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Modification of Generator In Electrolux Refrigerator

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Abstract - *Over last few years, the energy is the strength of development of science and technology along with the economic development. In addition to men, machine, material and money, energy, is also the fifth factor of the production. The objective of this paper of the paper is to do modification in an Generator-Heat exchanger in an conventional vapour absorption refrigeration system by using the natural resources as the heat input in generator. So for that the conventional burner heated or electrically heated generator is replaced by solar collector which supplies the heat absorbed on it and heats the water passing from it. This water is passed in to the heat exchanger where mixture of liquid ammonia and water get heated and the vapour ammonia is generated which is supplied for further process. Other components like condenser, absorber, and evaporator etc and its process remain same.*

***Key Words*: Generator- Heat exchanger, Vapour Absorption, Natural resources, Solar heating, Environment.**

1.INTRODUCTION

1. Solar energy is available in abundant form in a nature. The power from the sun is absorbed by the earth is approximately 1.9×10^11 MW which is larger compared to the energy used by the population by other sources on the earth. So, the solar energy can supply present and future needs of people continuously by proper use of it. This makes the solar energy the most promising of the unconventional source of energy. Along with this the solar energy has two more advantages first unlike fossil fuel and nuclear power it is an environmental clean source of energy. Second, it is free of cost and available in abundant form rather than in winter and monsoon season. The solar energy can reach each and every place of the earth where the people can live. However the main problem is that it is dilute source of energy.

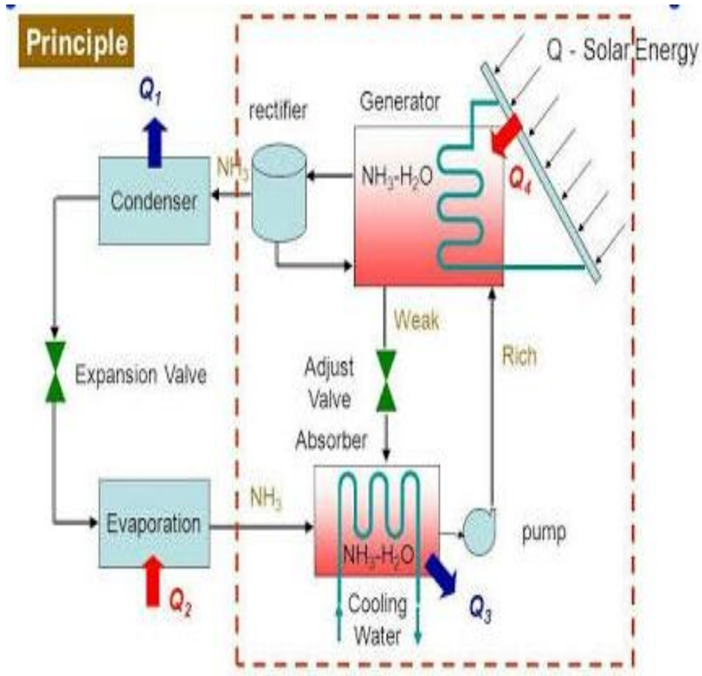

Figure 1: Basic principle of the solar powered system

Flat plate collectors : Flat plate collectors is an insulated weather proofed box containing a dark absorber plate under one or more transparent covers. Where temperature below 90°C are adequate, as they are for space and service water heating flat plate collectors are convenient to use. They are made in rectangular from about 1.7 to 2.9 m^2 in area and are relatively simple to make.

Parts of flat plate collectors:

Cover plate: It is made up of glass tempered with a low iron content and 3.2-6.4 mm thick. The collector has 85% transmittance when this type of glass is used.

Absorber plate: It is made up of copper because of its high conductivity .Moreover, it is corrosion resistant. These copper plates 0.05 mm thick with 1.25 cm tubes. Tubes are spaced 15cm apart, the efficiency is 97%.Also, black paint over copper plate is used which has absorptance= 0.85-0.9 and emmitance= 0.08-0.12.

Insulation: It is made up of steel, aluminum or fiber glass.

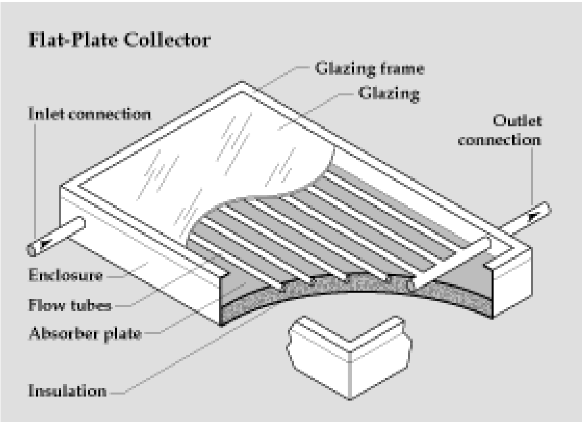

Figure 2 : Flat plate collector

2. Vapour Absorption Refrigeration System

The VARS is just similar to the class of the compression refrigeration system rather than that in this system the compressor is replaced by other four components: Generator, Absorber, Heat exchanger and Rectifier. Just similar to vapour compression systems, vapour absorption refrigeration systems have also been commercialized and are widely used in various refrigeration and air conditioning system but still they are not popular in India. Since, VARS system runs on low grade energy, they should be operated where low grade energy like waste energy or solar energy is available. Since the conventional VAR system uses the natural refrigerants like water & ammonia as they are environment friendly. The basic components of the system are the generator, absorber, pump, rectifier, condenser, expansion valve, evaporator and a heat input to the generator via a heat exchanger.

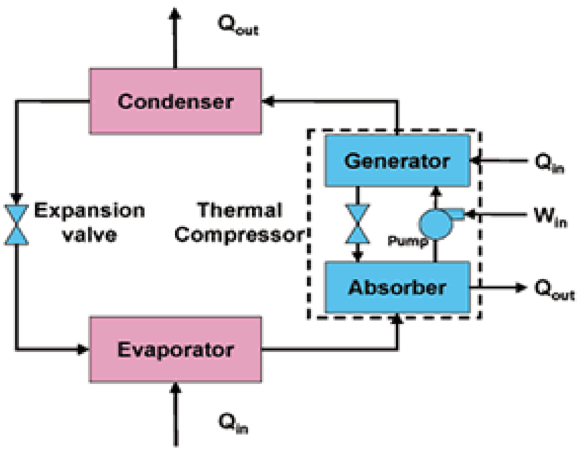

Figure 3 : Vapour Absorption Refrigeration cycle

In most of the vapour absorption refrigeration system the NH_3-H_2O has been widely used where the NH_3 is used as a refrigerant while H_2O is used as a absorbent. Ammonia is only refrigerant which is still used in refrigeration system very widely due to having most of the properties which the ideal refrigerant is having like low volumetric displacement, low cost, low weight of liquid per ton of refrigeration and high efficiency. Due to low production and maintenance cost of ammonia it is widely used in ice plants and cold storages nowadays. Ammonia is having freezing point of -77°C so it can be also used for the low temperature use. Since both NH_3 and H_2O are volatile, the cycle needs rectifier to strip away water that normally evaporates with NH_3. Without rectifier the water would accumulate in the evaporator and offset the system performance.

3. Electrolux Refrigeration System : This kind of system is developed by an American company "Electrolux" in order to remove the use of pump in the vapour absorption system.

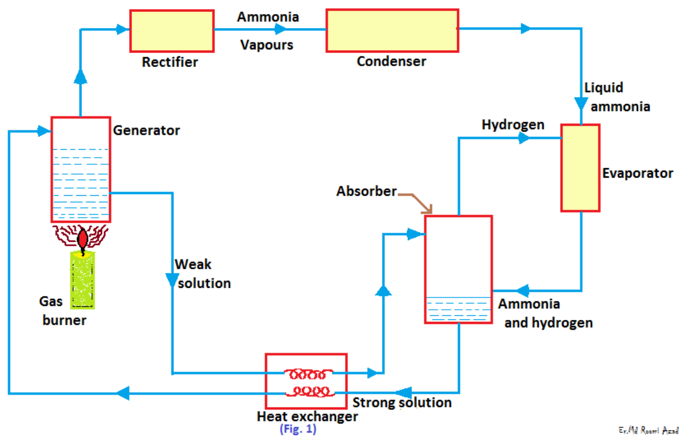

Figure 2 : Electrolux Refrigeration system

The most of the refrigerator which employs vapour absorption system in consist of Electrolux refrigeration system. As it consist of three fluids Ammonia, Water and H_2 it is also called as "3-Fluid system". This system makes the refrigerator completely free from moving elements. The H_2 is used as a pressure equalizing inert gas in order to maintain the total pressure constant throughout the system.

3.1 Working Principle of Electrolux System:

Electrolux refrigerator is a domestic refrigerator & is the best known type of refrigerator. Here pump is dispersed with the small energy supply by means of heater which may be electric or gas. The principle involved makes use of properties of gas-vapour mixture. If the liquid is exposed to an inert atmosphere, it will evaporate until the atmosphere is saturated with vapour of liquid. This evaporation requires heat which is taken from surrounding in which evaporation takes place. A cooling effect is thus produced the partial pressure of refrigerator vapour must be low in evaporator & higher in condenser.

The liquid NH3 leaving the condenser enters the evaporator & evaporates into 'H2' at the low temperature corresponding to its low partial pressure. The mixture of NH3 & H2 passes to the absorber into which it is also admitted. The H2O absorb the NH3 & H2 returns to the evaporator. In absorber NH3, passes from the NH3 convert into H2O convert as NH3 in water solution. The actual plat includes refrigerants & practical modification. The complete cycle is carried out entirely by gravity flow of refrigerant. The H2 gas circulates only from the absorber to the evaporator with this type of machine & is not important since the energy input is small. It has not been used for industrial purpose as the C.O.P of the system is very low.

4. Mathematical modeling: To carry out the calculation the operating pressure is to be determined. For that the condenser pressure (Pc) and evaporator pressure (Pe) is to be determined.

A. Condenser pressure (Pc):

- The pressure to be maintained in the condenser for changing the phase of ammonia vapours into ammonia liquid depends on type of condensing medium used and its temperature.
- In this system, water is used as a condensing medium. Water is available at a temperature of 25°C. i.e. condensing temperature is Tc = 25°C.
- For condensing ammonia vapours at 25°C, the corresponding pressure required can be noted from the refrigeration table of ammonia(R-717).In this way the condenser pressure is fixed at Pc=10 bar.

B. Evaporator pressure (Pe):

- The evaporator pressure can be fixed according to the minimum temperature required to be maintained in the evaporator chamber. The pressure maintained in the evaporator should be as close to the atmospheric pressure as possible, because maintaining higher pressure is difficult and costly also. Hence the evaporator pressure is to be maintained around at 1bar.
- By plotting the chart between enthalpy Vs concentration chart we can obtain following enthalpies at different point of system.

h1= 1630KJ/Kg ; h2=h3= 460KJ/Kg ; h4=1530KJ/Kg.

- Now, as in our laboratory the conventional refrigeration system is having refrigerating capacity of 80 KJ/min (0.38TR).
- So, the refrigerating effect produced or heat absorbed by ammonia refrigerant in the evaporator is Qe= h4-h3 KJ/Kg of ammonia. Say the mass flow rate of ammonia is Mr.

Therefore, Mr (h4-h3)=80 KJ/min

Therefore, Mr (1630-460)=80

It gives Mr= 0.0683Kg/min=4.10 Kg/hr

Hence the mass flow rate of ammonia through the evaporator is Mr= 0.068 Kg/min.

5. Calculation:

a. Mass flow rate of ammonia as refrigerant

Mr= 0.068 Kg/min

b. Heat removed in the evaporator

=refrigerating effect

=Mr (h4-h3)

=80 KJ/min

If cold water flow rate is Mw then

Mw Cp ΔT= 80 KJ/min, if ΔT= 17°C then Mw= 1.123 Kg/min.

c. Heat removed in condenser

Qc= (h4-h3)per kg of ammonia

i.e. Qc = Mr (h2-h1)

= 0.068(1630-460)

= 79.56 KJ/min

d. Heat given in the generator

Say Qg is the heat supplied in the generator and Qd is the heat removed from water vapour.

Qd is given by Qd= (h12-h1) per kg of ammonia

Qd = 0.068(1760-1630) = 8.84 KJ/min

Now using equation Qg-Qd = (h1-ha)

Therefore, Qg - 8.84 = 0.068(1630-70) = 114.92 KJ/min

Thus, the amount of heat required in the generator for running this unit is Qg = 114.92 KJ/min.

- This amount of heat is provided by hot water coming out of solar flat plate water heater. The temperature of hot water is about 84°C. We can reasonably assume that heating in generator is produced at about 80°C considering losses of heat.

e. Calculation of solar collector

Useful energy (energy absorbed by solar flat plate collector) is given by Qu = K×S×A

Where,

K =efficiency of collector plate(assume 0.85)

S = average solar heat falling on earth's surface = 6 kw-hr/m^2/day=250 W/m^2

A= area of collector plates

Now heat required in the generator Qg = 114.92 KJ/min

= 114.92×(1000/60)J/s

= 1915 W

Hence approximate area of the collector plates required for providing this much amount of energy = 1915/(250×K)

= 1915/(250×0.85)

= 9 square meters(approx)

Hence total area of collector plates A = 9 m^2.

Thus, Qu = 0.85 × 250 × 9 = 1912 J/s.

This is the net heat input to the system, which is running as a refrigeration unit of 0.38 TR capacity.

The work done by the pump for raising the pressure is negligible and hence neglected.

f. COP of the system

COP = Refrigerating effect / Heat input in generator

= Qe / Qg

Neglecting pump work COP = 80/114.92

= 0.696

Now the COP of the whole system(Including Solar water heater) can be calculate as,

COP = Net refrigerated effect produced / Heat input at solar collector

Heat input at the collector = solar constant × area

$= 250\ W/m^2 \times 9\ m^2$

= 2250 W

= 2250 × 60 J/min

= 135 KJ/min

Hence, COP = 80/135 = 0.592

Hence theoretical COP of the whole system comes out to be 0.592

3. CONCLUSIONS

The result can be summarized as follows:

- Mass flow rate of cold water = 1.123 Kg/min
- Condenser pressure = 10 bar
- Evaporator pressure = 1 bar
- Heat input required in generator = 114.92 KJ/min
- Area of solar collector required = 9 m^2
- Output temperature of water from solar heater = 84°C
- COP of refrigeration unit = 0.696
- COP of whole system(with solar system) = 0.592

In light of the above results it is clear that, the feasibility of the solar powered vapour absorption refrigeration system can be successfully employed in a place where cooling effect is required. Here, by using solar collector the solar radiation is absorbed on the absorber plate and the water is heated in that portion. This heated water is supplied to the generator-heat exchanger where the mixture of liquid ammonia and water is heated and converted in to vapour ammonia. This ammonia is used further in a system for cooling effect.

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