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SOLAR BASED VAPOUR ABSORPTION SYSTEM

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ABSTRACT

The vapour absorption system uses heat energy, instead of mechanical energy as in vapour compression system, in order to change the condition of the refrigerant required for the operation of the refrigeration cycle. In this system, the compressor is replaced by an absorber, a pump, a generator, and a pressure reducing valve. This complete papers discuss about the theoretical calculations are made of different components of the systems like evaporator, absorber, condenser and pump of vapour absorption system for a capacity of 0.25TR and experimentally developed and run system to validated for reducing the temperature for the free of cost of operation.

Keywords- *Solar heating system, vapour absorption system, ammonia, water, pump.*

I. INTRODUCTION

A considerable portion of the total energy consumption of the world is centered in the transport sector (Mei et al.estimate a value of about 25 percent for the United States). Automobiles and trucks alone account for approximately 80 percent of all transportation energy expenditures. These internal combustion engines typically have a thermal efficiency of 40 percent. The remaining energy is rejected to the atmosphere in the form of hot exhaust gases or as energy convected from the radiator and the engine [1]. In the vapour absorption refrigeration (VAR) system, a physicochemical process replaces the mechanical process of the vapour compression refrigeration (VCR) system by using energy in the form of heat rather than mechanical work. The main advantage of this system lies in the possibility of utilizing waste heat energy from industrial plants or other sources and solar energy as the energy input.[2]

A vapour absorption refrigeration system is a heat operated unit which uses refrigerant (NH_3) that is alternately absorbed by and liberated from the absorbent (water). The vapour absorption system uses heat energy, instead of mechanical energy as in vapour compression system, in order to change the condition of the refrigerant required for the operation of the refrigeration cycle. In this system,

the compressor is replaced by an absorber, a pump, a generator, and a pressure reducing valve. These components in the system perform the same function as that of compressor in vapour compression system.

II. CYCLE COMPONENTS

Generator

Purpose of the generator is to deliver the refrigerant vapour to the rest of the system. Generator is a closed vessel helical coil heat exchanger. Their characteristics of heat transfer are much better than that of straight heat exchangers with remarkable increase in heat transfer co-efficient. The flow geometry of a helical heat exchanger is such that a temperature cross is managed within a single unit.

Condenser-: The purpose of condenser is to condense the refrigerant vapours. Inside the condenser, cooling water flows through tubes and the hot refrigerant vapour fills the surrounding space. As heat transfers from the refrigerant vapour to the water, refrigerant condenses on the tube surfaces. The condensed liquid refrigerant collects in the bottom of the condenser before travelling to the expansion device. The cooling water system is typically connected to a cooling tower.

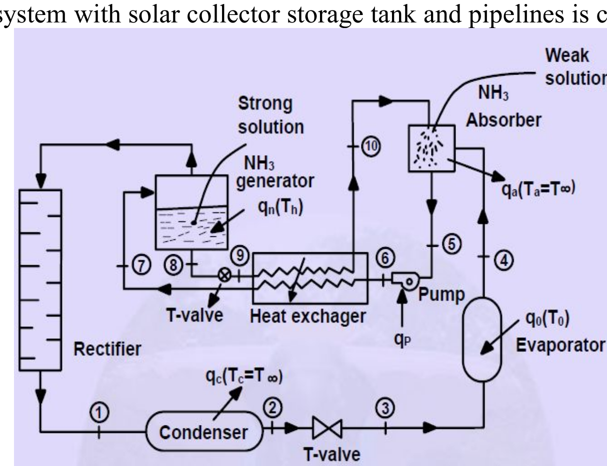
Expansion devices-: From the condenser the liquid refrigerant flows through an expansion device into the evaporator. The expansion device is used to maintain the pressure difference between the high-pressure (condenser) and low pressure (evaporator) sides of the refrigeration system by creating a liquid seal that separates the high pressure and low pressure sides of the cycle.

Evaporator-: The purpose of evaporator is to cool the circulating air. The evaporator contains a bundle of tubes that Carry the system water to be cooled or chilled. High pressure liquid condensate (refrigerant) is throttled down to the evaporator pressure at this low pressure the refrigerant absorbs heat from the circulating water and evaporates. The refrigerant vapours thus formed tend to increase the pressure in the vessel. This will in turn increase the boiling temperature and the desired cooling effect will not be obtained. So, it is necessary to remove the refrigerant vapours from the vessel into the lower pressure absorber.

Absorber-: Inside the absorber the refrigerant vapour is absorbed by the NH_3- H_2O. It condenses from a vapour to a liquid. The absorption process creates a lower pressure within the absorber. This lower pressure, along with the absorbent affinity for water induces a continuous flow of refrigerant vapour from the evaporator. In addition the absorption process condenses the refrigerant vapours and releases the heat removed from evaporator by the refrigerant. The heat released from the condensation of refrigerant vapour and their absorption in the solution is removed to the cooling water that is circulated through the absorber tube bundle.

Pump-: Pump is a device used to move fluids, such as liquid refrigerants. Pump displaces a volume by physical or mechanical action. Pump converts the mechanical energy from a motor to energy of a moving fluid. Some of the energy goes into kinetic energy of fluid motion and some into potential energy represented by a fluid pressure or by lifting the fluid against gravity to a higher level.

Solar water heater-: We are blessed with Solar Energy in abundance at no cost. The solar radiation incident on the surface of the earth can be conveniently utilized for the benefit of human society. One of the popular devices that harness the solar energy is solar hot water system (SHWS). A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water**.** The solar energy incident on the absorber panel coated with selected coating. The water passing through the risers get heated up and are delivered the storage tank. There-circulation of the same water through absorber panel in the collector raises the Temperature to 85^0 C (Maximum) in a good sunny day. The total system with solar collector storage tank and pipelines is called solar hot water system.[3]



Mainly two type of circuit are used in vapour absorption cycle

Hot water circuit: First the available cold water is filled in the entire circuit of collecting tank, solar panel's riser pipes, header pipes & generator coils. Then the entire system is placed in open atmosphere to receive solar radiation. The radiation received by the absorber plate is transferred to the water in the riser pipes. As a result the water gets heated and the density decreases. As the hot water is less dense than cold water it automatically rises up and enters the collecting tank. The relatively cold water from collecting tank replaces the hot water in the riser pipes and the procedure repeats. The collected hot water then circulates in the coil placed in the generator where the hot water gives off its heat to the refrigerant. So in the hot water circuit the water receives heat in the solar panel and gives off the heat in the generator.

Refrigerant circuit: The refrigerant gets separated from the aqua ammonia solution in the generator by absorbing the heat from the hot water in the generator coil. The ammonia after getting vaporized flows through the circuit and enters the condenser. In the condenser the refrigerant vapour gives off its heat to the surrounding air and gets converted into liquid ammonia. So the refrigerant gives off its latent heat in the condenser. The liquid refrigerant then enters the capillary tube where the pressure drops to the evaporator pressure. The low pressure low temperature liquid refrigerant then enters the evaporator receives heat and produces the refrigerating effecting in the evaporator cabinet. The refrigerant gets converted into vapour after receiving the heat. The vapour refrigerant is absorbed by the water present in the absorber. This is due to the chemical affinity of the water towards ammonia. This is the motive force for the refrigerant. In the absorber the ammonia vapour mixes with water and results in aqua ammonia solution. This solution is pumped to the generator pressure by a fractional HP pump. In the generator the ammonia gets vaporizes and separates from the solution. If any amount of ammonia remains in the solution it is sent back to the absorber through capillary tube.

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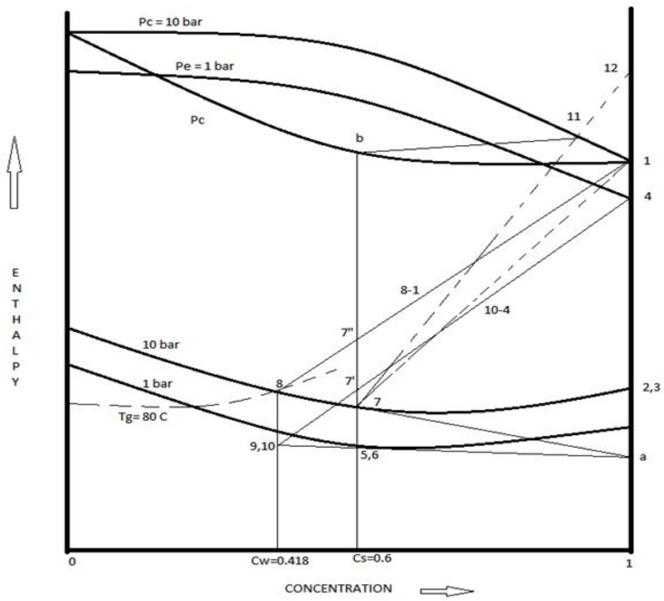

EXPERIMENTAL SETUP-: Based on above theoretical value calculations the all the components of system are assemble for the vapour absorption refrigeration system as shown in Fig.

Fig.2 Complete view of vapour absorption refrigeration system.

The papers discuss about the complete theoretical calculations and design the system as per the theoretical calculations and experimentally validate the system with reducing the temperature.
Evaporator pressure (P_e) -: now we will maintain minimum pressure is equal to 2 bar. Corresponding saturation temperature in the evaporator (Ammonia vapour) becomes -19^0 c. Now condenser pressure and evaporator pressure point can be plotted on pressure enthalpy chart as point 1,2,3 and 4.

Enthalpies of these corresponding point is,

h_1 = 1465 kj/kg h_2 = 90 kj/kg

h_3 = 90kj/kg h_4 = 1420 kj/kg

Now, Refrigeration capacity of the system is 2TR then mass flow rate of ammonia

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$M_r (h_4 - h_3) = 2TR$

Mr(1420 - 90) 2x210

Mr.1330 = 420

Mr = 0.32 kj/min

Then mass flow rate of ammonia in evaporator is **Mr = 0.32 kj/min**

Heat absorb by the refrigerant (NH_3) in the evaporator is $Qe = H_4 – H_3$ The temp. Of inside the generator is more than 85^0C which is comes from solar water heater but we are taking 80^0c due to some losses in the chart point 8 intercept the pressure line 10 bar. After intersection we can find out the concentration of this week solution. The value of Cw = 0.418 from the chart. If one time point 8 is fixed then point 5 automatically fixed. From the absorber strong aqua solution coming out from evaporator. The concentration of this point depends upon the degasifying factor. we can find out the concentration of the aqua solution

C_5 = Cw + 0.32 = 0.418+0.32, C_5 = 0.74 So, we have find the pressure and concentration at the point 5.When refrigerant flow from evaporator to condenser (Pe to Pc) the pressure will be increases it passes through pump, but the concentration will be same like point 5. so, point 6 and point 5 will be coincides, when the strong low aqua solution passing through heat exchanger it gain heat so enthalpy of this point will rise but there is no effect on concentration and pressure(Pc). So the point 7 can be marked on enthalpy-concentration chart. Now join the point 7 and 8 and extend line from right side and cut the Y axis at the point ‘b’ after we will draw the line between point 5 and b and extend from left side to cut the vertical line of Cw and point 8 at the point 9 and 10.Now we are showing week liquid solution coming from heat exchanger after providing heat from strong solution. so enthalpy will reduce but the concentration does not change of the week solution in heat exchanger. When it passes through pressure reduction valve reduce pressure (Pe) but enthalpy will be same, so point 10 and 9 at same point.

Absorber-: In the absorber week solution coming at condition 10 and pure ammonia comes at condition 4 after both are mixing stronge aqua solution comes out at condition 5. Now draw the line between point 4 and point 10 and extend the vertical line passing through point 7 till it cut at point 7’’ .

Generator-: In the generator, the strong qua solution entered in the generator at condition 7 and vapour comes at point 1 and ammonia and week aqua at condition 8 in the generator strong aqua is heated by supplying the heat Qg. Now draw line between point 1 and 8 and extend the vertical line through point 7 at the line 1-8, point 7’’ will be marked.

Calculation-:

[A] Mass flow rate of ammonia as refrigerant Mr = 0.32 KJ/Min

[B] Heat removed in evaporator is depends on refrigeration effect so,

Heat remove in evaporator = refrigeration effect

Mr. $(H_4 – H_3)$ = 2 TR = 2 x 210 KJ/Min

Let the mass flow rate of cold water is Mw then

Mw Cp ΔT = 420 KJ/Min if $\Delta T = 16^0C$

Then, Mw x 67.2 = 420, **Mw = 6.25 KJ/Min**

[C] Removable of heat from the condenser by circulating cooling water then,

Qc = Mr. $(h_4 – h_3)$ = 0.32 (1420- 90) ,

Qc = 425.6 KJ/Min

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[D] Heat remove in absorber is $Qa = (h_{7''} – h_5)$ per kg of aqua the tringle 10-7''-5 towards right till 10-7'' cut at 4 and 10-5 cuts at point 'a' on x axis then, $Qa = Mr.(h_4 - ha) = 0.32 (1420 – 70)$

Qa = 432 KJ/Min For removing the large heat we need cooling water, from enthalpy- concentration change the temperature of the aqua solution at condition 7'' is 80^0C. So during heat transfer water gets heated from 25^0C to 80^0C.

Let Mw_2 is mass flow of cooling water then,

$Mw_2 Cp(T_2 – T_1) = 432$

Mw_2 4.2 (80 - 25) = 432

Mw_2 = 1.87 Kg/Min

So, In absorber cooling water required at 1.87 kg//min

[E] In the generator let Qg is the heat given to the generator and Qr is the heat extract from water vapour then net heat remove per kg of aqua is $Qg – Qr = (h_{7'} – h7)$ per kg of aqua in the chart extending in the tringle 8-7-7' towards right till 8-7' cut at 1 and 8-7 cut at y axis. Then heat extract from ammonia is $Qg – Qr = (h_1 - ha)$ per kg of ammonia, extend the vertical line 7-7' up to it cuts the auxiliary line Pc and make point 'b' from b draw a horizontal line to cut the line Pc in vapour region at the point 11 and now join the point 7 and 11 and extend the line till it cut y axis at 12. So, heat extract from ammonia will be

$Qr = Mr. (h_{12} – h_1) = 0.32 (1760 - 1465)$,

Qr = 94.4 KJ/Kg

Now, heat remove of ammonia per kg

$Qg – Qr = Mr. (h_1 - ha)$

Qg – 94.4 = 0.32 (1465 - 70)

Qg = 540.8 KJ/Min

So, heat is provided from the solar water heater is 540.8 kJ/Min. The temp. Of the hot water coming out from the flat plate collector.

III. RESULTS AND CONCLUSIONS

As calculated earlier, the heat input required to run the 0.25 TR vapour refrigeration system, for the operating conditions designed, is about 540.8 KJ/min. This heat in the generator is supplied by the hot water coming from the solar flat plate water heater.

IV. ACKNOWLEDGEMENT

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REFERENCES

1. *Ajit Apte, Notes on Ammonia Absorption Refrigeration Plants for Economical and Enviro-friendly Refrigeration" Dossat RJ. Principles of refrigeration. 2nd ed. New York: John Wiley and Sons; 1981.*
2. *Haseler LE, et al. A design study for absorption cycle heat pumps for domestic heating. Report no. G1157 UK: Engg. Sci. Div., AERE Harwell; 1978a.*
3. *Haseler LE, et al. Absorption cycle heat pumps for domestic heating. Report no. G1049 UK: Engg. Sci. Div.,AERE Harwell; 1978b.*
4. *W.F. STOECKER ,"Refrigeration and air conditioning"Mcgraw hill book co.,Inc. pp. 179-83,1958.*

ISSN 2348 – 8034
Impact Factor- 3.155

5. *V.F. TCHAIKOVSKY. And A.P. KUTEZSOV, "Utilisation of refrigerant mixtures in refrigerating compression machinery", Air Conditioning And Refrigeration in india. Vol.4,1964*
6. *B.H. JENSLINGS, and P.L. BLACKSHEAR, "Tables of specific volume of aqua ammonia solutions",ASHRAE Handbook, pp.187. 1951.W.-K. Chen, Linear Networks and Systems (Book style). Belmont, CA: Wadsworth, 1993, pp. 123–135.*
7. *V K BAJPAI, Proceedings of the World Congress on Engineering 2012 Vol III WCE 2012, July 4 - 6, 2012, London, U.K.*