CH.3

TEST REG. & EXPERIMENTAL SETUP

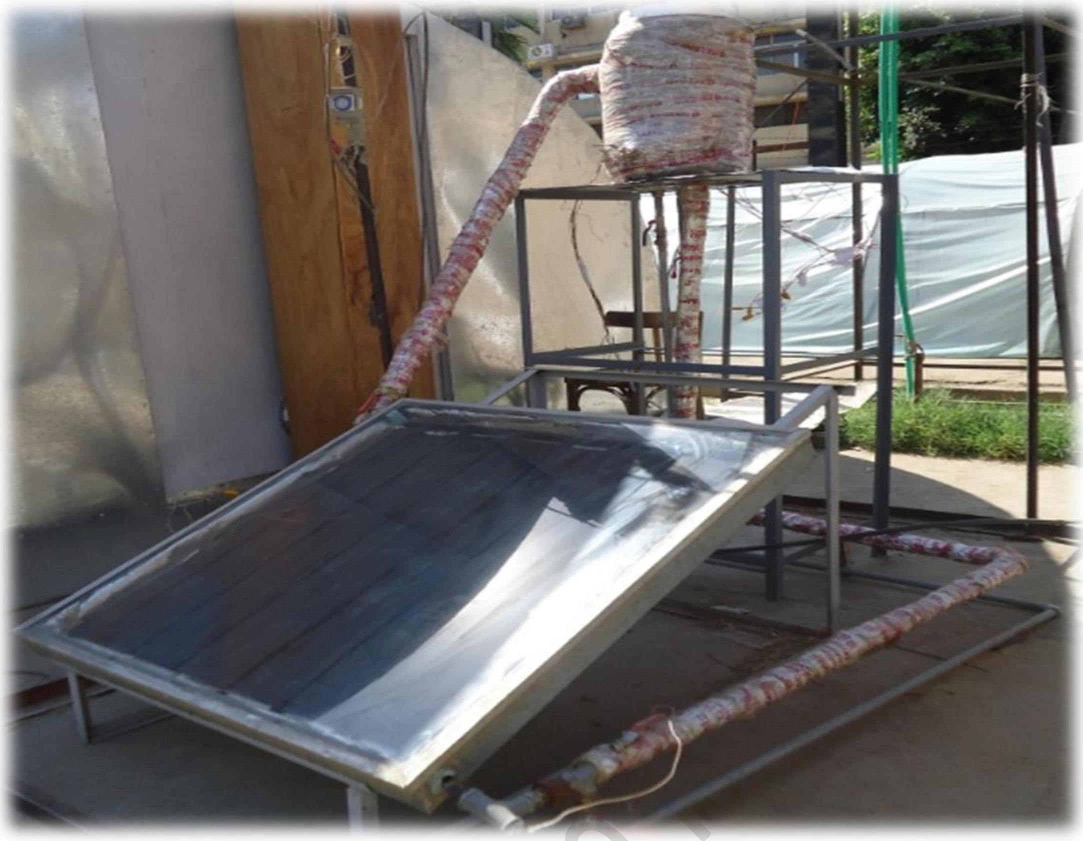

Fig 3.1 our solar water heating system

3.1 Introduction

This chapter deals with the matter of documentation of the experimental work in this project, including the next content:

1. **An introduction to experimental part of the project-the flat plate solar collector- and its principle of work.**
2. **The steps for manufacturing every part of the flat plate solar collector we made, including the pictures and drawings of each part and for the final arrangement and also materials used with its properties.**
3. **The steps of modifying the system with PCM capsules.**

3.2 Materials

Selecting the suitable and effective materials is considered to be one of the important – or basic – steps in manufacturing such a

sensitive device like flat plate solar collector , because if we want to get the higher efficiency you can from the unit you must select your materials carefully .

For example, the absorber material must have a very high thermal conductivity to conduct heat fast and effectively to the pipes and then to the heating fluid with minimum value of losses.

The same thing for the selective coating that is painted on the absorber which allows the absorber metal to absorb the largest amount of energy it can absorb form the sun.

Also the same thing for selecting the suitable materials for insulation which provide better insulation in each case to reduce the heat losses as much as we can.

This Table summarizes all data related to the materials used in the experimental work

For collector		
Materials	DESCRIPTION	
Riser	**diameter**	**11 mm**
Header	**diameter**	**15 mm**
Plate (fin)	**Area**	**(0.9*0.9) m^2**
Aluminum box	**Volume**	**(1*1*0.08)m^3**
Glass cover	**Area**	**1 m^2**
Aluminum edges	**Length**	**4 m**
Glass wool	**Area**	
Paint(primer)	**Weight**	**0.25 kg**
Paint(black)	**Weight**	**o.25 kg**
Pipes welding	**Type**	**oxygen welding using copper wire**
Rivet welding		
Rubber tape	**Length**	**4 m**

For piping system		
Pipes	**length & diameter**	**16 m &0.5 inch**
Elbow	**number**	**7**
T-joint	**number**	**4**

Glass wool	Area	1.2 m^2
Valves		
Other joints		

For tank		
Tank	volume	30 liter
Faucet		
Glass wool	Area	1 m^2
Others		

Latent heat storage system (PCM capsules)		
Paraffin wax	melting point	53 ^{0}C
Balls	diameter	8 cm
Thermo couple welding with balls	Type	oxygen welding using copper wire
Epoxy		
Thermocouple	Usage	Measure temp.
K-type joint		

Steel	Thermal Conductivity	55
Aluminum	Thermal Conductivity	202
Copper	Thermal Conductivity	386

3.3. The Manufacturing Process

3.3.1 The Collector

The collector is an aluminum section box 100 cm length by 100 cm width and 8 cm depth contains the absorber, the glass and the insulation.

3.3.1.1 Absorber

It is made of copper. The surface is covered with a flat black material of high Absorption. Copper is used so it is possible to apply

a selective coating that maximizes the Absorption of solar energy and minimizes the radiation emitted by plate.

Copper which has high conductivity and is corrosion-resistant is the material for absorber plates. For a copper plate 0.9*0.9 m^2 & 0.035 cm thickness with 1.1 cm tube diameter spaced 11 cm apart in good thermal contact with the copper.

Material	**Absorber fins copper & K=385 W/m·°C**
	Tubes: copper (CDA 1220/0 alloy)
	Headers: copper (CDA 1220/0 alloy)
Dimensions	**Riser's diameter: 11 mm**
	Tube spacing: 110 mm
	Header diameter: 15 mm
	Fin thickness: 0.35 mm
Expansion	**To allow for thermal expansion, the absorber is free to float within the collector container.**
Max temp.	**Maximum Temperature is 100°C.**

Table of Properties of the absorber

<u>Steps:</u>

1- Cutting 7 pipes (risers) with diameter11mm and equal dimensions.

2- Cutting two pipe (headers) with diameter 15 mm into two equal dimensions.

3- Drilling the two pipes 7 holes on the same straight line including equal distances.

4- Welding the 7 pipes in the places of the holes of the headers pipes (oxygen welding using copper wire).

5- Formation of the copper plat to open base trapezoidal to make the working fluid spread in all pipes to exchange large amount of heat with fin.

6- The riser pipes were linked with the copper plate using copper wires instead of using the welding along the pipes.

Fig 3.2 the absorber (copper plate & pipes)

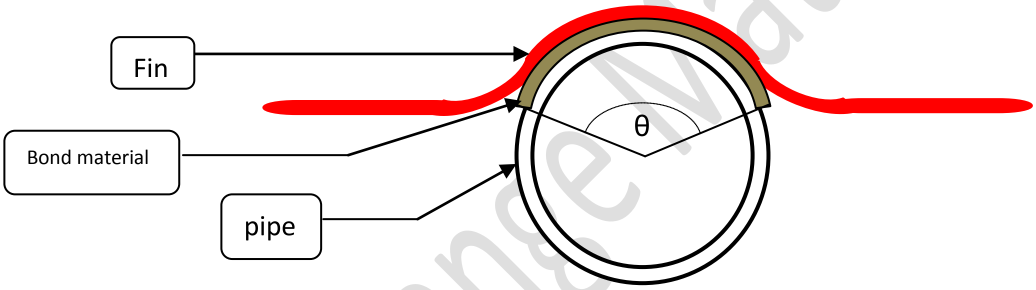

Fig 3.3 welding of plate fin and riser pipe

3.3.1.2 Glass Cover

To reduce convective and radiative heat losses from the absorber, one or two transparent covers are generally placed above the absorber plate. We use one transparent cover made from tampered glass.

Acover plate for a collector should have a high transmittance for solar radiation and should not detoriate with time. The material most commonly used is glass. A 0.5 cm sheet of window glass transmits 85 percent of solar energy at normal incidence. And all glass is practically opaque to long-wavelength radiation emitted by the absorber plate.

We use 5mm single sheet of low-iron tempered glass with rubber seal around the edges and aluminum edges.

Thickness	5 mm
Spacing	Glazing to absorber: 25 mm
Physical Treatment	All glazing is tempered with swiped edges and has a

	shallow stipple pattern to reduce seculars reflectance.
Operating Temperature Range	**Min: below -46°C; max: 260°C.**
Energy Transmission	**Solar spectrum (0-3 micrometers) 89.5%.**

Table: Properties of the cover plate

Fig 3.4 glass cover of flat plate

3.3.1.3 Insulation

These are some materials such as glass wool and they are placed at the back and sides of the collector to reduce heat losses.

Collectors are insulated around the sides and back with glass wool.

Thickness:	**Side: 25 mm**	**Back: 40 mm.**
Thermal Conductivity	**0.035 W/m·°C at 24°C**	
Operating Temperature Range:	**Maximum continuous operating temperature is 232°C**	

Table Properties of the Insulation

Fig 3.5 **Insulation of flat plate collector**

3.3.1.4 Enclosure

A box of Aluminum (1*1) m^2 that the collector is enclosed in holds the components together, protect them from weather, facilitates installation of the collector on a roof or appropriate frame.

The collector enclosure is usually made from aliminium in order to prevent heat from escaping through the back of the collector, a layer of insulation is placed behind the absorber plate.

Fig 3.6 **the box of flat plate collector**

3.3.1.5 The solar collector assemblage

The collector is assembled in four stages. First, the collector frame and backing sheet are assembled. Second, the back and side insulation are installed. Third, the tested absorber assembly is

inserted, and finally, the glazing, Rubber tape and Aluminum edges are installed.

- **Insulation**

  Insulation is placed on the aluminum back and along the sides.

- **Absorber Assembly**

  The absorber is fitted into the insulated container with the inlet and outlet connection pipes protruding through the sides.. The absorber is free to expand or contract inside the container.

- **Glazing Assembly**

  The glass is cleaned and fitted above Rubber tape which fitted at the edges of container. A removable aluminum cap (edges) stripping is then secured to the container with stainless steel screws.

- **Collector Container**

  Collector container sides are fabricated from aluminum extrusions with an integral mounting channel. The bottom is an aluminum sheet which fits into a slot in the frame and is riveted to the sides.

  Extruded framework is aluminum alloy. The back sheet is aluminum sheet with a thickness of 0.5 mm.

- **Moisture Control System**

  holes in the back sheet allow sufficient air flow through the collector to remove any condensation or moisture.

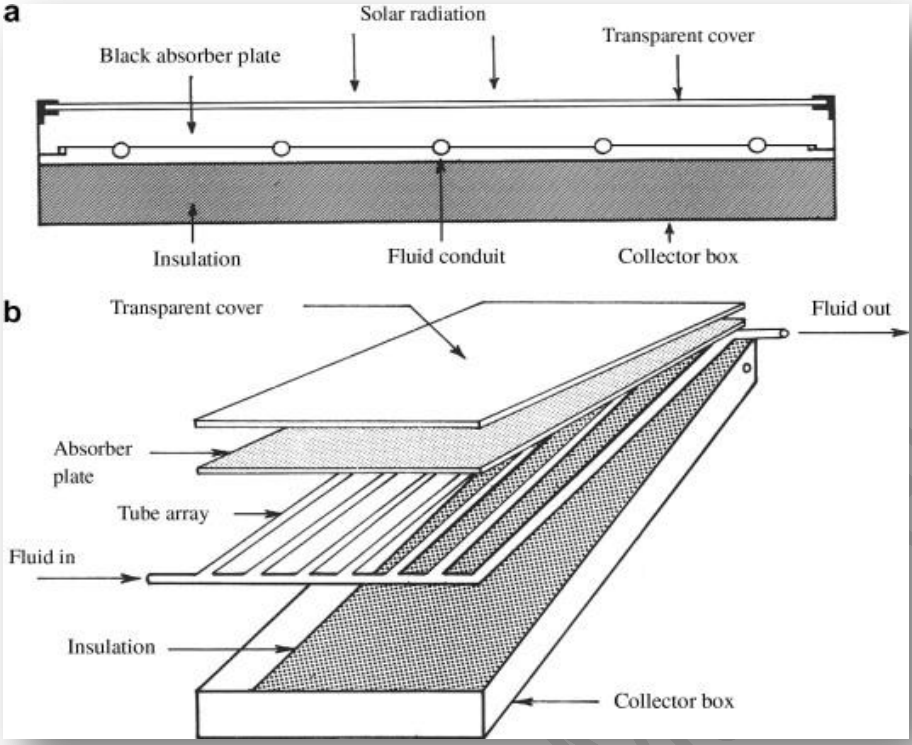

Fig3.7 assembly of flat plate collector

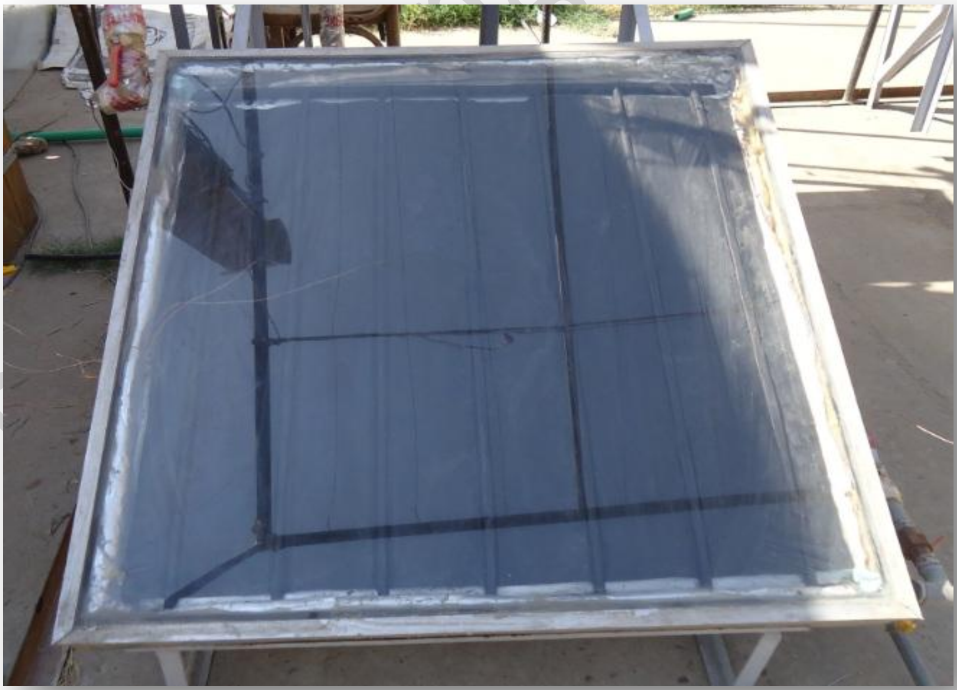

Fig 3.8 the flat plate collector

3.3.2 The Base

The base of collector make angle 30 degree with Horizontal.

Fig 3.9 the collector and its base together

3.3.3 The Tank

Useful heat energy stored in the tank which insulated by glass wool to decrease heat losses. Our tank has a capacity of 30 litres.

Fig 3.10 the storage tank

Fig 3.11 insulated storage tank

3.3.4 Thermosyphon system is operating system

For storing water overnight or on cloudy days, a storage tank is needed. A very simple way of doing this, making use of the thermosyphon system.

The principle of the thermosyphon system is that cold water has a higher specific density than warm water, and so being heavier will sink down. Therefore, the collector is always mounted below the water storage tank, so that cold water from the tank reaches the collector via a descending water pipe. If the collector heats up the water, the water rises again and reaches the tank through an ascending water pipe at the upper end of the collector. The cycle of tank–water pipe–collector ensures the water is heated up until it achieves an equilibrium temperature. The consumer can then make use of the hot water from the top of the tank, with any water used is replaced by cold water at the bottom.

The collector then heats up the cold water again. Due to higher temperature difference at higher solar irradiances, warm water rises faster than it does at lower irradiances.

Therefore, the circulation of water adapts itself almost perfectly to the level of solar irradiance. A thermosyphon system's storage tank must be positioned well above the collector, otherwise the cycle can run backwards during the night and all the water will cool down. Furthermore, the cycle does not work properly at very small height

differences. In regions with high solar irradiation and flat roof architecture, storage tanks are usually installed on the roof.

Thermosyphon systems operate very economically as domestic water heating systems, and the principle is simple, needing neither a pump nor a control. However, thermosyphon systems are usually not suitable for large systems, that is, those with more than10 m^2 of collector surface. Furthermore, it is difficult to place the tank above the collector in buildings with sloping roofs, and single-circuit thermosyphon systems are only suitable for frost-free regions.

Flow Rate	**1 L/min.**
Maximum Operating Pressure	**Factory tested to 1724 kPa.**
Maximum Operating Temperature	**300°C.**
Heat Transfer Fluids	**water**

Table Properties of the thermosyphon system

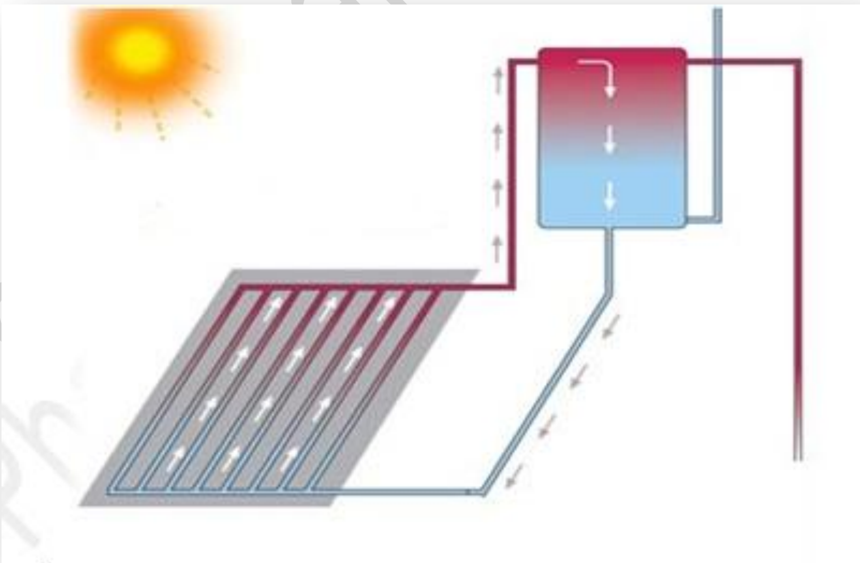

Fig 3.12 Thermosyphon system

3.4The Final Arrangement

Fig 3.13 final arrangement our solar water heating system