Palestine Polytechnic University

Collage of Engineering

Mechanical Engineering Department

Hebron – Palestinea

Analayzing and Building of solar Assisted absorption cycle

By

Mohammad murrar

Mohammad jundi

Hazem abu obeid

Submitted to the Collage of Engineering

In partial fulfillment of the requirements for the

Bachelor degree in Automotive Engineering.

Supervisor Signature

....

16/1/2020

Department Head Signature

....

Jan. 2020

Palestine Polytechnic University

College of Engineering and Technology
Mechanical Engineering Department

Analyzing and Building of solar Assisted absorption cycle

Graduation project

Project team

Mohammad murrar **Mohammad Jundi**

Hazem abu obeid

Project supervisor

Eng: Mohammad Awad

Hebron – Palestine

December 2019

Dedication

We gift this project

To our parents who raised us

To who carry candle of science

To light avenue

Of live

To all student &who

wish to look for

the future

to who love the knowledge &

looking for all is new

in this world

Acknowledgments

Our thanks go first to our adviser Eng. mohammad Awad.

Which his guidance and support made this work possible, who gave us constant encouragement, intuitive wisdom, and resolute leadership was instrumental in completing this work.

We also thank every one helped us and encouraged us.

And finally, our ultimate thanks go to all lectures, doctors, engineers, and to the great edifice of science, (Palestine Polytechnic University), for their effort and guidance which helped building our characters to become successful engineers.

Abstract

Refrigeration is major energy consumer in our world today , because of global warming the world should be aware to this point and depends on renewable energy.

This project presents a new methodology for the synthesis of absorption refrigeration systems integrated with different types of fossil energies and renewable energies to operate these heat-powered systems to release the vapor at higher pressure.

This project can be used in remote areas in which there is no electricity to have the refrigerating effect and its real and exciting possibility.

The most important results that we obtained in this report , at the temperature water in storage tank equal 84the temperature in refrigerator is 9.1^0C.

التبريد هو المستهلك الرئيسي للطاقة في عالمنا اليوم , بسبب ظاهرة الاحتباس الحراري يجب على العالم أن يدرك هذه النقطة وان يعتمد على الطاقة البديلة.

يقدم هذا المشروع منهجية جديدة لتركيب أنظمة التبريد الامتصاصية المتكاملة مع أنواع مختلفة من الطاقات الاحفورية والطاقات المتجددة لتشغيل هذه الأنظمة التي تعمل بالحرارة لإطلاق البخار بضغط عالي .

يمكن استخدام هذا المشروع في المناطق التي لا تستطيع استخدام الكهرباء للحصول على التبريد

اهم النتائج التي حصلنا عليها , انه عندما تكون حرارة الماء في الخزان تساوي 84 سلسيوس تكون الحرارة داخل الثلاجة تساوي 9.1 سلسيوس .

List of contents:

List of Figure :

List of Table :

Chapter 1

1.1 Overview

As the world becomes more self-aware of changing climate conditions caused by global warming , it is vital to reassess our dependence on the burning of fossil fuels to gain energy . The alternatives for gaining this energy can be found in several sources of renewable energy such as solar ,wind , biomass and wave etc .

In particular , the solar energy alternatives is now being more closely examined in an attempt to utilize this as a source of energy for both domestic and commercial ; and users such as refrigerators , air conditioners ,hot water heaters and desalination for water recycling etc .

In recent years , increasing attention is being given to the use of heat and solar energy in energizing refrigerating systems . Solar powered refrigeration and air conditioning have been alternative during the last twenty years , since the availability of sunshine and the need of refrigeration both reach maximum levels in the same season .

One of the effective from solar refrigeration is in the production of cooling effect .

In this project NH_3 and H_2O in solar absorption cycle and using solar plate trough to reach high temperature on surface of generator used .

1.2 Problem statement

In this project it is supposed to energy conservation, because in this project will be replace the electrical compressor , and electrical heater by flat plate collector .The electrical compressor and electrical heater spends a lot of energy but the solar mirror save it .

Recognition of the Need

1. A good price for solar system
2. Support the national economy.

1.3 Project objectives

The main objective to uses solar energy for refrigeration

Energy conservation: In this project we will use the thermal solar system instead of the compressor, or electrical heater.

Less noise : The noise of any refrigerator cycle coming from compressor , but there is no noise in this system ,because it doesn't use compressor.

Preserving the environment: in this project Preserving the environment because , Electricity comes from burning fuel and this is dangerous to the environment, but in this system we do not use electricity we use natural energy .

less Faults: The most faults in any refrigerator cycle happen by compressor and electrical device but the faults in solar system is less .

1.4 literature Review

Reference [1]: Absorption cycle is one of the promising methods to utilize the solar heat for space cooling in domestic and industrial applications. Until recently the absorption cooling technology was not readily available for small capacity applications and was quite expensive compared to the traditional vapor compression cooling technology. However, there is a significant opportunity to combine an absorption system with building envelop design to provide environmentally benign way of controlling internal environment using solar energy.

There are two basic types of absorption cooling cycles:

(1) Lithium Bromide (LiBr)-Water and

(2) Ammonia-Water.

Reference [2] :A simple effect one stage ammonia-water absorption cooling system fueled by solar energy is analyzed. The considered system is composed by a parabolic trough collector concentrating solar energy into a tubular receiver for heating water. This is stored in a fully mixed thermal storage tank and used in the vapor generator of the absorption cooling system.

Reference [3]Solar thermal systems can be used to produce cooling. It has positive economic, environmental, and social effects on human life. Solar thermal absorption systems are feasible for industrial or domestic applications, considering that solar radiation is unlimited and available in most parts of the world. Designed and tested solar collector is a critical component for solar cooling absorption systems. The study reveals that evacuated tube collectors are best option for solar cooling than the other types and the double-effect absorption chiller with evacuated flat plate collectors show a good energetic and economic performance under different climatic conditions. In other hand, in spite of, there are various working fluids that have theoretically shown good performance, there is still a need to experimentally verify it.

1.5 Time schedule

TABLE1. 1:Time schedule

Tasks/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Selecting project title	■															
Collection data and information on the subject of the project		■	■	■	■	■	■	■	■	■	■					
Identify function and task		■	■	■	■	■	■	■								
Design and analysis									■	■	■	■	■	■		
Documentation		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

1.6 The budget

TABLE1. 2: Budget

Tools	price $	Number of tools	Total price
temperature sensor	10	2	20
Electrical heater	10	1	10
Electric valve	50	3	150
Pump	100	1	100
Solar plate +tank +pipe	200	1	200
Plc controller	150	1	150
Total cost $			580$

Chapter 2

2.1Thermal Solar system

The Thermal solar system Absorption sun radiation by solar mirror and transfer radiation to thermal energy then use it to heat water using in any thing . Thermal solar system was discovered before 100year and, it is now used by many people because of the economical energy saving system and also became highly efficient.

Solar System Components:

1-collector: Solar energy (solar radiation) is collected by the solar collector's absorber plates. Selective coatings are often applied to the absorber plates to improve the overall collection efficiency.

There are several types of solar collectors to heat liquids. Selection of a solar collector type will depend on the temperature of the application being considered and the intended season of use (or climate). The most common solar collector types are: unglazed liquid flatplate collectors; glazed liquid flat-plate collectors; and evacuated tube solar collectors.

- Evacuated tube solar collectors:

This consists of tubes of glass There is a copper pipe inside the glass tub and inside pipe Thermal liquid, one inside the other, made of borosilicate glass. The outer tube is transparent and allows the sunlight to pass through it with very little reflection. The internal heat-insulated pipe is coated with a black or blue layer that absorbs the sun's rays falling by up to 95%. this type the radiation of solar vertical on the pipe can be very efficient. Working principle in this type depends on pressure in pipe and vacuum the Boiling temperature of Thermal liquid in pipe is 30 ^{0}C the Thermal liquid is evaporate and rise to top, When reach the top of the copper tube, repeated in a continuous formula and lead to water heating.

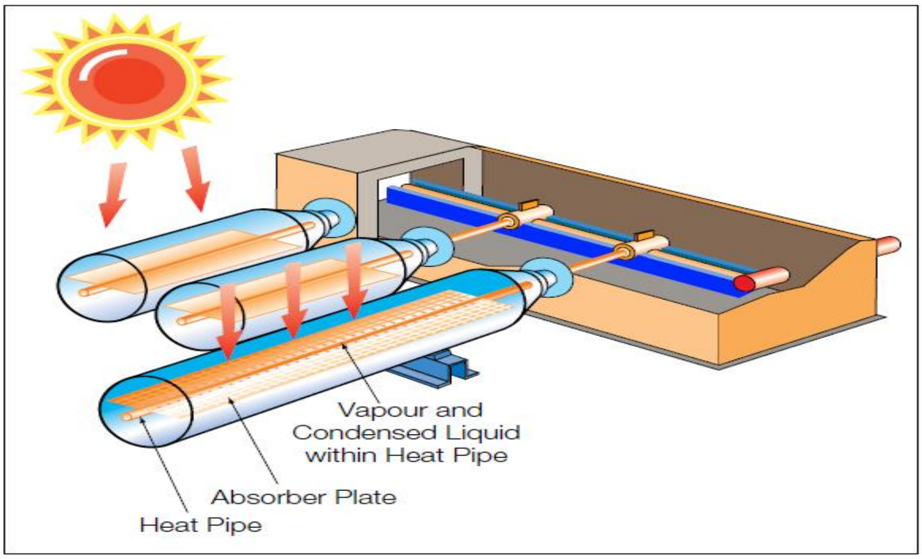

Figure 2. 1: component of Evacuated tube solar collectors

- Flat plate collector :

This type is plate Absorbed made from aluminum, or copper, and it is Isolated by polyatan or fiberglass.   the color of surface must be black . This type the radiation falling off on surface.

The surface absorb radiation solar and it heat transfer to water in pipe below the surface .

The benefit of this type related to life span is 25year but the efficiency is 40%.

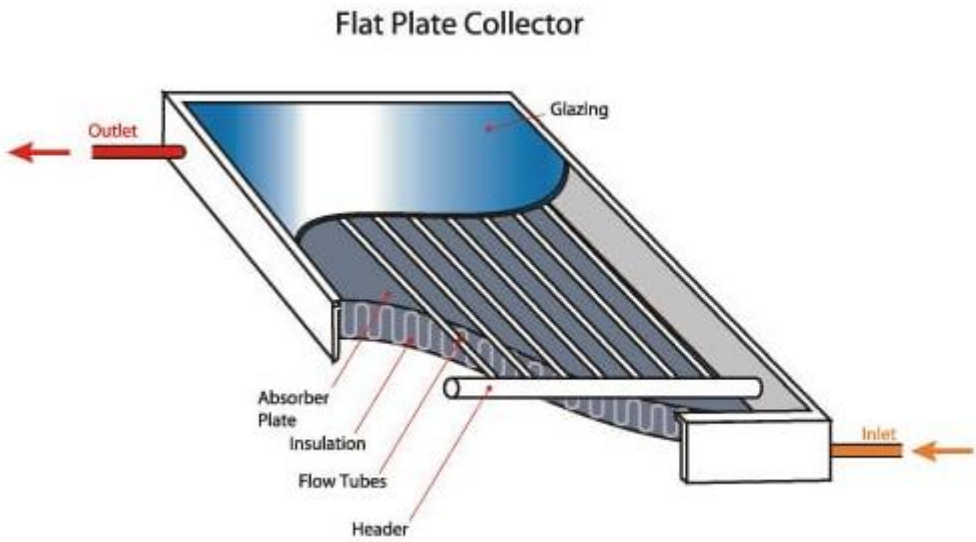

Figure 2.2 : component flat plate collectors.

2-Hot water storge tank insulator: Its capacity starts from 100 to 300 liters depending on usage .

3- Metal installation structure holds both the solar collectors and the reservoir, and the probe must be fitted to achieve an ideal tilt angle, as in solar panels.

4-Electrical heater Backup.

Working principle:

when water enter the pipe in collector, the heat transfer from the plate to pipe and to the water, in the pipe water is heated and the density is less so the hot water move to the top of plate and exit it by pipe to storge tank.

2.2Absorption cycle

The Absorption cycle is a type of refrigeration cycle, the refrigerant used in this cycle is NH3(R717) .

Circuit parts :

The circuit consists of evaporator, condenser, expansion valve ,generator and absorber . In the figure 2.3 absorption cycle.

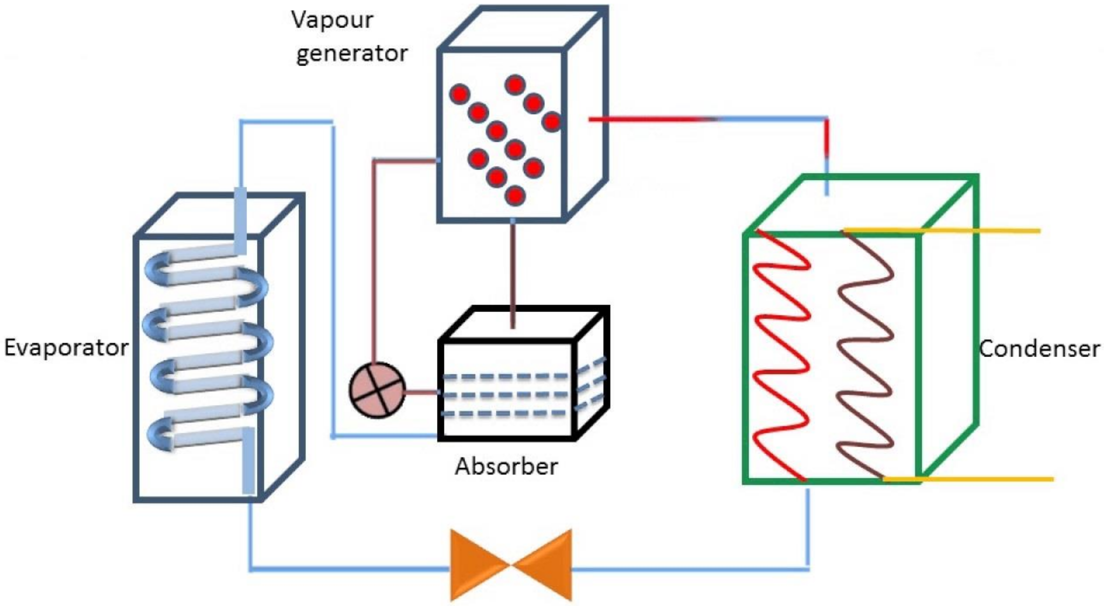

Figure2.3: absorption cycle

Working principle:

1) **Evaporator**: in the evaporator where the refrigerant pure ammonia (NH_3) in liquid state produces the cooling effect. It absorbs the heat from the substance to be cooled and Evaporation occurs. In this point, the ammonia passes to the absorber in the gaseous state.

2) **Absorber**: In the absorber the weak solution of ammonia-water is already present. The water is used as the absorbent in the solution, it unsaturated and it has the capacity to absorb more ammonia gas. As the ammonia from evaporator enters the absorber, it is readily absorbed by water and the strong solution of ammonia-water is formed. During the process of absorption heat is liberated which can reduce the ammonia absorption capacity of water; hence the absorber is cooled by the cooling water. Due to absorption of ammonia, strong solution of ammonia-water is formed in the absorber

.

3) **Pump**: The strong solution of ammonia and water is pumped by the pump at higher pressure to the generator.

4) **Generator**: The strong solution of ammonia refrigerant and water absorbent are heated by the external source of heat such as steam or hot water. It can also be heated by other sources like natural gas, electric heater, waste exhaust heat etc. Due to heating the refrigerant ammonia gets vaporized and it leaves the generator. However, since water has strong affinity for ammonia and its vaporization point is quite low some water particles also get carried away with ammonia refrigerant, so it is important to pass this refrigerant through separative.

Proprieties of NH3:
Freeze temperature is :-77^{0}C.
Melt temperature is : -33 ^{0}C.
Molar mass :17.031g/mol.

The advantages of this cycle:
1-less noise.
2-energy saving.

The defect in this cycle :

1- The COP is few.
2- The Concentrations of fluids are critical for stable operation.
3- The cycle is large than any cycle.

Chapter 3

3.1 Refrigeration and Absorption cycle

Refrigerant (ammonia +H2O)

Ammonia is a colorless inorganic compound of nitrogen and hydrogen with the formula NH_3, usually in gaseous form with a characteristic pungent odor. Ammonia is irritating to the skin, eyes, nose, throat, and lungs. It is essential for many biological processes and has various industrial applications.

This cycle is based on a mixture of two substances, one of which is much more volatile than the other. it is available in two versions: one in which the volatile component is a refrigerant in fluid for instance NH_3 in H_2O ,and another in which the solvent ,water ,is also a volatile fluid ,the other component being a salt .

Since NH_3 is much more volatile than H_2O ,it evaporates at a lower temperature than pure water ,at a higher temperature and a higher pressure than pure ammonia .

This means that ammonia vapour at higher pressure , as if from a compressor ,is conveyed into condenser .

At this point it is necessary to close the cycle so that it might start again ,this means restoring the original mixture to enable it to evaporate again in generator .

The residual mixture in generator is warm and contains little NH_3 :therefore it has to be cooled and enriched again by having it absorb the NH_3 vapour that leaves evaporator.

Both components are transferred to absorber where they are mixed, energy is developed (mixing enthalpy) ,as this energy would prevent the vapour from being absorber , a special cooling process be applied .

The weak mixture has to be cooled ,this fact can be exploited to preheat strong (rich) mixture returning to generator .

Furthermore, it is known that , in the compression cycle ,the more one can under cool the liquid before it reaches the expansion valve, the greater will be the cooling effect obtained ,while at the same time evaporation in expansion valve is prevented .

As pointed out above ,this is limited by the refrigerant available ,and by the need not to overheat the vapor .In this case , there are no limits :by using the cold vapor that comes out of the evaporator ,in fact ,we can under cool the same quantity of liquid NH_3 that reaches expansion valve . And since the vapor is at the lowest temperature in the entire process, the liquid can be greatly under cooled . Obviously ,the vapour that reaches the absorber is less cold ,but since its mass is merely a fraction of the weak solution which also reaches absorber and furthermore, since the absorption process generated a considerable quantity of heat ,the greater enthalpy of the incoming vapour represents a negligible fraction of the total quantity of heat which has to be removed from the absorper .

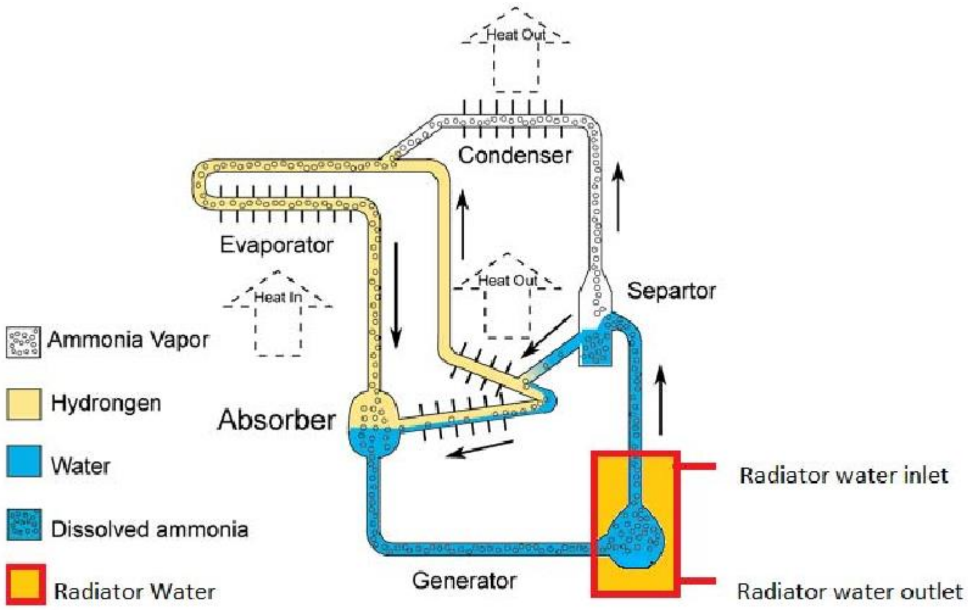

Figure3.1 Absorption cycle Reference [7]

The components of absorption cycle

Generator

The generator is the mechanical part employed to enable the solution contained in it to be depleted of its ammonia content.

In keeping with the foregoing description, the solution reaching the generator must contain the greatest possible quantity of ammonia and hence the generator must receive the so called rich (strong) solution .

This is not sufficient : as the strong solution gradually heats up , in fact ammonia is released in gaseous and the solution is depleted ,changing into a poor (weak) solution . Furthermore if more heat is applied , the solution boils and the entire ammonia content evaporates . But while it is true that ammonia evaporates , it is also true that the pressure in the boiler rises and therefore , we have a rich solution which gradually heats up and loses ammonia , but at the same time its pressure rises.

Condenser

This is used to condense gaseous ammonia into liquid ammonia .The condensation (or liquefaction) process takes place as the ammonia gas heat to the external air or to a water stream .

Air condensers are more widely used in small systems for domestic use , while water condenser are preferred to equip commercial and industrial refrigerators . A water condenser may be either of the so-called countercurrent or immersion system .

As will shall see later on , some "contact" units also exist ,in addition to the so-called multi – tube countercurrent system .The countercurrent system is used most widely .

In both air and water condensers ,the ammonia fluid goes through three physical phases .

And namely :the first phase remove the overheating calories from gas ,it deprives the gas of heat contained in it until the gas begins to condense and the first drop of liquid appears .

The second phase helps remove the liquefaction calories ,or in other words , the gas is deprived of the calories so that , the temperature remaining the same .it may become a liquid . In actual practice ,this is the phase of the mixing of the ammonia gas with its liquid . This portion of the condenser represents the most important part of the condenser .

Evaporator

The evaporator enables the liquid ammonia to evaporate and in doing so absorb the heat necessary to change from liquid to gas .

In industrial units all that is necessary is to load the ammonia into a system of smooth tubes , or radiators , where it evaporates . it is the same system as is used in compression refrigerators .

However , with reference to the above consideration on the construction of an evaporator , it should be kept in mind that an evaporator contains hydrogen too .Furthermore ,we know that hydrogen is added in order to equate the high pressure of the condenser inside the evaporator .

Since we want the ammonia to evaporate ,the lower is the temperature of this fluid ,the greater are the figures supplied ; hence the presser of the hydrogen has to be high .

Thus , the hydrogen must be free to expand or contract , so that its pressure added to that of gaseous ammonia , might equate the pressure of the high area .

As a result , at a later stage in the evaporator we have the simultaneous presence of hydrogen and ammonia , both of them in gas form .

To enable the evaporator to operate properly it is necessary for the ammonia to reach it continually and as cold as possible

The function of the hydrogen is to equate the pressures . It circulates between the evaporator and the absorber . Its high pressure facilitates the refrigerating effect in the evaporator .

Sometimes , as mentioned above the unit is fitted with a cylindrical body filled with hydrogen and located on top of the condenser : this serves as a plenum chamber or manifold to have a large quantity of hydrogen and equate the pressures more efficiently .

Absorber

Once the ammonia has evaporated and has produced the "cold " , it must be allowed to start the cycle again . This means it must be incorporated (absorbed) into the water so that it might evaporate again . The mechanical part where the physical phenomenon of absorption takes place is known as "absorber" .

With these premises in mind , it should be noted that the absorber must be designed to accomplish the following :

1- receive the water from the boiler , or more precisely ,enable the "poor" (weak) solution from the boiler to enter freely into it .

2- Permit the entry of the cold ammonia / hydrogen mixture coming from the evaporator

3- Enable the hydrogen which is released to escape and return to the evaporator or move into the gas temperature exchanger or into the container placed above the condenser ,which serves as a hydrogen deposit or plenum chamber .

4- 4-Enable the weak solution to cool down to a considerable extent to absorb the gaseous ammonia to be released from the ammonia /hydrogen mixture coming from the evaporator and the gas temperature exchanger .

5- 5-Enable the "poor" solution to become intimately bound with the ammonia and thereby become a "rich" solution .

6- Eliminate the absorption heat .

Advantages of the absorption cycle

Since we are dealing with a two – component mixture , we have an extra degree of freedom .In the compression system , in fact ,once the temperature at the evaporator has been fixed , the intake pressure is also determined while the temperature of the refrigerant determines the condenser – the delivery pressure . With the solution so as to modify the pressure of the NH3 at the condenser .

In order to obtain very low temperature it is possible to use more complex cycle (as in multi-stages compressor cycles), without, however having to spend much more energy , because instead of having pure NH3 evaporate, the NH3 can be released from a convenient solution so as to obtain temperatures lower than the NH3 freezing point (-77C) .

In fact , from the bottom part of the diagram it can be seen that for given compositions of the solution being considered temperature of down to

-90C can be attained .

Another considerable advantage lies in the fact the only mechanical part of the system is the pump adopted to circulate the solution and a stand – by unit can be installed at very low cost . All the other parts are merely subjected to the safety provisions on pressure equipment , involving no maintenance requirements .

In other words , an absorption system affords much greater reliability than a compression system

Another advantage is the possibility to make use of heat by-products , such as hot condensate , exhausted vapour and smoke . Furthermore , absorption system can be used in some chemical plants where , in addition to the refrigeration process , it is also necessary to cool down fumes , vapor and the like . These systems can make use of the cooling process and hence the energy involved – which may consist of huge quantities , in some cases – supplies cold free of charge , instead of being wasted .

To sum up , this is a highly versatile system and from a certain potential up , it is also extremely convenient compared to the corresponding compression system .

3.2 cycle of solar system

In this section will explain the mechanical cycle of solar system to heat exchanger, and also talk about all the parts and components used and their components.

The system in figure 3.2:

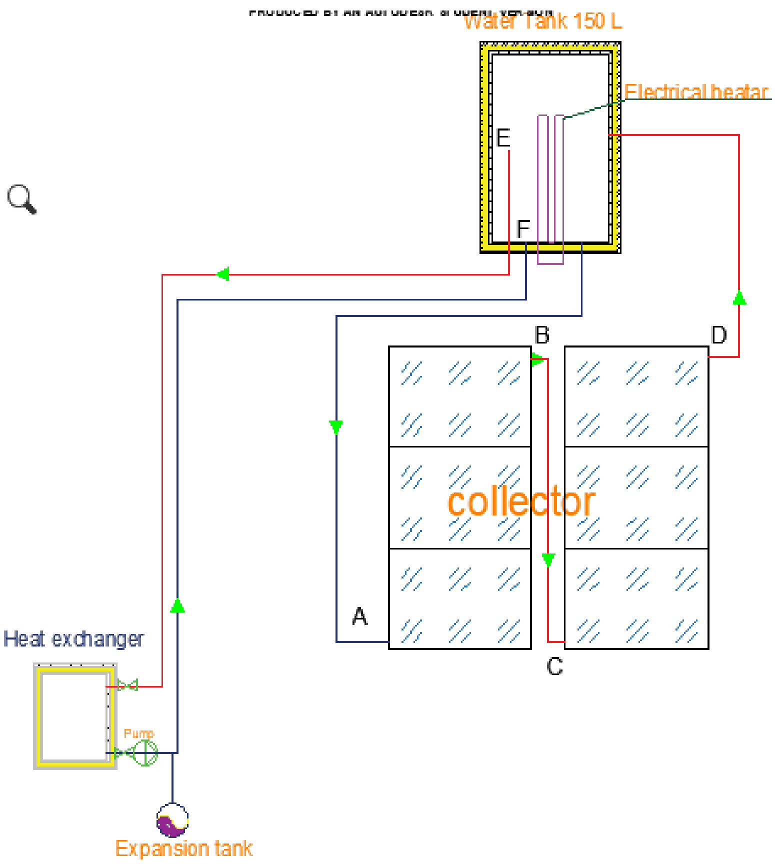

Figure3.2: Mechanical design of system

The parts used in the system the flat plate collector , storage water tank , pump , heat exchanger ,and electrical heater backup in the tank .

Principle work:

The water from storge tank move to first collector at point A, and exit from first collector at point B to enter second collector at point C, and exit from second collector at point D to storge tank.

The hot water rises to the top of the tank and exits from the tank from point E to the heat exchanger and returns to the storage tank from point F.

When the temperature in storage tank less than 70^0C the heater is run to 85^0C.

Parts and details of this system:

1. Solar collector(flat plate):The collector plate we use to absorb the sun radiation and transfer thermal energy to water from the pipe under plate . when water enters the pipes, heat exchange occurs between the water and the surface collector.

Figure3.3: collector and details .

Collector details :

- Pipe inlet and outlet: the diameter is 1" the water enter and exit collector by this pipe.
- Header : the diameter is 1" use to collection between pipe to flow tubes.
- Flow tubes : the diameter is 1/2" use to heat exchange between plate and water flow in.
- Absorber plate : this is metal steel thickness is 1mm use to absorber radiation sun.
- Insulation: there is polyatan or fiberglass Used to prevent heat leakage thickness is 50mm.
- Glass: it is used to protect the surface from corrosion and save the heat between glass or absorber.

2. Storge tank : is a tank insulated used to storge water to use after the absence of the sun the figure 3.4 explain the details of storge tank.

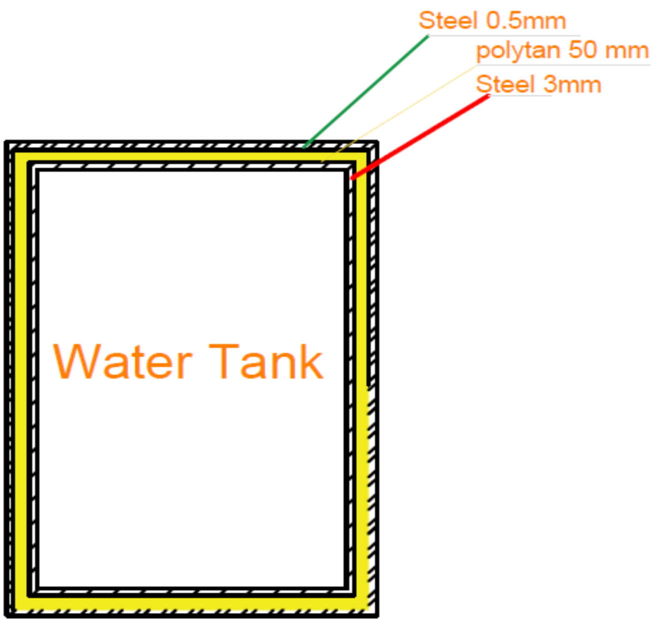

Figure3.4:Details storge tank.

Storge tank details :

- Thickness of steel inside 3mm .
- Thickness of insulation(fiberglass) is 50mm.
- Thickness of shell steel is 0.5mm.
- The volume of tank is 150 L.

Figure3.5: Insulator storage tank .

3. Insulator PEX pipe 16mm :Use to transfer water in the system.in the figure 3..6 details of pipe .

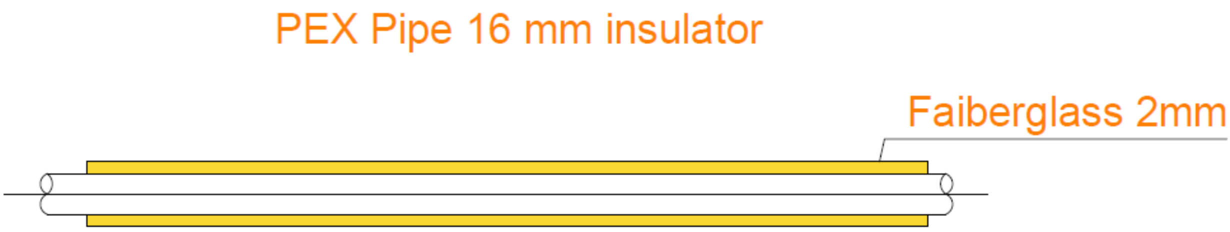

Figure3.6: Insulator PEX pipe 16mm

- Pipe PEX 16 mm :return and supply Internal diameter is 16mm outside diameter is18.2mm the length is 5m.
- Fiberglass :use to insulate the pipe to reduce the loss of energy .

Cross Linked Pex Pipes

No.	Des.	Size	Thick
41-3100	Golani	16mmX100m	2.2mm
41-3101	Flexnor	16mmX100m	2.2mm
41-3102	Royal	16mmX100m	2.2mm
41-3120	Golani	20mmX100m	2.8mm
41-3121	Flexnor	20mmX100m	2.8mm
41-3122	Royal	20mmX100m	2.8mm
41-3141	Flexnor	25mmX50m	2.8mm

Isolated Cross Linked Pex Pipes

No.	Des.	Size
41-3200	Golani	16mmX50m
41-3201	Flexnor	16mmX50m
41-3202	Royal	16mmX50m
41-3300	Golani	16mmX100m
41-3301	Flexnor	16mmX100m
41-3302	Royal	16mmX100m

Figure3.7PEX pipe.

4. Circulator hot water pump : we use the pump to recycling hot water in this system.

Figure3.8: Circulator hot water pump

5. Expansion tank : It is used to protect the system by means of an internal rubber membrane that enters water into it when it expands.

Figure3.9: Expansion tank.

6. Heatexchanger : Used for heat transfer from the hot water to generator in cooling cycle, the figure 3.10 explain the details of heat exchanger.

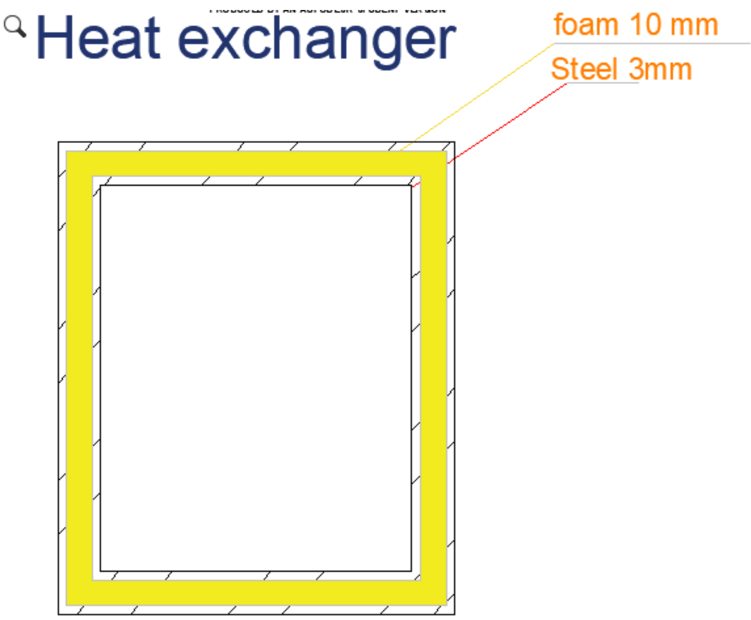

Figure3.10details of heat exchanger.

- Internal steel thickness 3mm .
- Insulator (fiberglass) thickness 10mm.
- Internal diameter =7.5cm.
- The length is 20 cm.

Chapter 4

4.1 **Electrical component**

1. **temperature sensor** : the name is LM35 (ACTIVE)

1.1 Features

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full −55°C to 150°C Range
- Suitable for Remote Applications
- Low-Cost Due to Wafer-Level Trimming
- Operates From 4 V to 30 V
- Less Than 60-µA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load

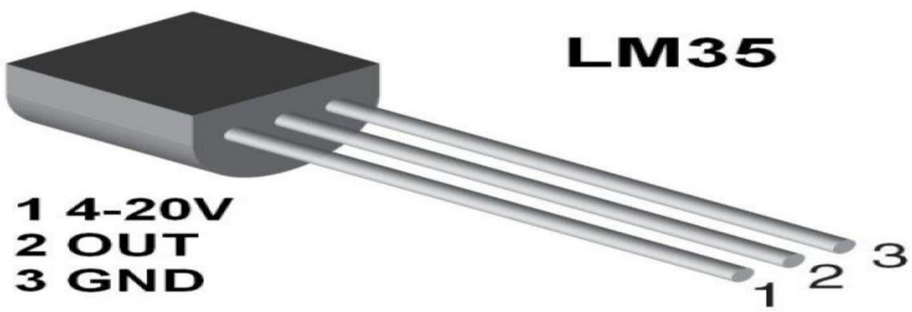

Figure 4.1: lM35 sensor

2. **Electrical heater**

Good for :-

1. Heating smaller spaces , like bedrooms
2. Very cheap to bay
3. Be aware that
4. they are more expensive to run than most other heating options
5. their heat output is low compared to most other heater types
6. all electric heaters are equally efficient as they convert all the electricity they use into useful heat
7. there are different types (radiant, convection, fan) that deliver heat in different ways to suit different situations
8. Many have built-in thermostats, but generally they are not very accurate.

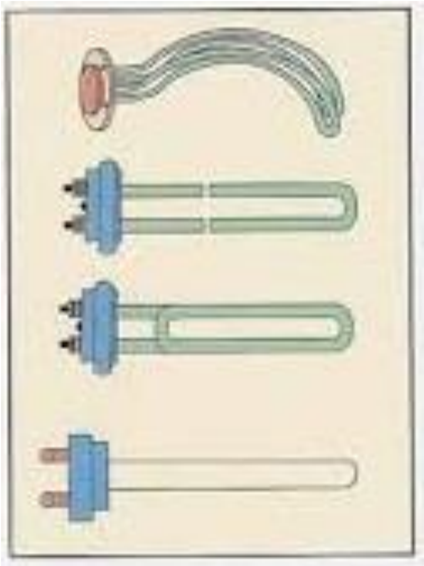

Figure 4.2 electrical heater

3. Electric valve

All orders entered using this guide must state actual fluid, fluid pressure, fluid concentration, and fluid temperature of the application. Actual fluid is extremely important when elastomeric options are specified because other substitutions may be required. ASCO valves are available to control many acids, alcohols, bases, solvents, and corrosive gases and liquids. Modified or special designs are sometimes required, depending upon the application. Corrosion occurs either as a chemical or electrochemical reaction. Therefore, consideration must be given to both the galvanic and electromotive force series, as well as to pressure, temperature, and other factors that might be involved in the application.

Table 4.2 voltage range electrical valve

Voltage Range	Minimum Voltage	Maximum Voltage
100-240V/50 or 60Hz/DC	85	264
24-120V/50 or 60Hz/DC	20.4	132
12-24/DC only	10.4	26.4

Figure 4.3:electrical valve

4. **Pump**

Good for:-

i. low running costs (when you use them properly)
ii. producing instant heat
iii. convenience - you can control the temperature with thermostat and use the timer

Be aware that :-

- they must be sized correctly - for the space and the climate - to work well (if you live in a colder area, ask the supplier to size the heat pump based on its low temperature performance
- some are a lot more efficient than others - look for the Energy Rating Label (the more stars, the more energy efficient
- they will not work during a power cut

Figure 4.4:pump

4.2Control in system

In this system we need to controller to control of all electrical device in order to ensure that the system does not stop and it work in the right way.

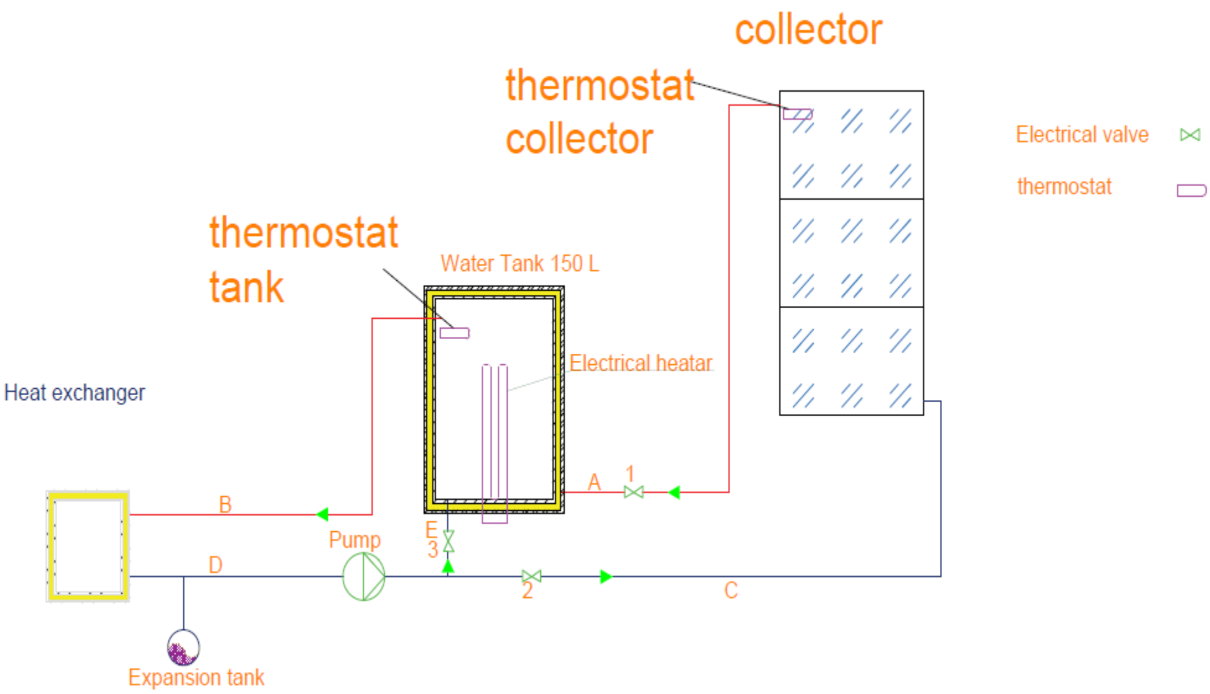

Figure 4.5:the system with thermostat

Function of the control system:

At the temperature in collector equal 65 °C and above the thermostat collector gives an order to controller panel to open the valve 1 and valve 2 and close valve 3 .When the temperature is less than 65°C the thermostat collector gives an order to controller panel to close the valve 1 and valve 2 and open valve 3. When the temperature in the tank is less than 75°C thermostat tank it gives an order to controller panel to turn on the heater when the temperature in tank is 83 °C the thermostat tank gives an order to controller panel to turn off the heater.

In figure 4.6 the block digram of control system and discrbtion the work principle of the system

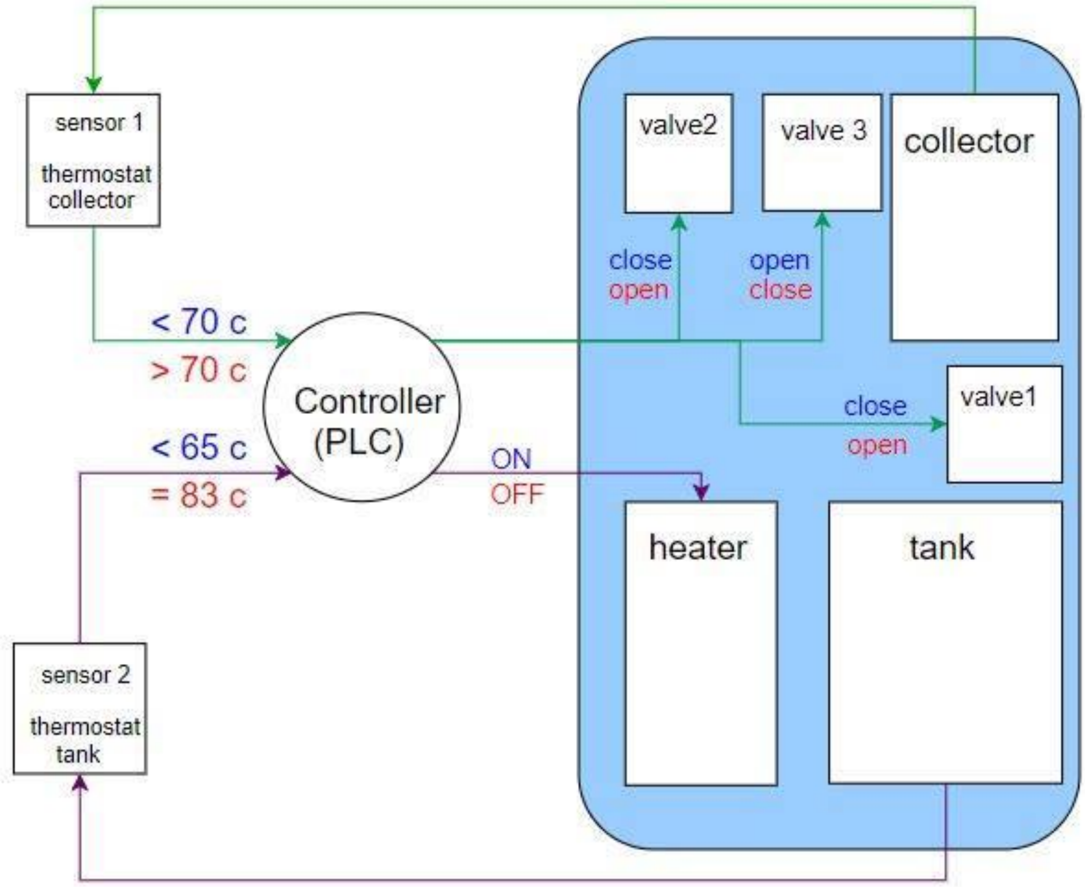

Figure 4.6block diagram of control in the system

Chapter 5

5.1 Volume water in the system:

V_{water}=$V_{\text{ water in pipe}}$+ $V_{\text{water in storage tank}}$+ $V_{\text{ water in heat exchanger}}$.

$V_{\text{ water in pipe}}=\pi r^2 L$……………………………………………………………..5.1.

V: volume.

Π:3.14

r: radius

L: length

m: meter

mm: millimeter = 1000m

Volume water in pipe:

The length of pipe is 10 m supply, and 10 m return.

The radius of pipe is 8 mm.

$V_{\text{ water in pipe}}=3.14\times (8\times10^{-3})^2\times20=4.0186\times10^{-3}m^3$.

Volume water in heat exchanger:

The length of heat exchanger is 200mm.

The radius of heat exchanger is 37.5mm.

$V_{\text{ water in heat exchanger}} =3.14\times (37.5\times10^{-3})^2\times0.2=8.83\times10^{-4}m^3$.

Volume water storage tank:

We have used storage tank 150 liter.

$V_{\text{water in storge tank}}=0.15\ m^3$.

$V_{water}=4.0186\times10^{-3}+8.83\times10^{-4}+0.15=0.155m^{3.}$

5.2 Heating load:

The lode required about generator from catalog of refrigerator is 75w.

5.3 Heating loss in the system

1. **Heating loss in heat exchanger:**

Length of heat exchanger =20cm **.**

The diameter in = 7.5cm.

Thickness steel in = 3mm.

Thickness insulated (fiberglass)=50mm.

K_{steel}=80.4W/m^{0}K.

K_{Foam}=80.4W/m^{0}K.

Temperature water supply in cycle =80℃.

Outside air temperature =8℃.

The heatexchanger type is shell and tube cylindrical and the heat transfer by conduction.

$Q_{loss\ Heatexchanger}=\frac{\Delta T}{\sum R}$ …………………………………………………………..5.2

$\sum R=R_{Steel}+R_{Foam}$…… ……. ……………………………………………….5.3

$R_{Steel}=\frac{\ln\frac{r2}{r1}}{2\pi kL}$……………………………………………………………...….5.4

$R_{Steel}=\frac{\ln\frac{3.78}{3.75}}{2\times3.14\times80.4\times0.2}$=7.9*10^{-5} K·m^2/W.

$R_{Foam}=\frac{\ln\frac{r3}{r2}}{2\pi kL}$.

$R_{Foam}=\frac{\ln\frac{8.78}{3.78}}{2\times3.14\times0.048\times0.2}$=38.52 K·m^2/W.

$\sum R=(7.9\times10^{-5})+38.52=38.5200846$.

$\Delta T = (80-8) = 72.$

$Q_{Heatexchanger}=\frac{72}{38.5200846} = 1.86W.$

2. Heating loss in storage tank:

Length of storage tank=107cm.

The diameter in = 58cm.

Thickness steel in = 3mm.

Thickness insulated (fiberglass)=50mm.

Thickness shell steel =0.5mm.

K_{steel}=80.4W/M^{0}K.

$K_{fiberglass}$=80.4W/M^{0}K.

T_{in}=80℃.

T_{out}=8℃.

The storge tank is cylindrical and the heat transfer by conduction.

$Q_{loss\ in\ storge\ tank} = \frac{\Delta T}{\sum R}$.

$\sum R = R_{Steel} + R_{Fiberglass} + R_{shell}$.

$R_{Steel} = \frac{\ln\frac{r2}{r1}}{2\pi kL}$.

$R_{Steel} = \frac{\ln\frac{29.3}{29}}{2\times3.14\times80.4\times1.07}$=1.9*10^{-5} K·m^2/W.

$R_{Fiberglass} = \frac{\ln\frac{r3}{r2}}{2\pi kL}$.

$R_{Fiberglassl} = \frac{\ln\frac{34.3}{29.3}}{2\times3.14\times0.048\times1.07}$=0.4884 K·m^2/W.

$R_{Shell} = \frac{\ln\frac{0.03435}{0.03430}}{2\times3.14\times80.4\times1.07}$=2.7*10^{-6}.

$\sum R$=2.7×10^{-6}+1.9×10^{-5}+0.488=0.488511 K·m^2/W.

$\Delta T = (80 - 8) = 72^{O}C$.

$Q_{\ loss\ in\ storge\ tank} = \frac{72}{0.488511} = 147W.$

3. **Heating loss in pex pipe:**

Total Length of pex pipe =20m

The diameter in = 16mm.

Thickness pipe = 2.2mm.

Thickness insulated (fiberglass)=2mm.

$K_{pex\ pipe}$=0.42W/m^{0}K.

$K_{fiberglass}$=0.048W/m^{0}K.

T_{in}=80℃.

T_{out}=8℃.

$Q_{loss\ in\ pex\ pipe} = \frac{\Delta T}{\sum R}$.

$\sum R = R_{pex\ pipe} + R_{Fiberglass}$.

$R_{pex\ pipe} = \frac{\ln\frac{r2}{r1}}{2\pi kL}$.

$R_{pex\ pipe} = \frac{\ln\frac{18.2}{16}}{2\times3.14\times0.42\times20} = 2.44\times10^{-3}$ K·m^2/W.

$R_{Fiberglass} = \frac{\ln\frac{r3}{r2}}{2\pi kL}$.

$R_{Fiberglassl} = \frac{\ln\frac{23.2}{18.2}}{2\times3.14\times0.048\times20} = 0.04026$K·m^2/W·

$\sum R = 2.44\times10^{-3} + 0.04026 = 0.04270$K·m^2/W.

$\Delta T = (80 - 8) = 72^0$C

$Q_{\ loss\ pex\ pipe} = \frac{72}{0.04270} = 1686W.$

5.4 Water heating load:

$Q_{water=}$v×p×cp× ΔT……………………………………………………………5.5

V:volum of water .

P: Proportion of solar energy dependence.

Cp: Thermal capacity of water.

ΔT:$T_{out\ watercollector}$ - $T_{in\ water\ collector}$.

Q_{water}=155kg×0.4×4.18kj/kg.^{0}C×72^{0}C /3600=5.18kW.

Heating load system:

Q_{system}= $Q_{\text{ loss pex pipe}}$+ $Q_{\text{ loss in storge tank}}$+ $Q_{\text{lossHeatexchanger}}$+ $Q_{\text{loss Heatexchanger}}$.

Q_{system}=75+ 1.86+147+1686+5180=7.09kw.

5.5 Heating load mirror:

Efficiency plate mirror =0.64.

Q_{mirror}= $\frac{Qsystem}{Efficiency}$……………………………………………………………5. 6

Q_{mirror}= $\frac{7.09}{0.40} = 17.7KW.$

5.6 Calculation of area plate:

Frome the cataluge :the plate mirror energy heating =3.92kw/m^2.

Area= Q_{Mirror}/3.92……………………………………………………………5.7

=11.1/3.92=4.5m^2.

5.7 Calculation Flow rate:

$m^{\cdot}$=Q_{total}/cp($T_{\text{Hot water}}$ –T_{return}) ……………………………………………………5.8

=9.6kw/4.18(80-8)=0.31kg/sec.

=0.31L/sec.

5.8 Calculation head :

H=H+H_{loss}…………………………………………………………...…..5.9

H_{loss} =4FLv^2/2gD……………………………………………….……….5.10

f is the friction factor.

L is the length of pipe being consider.

d is the pipe diameter.

v is the mean velocity of the fluid.

F=16/Re………………………………………………………………….5.11

Re= $\rho \frac{v\,d}{\mu}$……………………………………………………………….….5.12

v=q/A_{pipe}…………………………………………………………………5.13

$v=0.31\times10^{-3}m^3/(8\times10^{-3})^2\times\pi$.

=.15m/sec.

$Re=\frac{1000*0.1*0.016}{0.0014}=1742.8$.

F=16/1742.8=0.091.

$H_{loss}=4\times0.091\times20\times(0.15^2)/2\times9.81\times0.016=0.9m$.

H=3+0.045=3.9m.

5.9 Calculation volume of expansion tank :

$V_{expantion\ tank}=\frac{E\times V/(1-\left(\frac{Pmin}{Pmax}\right))}{k}$……………………………………………………………….5.14

E: Thermal expansion coefficient of water at 85 ° C=0.039.

V=volume water in the system = $0.152m^2$.

K: Filling coefficient of the tank=0.5from catalog.

P_{max}=4bar.

P_{min}=1bar.

$V=(0.039\times0.152/0.75)/0.5=0.015m^3$=15liter.

Chapter 6

6.1Methods

1. At the first we have collection the information and data, about project .
2. We have identified all the necessary parts in this system:

- Area Collector.
- Volume of Storage tank
- Type of pipe and length
- Volume of heat exchanger about generator
- Volume of expansion tank
- Flow rate and type of pump.

The total cost of all part is 655$.

Table 6. 1 total cost of project

Parts	Total cost($)
pump	100
pipe	50
Collector with storage tank whit heater	150
Controller with thermocouple	70
Thermocouple with monitor	15
Screws and joint	120
Expansion tank	70
Wire	15
Insulators	35
Finishing	30
Total cost	655

After purchasing the parts, we assembled the system as follows:

3. We installed the collector to the south to get the highest efficiency and joint the 2 plate by series to increasing the temperature of water in cycle, and we connected the storage tank whit collector. the figure is system after installed.

Figure 6. 1 the collector instilled.

We connected tow line supply or return on storage tank .

Figure 6. 2 the return or supply line on tank.

Figure 6. 3 the return or supply line to heat exchanger.

We insulated the all pex pipe.

Figure 6. 4 the pipe with insulator

We connected the controller whit thermocouple with heater.

Figure 6. 5 controller

Figure 6. 6 controller connected with heater or thermocouple on tank

We have entered the thermocouple on the storage tank.

Figure 6. 7 heater and entrance thermocouple

We have installed the heat exchanger about generator of refrigerator by the thermal silicon and Screws.

Figure 6 .8 heat exchanger before installed

We have installed the pump at return line.

Figure 6. 9 recycle pump at the system

We have installed the explanation tank at return line.

Figure 6. 10 expansion tank at the system

We have insulted the heat exchanger by foam.

Figure 6. 11 heat exchanger whit insulator

We have installed the thermocouple on evaporator to measure the temperature on refrigerator.

Figure 6. 12 thermocouple at evaporator

Figure 6. 13 mointor of thermocuple

After this step the system is finished and Ready to run.

Time work in project.

Table 6.2 time work in project

Task/week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Search for the necessary equipment																
Buy the parts																
Instilled the system																
Finished system																
Get the result																
Processing the report																

6.2Result

In this chapter will be browsed the reading of temperature in Refrigerator, Outer atmosphere, generator of Refrigerator , water in solar system cycle.

And will be discussion result.

In this table we can see the reading of temperature of the system in tow day of November and one in the December .

At first day:

Table 6. 3 result at first day

Time	Atmosphere Temperature(°C)	Water at cycle temperature(°C)	Generator temperature(°C)	Evaporator temperature(°C)
9.00AM	18.5	56	53	16
10.00AM	19	58.5	55	16
12.00AM	22	62	60	14.8
2.00PM	25	64	61.5	14.5

At second day:

Table 6. 4 result at second day

Time	Atmosphere Temperature(°C)	Water at cycle temperature(°C)	Generator temperature(°C)	Evaporator temperature(°C)
9.00AM	20	55	51	14
10.00AM	21	57.5	54	13.4
12.00AM	25	66	62	12.1
2.00PM	28	68	67	10.5

At third day with heater :

Table 6. 5 result at third day

Time	Atmosphere Temperature(°C)	Water at cycle temperature(°C)	Generator temperature(°C)	Evaporator temperature(°C)
9.00AM	15	43	38	15
10.00AM	15.5	75	72	11
12.00AM	16.2	84	82	9.1
2.00PM	18	80	78	10.3

Figure 6. 14 temperature In refrigerator

Figure 6. 15 temperature water on storage tank

The less value of temperature in the third day when the temperature of water in cycle is 84℃, and the temperature in generator is 82℃.

6.3Recommendations:

1. Enter the generator on the collector daric.
2. Replace the water to chemical compounds to incising the efficiency.
3. Track the system during days when temperatures are higher for better results.
4. Work to develop the system through:

- Remove the water tank to less volume , budget ,of system and to economy of electrical and to remove the pump.
- Add compounds to water in solar system cycle to increasing vapor temperature of water because the beater temperature on generator is more than 100℃, but the water on 100℃ is vapor .
- Add the previously described control system in a chapter 4.

5. The implementation of this system at high cooling loads.
6. Use the Evacuated tube solar collectors to get better efficiency ,and increasing temperature water in solar system.

6.4 Safety:

- ✓ Do not operate the system when it is empty of water to keep the pump.
- ✓ Check the expansion tank before starting to keep the pipes in system.
- ✓ Check the vent of system before starting to keep the pump.
- ✓ The diameter of wire is tall than 2.5 because the current of heater is 10amper to keep the electric net.
- ✓ Use the circuit briker 16 ampere to keep the electrical part in system.

Reference

Reference [1]:https://www.e-education.psu.edu/eme811/node/670
Reference [2]:CameliaStanciu, DorinStanciu * and Adina-TeodoraGheorghian
Reference [3]:Z. NEFFAH, M. ABBAS, W. TAANE. http://www.umc.edu.dz/images/09-NEFFAH.pdf
Reference[4]: https://www.sciencedirect.com/science/article/pii/S0378778809002163

Reference[5]: Solar-assisted absorption air-conditioning systems in buildings: Control strategies and operational modes

Reference[6]: Performance analysis of small capacity absorption chillers by using different modeling methods

Reference [7]: https://www.researchgate.net/figure/Schematic-of-a-triple-fluid-vapours-absorption-refrigeration-system_fig1_295906905