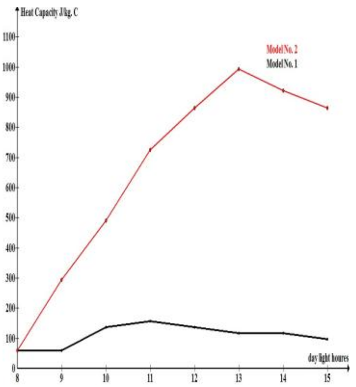


Figure (8a) Models No. (1-2)

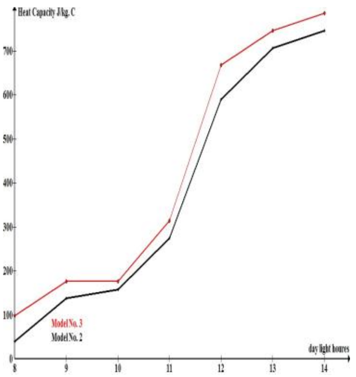


Figure (8b) Models No. (2-3)

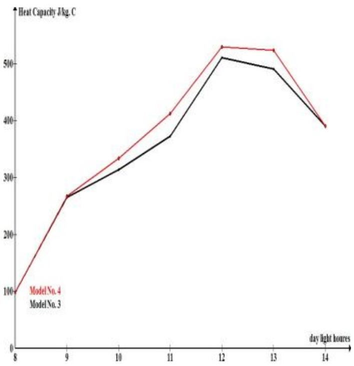


Figure (8c) Models No. (3-4)

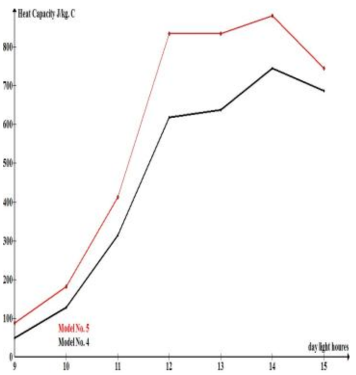


Figure (8d) Models No. (4-5)

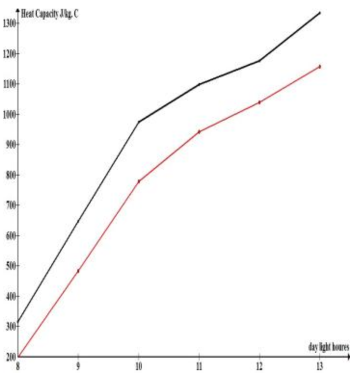


Figure (8e) Model No. (5-6)

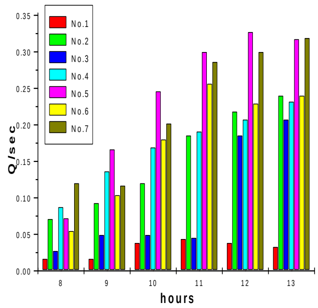


Figure (8f) All Models

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