INTERNATIONAL RESEARCH JOURNAL OF INDIA
ISSN 2454-8707 VOLUME-II,ISSUE-IX,MAY-2017

REVIEW PAPER ON VAPOUR ABSORPTION SYSTEM OF REFRIGERATION BY USING BIOGAS AND SOLAR ENERGY

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ABSTRACT

Need-working of vapour absorption systems-thernal analysis of VARS-use of bio-gas for operating VARS-solar energy for operating VARS-conclusion.

KEY WORDS:

VARS, energy efficent, eco-friendly systems, thermal analysis, solar energy, bio-gas.

INTRODUCTION:

Vapour absorption refrigeration system is not a new concept. During the period of , "French civil war only, French scientist Ferdinand Carre" had manufactured vapour absorption machines on a commercial scale for the first time. After 1915 onwards, the development of vapour compression system has reduced the use of vapour absorption systems. In a recent years, global warming and environmental pollutions are increasing day by day. This has forced to carry out research work in design and development of eco-friendly refrigeration's system using renewable and clean energy sources such as biogas and solar energy This paper gives the clear idea about the working of vapour absorption systems and their thermodynamic analysis so as to carry out research to improve their performance. In this paper application of solar energy and biogas for vapour absorption machines is also explored.

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VAPOUR ABSORPTION REFRIGERATION SYSTEMS

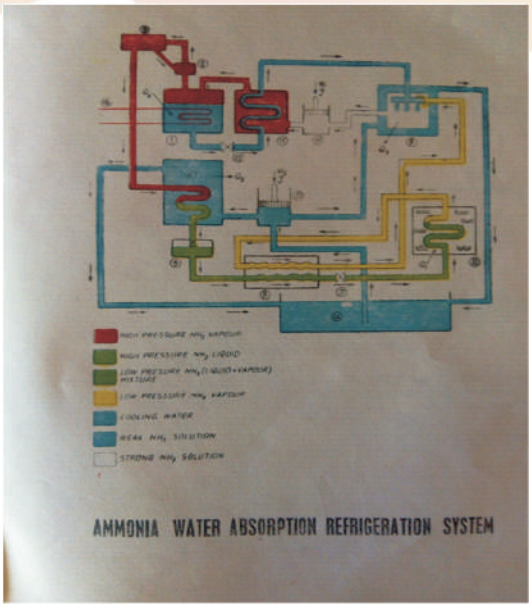


FIG NO:1

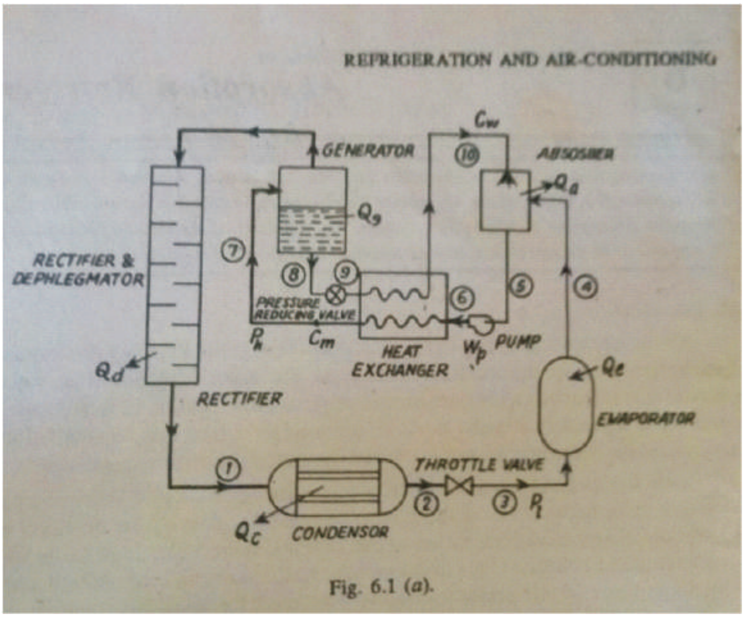


FIG NO:2

The basic components of practical ammonia & water absorption system shown in the fig. No 1 are; 1)Generator 2)Analyser 3)Rectifier 4)Condeser 5)Receiver 6)Heat exchanger (HE1) orLiquid sub cooler 7)Expansion Valve (EV1) 8)Evaporator 9)Water jacketed Absorber 10)Pump (P1) 11) Heat exchanger (HE2)(Aqua ammonia heat exchanger) 12)Expansion Valve (EV2) 13) Pump(P2) 14)Pond containing cooling water 15)Heating coil

WORKING

1)Generator: In this unit , Heat energy is given to the strong solution of ammonia entering it through heat exchanger(11) from absorber(9). Therefore evaporation of ammonia takes place

2)Analyser: The evaporated ammonia vapour contains some amount of water vapours in it. These water vapours are condensed in analyser by bringing them in contact with aqua ammonia

3)Rectifier: Remaining water vapours in ammonia vapours are condensed by using cooling water
4)Condenser: The dry ammonia vapour entering it is condensed by circulating cooling water throgh it
5)Receiver: Mixture of liquid ammonia &ammonia vapour is received by the receiver&then passed throgh the heat exchanger(HE1)or Liquid sub cooler
6)Liquid sub cooler(HE1): In this unit,Liquid refrigerant (NH3liquid)is subcooled byusing low temperature ammonia vapour
7)Expansion Valve: This subcooled liquid refrigerant is then passed through expansion valve where throttling expansion of refrigerant liquid takes place.
8)Evaporator: This partially evaporated refrigerant liquid absorbs heat in evaporator&evaporates.
9)Water jacketed Absorber: Ammonia vapour formed in evaporator enters the absorber where it gets dissolved in weak solution returned from generator to absorber. Hence rich solution of ammonia is formed. Cooling coil provided in absorber cools ammonia&water solution &it's ammonia absrbing capacity increases.
10)Pump(P1): It supplies rich solution of ammonia at low pressure in the absorber to generator at high pressure through heat exchanger.
11)Heat exchanger (HE1): It exchanges heat energy between weak hot solution &strong cold solution.
12)Pressure reducing device (Expansion Valve EV2): It reduces the pressure of weak solution from generator pressure to absorber pressure.
13)Pump(P2): Circulates cooling water through condenser & absorber from pond.

The C.O.P. Of this system is given by

C.O.P = Q1/Q2+W1+W2 = Heat absorbed/ Energy supplied

Heat absorbed in evaporator = Q1
Energy supplied = Heat supplied in generator + Energy supplied in terms of pump works(W1 & W2)for pumps p1 and p2
Design of experimental setup for thermal analysis of vapour absorption system of refrigeration

Table1
Properties of Ammonia(R717)

Properties of Ammonia(R717)	Values
Molecular weight	17.031
Normal boiling point	33.35℃
Critical temperature	132.4℃
Critical pressure	112.97bar
Critical volume	4.13m3
Freezing point	-77.7°C
Cp/Cv (γ)	Cp/Cv (γ): 1.31
Latent heat of vaporization	1315.5 kJ/kg
Mass of refrigerant circulated per ton	(0.19kg/min standard)
Volume of liquid refrigerant circulated per ton	0.32lit/min at 30°C(standard)

The following specific parameters are assumed for theoretical calculation of the complete system design:
Condenser pressure: 5 bar,
Evaporator pressure: 2 bar,
Capacity of refrigeration: 0.25 TR,

Degasification factor: 0.1.

i) Heat removed in condenser (Qc):

The amount of heat removed in the condenser is given by:

Qc = (h2-h1) kJ/kg of NH3. (1)

Where h is enthalpy at different points on chart. As NH3 saturated vapour enters in and NH3 saturated liquid comes out.

ii) Heat absorbed in the evaporator (Qe):

The amount of heat absorbed in the evaporator is given by:

Qe = (h4-h3) kJ/kg of NH3. (2)

where h4 is the heat of saturated vapour at Pc and h3 is the heat of mixture of NH3 liquid and vapour at Pe or heat of NH3 liquid at points ‘2’ as 2-3 is constant enthalpy throttling process.

iii) Heat removed from the absorber (Qa):

When NH3 vapour at point 4 and aqua at point 10 are mixed, the resulting condition of the mixture in the absorber is represented by 7’’ and after losing the heat in the absorber (as it is cooled), the aqua comes out at condition 5. Therefore, the heat removed in the absorber is given by:

Qa = (h7-h5) kJ/kg of aqua. (3)

iv) Heat given in the generator (Qg):

Qg is the heat supplied in the generator and Qd is the heat removed from the water vapour, then the heat removed per kg of aqua is given by:

(Qg-Qd) = (h7’-h7) kJ/kg of aqua.

As the aqua goes in at point 7 and comes out at condition 8 and 1 which can be considered a combined condition at 7’. By extending the triangle 8-7-7’ towards right till 8-7’ cuts at 1 and 8-7 cuts at ‘a’ on y-axis then, the heat removed per kg of NH3 is given by:

(Qg- Qd) = h1-ha kJ/kg of NH3. (5)

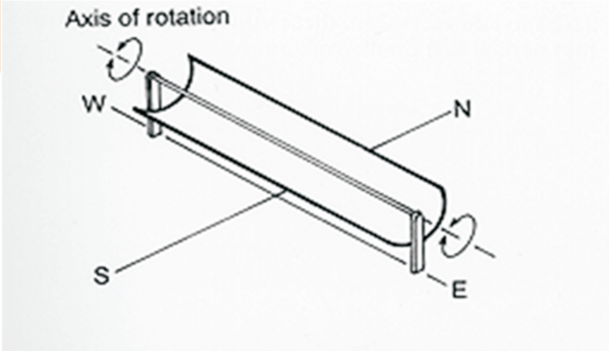
For finding out Qd separately, extend the vertical line 7-7’ till it cuts the auxillary Pc line and mark the point ‘b’. Then draw horizontal line through ‘b’ which cuts the Pc line in (in vapour region) at point 11. Then join the points 7 and 11 and extend that line till it cuts y-axis at 12. Therefore, Qd is given by:

Qd = (h12-h1) kJ/kg of NH3. (6)

The table 2 shows the values obtained on enthalpies based on enthalpy concentration chart of Ammonia (R717).

Table 2

Enthalpy values on different points on enthalpy entropy chart of Ammonia (R717). Point	Enthalpy (kJ/kg)
h1	1632.462
h2	376.722
h3	376.722
h4	1632.462
h5	41.858
h6	41.858
h7	133.9456
h8	209.29
h9	92.0876



One-axis tracking parabolic trough with axis oriented east-west

Based on above enthalpies calculation values the following results are obtained for the design load of different component of the system.

i) Mass flow rate of NH_3 through evaporator (*mf*):

mf = Cooling load/ h4 - h3

= (0.25x0.35)/(1632.462-376.722)

mf = 6.968×10-4kg/s=2.51kg/h.

ii) Heat rejected in absorber (*Qa*):

Qa = mr× x× (h4-ha)

= 6.968 x 10-4 x (1632.462-(-334.864))

Qa =1.371kW.

iii) Heat removed in condenser (*QC*):

QC = mr ×x× (h1- h2)

= 6.968 x 10^-4 x (1632.462-376.722)

QC = 0.875kW.

iv) Mass of strong solution handled by pump per second (*ms*):

Enthalpy balance across heat exchanger is,

Heat lost by weak solution = heat gained by strong solution,

mw × (h8-h9) = (mw + 1)×(h7-h6)

mw× (209.92-92.0876) = (mw+1)× (133.9456-41.858)

mW = 3.6667kg/kg of NH3.

Hence, mass of strong solution handled by pump (ms),

ms = mr × (mw +1) = 6.968 x 10-4× (3.6667+1)

Therefore, ms= 3.2517×10-3 kg/s.

v) Heat supplied to generator temperature = 75°C.

Qg = mr x (h12 – ha)

= 6.968 x 10-4 x (1820.823-(-334.864))

Therefore, *Qg = 1.502kW.*

vi) Design of pressure vessel for generator:

At pressure 5bar, with diameter (*d*) =200mm, and assuming 33% overload, the design pressure,(*Pd*) obtained 6.65bar.Design pressure (*Pd*) =1.33 xP = 6.65bar. Therefore, thickness of pressure vessel as thin

cylinder, [(*Pd* x d)/2 *xt*] =330N/mm2 (330N/mm2 assuming C40 as a material for pressure vessel from PSG data book).
Therefore, t=8mm.

vii) Design of air cooled condenser:
Calculations are made and obtained LMTD (Log Mean Temperature Difference) = 42.45°C, and length of coil=1.87m.

3. BIOGAS PLANT

1. Biogas • Biogas is a clean and efficient fuel. • It is a mixture of: – Methane (CH_4) – Carbon dioxide (CO_2) – Hydrogen (H_2) – Hydrogen sulphide (H_2S) • The chief constituent of biogas is methane (65%).
2. Production of Biogas - The biogas plants There are two types of biogas plants in usage for the production of biogas. These are: • The fixed- dome type of biogas plant • The floating gas holder type of biogas plant
3. Fixed dome type of Biogas Plant
4. Raw materials required • Forms of biomass listed below may be used along with water. • Animal dung • Poultry wastes • Plant wastes (Husk, grass, weeds etc.) • Human excreta • Industrial wastes(Saw dust, wastes from food processing industries) • Domestic wastes (Vegetable peels, waste food materials)
5. Construction The biogas plant is a brick and cement structure having the following five sections: • Mixing tank present above the ground level. • Inlet tank: The mixing tank opens underground into a sloping inlet chamber. • Digester: The inlet chamber opens from below into the digester which is a huge tank with a dome like ceiling. The ceiling of the digester has an outlet with a valve for the supply of biogas. • Outlet tank: The digester opens from below into an outlet chamber. • Overflow tank: The outlet chamber opens from the top into a small over flow tank.
6. Working of Fixed Dome type Biogas Plant • The various forms of biomass are mixed with an equal quantity of water in the mixing tank. This forms the slurry. • The slurry is fed into the digester through the inlet chamber. • When the digester is partially filled with the slurry, the introduction of slurry is stopped and the plant is left unused for about two months. • During these two months, anaerobic bacteria present in the slurry decomposes or ferments the biomass in the presence of water. • As a result of anaerobic fermentation, biogas is formed, which starts collecting in the dome of the digester.
7. Cont.. • As more and more biogas starts collecting, the pressure exerted by the biogas forces the spent slurry into the outlet chamber. • From the outlet chamber, the spent slurry overflows into the overflow tank. • The spent slurry is manually removed from the overflow tank and used as manure for plants. • The gas valve connected to a system of pipelines is opened when a supply of biogas is required. • To obtain a continuous supply of biogas, a functioning plant can be fed continuously with the prepared slurry.
8. Advantages of fixed dome type of biogas plant • Requires only locally and easily available materials for construction. • Inexpensive. • Easy to construct.
9. Floating gas holder type of biogas plant
10. Construction The floating gas holder type of biogas plant has the following chambers/ sections: • Mixing Tank - present above the ground level. • Digester tank - Deep underground well-like structure. It is divided into two chambers by a partition wall in between. • It has two long cement pipes i) Inlet pipe opening into the inlet chamber for introduction of slurry. ii) Outlet pipe opening into the overflow tank for removal of spent slurry. • Gas holder - an inverted steel drum resting above the digester. The drum can move up and down i.e., float over the digester. The gas holder has an outlet at the top which could be connected to gas stoves. • Over flow tank - Present above the ground level.
11. Working • Slurry (mixture of equal quantities of biomass and water) is prepared in the mixing tank. • The prepared slurry is fed into the inlet chamber of the digester through the inlet pipe. • The plant is left unused

for about two months and introduction of more slurry is stopped. • During this period, anaerobic fermentation of biomass takes place in the presence of water and produces biogas in the digester. • Biogas being lighter rises up and starts collecting in the gas holder. The gas holder now starts moving up.

12. Cont.. • The gas holder cannot rise up beyond a certain level. As more and more gas starts collecting, more pressure begins to be exerted on the slurry. • The spent slurry is now forced into the outlet chamber from the top of the inlet chamber. • When the outlet chamber gets filled with the spent slurry, the excess is forced out through the outlet pipe into the overflow tank. This is later used as manure for plants. • The gas valve of the gas outlet is opened to get a supply of biogas. • Once the production of biogas begins, a continuous supply of gas can be ensured by regular removal of spent slurry and introduction of fresh slurry.

13. Disadvantages of floating gas holder type biogas plant • Expensive • Steel drum may rust • Requires regular maintenance

14. Advantages of biogas as a fuel • High calorific value • Clean fuel • No residue produced • No smoke produced • Non polluting • Economical • Can be supplied through pipe lines • Burns readily - has a convenient ignition temperature

15. Uses of biogas • Domestic fuel • For street lighting • Generation of electricity • If compressed, it can replace compressed natural gas for use in vehicles

16. Applications The Biogas Train "Amanda" Sweden A biogas bus, Sweden

17. Advantages of biogas plants • Reduces burden on forests and fossil fuels • Produces a clean fuel - helps in controlling air pollution • Provides nutrient rich (N & P) manure for plants • Controls water pollution by decomposing sewage, animal dung and human excreta.

18. Limitations of biogas plants • Initial cost of installation of the plant is high. • Number of cattle owned by an average family of farmers is inadequate to feed a biogas plant.

19. Recent Developments • With the many benefits of biogas, it is starting to become a popular source of energy and is starting to be used in the United States more. • On 5 October 2010, biogas was injected into the UK gas grid for the first time. As of September 2013, there are about 130 non-sewage biogas plants in the UK. • Germany is Europe's biggest biogas producer and the market leader in biogas technology. • To create awareness and associate the people interested in biogas, the Indian Biogas Association was formed. India's Ministry of New and Renewable Energy offers some subsidy per model constructed.

20. Conclusion Biogas is a clean source of energy. Biogas plants have been in operation for a long period of time, especially in rural areas around the globe. The research organizations should focus on newer efficient low cost designs. The governments can play important role by introducing different legal frameworks, education schemes and the availability of technology and simultaneously creating more awareness and providing more subsidies.

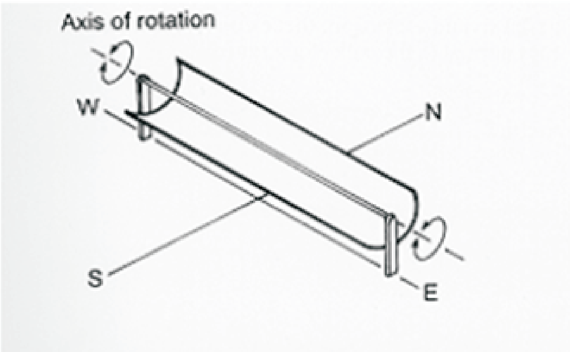
Our sole purpose is to use the above bio-gas energy to supply the heat to the generator of vapour absorption system of refrigention

4.SOLAR ENERGY

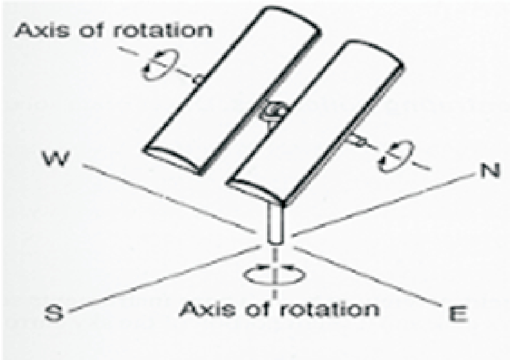
For applications such as air conditioning, central power generation, and numerous industrial heat requirements, flat plate collectors generally cannot provide carrier fluids at temperatures sufficiently elevated to be effective. They may be used as first-stage heat input devices; the temperature of the carrier fluid is then boosted by other conventional heating means. Alternatively, more complex and expensive concentrating collectors can be used. These are devices that optically reflect and focus incident solar energy onto a small receiving area. As a result of this concentration, the intensity of the solar energy is magnified, and the temperatures that can be achieved at the receiver (called the "target") can approach several hundred or even several thousand degrees Celsius. The concentrators must move to track the sun if they are to perform effectively

PARABOLIC TROUGH SYSTEM

Parabolic troughs are devices that are shaped like the letter “u”. The troughs concentrate sunlight onto a receiver tube that is positioned along the focal line of the trough. Sometimes a transparent glass tube envelops the receiver tube to reduce heat losses



One-axis tracking parabolic trough with axis oriented east-west



Two-axis tracking concentrator

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