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OPTIMIZTION AND INVESTIGATE OF AN AIR CONDITIONING SYSTEM WITH LOW ENERGY CONSUMPTION AND ADAPTED WITH LOCAL CLIMATE

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Abstract

Due to the expensive cost of electricity which the traditional refrigerating equipment consumes (the mechanical pressure cycle), resorting to special thermal refrigerating cycles using free energy or the emitted thermal energy from the industrial operations.

The exploitation of the thermal emission results from industrial operations in Hassi Messaoud, the ideal solution for providing and affective refrigeration which doesn’t high cost a lot in the residence bases in the area and the offices. We noticed at the end of this work that the coefficient of performance (COP) in absorption refrigerating cycle is fixed and this backs to the fixed rate of thermal energy that is exploited by the thermal changer.

Résume

En raison du coût élève de l'électricité consommée par l'équipement de réfrigération traditionnel (à pression mécanique), en utilisant un cycle de réfrigération thermique qu'utilisant de l'énergie émettrice des opérations industrielles.

L'exploitation des émissions des procédés industriels à Hassi Messaoud représente une solution idéale pour une climatisation à moindre cout dans les bases de vie à la région de Hassi messaooud ainsi que les bureaux ont cette région. Nous avons remarqué à la fin de ce travail que le facteur d'efficacité COP dans le cycle de réfrigération a absorption est constant et cela résulte du flux thermique constant exploité par l'échangeur thermique.

ملخص

نظرا لتكلفة الباهظة للكهرباء التي تستهلكها اجهزة التبريد التقليدية (الضغط الميكانيكي) فان الالتجاء الى دورات تبريد حرارية خاصة باستعمال طاقة مجانية او الحرارة المنبعثة من العمليات الصناعية امرا ضروري في الوقت الراهن .

يعتبر استغلال الانبعثات الحرارية الناتجة من العمليات الصناعية بمدينة حاسي مسعود الحل الامثل لتوفير تبريد فعال وعير مكلف لقواعد الحياة وكذا مكاتب العمل في المنطقة .

وقد لاحظنا في نهاية هذا العمل ان معامل الفعالية لدورة التبريد يكون ثابت وهذا راجع للقيمة الثابتة للطاقة الحرارية المستغلة من طرف المبدل الحراري .

Nomenclature :

COP	Coefficient of performanceh
h	Specific enthalpy (kJ/kg.)
P	pressure (kPa)
T	temperature (K)
S	entropy (kj/K)
ΔS_{total}	total entropy change
ΔS_{sys}	entropy change of the system
ΔS_{surr}	entropy change of the surroundings
Q_e	the heat transferred to the evaporator
Q_g	the heat transferred to the generator
Q_{a+c}	the heat transferred from the absorber and condenser
W_p	the work input to the solution pump
T_e	evaporator temperature
T_g	generator temperature
T_o	absorber and condenser temperature

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Dedication

*To my whole Family « **Benzeghmane** »*

To my parents

To my wife and children

I dedicate this work

BOURAHLA BENZEGHMANE

Dedication

*my whole family « **kat** »*

To my parents

To my brothers and sisters

dedicate this work

KAT MOHAMED ALI

Acknowledgements

First of all, our thanks go to Allah the Almighty who gave us the power to complete this work.

We would like to express our full gratitude to our Supervisor,

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and academic support.

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Finally, we are very thankful to all who helped us in conducting our work.

GENERAL INTRODUCTION :

In Algeria, 60% of buildings consume energy in daily different fields such as refrigerators, air conditioners and all what makes human comfortable and cannot dispense of using them in nowadays life specially in South Algeria where the weather is very hot . 90% from the electrical energy comes from the thermal energy installed specially in south Algeria [1].

Recently, the petrol is in decreasing, Algeria will suffer from this decreasing in the coming generations because all its economics depend on this non-renewable energy so that it requires compensating this problem with the renewable energies that do not harm the environment and last forever such as solar energy, eolian, hydraulics, geothermal….

And to preserve this energy we should economize it the maximum and use it wisely without wasting it to find solutions to this tough problem.

To solve this problem we should work on the waste energies by refrigeration absorption to lead us to the decrease of the global warming and we should pay attention to Industrial thermal waste and the domestic application with the usage of the hot water of the area that is related to as a recourse of the temperature for alimentation of the boiler.

In this dissertation the work is divided into three chapters

the first one is dealt with the review of the refrigerating system and mentioning some of the researches that are related to this field (absorption refrigerating cycle), whether the second chapter is concerned with the studied system and defining it and giving some illustrations about the thesis.

Finally in the third chapter we will discuss the results that is lead by the whole dissertation .

Chapter I

1.1 a Brief history of refrigeration:

The methods of production of cold by mechanical processes are not quite recent. Long back in 1748, WILLIAM COOLEN of Glasgow University produced refrigeration by creating partial vacuum over ethyl ether. but, he could not implement his experience in practice. The first development took place in 1834 when Perkins proposed a hand-operated compressor machine working on ether. Then in 1851 came Gorrie’s air refrigeration machine, and in 1856 Linde developed a machine working on ammonia.

The pace of development was slow in the beginning when steam engines were the only prime movers known to run the compressors. with the advent of electric motors and consequent higher speeds of the compressor, the scope of applications of refrigeration widened. The pace of development was considerably quickened in the 1920 decade when DU PONT put in the market a family of new working substances. the fluoro-chloro derivatives of methane, ethane, popularly known as chloro-fluorocarbons or CFCs----under the name of Freons. Recent developments involve finding alternatives or substitutes for Freons , since it has been found that chlorine atoms in Freons are responsible for the depletion of ozone layer in the upper atmosphere . Another noteworthy development was that of that ammonia –water vapour absorption machine by Carre. these development account for the major commercial and industrial application in the field of refrigeration.

A phenomenon called Peltier effect was discovered in 1834 which is still not commercialized advances in cryogenics, a field of very low temperature refrigeration, were registered with the liquefaction of oxygen by Pictet in 1877. Dewar made the famous Dewar flask in 1898 to store liquids at cryogenic temperatures. Then followed the liquefaction of other permanent gases including helium in 1908 by Onnes which led to the discovery of the phenomenon of superconductivity. Finally, in 1926, Giaque and Debye in dependently proposed adiabatic demagnetization of a paramagnetic salt to reach temperatures near absolute zero [2].

YEARS	AUTHOR	TITLE	Main idea
2011	Lian, H., Li, Y., Gu, C	An overview of domestic technologies for waste heat utilization. Energy Conservation Technology (Chinese) 29, 123.	this paper shows the technologies used in china and indicates the characteristics and application of wasting energies and the exploitation of cycling system to decrease temperature.
2013	Markides, C.N	The role of pumped and waste heat technologies in ahigh-efficiency sustainable energy future for the UK. Appl. Therm. Eng. 53, 197.	providing suggested solutions that are being proposed towards the establishment of a sustainable energy landscape.
2014	Hammond, G.P., Norman, J.B.	Heat recovery opportunities in UK industry. Appl. Energy 116, 387.	In the United Kingdom estimated the technical potential of various heat recovery technologies.
2016	Law, R., Harvey, A., Reay, D.,	A knowledge-based system for low-grade waste heat recovery in the process industries. Appl. Therm. Eng. 94, 590.	Recommended solution for the heat waste.
2016	Khan, M.M., Zaman, K., Irfan, D., Awan, U., Ali, G., Kyophilavong, P., Shahbaz, M.,Naseem, I.	Triangular relationship among energy consumption, airpollution and water resources in Pakistan. J. Clean. Prod. 112, 1375.	The literature review oppose the findings about different variables in Pakistan and prediction about 10 years in the future.

Table1.1: review of waste heat recovery

1.2 Classification of refrigeration systems :

Two main classes of refrigeration systems can be distinguished; those are Mechanical energy to operate, the mechano-refrigeration systems and which Consume mainly thermal energy, the thermo-refrigerating systems

1.2.1 Mechanical refrigeration systems:

among them, two families stand out:

a / Liquefiable vapor compression systems,

b/ Using gas cycles systems

a.1 Vapor compression systems

A first description of the cycle was given in 1805 by the American Oliver Evans (1755-1819) But it was to the American Jacob Perkins (1766-1849), who worked in England that we owe him Firstly patent. And a first model operating with ethyl ether (1835).

The first Compression machines which had an industrial success are the work of a Scotich emigrant in Australia, James Harrison (1816-1893) (patents 1855-56-57). The machines were manufactured In England, they could produce ice or cool brines, liquids Refrigerators. The refrigerant was always ethyl ether [3].

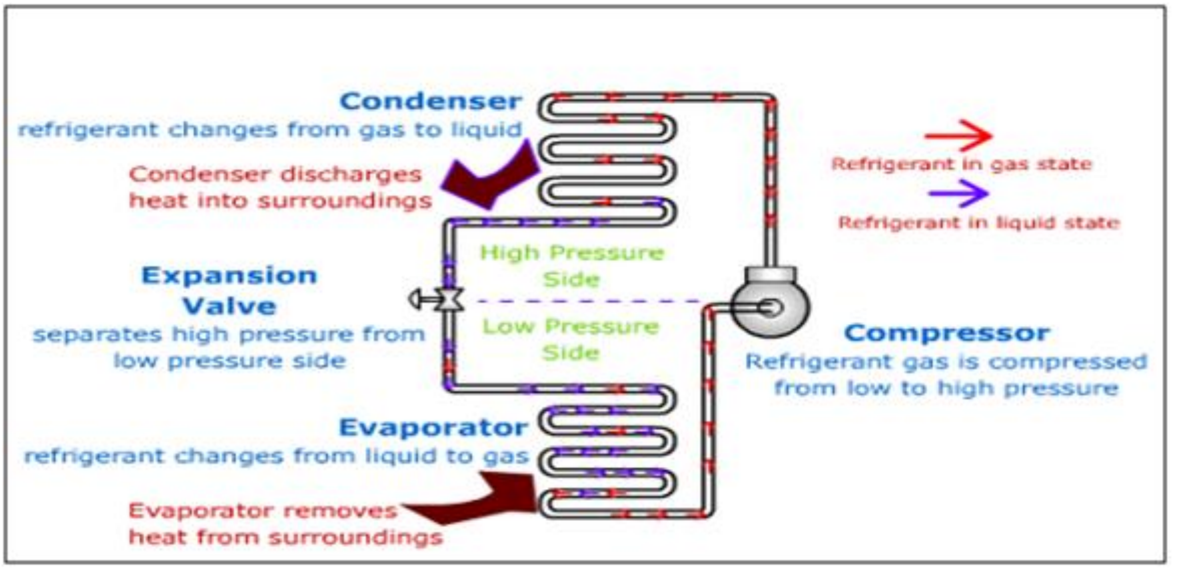

FIGURE 1.1: Schematic diagram of vapor compression refrigeration system .

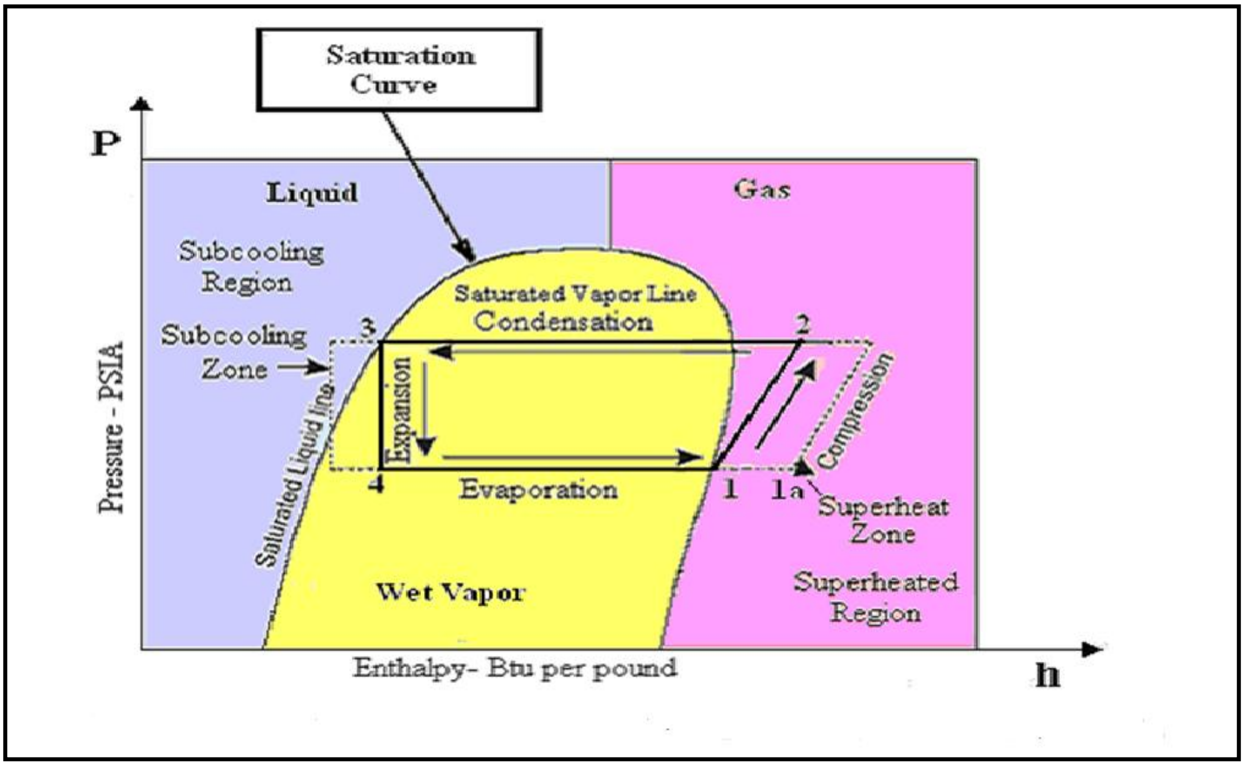

FIGURE 1.2: P H diagram of Vapor compression refrigeration system [4].

a.2 Advantage and disadvantages of vapour compression

Advantage:

1. It has smaller size for given capacity of refrigeration.

2. It has less running cost.

3. It can be employed over a large range of temperatures .

4. The coefficient of performance is quite high.

Disadvantages:

1. The initial cost is high .

2. The prevention of leakage of refrigerant is the major problem in vapour compression system.

3. Many systems still use HCFC refrigerants, which contribute to depletion of ozone layer.

a.3 Coefficient of performance :

$$COP = Q_{eva} / w_{com}$$

b - Using gas cycles systems

Here the active fluid does not change state during the refrigeration cycle but remains gaseous. When it is compressed, the gas heats up, then it is cooled under pressure to the temperature then it is relaxed, which results in a lowering of its temperature.

The first machine "outdoors" is due to the American John Gorrie (1803-1855) to cool the brine at -7 ° C (patents 1850-51). Inspired by the air of Pastor Robert Stirling (1837) the Scot Alexander Kirk (1830-1892) directed a closed cycle machine that regularly produces, for about ten years.

Since 1864 a temperature of -13 °C. In this technique we can cite the contributions of the German Franz Windhausen (1829-1904), the American Leicester Allen (1832-1912) and the French Paul Giffard (1837-1897) [3].

The development of these systems was less than that of the steam compression machines because their efficiency is reduced in the ordinary field of refrigeration, freezing and air conditioning. However, they are at the origin of most cryogenic cycles for liquefaction of gases and production of low temperatures.

1.2.2 Thermo-refrigeration systems:

One can distinguish among these refrigerating systems consuming thermal energy:

a/ Absorption systems.

b/ bsorption and thermo-chemical systems.

c/ Ejection systems.

a.1 Absorption systems:

Although their importance is much smaller than compression systems, they are currently the only thermo-refrigeration systems that are developing. Here the circulation of the refrigerant is not due to a mechanical compressor but to the circulation by pump of an absorbent liquid whose content, of refrigerant absorbed, depends on the temperature and the pressure.

Mechanical work required is very small, the system, on the other hand, consumes heat, the father of these systems is the French Ferdinand Carré (1824-1900) who patented in 1859 the first continuous absorption machine using the refrigerant: ammonia - absorbent water.

These machines were almost immediately operational. Their thermodynamic study did not start until 1913 with the German man Edmund Altenkirch and was continued during the first half of the 20th century. We should also mention the work of the Italian Guido Maïuri on these machines and those two people the Swedes von Platen and Munters on the absorption-diffusion cycle for absorption refrigerators without a pump (1920).

In the 1940s, the lithium water-bromide absorption machine was introduced in the United States, where water was the refrigerant; This adaptation of the Carre cycle Is widely used in air conditioning.

Discontinuous absorption systems, although they appear very early, do not develop the idea (devices to cool the jars of water of Edmond Carre - 1866).

a.2 Advantage and disadvantages of absorption systems

Advantage

1. No electricity required.
2. No chance of leakage.
3. High system reliability, very few failures.
4. waste heat can be used.
5. system not effected by variation of loads.

Disadvantages:

1. Low cop.
2. Higher cost initially.
3. Need to be installed perfectly horizontally .

a.3Comparison between Vapor Compression and Absorption system:

Absorption system	**Compression System**
a) Uses low grade energy like heat. Therefore, may be worked on exhaust systems from I.C engines,etc	a) Using high-grade energy like mechanical work.
b) Moving parts are only in the pump, which is a small element of the system. Hence operation is smooth.	b) Moving parts are in the compressor. Therefore, more wear, tear and noise.
c) The system can work on lower evaporator pressures also without affecting the COP.	c) The COP decreases considerably with decrease in evaporator pressure.
d) No effect of reducing the load on performance.	d) Performance is adversely affected at partial loads.
e) Liquid traces of refrigerant present in piping at the exit of evaporator.	e) Liquid traces in suction line may damage the compressor.

Table 1.2. Table comparison between vapor compressions and absorption.

a.4 Coefficient of performance:

COP = Q eva /Q boi

b. Absorption and thermo-chemical systems:

They appeared later, mostly in the first half of the 20th century. Their operation based on the thermal effects which accompany the sorption or physical desorption of gas on a solid (absorption systems) or the formation or decomposition of chemical compounds with a refrigerant gas (thermo-chemical systems) Is naturally discontinuous. Still little used, they are the subject, at present, of numerous researches.

c.1 Ejection refrigeration system:

Although it can be used with other refrigerants, it is with water that the refrigerating ejection system entered the scene in 1908. The paternity comes back to the French man Maurice Leblanc (1857-1923). The lowering of the temperature of the water, which vaporizes under low pressure, it is obtained by aspirating the vapor formed by the means of the ejector, or deceived, supplied by a jet of hot steam coming from a boiler[3].

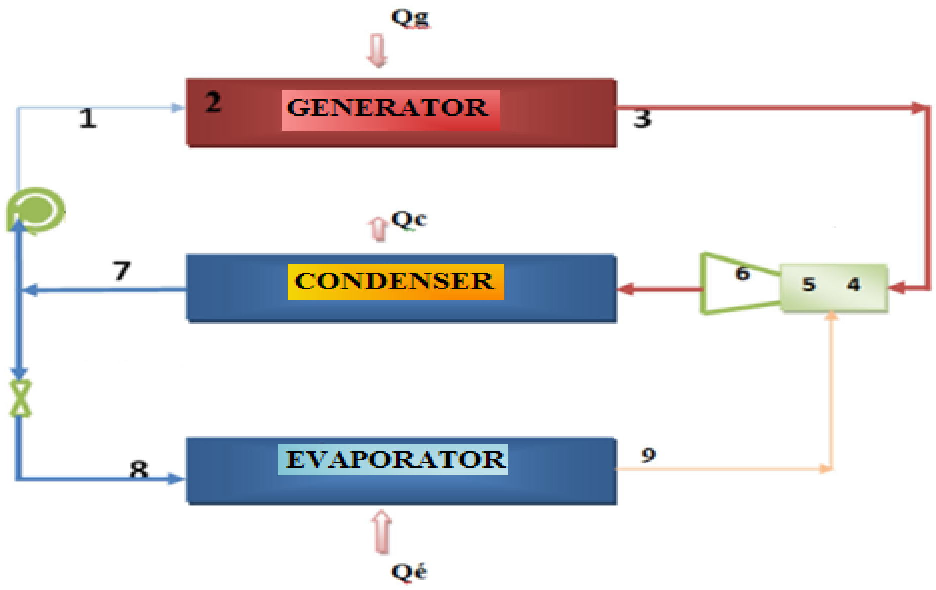

FIGURE1.3 : Schematic diagram of a ejection refrigeration system[5].

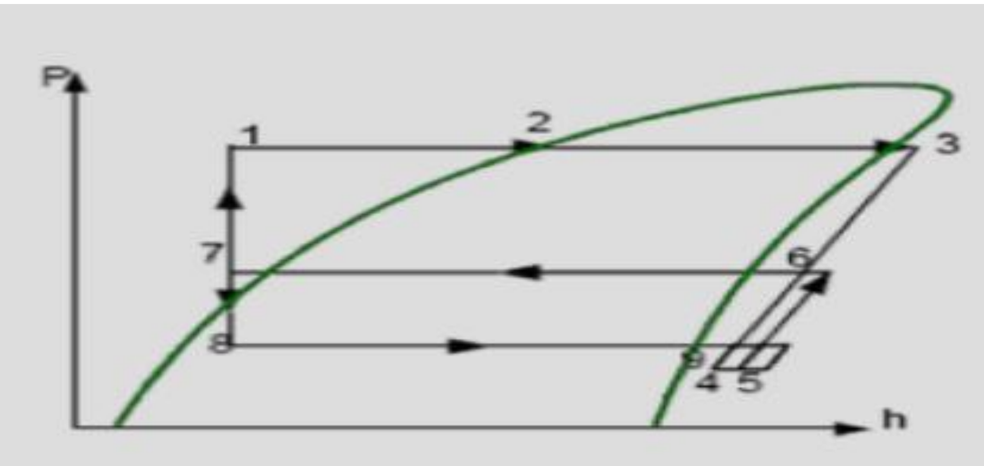

FIGURE1.4 : diagram P H of a ejection refrigeration system[5].

The ejector is at first convergent nozzle - the increase in speed of the jet decreases the pressure which allows the desired suction - then slowly diverging - the progressive increase of the section offered to the steam slows down its speed and the pressure rises. This system which has very specific niche applications is Not very widespread.

c.2 Advantage and disadvantages of ejection systems:

Advantages:

1. Instead of using noble energies (Electric energy, kinetic energy ...), the Ejecto-compression cycle uses free or non-harmful thermal energies (Solar energy).
2. It recycles the lost energies in the form of heat.
3. It has a very simple mechanical system without moving parts.
4. It does not require expensive maintenance or maintenance (no lubrication or friction).
5. The manufacture of a refrigeration machine with supersonic ejector is very simple.

Disadvantages:

1. The use of direct evaporation to produce chilled water is usually limited as volume of vapor is to be handled.
2. About twice as much heat must be removed in the condenser of steam jet per Ton of refrigeration compared with the vapor compression system.
3. The system is useful for comfort air-conditioning, but it is not Feasible for water temperature below 40C°.

Chapter II

2.1 What is absorption refrigeration?

Absorption refrigeration is another method of refrigeration, which instead of mechanical work of the compressor utilizes locally available heat sources. Absorption is a chemical process in which molecules of the refrigerant enter a bulk phase of a transport medium.

Absorption is not to be confused with adsorption, which means binding of refrigerant's molecules on the surface of a highly porous solid medium (adsorbent) — not within its volume.

The absorption refrigeration systems are much more complex than vapor compression systems, thus they occupy more space and are more expensive

Absorption is economically attractive only if there is a source of inexpensive thermal energy available — the unit cost of thermal energy is low relative to electricity (and is predicted remain low in the future).

The heat source could be either natural or artificial. The natural energy sources include renewables such as solar energy or geothermal energy. The artificial heat source is typically waste heat of some industrial process (e.g. in power plants or production facilities) or exhaust gases from the engines. The most attractive sources are at the temperature (100c°_200c°) [6].

2.2 Description of absorption cycle:

absorption refrigeration system (Figure 2.1), the mechanical compressor is replaced by two heat exchange units, a generator and an absorber, which create a heat driven heat transfer from a low temperature to a high temperature. Even though these two units replace the function of a mechanical compressor, electric pump still can be found in most absorption refrigeration system as a common and simple way to circulate the working fluid from the low pressure level to the high pressure level. However, the electric pump only consumes a small amount of energy compared to the overall system, and is considered negligible. A single substance of working fluid is generally used for the entire heat transfer process within a compression system, but this cannot be achieved in an absorption system. The working fluid in an absorption system consists of two or more substances which will act as the absorbent and refrigerant. The refrigerant actually is the real working fluid for the refrigeration process while the absorbent will treat the refrigerant to a specific condition for a complete cycle continuation. Most commercial chillers in the world are mechanical chillers, meaning that an electrically-driven mechanical compressor is used. The most common types are reciprocating, centrifugal and screw compressors.

The absorption refrigeration cycle has recently attracted much research attention because of the possibility of using waste thermal energy or renewable energies as the power source, thus reducing the demand for electricity supply [7].

Absorption cycles are used in applications where one or more of the exchanges of heat with the surrounding is a useful product, for example refrigeration, air conditioning and heat pumping.

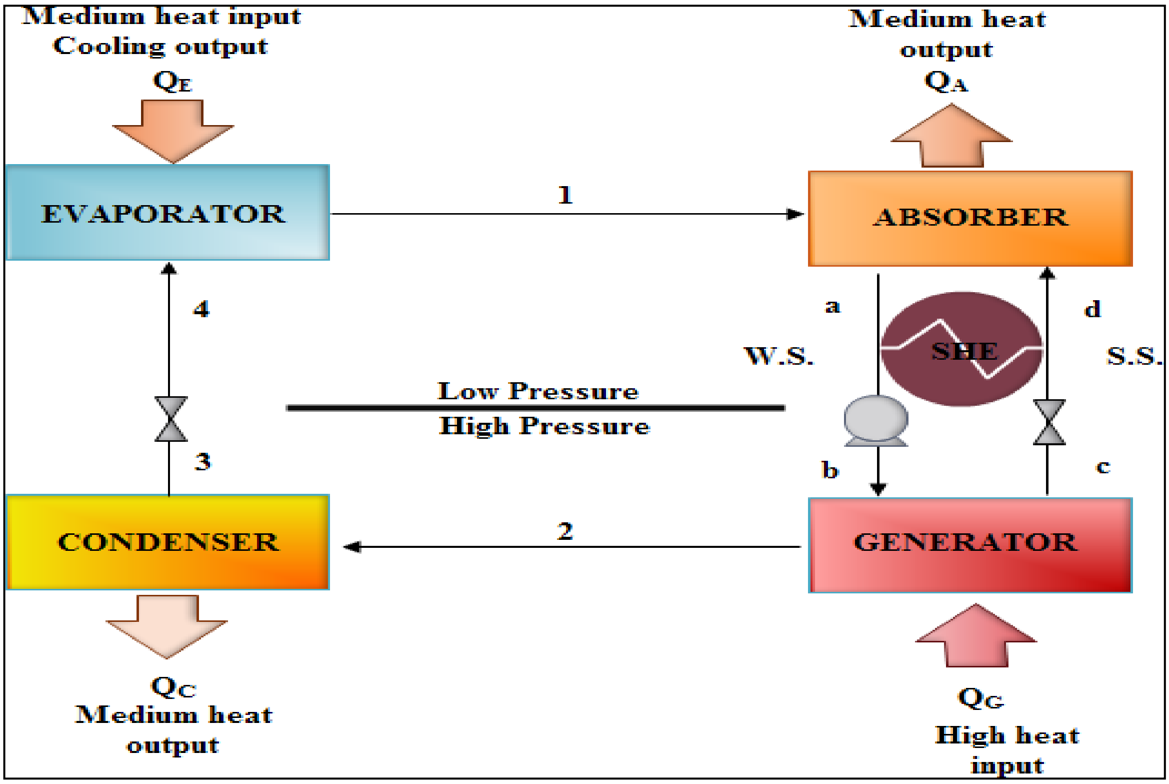

FIGURE 2.1: Schematic A simple absorption refrigeration system.

The two great advantages of the absorption cycles compared to other cycles with similar production.

- No large, rotating mechanical equipment is required .
- Any source of heat can be used, including low temperature sources.

2.3 working principle absorption cycle :

Absorption refrigeration systems are much like vapour compression cycles but the compressor is replaced by a generator and the absorber (Figure 2.2). Refrigerant enters the evaporator in the form of a cool, low-pressure mixture of liquid and vapour (4). Heat is transferred from the relatively warm water to the refrigerant, causing the liquid refrigerant to boil. The absorber draws in the refrigerant vapour (1) to mix with the absorbent. The pump pushes the mixture of refrigerant and absorbent up to the high pressure side of the system. The generator delivers the refrigerant vapour (2) to the rest of the system. The refrigerant vapour (2) leaving the generator enters the condenser, where heat is transferred to water at lower temperature, causing the refrigerant vapour to condense into a liquid. This liquid refrigerant (3) then flows to the expansion device, which creates a pressure drop that reduces the pressure of the refrigerant to that of the evaporator.

The resulting mixture of liquid and vapour refrigerant (4) travels to the evaporator to repeat the cycle [7].

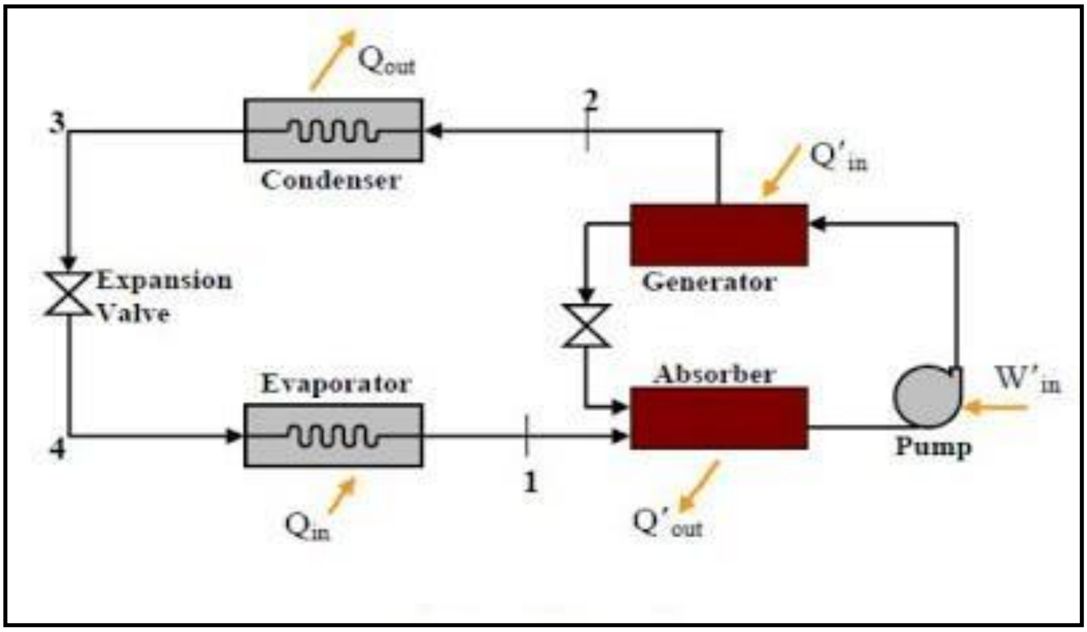

FIGURE 2.2: Schematic diagram of a simple absorption refrigeration system

The most commonly used refrigerant-absorbent pairs in the absorption systems are:

1. Water-Lithium Bromide (H_2O-LiBr) system for above 0^oC applications such as air conditioning. Here water is the refrigerant and lithium bromide is the absorbent.

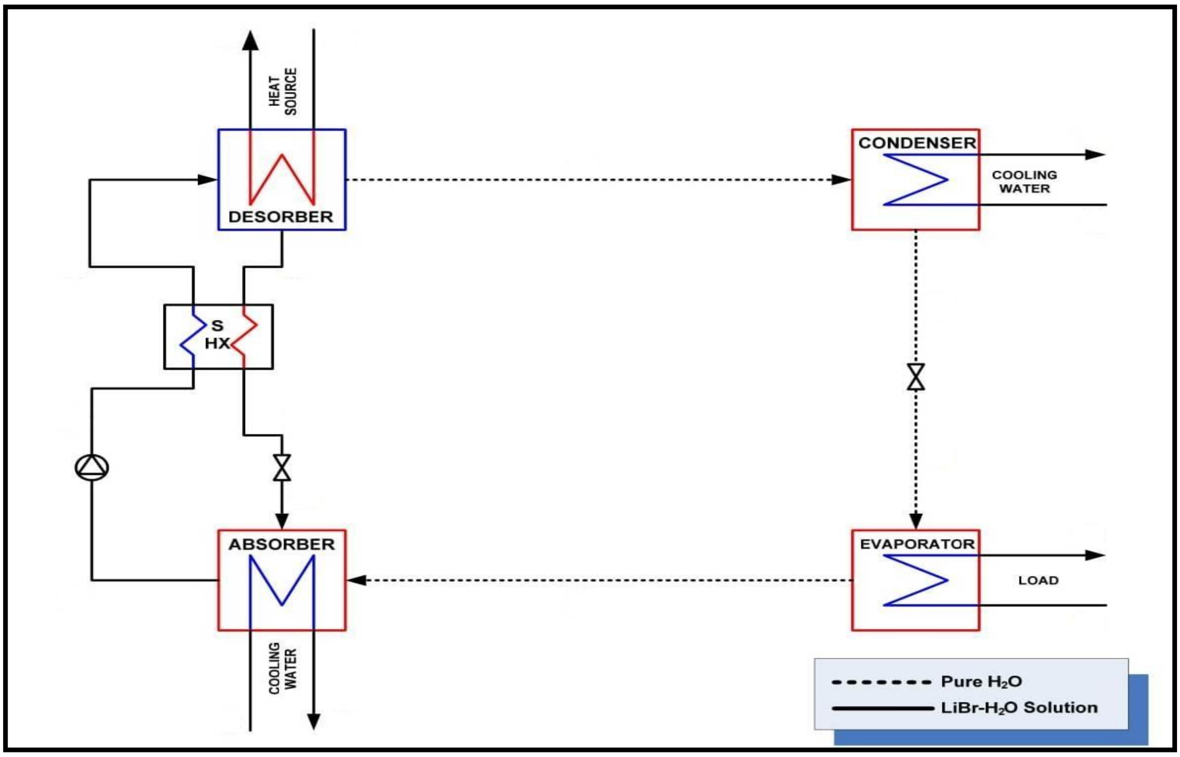

FIGURE 2.3: Single effect LiBr-H2O absorption refrigeration

2. Ammonia-Water (NH_3-H_2O) system for refrigeration applications with ammonia as refrigerant and water as absorbent.

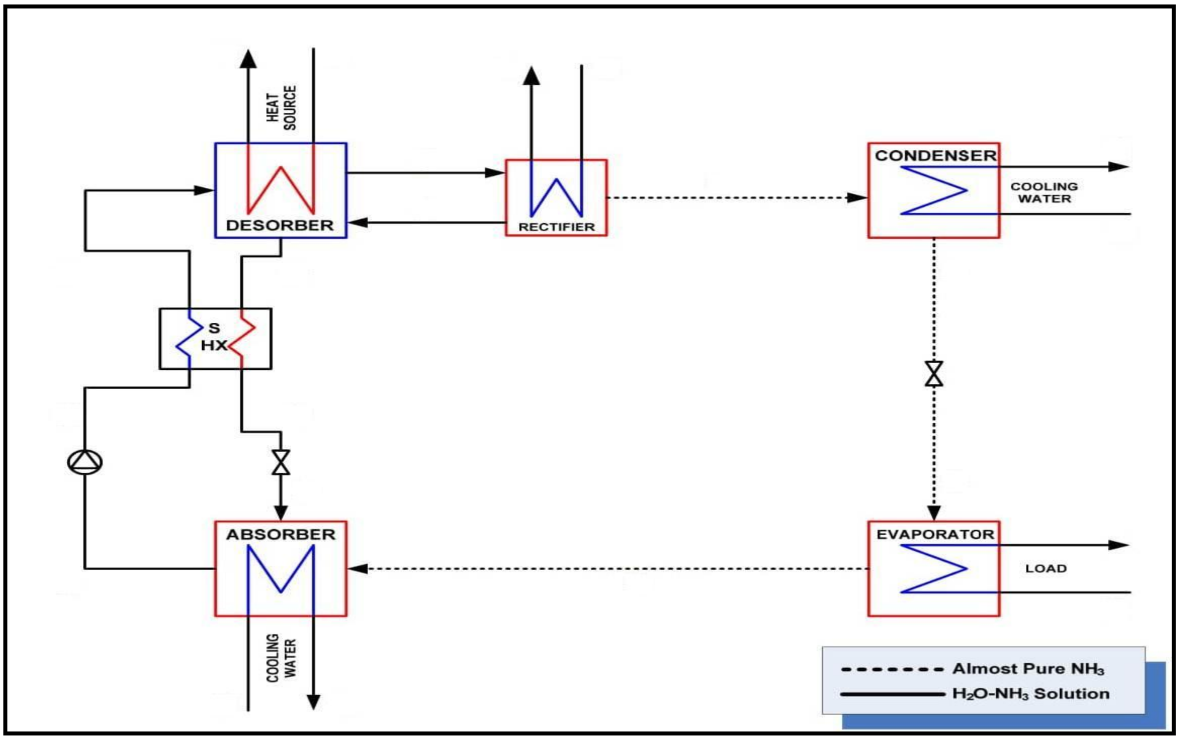

FIGURE 2.4: Single effect H_2O-N_3H absorption refrigeration

3. Of late efforts are being made to develop other refrigerant-absorbent systems using both natural and synthetic refrigerants to overcome some of the limitations of (H_2O-LiBr) and (NH_3-H_2O) systems.

4. Currently, large water-lithium bromide (H_2O-LiBr) systems are extensively used in air conditioning applications, whereas large ammonia-water (NH_3-H_2O) systems are used in refrigeration applications .

5. used in a pumpless form in small domestic refrigerators [8].

2.4 Coefficient of performance of absorption refrigeration system:

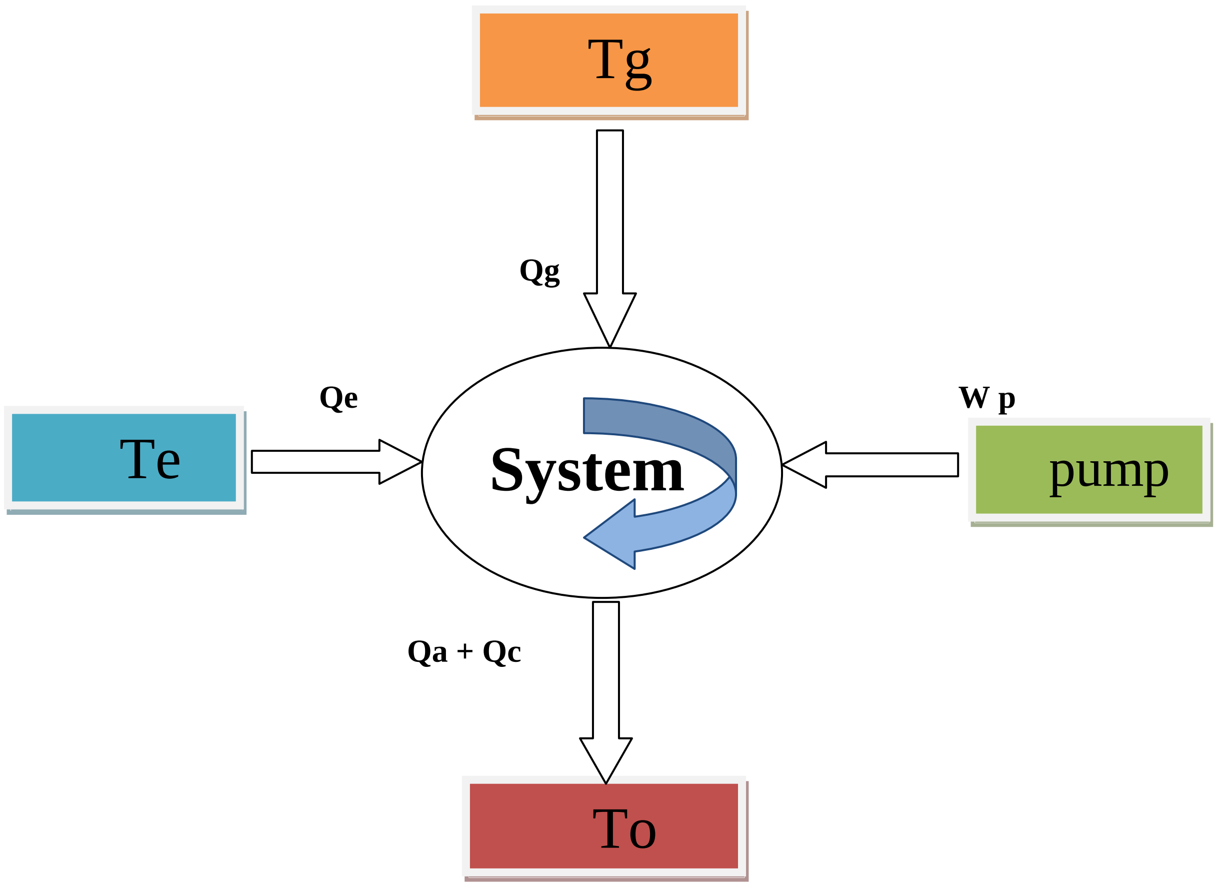

FIGURE 2.5: various energy transfers in a absorption refrigeration system.

From first law of thermodynamics,

$$Q_e + Q_g - Q_{c+a} + W_p = 0 \qquad \textbf{(II.1)}$$

where Q_e is the heat transferred to the absorption system at evaporator temperature T_e, Q_g is the heat transferred to the generator of the absorption system at temperature T_g, Q_{a+c} is the heat transferred from the absorber and condenser of the absorption system at temperature T_o and W_p is the work input to the solution pump.

From second law of thermodynamics,

$$\Delta S_{total} = \Delta S_{sys} + \Delta S_{surr} \geq 0 \qquad \textbf{(II.2)}$$

where ΔS_{total} is the total entropy change, which is equal to the sum of entropy change of the system ΔS_{sys} and entropy change of the surroundings ΔS_{surr}. Since the refrigeration system operates in a closed cycle, the entropy changes of the working fluid of the system undergoing the cycle is zero, i.e., 0Ssys=Δ. The entropy change of the surroundings is given by:

$$\Delta S_{surr} = -\frac{Q_e}{T_e} - \frac{Q_g}{T_g} + \frac{Q_{a+c}}{T_0} \geq 0 \qquad \textbf{(II.3)}$$

Substituting the expression for first law of thermodynamics in the above equation

$$Q_g\left(\frac{T_g - T_o}{T_g}\right) \geq Q_e\left(\frac{T_o - T_e}{T_e}\right) - W_p \qquad \textbf{(II.4)}$$

Neglecting solution pump work, W_p; the COP of VARS is given by:

$$COP_{VARS} = \frac{Q_e}{Q_g} \leq \left(\frac{T_e}{T_o - T_e}\right)\left(\frac{T_g - T_o}{T_g}\right) \qquad \textbf{(II.5)}$$

An ideal vapour absorption refrigeration system is totally reversible (i.e., both internally and externally reversible). For a completely reversible system the total entropy change (system+surroundings) is zero according to second law, hence for an ideal VARS

$$\Delta S_{total,rev} = 0 \Longrightarrow \Delta S_{surr,rev} = 0$$

Hence:

$$\Delta S_{surr,rev} = -\frac{Q_e}{T_e} - \frac{Q_g}{T_g} + \frac{Q_{a+c}}{T_o} = 0 \qquad \textbf{(II.6)}$$

Hence combining first and second laws and neglecting pump work, the maximum possible COP of an ideal VARS system is given by:

$$COP_{ideal\ VARS} = \frac{Q_e}{Q_g} = \left(\frac{T_e}{T_o - T_e}\right)\left(\frac{T_g - T_o}{T_g}\right) \qquad \textbf{(II.7)}$$

Thus the ideal COP is only a function of operating temperatures similar to Carnot system. It can be seen from the above expression that the ideal COP of VARS system is equal to the product of efficiency of a Carnot heat engine operating between T_g and T_o and COP of a Carnot refrigeration system operating between T_o and T_e, i.e.,

$$COP_{ideal\ VARS} = \frac{Q_e}{Q_g} = \left(\frac{T_e}{T_o - T_e}\right)\left(\frac{T_g - T_o}{T_g}\right) = COP_{Carnot} \cdot {}_{Carnot}$$

Thus an ideal vapour absorption refrigeration system can be considered to be a combined system consisting of a Carnot heat engine and a Carnot refrigerator as shown in Fig.14.4. Thus the COP of an ideal VARS increases as generator temperature (T_g) and evaporator temperature (T_e) increase and heat rejection temperature (T_o) decreases. However, the COP of actual VARS will be much less than that of an ideal VARS due to various internal and external irreversibilities present in actual systems. [8].

2.5 Thermodynamic analysis of the system :

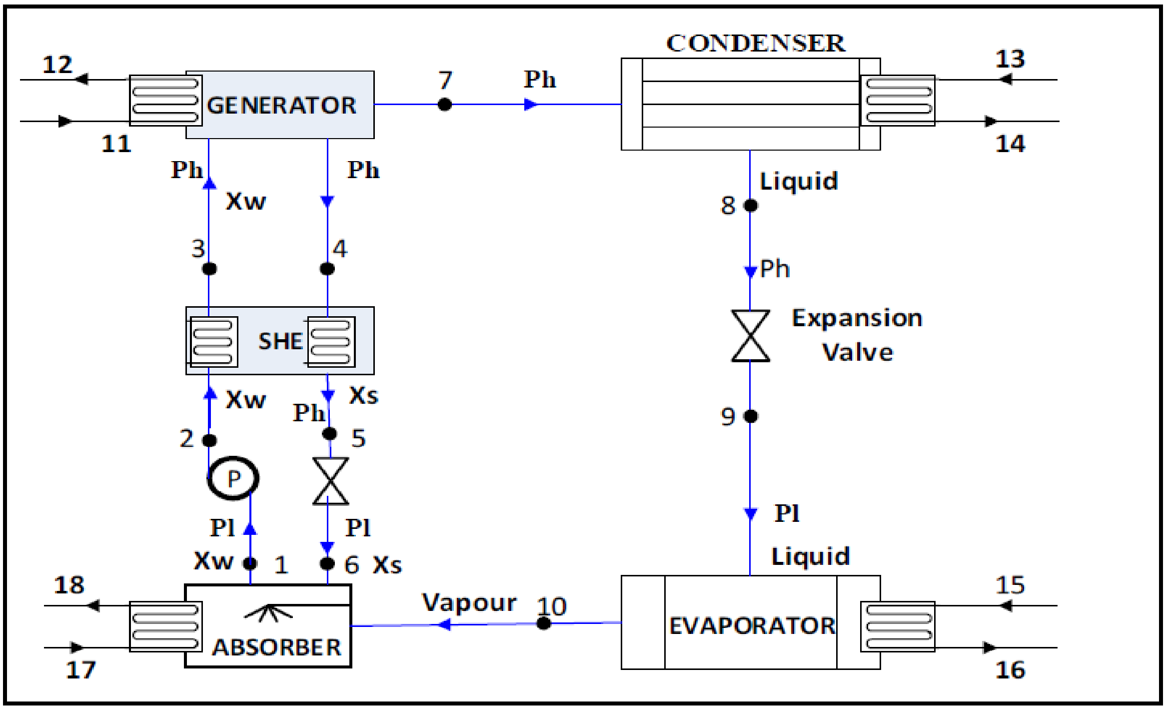

FIGURE 2.6: NH3-H2O absorption refrigeration system

A schematic of a typical water–ammonia absorption refrigeration system is illustrated in Figure 2.4. The system includes a generator, absorber, condenser, evaporator, and a solution heat exchanger. The determination of the thermodynamic properties of each state point in the cycle, the amount of heat transfer in each component, and the flow rates at different lines depend on the generator temperature, evaporator temperature, condenser temperature, absorber temperature, liquid-liquid heat exchanger effectiveness, and the refrigeration load.

For carrying out a thermodynamic analysis of the proposed vapour absorption refrigeration system, the following assumptions were made:

- No pressure changes except through the flow pump and pressure expansion valve.
- At point 1, 4 and 8, there is only saturated liquid.
- At point 10, there is only saturated vapour. Pumping is isentropic. Assume a weak solution

contains a larger percentage of refrigerant and a smaller percentage of absorbent and a strong solution contains a larger percentage of absorbent and a smaller percentage of refrigerant. The

percentages of the weak solution at state 1, 2 and 3 and the percentages of the strong solution at state 4, 5 and 6 will remain same. The temperatures at thermodynamic states 11, 12, 13, 14, 15,16, 17 and 18 are the external circuit for water which is used to input heat for the components of the system shown in Figure 2.4.

- This system has two pressure limits; one is a high-pressure limit and the other is the low-pressure limit.

P1 = P6 = P9 = P10 = Low pressure.

P2 = P3 = P4 = P5 = P7 = P8 = High pressure. [7]

2.6 Components of the absorption cycle:

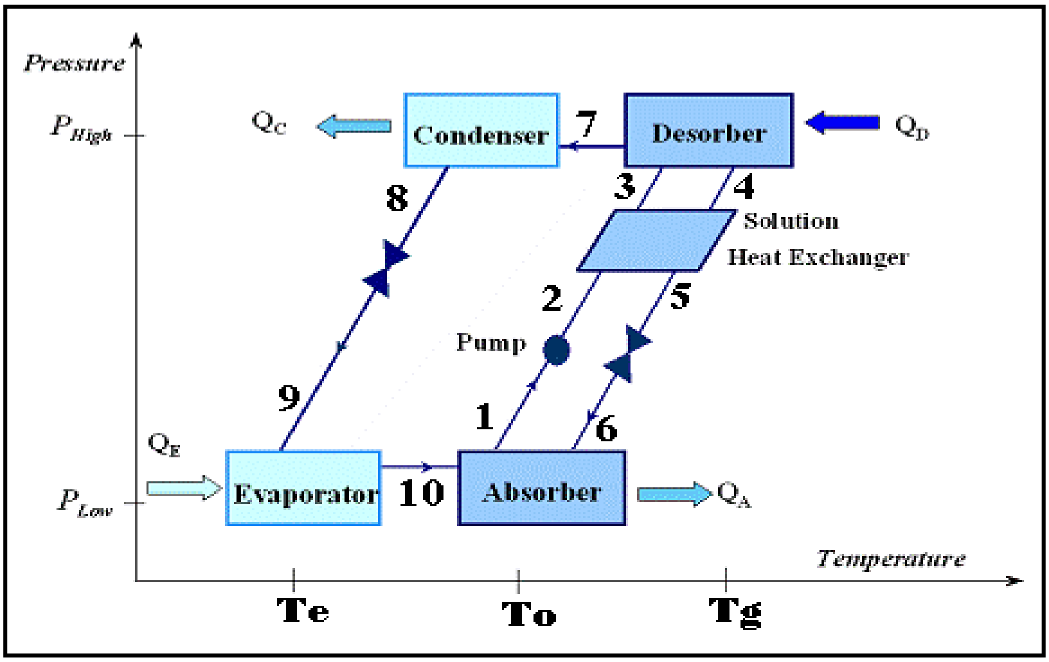

Figure 2.7. Schematic diagram of an absorption refrigeration system in Dühring diagram.

Components	**States**	**Process**
Absorber	6,10 → 1	Absorption of refrigerant into absorbent Heat of absorption release to ambient
Solution Pump	1 → 2	Isentropic solution pressurization
Solution Heat Exchanger	2 → 3 and 4 → 5	Regenerative pre-heating
Generator	3 → 4,7	Vaporization of refrigerant from solution Heat of desorption induction fromheat source.
Condenser	7 → 8	Refrigerant condensation Heat rejection to ambient.
Evaporator	9 → 10	Refrigerant vaporisation Heat absorption from the device/chamber.
Solution Valve	5 → 6	Isenthalpic solution Expansion.
Refrigerant Valve	8 → 9	Isenthalpic refrigerant expansion.

Table 2.1. Main components and processes in absorption refrigeration [9].

2.6.1 Absorber:

The absorber is a chamber where the absorbent and the refrigerant vapour are mixed together. It is equipped with a heat rejection system, i.e. bundles of tubes as in the condenser, and operates under a low pressure level which corresponds to the evaporator temperature. The absorption process can only occur if the absorber is at a sensible low temperature level, hence the heat rejection system needs to be attached. The mixing process of the absorbent and the refrigerant vapour generate latent heat of condensation and raise the solution temperature. Simultaneous with the developmental processing of

latent heat, heat transfer with cooling water will then lower the absorber temperature and, together with the solution temperature, creates a well-blended solution that will be ready for the next cycle. A lower absorber temperature means more refrigerating capacity due to a higher refrigerant's flow rate from the evaporator.

2.6.2 Generator/ desorber :

The desorber operates under high pressure which is controlled either by the temperature of the incoming heat to the desorber or the condensation temperature required by the cooling water entering the condenser. The desorption process generates vapour and extracts the refrigerant from the working fluid by the addition of the external heat from the heat source; it could be desorption of water out of a lithium bromide-water solution or ammonia out of a water-ammonia solution. The refrigerant vapour travels to the condenser while the liquid absorbent is gravitationally settled at the bottom of the desorber; the pressure difference between the desorber and the absorber then causes it to flow out to the absorber through an expansion valve.

2.6.3 Condenser:

A liquid state of a refrigerant is a must in order for the refrigeration process to run. Hence, the vapour phase of a refrigerant from the desorber is altered to a liquid by the condenser. The condensing process of a high pressure refrigerant vapour is done by rejecting the vapour's latent heat to the sink, following a regular heat balance formulation.

2.6.4 Evaporator:

The temperature of evaporation regulates the lower pressure level of the absorption system. a low pressure of two phase refrigerant from the flow restrictor continues to evaporate due to the addition of latent heat from the refrigeration environment. a complete evaporation process will convert the two phase refrigerant into vapour.

2.6.5 Expansion valve:

An expansion valve is a component that reduces the pressure and splits the two different pressure levels. In a simple model of a single effect absorption refrigeration system, the pressure change is assumed only to occur at the expansion valve and the solution pump. There is no heat added or removed from the working fluid at the expansion valve. The enthalpy of the working fluid remains the same on both sides. The pressure change process between the two end points of the expansion valve, while there is no mass flow change and the process is assumed as an adiabatic process, can change the volume if the fluid generates a small amount of steam phase via flashing.

2.6.6 Solution heat exchanger:

A solution heat exchanger is a heat exchange unit with the purpose of pre-heating the solution before it enters the desorber and removing unwanted heat from the absorbent. The heat exchange process within the solution heat exchanger reduces the amount of heat required from the heat source in the desorber and also reduces the quantity of heat to be rejected by the heat sink (cooling water) in the absorber as well.

2.6.7 Solution pump:

Although the main distinction between compression and absorption refrigeration is the replacement of the mechanically driven system by a heat driven system, the presence of a mechanically driven component is still needed in an absorption system. A solution pump will mainly circulate and lift the solution from the lower pressure level side to the higher pressure level side of the system. To maintain this pressure difference, a centrifugal type pump is preferable. Assuming the solution is an uncompressible liquid, in other words the specific volume of the liquid (*v*) will not change during the pumping process, the power requirement to lift the solution with mass flow from pressure level *P1* to *P2* 2.2 [10]

2.7 Thermal energy waste

There is high thermal energy in many fields in the world in hot ground water or produced from the centers of production of electricity or nuclear reactors or in engines, but why not exploit it?

2.7.1Nuclear Energy:

In the developed countries in the nuclear field is losing significant thermal energy

FIGURE 2.8: a nuclear center [11]

2.7.2 Algeria has factories to produce electric power gas turbines:

Most of Algeria is electricity output is from thermal centers.

FIGURE 2.9: thermal center [12]

2.7.3 In the oil field:

High thermal energy is lost in the oil field and also in hot ground water.

FIGURE 2.10: oil refining center [13]

2.7.4 Geothermal in Algeria :

Algeria is situated in northern Africa It ranks 16th in proved oil reserves. Currently, more than 98 percent of Algeria’s electricity. The Algerian government recently adopted a renewable energy program and new legislation (law on energy conservation and law on the promotion of renewable energy) that aims to produce 40 percent of its national consumed electricity from renewable energy sources by 2030.

The Geothermal Exploration Program in Algeria began in 1967, and was carried out by the Sonatrach National Oil Company. In 1982, the National Electricity Company Sonlegaz conducted geothermal studies in the north and east of the country in partnership with Italian company Enel. In the first phase, geothermal studies were mainly related to the north-eastern part of Algeria. From 1983 onwards, the work on geothermal energy was continued by the Center for Renewable Energies The program was extended in Algeria to the entire northern part of the country [14].

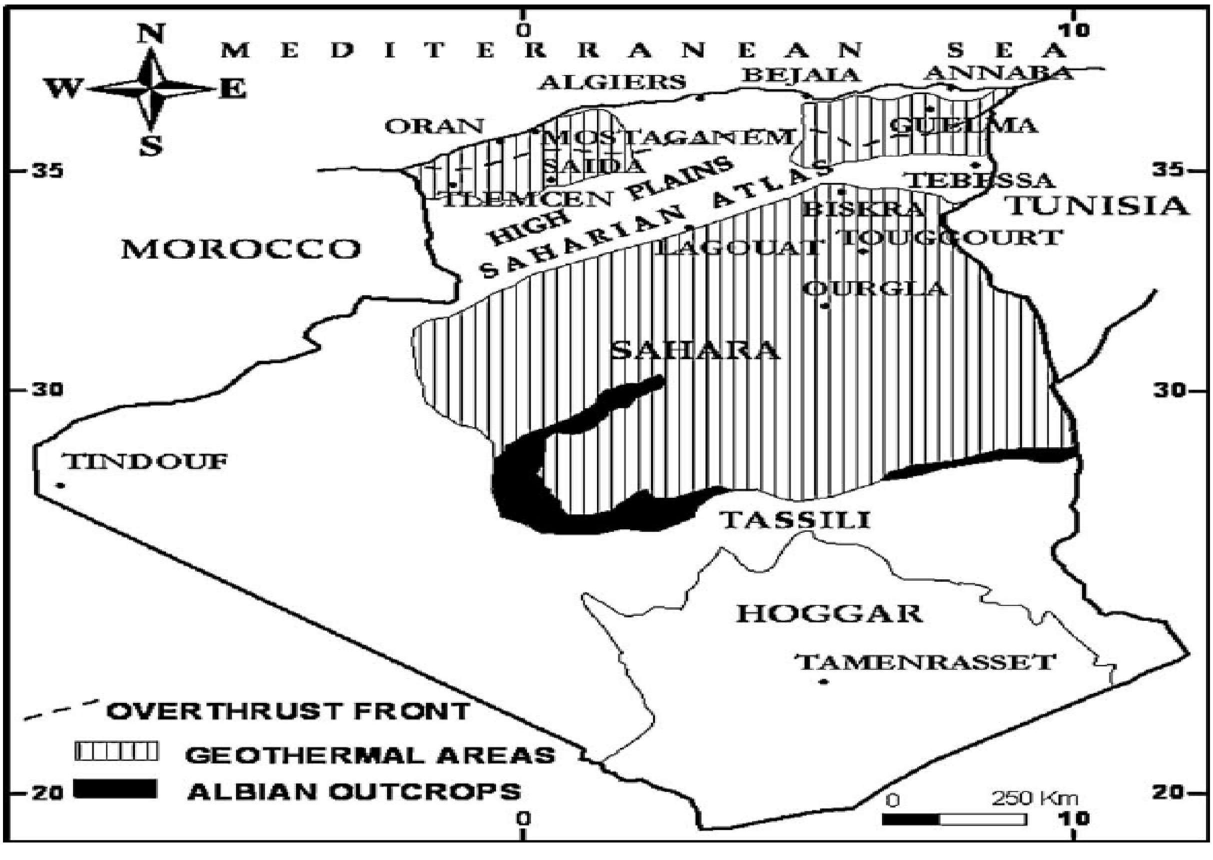

Figure 2,11: Main Algerian geothermal areas and albian outcrops [15].

Note that the thermal energy in Algeria is mostly in the desert.

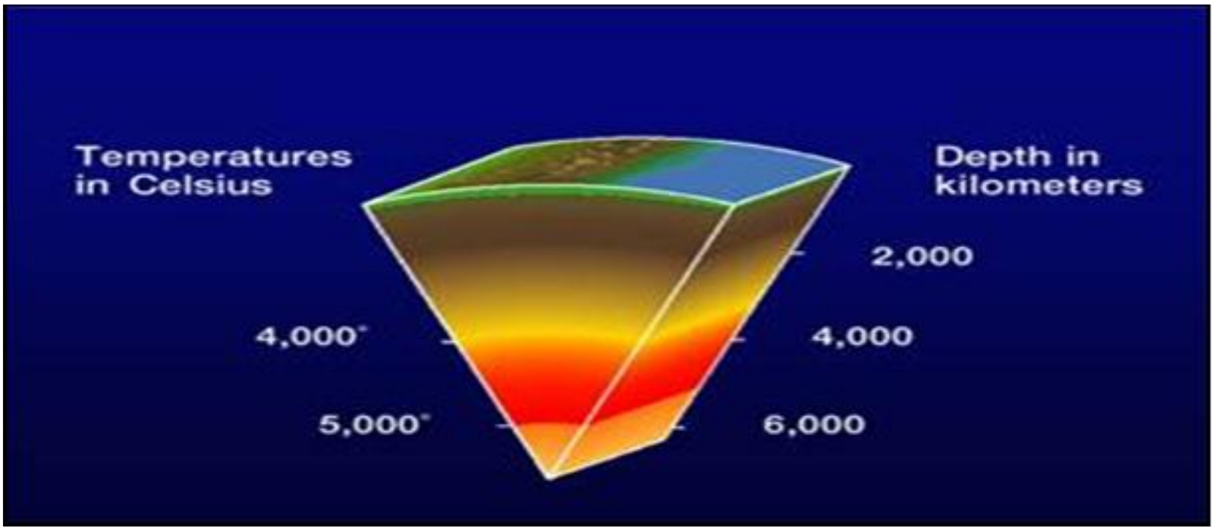

Figure2.12: Temperatures in the Earth [16].

2.8 Use of wasted energy in refrigeration :

the possibility of using waste thermal energy or renewable energies as the power source, thus reducing the demand for electricity supply.

To take advantage of this high temperature in the cooling it is enough to add heat exchanger in the absorption refrigeration.

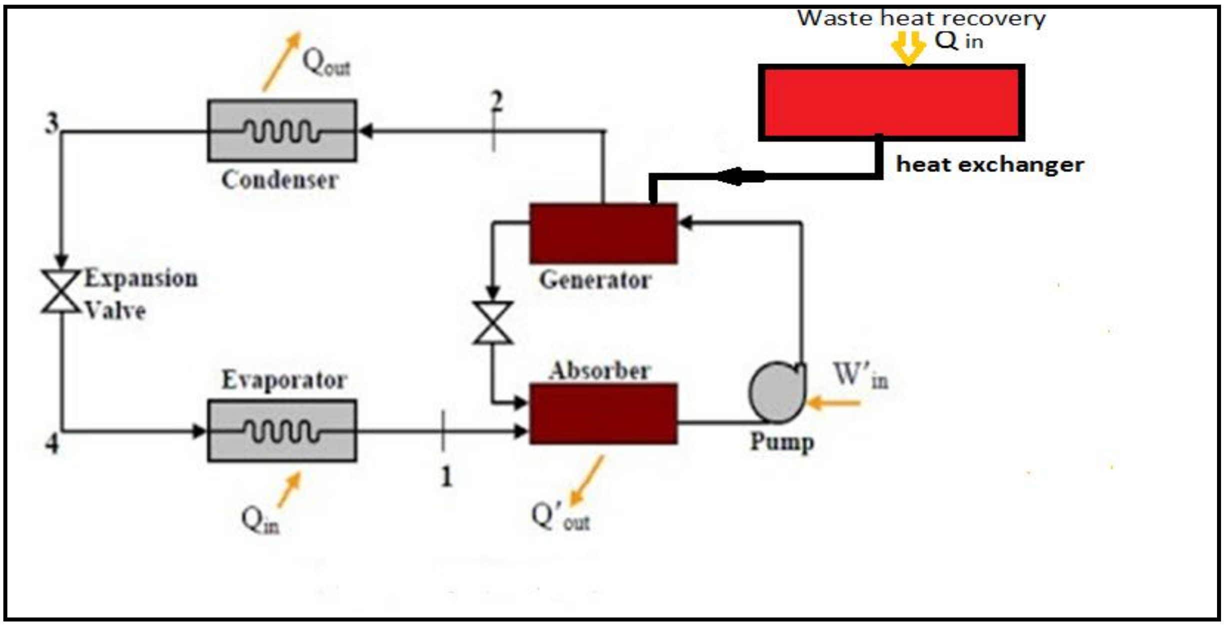

FIGURE 2.13: Schematic diagram of a simple absorption refrigeration system Connected to the heat exchanger.

2.8.1.Industrial:

The heat produced by the power plants in the gas turbines varies between(400C° , 500 C°).

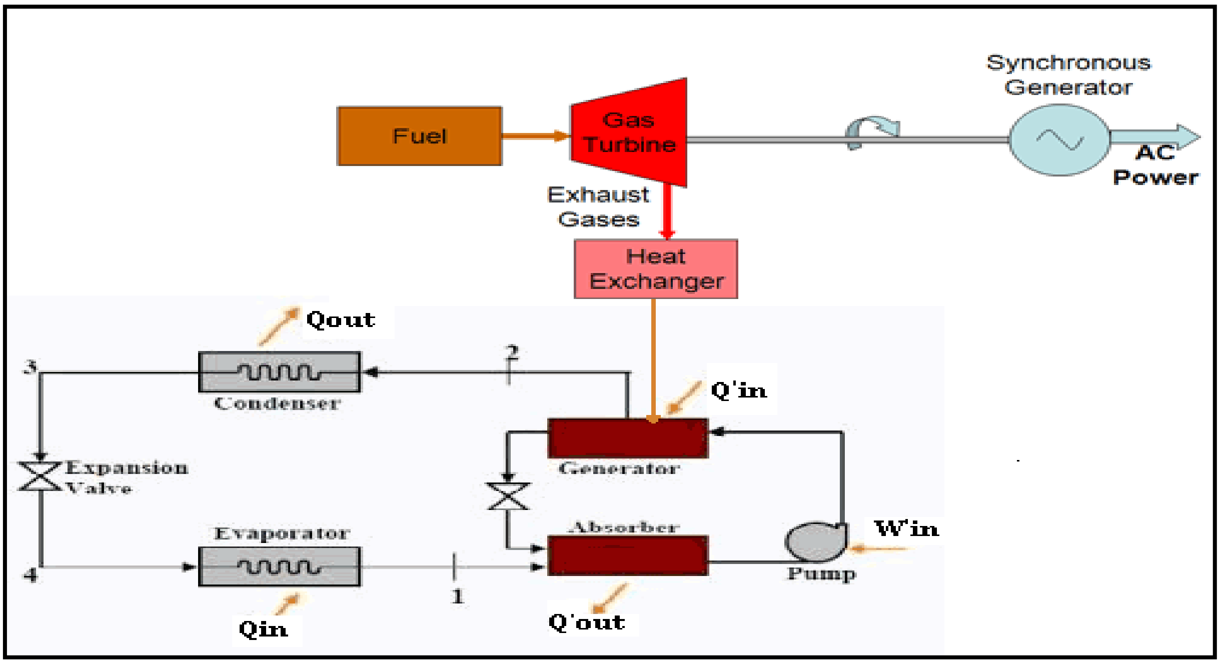

FIGURE 2.14: Schematic of a simple absorption refrigeration system Connected to the electricity production center.

2.8.2 domestic use:

Hot groundwater can also be used, in the region of Ouargla (Hassi ben abdalah) water temperature between (58C° . 60 C°) .

After the operation we get the water cooled, and give the absorption refrigeration system the necessary temperature.

Chapter III

3.1. Electricity production in Algeria by source (2012):

South Algeria has a generally very hot and sunny climate, and many buildings use air conditionings that are electrically powered in most of the time during the whole year.

Most of the electricity system depends on fossil fuels (Fig.3-1), which cost a lot and their emission harm the environment.

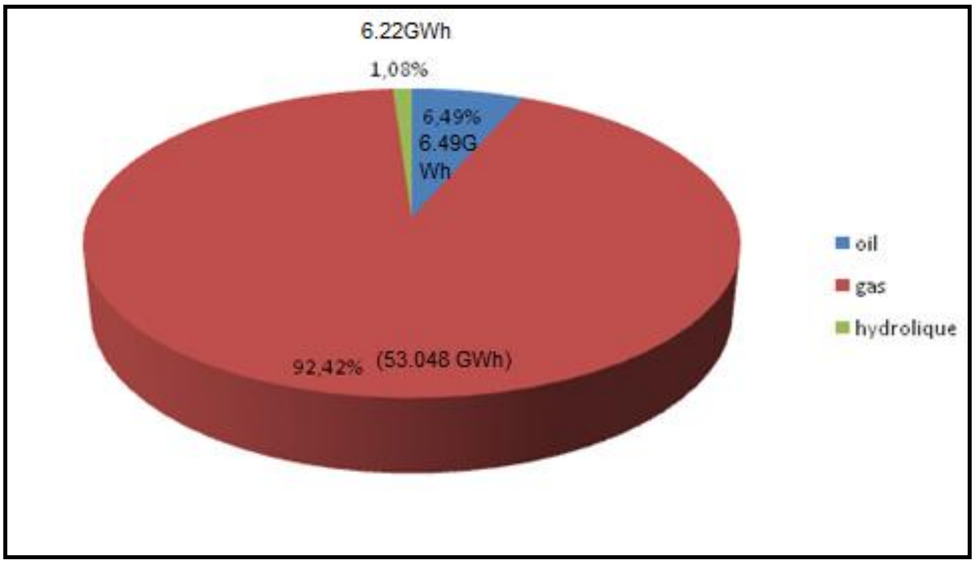

Fig 3-1: Electricity production by source (2012) [1]

The electricity shortage crisis, which affects the operation of cooling systems, causing discomfort in buildings, especially in the summer.

3.2.Weather data:

There is a lot of application that calculate the data of the weather such as the heat and humidity and sun radiation.

We have chosen the Meteonorme application to get weather data that is concerned with Hassi Messaoud city which is illustrated in the following graphs.

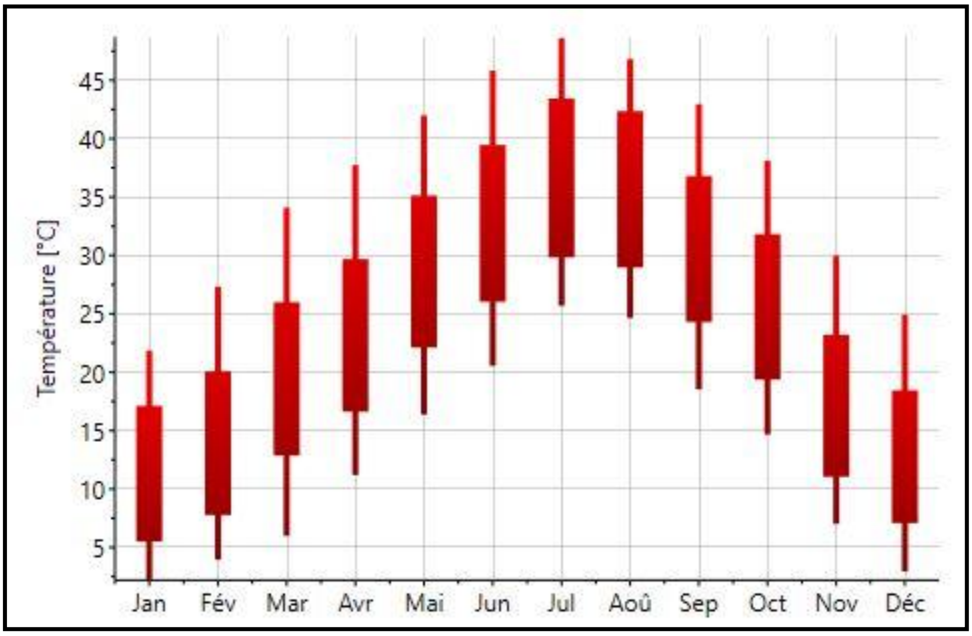

Fig 3.2: Monthly average variation of temperature during one year.

1- The first graph deals with the average monthly change of the temperature it illustrates how aggressive the weather of HASSI Messaoud and also the high temperatures during the period of April till October, which the temperature ranges from 35 degree to 45 degree and sometimes more than 45 degrees.

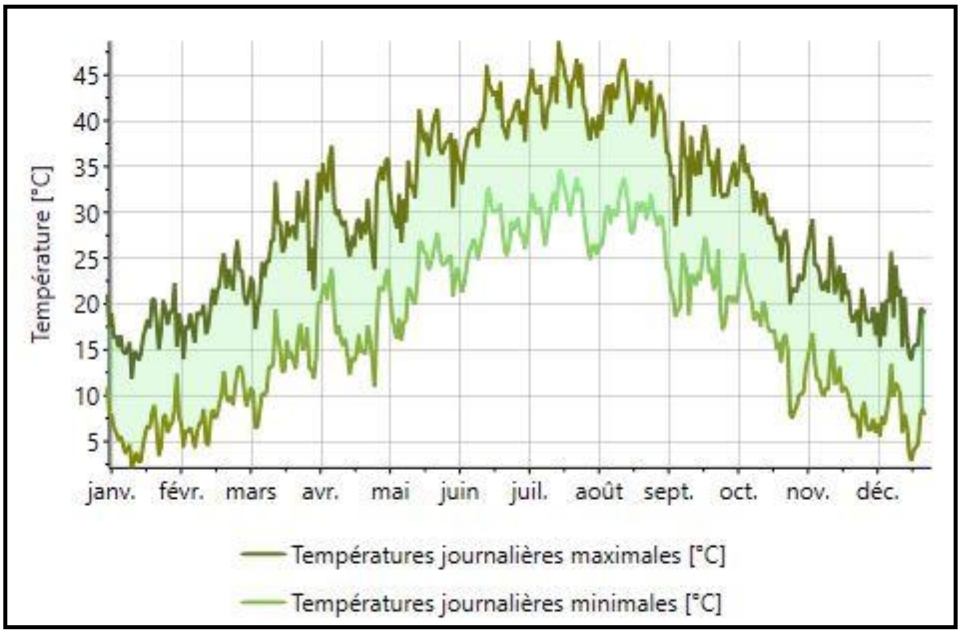

Fig 3.3: Daily average variation of temperature during one year.

2-The second graph shows the daily average temperature change and it suits the monthly change, these graphs prove the necessity of efficiency air conditioning systems for human comfort, and also we must find economical and sustainable systems.

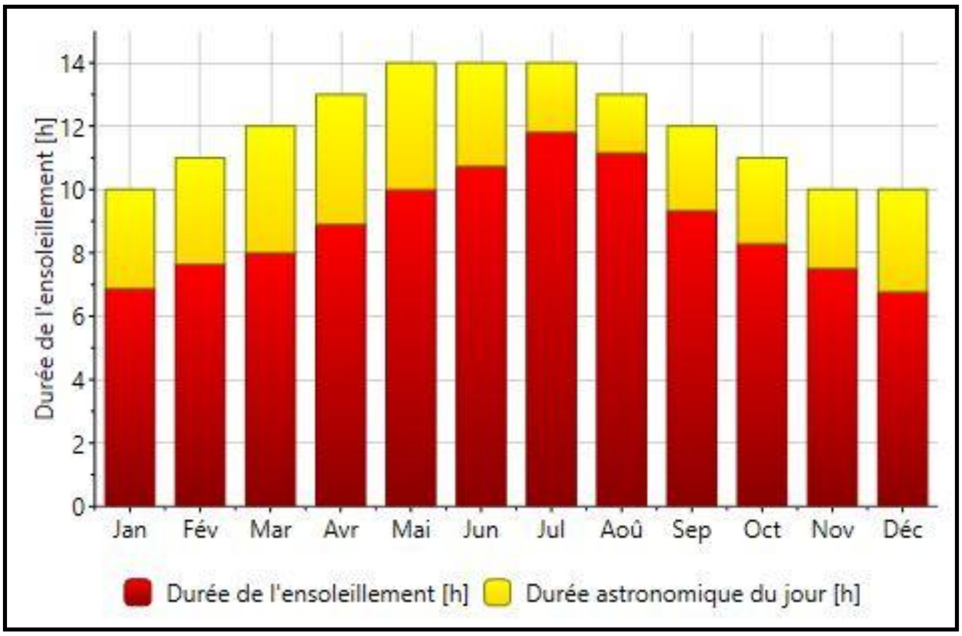

Fig 3.4: Duration of sunshine and Astronomical duration of the day during one year.

3-The third graph shows the intensity of the sun radiation and we see that it is more intensified during the period of April to October , this helps us to use it in producing the electrical energy to supply pumps and thermal energy for the devices (boiler) in the refrigeration system.

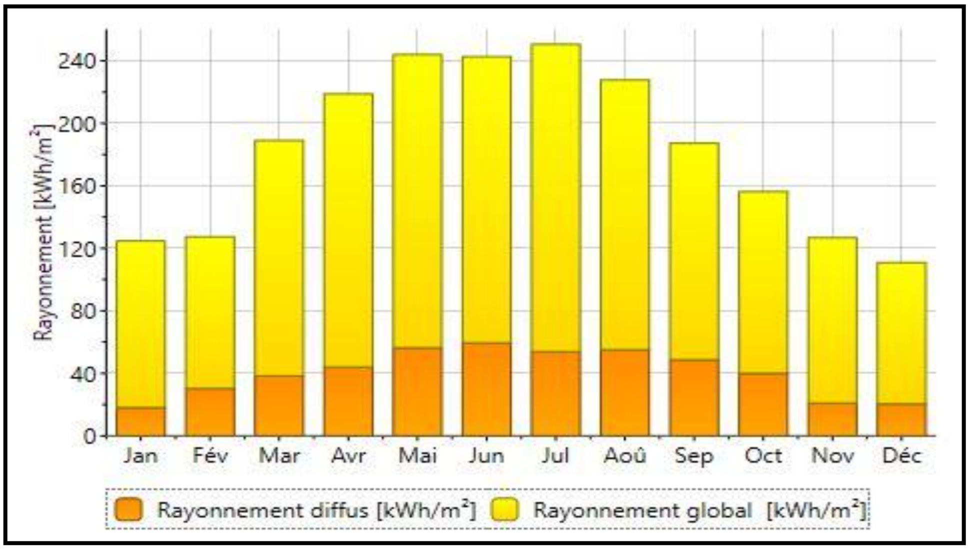

Fig 3.5: Diffuse and global radiation during one year.

4- The fourth graph represents the sunniest periods which support the third graph we notice that the period which the weather is sunny is the period that is mentioned before (between April and October).

3.3.Building data:

For this study we checked out the affection of weather data on the building that we worked on in the refrigerating system.

The following graphs are for both the affection of the heat on the building and also the refrigerating (needs) energy on the same building.

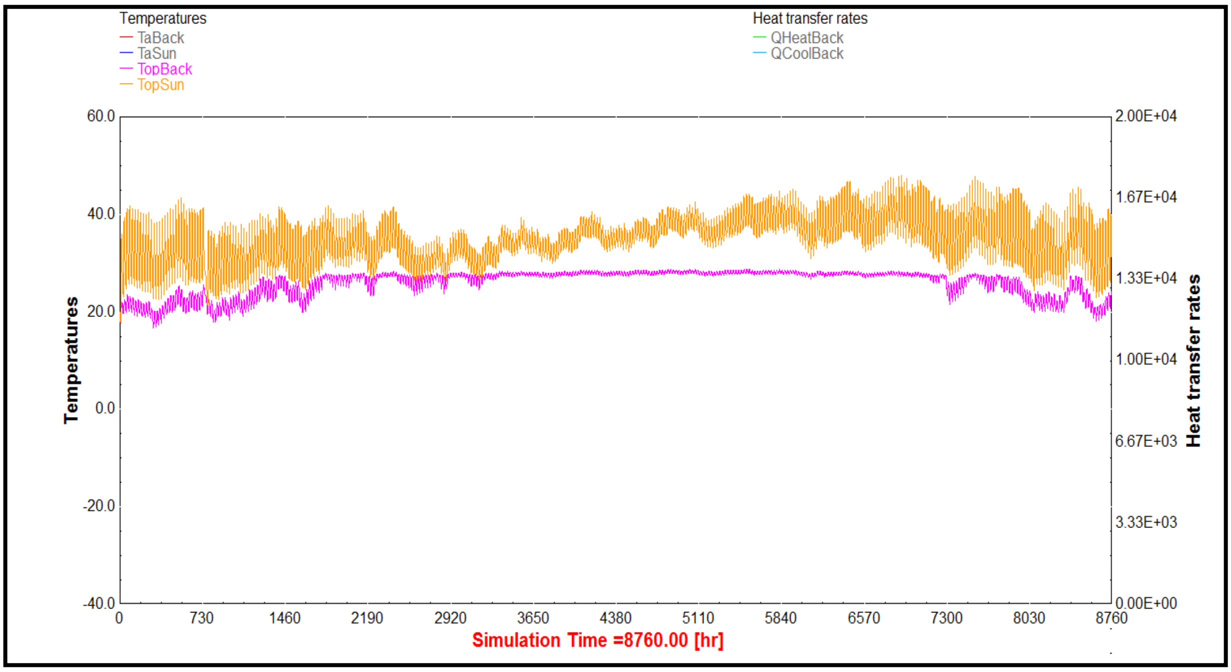

Fig 3.6: operative room temperature of building during one year.

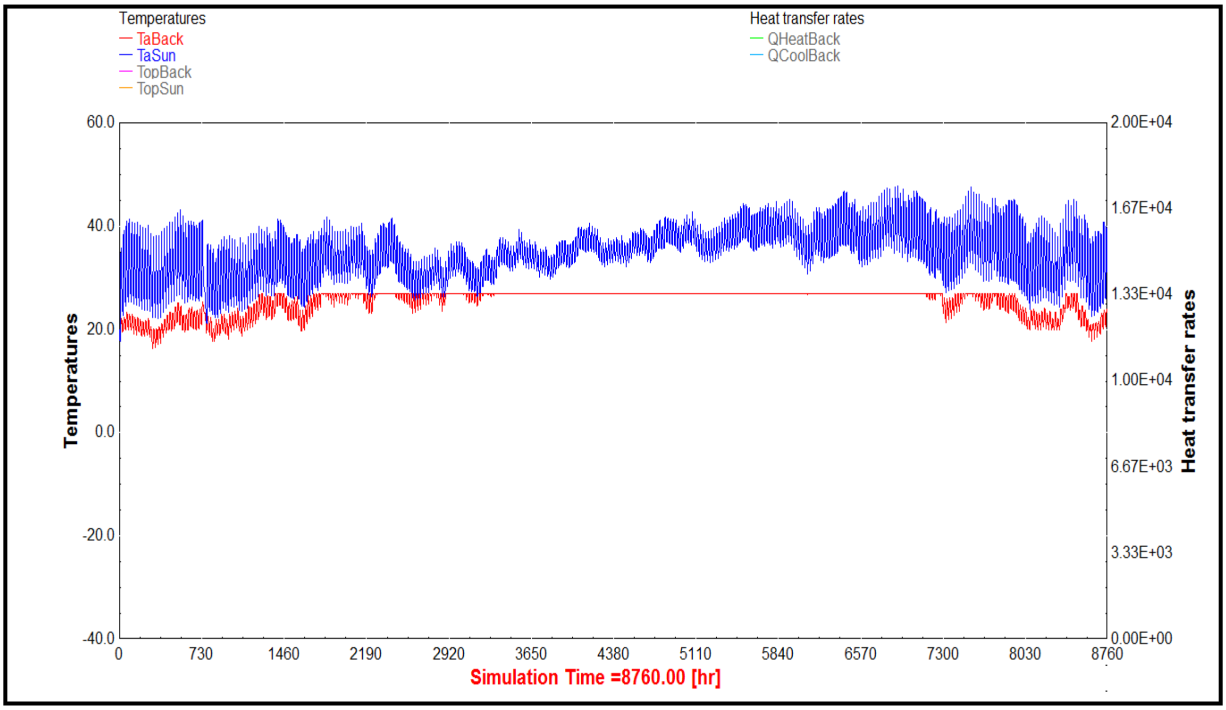

Fig 3.7: Air temperature °C of building during one year.

1- The first and the second graphs show the affection of sun radiation on the temperature of the external air of the building and the temperature of the room in all different sides of the building and this seems clear in the internal comfort factors and that leads to provide refrigerating system with taking in consideration the comfort factors such as the internal temperature of the room and humidity and the temperature of the internal surfaces.

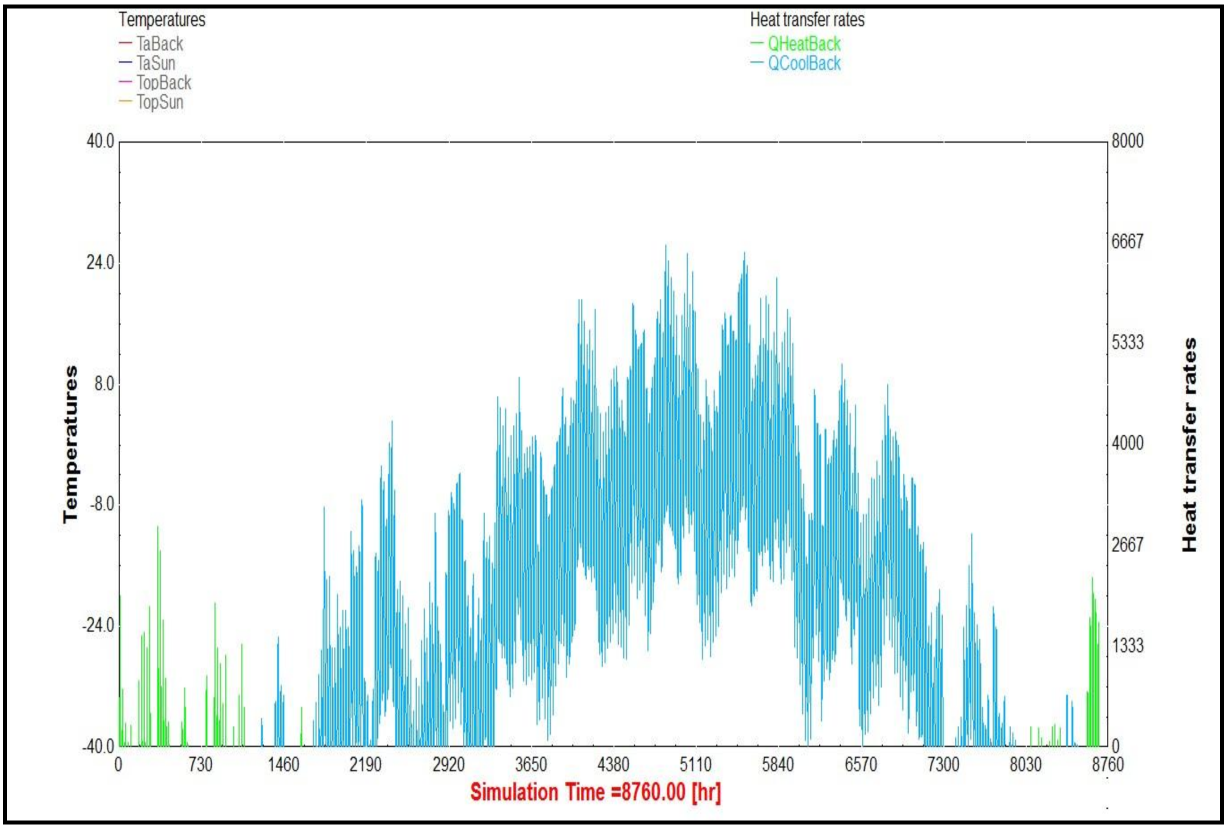

Fig 3.8: heating (Q heat) and cooling (Q cool) demand of building during one year.

2- The third graph shows the amount of energy required for refrigerating, In the period when the temperature increases in hot season between (1460hr-7300hr) and this indicates that we should provide a refrigerating system that should be affective with less power energy and this requires the usaging an economic cooling systems.

the following is the suggested system and defining the application that we will do it for the operation of simulation.

3.4.DESCRIPTION OF THE TRNSYS

TRNSYS (pronounced 'tran-sis') is an extremely flexible graphically based software environment used to simulate the behavior of transient systems. While the vast majority of simulations are focused on assessing the performance of thermal and electrical energy systems, TRNSYS can equally well be used to model other dynamic systems such as traffic flow, or biological processes.

TRNSYS is made up of two parts. The first is an engine (called the kernel) that reads and processes the input file, iteratively solves the system, determines convergence, and plots system variables. The kernel also provides utilities that (among other things) determine thermophysical properties, invert matrices, perform linear regressions, and interpolate external data files. The second part of TRNSYS is an extensive library of components, each of which models the performance of one part of the system. The standard library includes approximately 150 models ranging from pumps to multizone buildings, wind turbines to electrolyzers, weather data processors to economics routines, and basic HVAC equipment to cutting edge emerging technologies. Models are constructed in such a way that users can modify existing components or write their own, extending the capabilities of the environment [17].

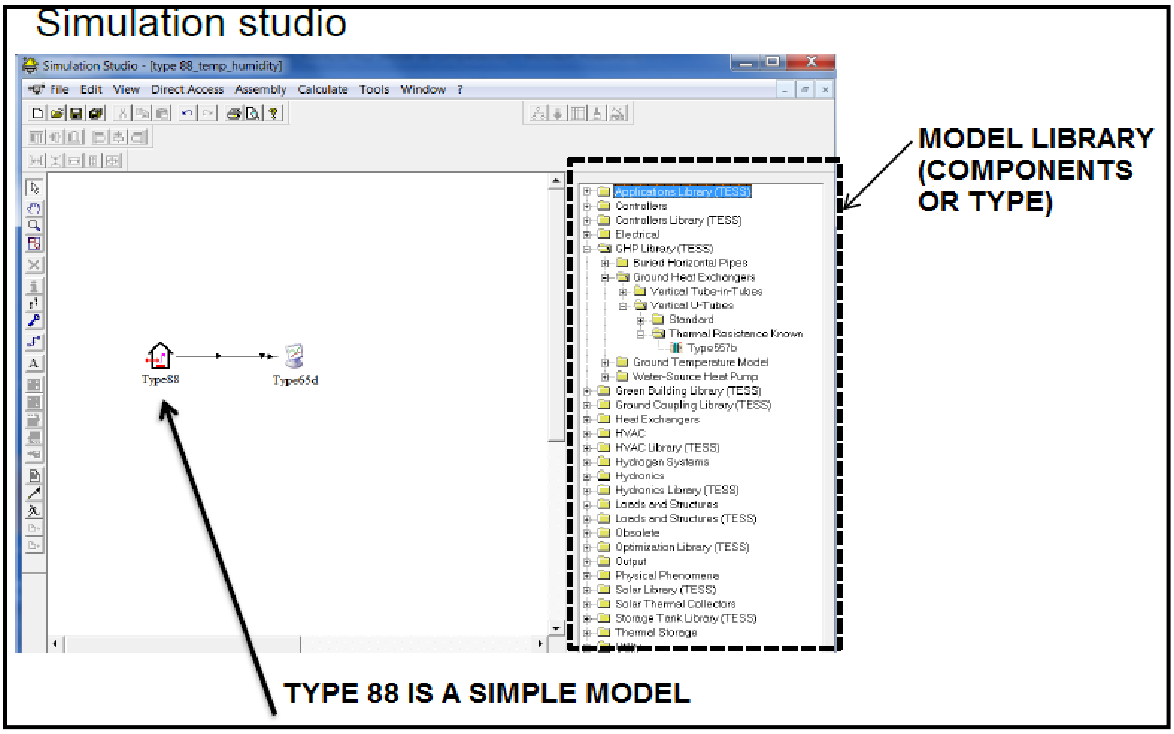

Fig 3.9 : TRNSYS SIMULATION

The system is modelled with the TRNSYS simulation program. TRNSYS is an acronym for a ‘transient simulation program’ and is a quasisteady simulation model. This program was developed by the University of Wisconsin by the members of the Solar Energy Laboratory (Klein et al., 1998). It is written in ANSII standard Fortran-77. The program consists of many subroutines that model subsystem components. The mathematical models for the sub-system components are given in terms of their ordinary differential or algebraic equations.

With a program such as TRNSYS, the entire problem of system simulation reduces to a problem of identifying all the components that comprise the particular system and formulating a general mathematical description of each. The type number of every TRNSYS subroutine used to model each component is also shown in Fig3.10.

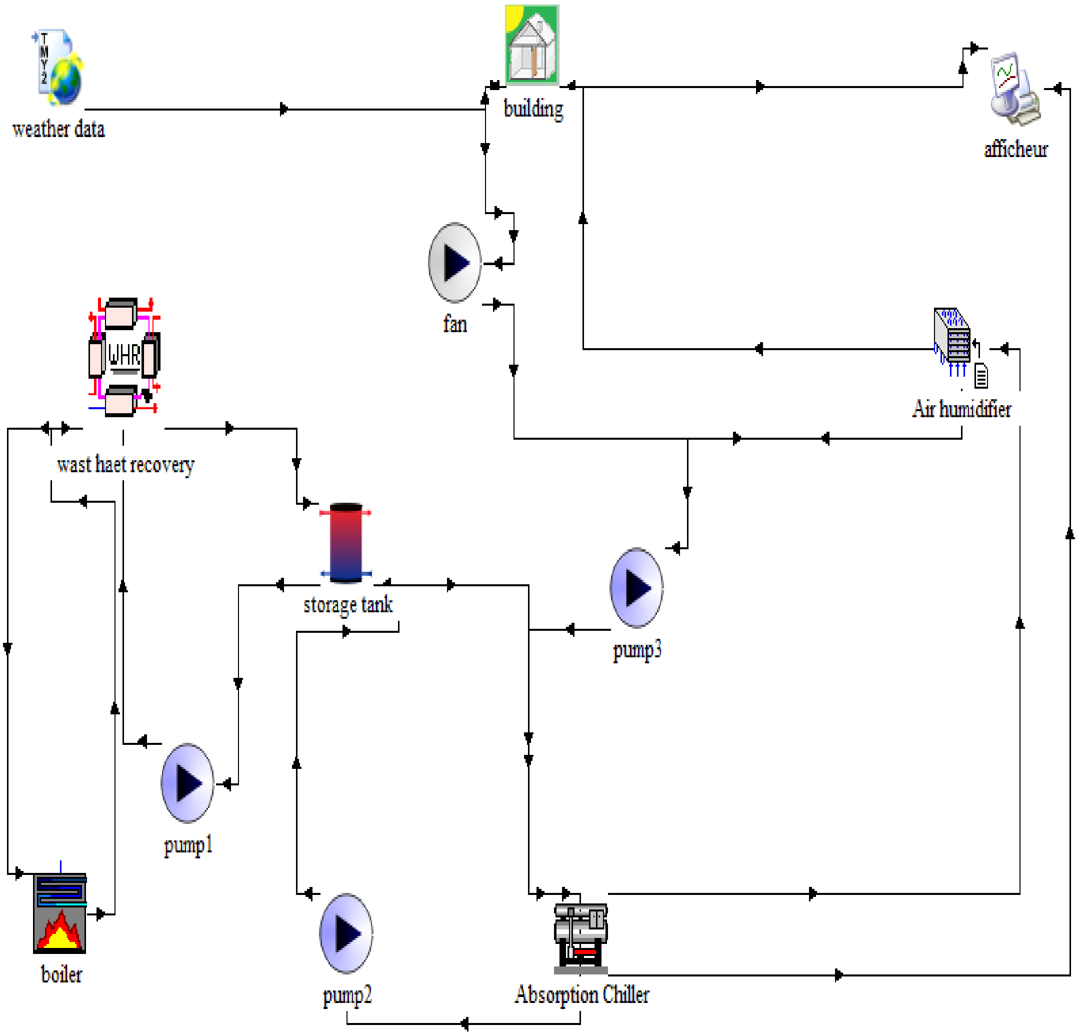

Fig 3.10: SYSTEME DESCRPTION.

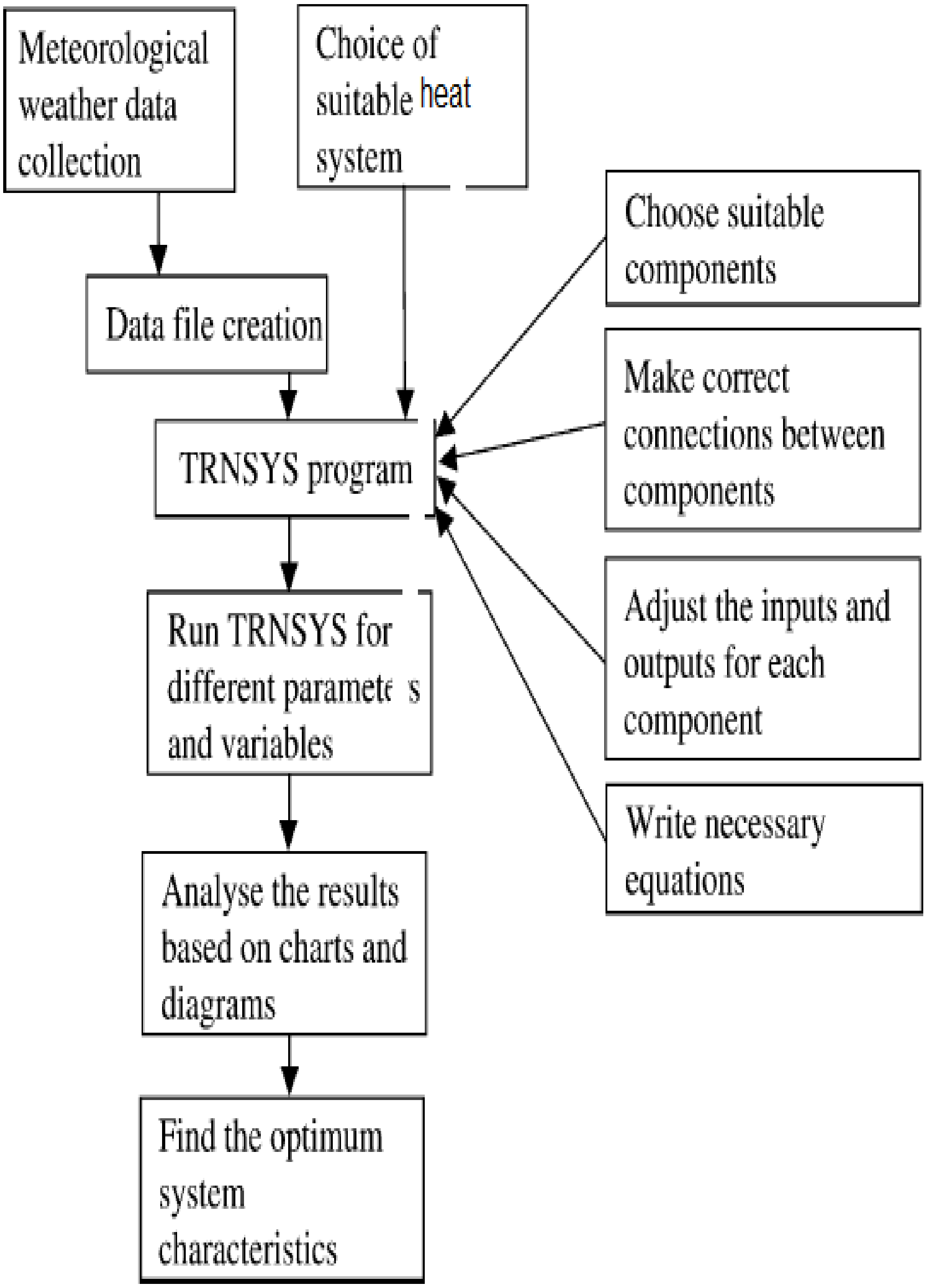

Fig 3-11. Flowchart of absorption air-conditioning project.

3.5.Coefficient of performance :

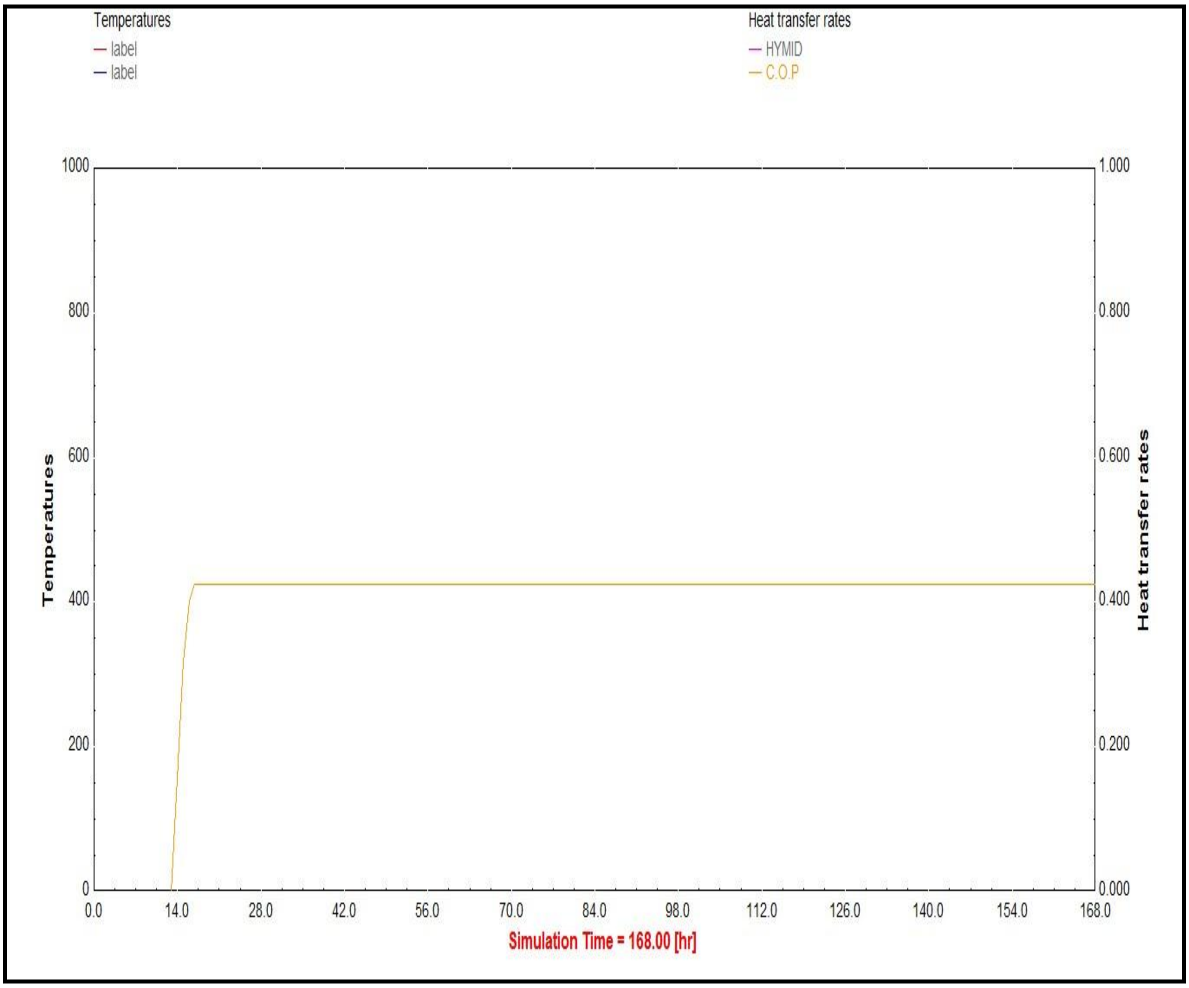

Fig 3.12: Coefficient of performance.

We noticed that the coefficient of performance of this cycle is constant with the time perhaps the reason is the big difference between the value of generate heat in the boiler (constant in our case) and the heat evacuated in the evaporated, we can’t verified this proposal because the TRNSYS is a closed box tools.

The advantage of a constant COP is we can obtain a continues human conditions comfort .

General Conclusion:

The purpose of this work is to make a way to exploit the thermal energy resulting from the turbine that exists in the industrial compound in Hassi Messaud city and also exploiting the thermal energy of the local hot water for the operation of the absorption refrigerating using the simulation application (TRNSYS) that through it we found precious pieces of information in the field of refrigeration and several kinds of refrigeration cycles (absorption) and we knew how to use and structure a certain refrigerating system in the application (TRNSYS) which is considered an important tool in nowadays time(dynamic) used in a lot of institutes and Scientific Research Centers especially in the renewable energy and building energy fields
It is also deduced the changes of temperature which requires an affective refrigeration and heating system because the temperature that affects the factors of the human comfort and all of that must be related to a good refrigerating system which doesn’t cost from the economic side.

Recommendations:

1- Usage of other thermal energies of daily life like water, the flood, and the hot fountains which is extracted from the ground.

2-Application and embodying the theoretical experiments practically just like the studied example.

3- The exploitation of another waste industrial thermal energies with temperatures and it is too many in the industrial life.

4- Use other thermal cycles to comparison.

5- Create a new component (new cycle of refrigeration) and add it to TRNSYS library.

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