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A Review on Vapour Absorption Refrigeration System

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A B S T R A C T

At the present time refrigeration plays a very important role in our daily as well as industrial life. But due to some problems for example, refrigerant the CFC is also affecting our ecosystem very rapidly. So there is need of working on these systems in order to avoid such harms. Vapour Absorption Refrigeration System acts as an alternative to existing systems as it requires low grade of energy for example; solar energy as it's renewable and present in enormous amount. So, in recent times a lot of research is going on to improve such systems that affects least to the environment and humanity but acts for same purpose in very efficient manner. This system consist of collector, evaporator, absorber the refrigerant in the system when come in contact with the water the cold water absorbs most of the ammonia in it after that the strong solution is conveyed up to the collector where the strong solution is heated to form a vapour then this vapours are condensed in condenser and then passed to expansion valve where temperature falls down then it is passed to the evaporator where the refrigerant absorbs the heat from the surrounding of the evaporative section.

Keywords: Absorber, Aqua-Ammonia Vapour, Coefficient of Performance, Generator, Solar Energy, Tonnage of Refrigeration

1. Introduction

Here introduce the paper, and put a nomenclature if necessary, in a box with the same font size as the rest of the paper. The paragraphs continue from here and are only separated by headings, subheadings, images and formulae. The section headings are arranged by numbers, bold and 9.5 pt. Here follows further instructions for authors.

1.1. Structure

Files must be in MS Word only and should be formatted for direct printing, using the CRC MS Word provided. Figures and tables should be embedded and not supplied separately. In our daily life whenever the term "refrigeration" comes in our mind; we simply think of refrigerator that works on the electrical supply and thus provides us chilled water, ice and preserves our beverages and eatables from getting exhausted. In these types of refrigerators the components that are used are "compressor, condenser, and evaporator and expansion valves". These different components plays different role but all of them are so very much needed in order to complete the refrigeration cycle. Fig-1 describes schematic description of vapour compression system. The compressor is utilized for the purpose of compressing low pressure and temperature vapour refrigerant to high pressure and temperature. In condenser the high pressure and temperature vapour refrigerant is cooled and condensed. In during this process, the refrigerant gives up its latent heat to the surrounding medium. Now in evaporator, liquid-vapour refrigerant is transformed into low pressure and temperature refrigerant at low pressure and temperature by absorbing the latent heat from the medium. At the end, comes role of expansion valves whose function is to allow to liquid refrigerant under high pressure

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and temperature to lower down its temperature and pressure so as to feed into the evaporator. Thus; in these steps the complete refrigeration cycle is completed and hence the net refrigeration effect is achieved]. There is also a term used “refrigerant” used which is circulated among these four components and which is the most essential need of the complete system. In common usage CFC is used as a refrigerant in the above described refrigeration system. The limitation related to it is that when it leaks into the atmosphere it depletes our ozone layer, which is keeping us safe and secured from the ultraviolet rays of the sun.

So now, in order to avoid this harm which is happening in our environment researchers are working on another type of refrigerating system known as “VARS i.e. VAPOUR ABSORPTION REFRIGERATION SYSTEM” and is system is somewhat different from the used one’s. The difference among the two systems is: - Firstly; in first system there is a compressor where as in VARS system here is no compressor and its role is played by combination of “absorber, generator and expansion valve”. Secondly; in VCRS system there is high grade of energy” is needed for performance of the system whereas in VARS system “low grade of energy” is utilized for example: solar energy, geothermal energy, wind energy and etc. Now in this paper we are going to take into account “solar energy” as it is renewable and available in large amount.

2. Literature Survey

V.K. Bajpai designed and studied vapour absorption refrigeration system, which is environment friendly. The system used by the V.K. Bajpai is having unit capacity. The refrigerant used is R-717 and water is used as absorber or the working medium, he used the flat plate collectors for heating the strong solution to vaporize and separate ammonia vapour from the water. He also described the performance of the system component and overall system for various working conditions.

Abhishek Sinha,S.R.Karale are studied and described the various methods to use the solar energy. In which solar electrical method, Solar Mechanical Methods, Solar Thermal Method, Desiccant, Cooling Thermal Energy Storage (CTES) System, Chilled Water Storage (CWS), Ice Thermal Storage (ITS), Ice Harvesters, External melt ice-on-coil storage systems are studied and tested for various parameters and conditions.

K Karthik has designed the model of vapour absorption system having 0.0168TR Capacity and tested it for various operating conditions and parameter. According to his study and calculations he proved that the solar powered vapour absorption system is feasible.

Nirajkumar Sharma, Mr. Pradip Singh, Dipak Gaur described and presented the 3.5 ton lithium-bromide and water refrigeration system, as well as they determined the cop of the system. They also studied the whole system for various working parameters and various working conditions. They also describes that the above systems how efficiently works and among which some are more feasible.

Dillip Kumar Mohanty, Abhijit Padhiary developed and described the vapour absorption refrigeration system; they also investigated the cop for various working conditions. The error analysis also taken to investigate the justifications of the system outcomes. And with the help of study they determined that optimal performance of the vapour absorption system is obtained for absorber of 400 ºC and generator temperature of 900 ºC.

Tarik A. Shaikh, Yogesh J. Morabiya done the mathematical modeling and study of the solar operated vapour absorption system and with the help of their study and analysis they also confirmed that the vapour absorption system is also a feasible way to finish the use of CFC’s and HFC’s ,They also developed the Li-Br model of vapour absorption system and determined the cop of the system.

Satish Raghuwanshi ,Govind Maheshwari has developed and studied the relation characteristics And performance of the single stage ammonia water vapour absorption system and confirms that the vapour absorption refrigeration by using solar power is feasible alternative for the conventional refrigeration system which are using the conventional power source.

M A Mehrabian and A E Shahbeik was developed a computer program for design and thermodynamic analysis of a single effect absorption chiller by means of Li-Br – H2O solution as working fluid. The condition of hot water entering to the disrober and leaving the desorbed, cooling water entering to the absorber and leaving from the condenser, chilled water entering to the and leaving from the evaporator, as well as the approach temperature ranges in condenser, evaporator, and absorber, the effectiveness of heat exchanger, the chiller refrigeration power consumption, and the ambient temperature are used as input data. The program code gives the thermodynamic properties of all phase state points, the design details of all heat exchangers in the cycle and the complete cycle performance. The results from the computer program are used for study and analyze the effect of design parameters on cycle performance. It is observed that the temperature of hot water, cooling water, and chilled water respectively, at the inlet of the disrober, condenser, and evaporator have a great variations on cycle coefficient of performance. The results of this program can be used either for sizing a new refrigeration cycle or rating an existing system. It can also be used for optimization purposes. The predictions of the present program are compared with other simulating programs and qualitative agreement is achieved.

K Muhammad Imran had done the irreversibility analysis of double effect Li-Br water vapour absorption chiller. He performs the analysis for four different operating conditions of chiller. He calculated the mass flow rates, specific entropies, specific enthalpies, energy balance, and irreversibility changes are also studied and calculated. The results of this author reveals that irreversibility changes in condenser, evaporator, and heat exchanger are less as compared to the irreversibility changes in the generator and absorber. He also determined the cop of his own designed system. Results are found as cop increases with increase in temperature of the high temperature generator, however irreversibility changes also increases with this increase in temperature thus reducing the availability of energy.

A. Ponshanmugakumar, M. Sivashanmugam and S. Stephen Jayakumar concentrated dishes and Vapour absorption machine (VAM). The storage tank was used instead of an Electrical AC compressor, by which the renewable energy can be utilized to its full extent. Numerical Simulation is done and the Total Heat output, Temperature distribution along the bed, Pressure, charging time, discharging time, Mass flow rate are calculated. The storage system contains Erythritol as PCM in HDPE spherical capsule, having the storage capacity 345,121 KJ/hr (for the tank capacity considering the latent heat and sensible heat of the heat transfer fluid)

3. Construction of references Components of vapour compression refrigearation system

The Components of vapour absorption refrigeration system are,

1) Absorber

2) Generator

3) Condenser

4) Expansion valve

5) Evaporator

6) Aqua pump

A. Absorber:

It is used to store the mixture of water and ammonia in particular proportion. Function is to produce the required aqua ammonia solution. Low pressure NH3 vapour is absorbed by the weak solution of NH3 which is stored in the absorber.

Inside the absorber of a vapour absorption system, the refrigerant vapour is absorbed by the solution. As the refrigerant vapour is absorbed, it condenses from a vapour to a liquid so that the heat it acquired in the evaporator is being released. The cooling water circulating through the absorber tube bundle carries away the heat released from the condensation of refrigerant vapours by their absorption in the solution.

B. Generator:

It is used to heat the strong aqua ammonia solution up to the boiling temperature of ammonia solution to produce ammonia vapors. Function is to separates the dissolved ammonia solution from the water ammonia solution.

In the generator, the solution vertically falls over horizontal tubes with high temperature energy source typically steam or hot water flowing through the tubes. The solution absorbs heat from the warmer steam or water, causing the refrigerant to boil (vaporize) and separate from the absorbent solution. As the refrigerant is boiled away, the absorbent solution becomes more concentrated. The concentrated absorbent solution returns to the absorber and the refrigerant vapour migrates to the condenser.

C. Condenser:

Condenser is a device or unit used to condense a substance from its gaseous to its liquid state. Application areas include air conditioning, industrial chemical processes such as distillation, steam power plants and other heat exchange system.

The purpose of condenser is to condense the refrigerant vapors. In the condenser, heat is extracted from refrigerant at constant pressure. The phase of the refrigerant changes from vapour to liquid state. As heat transfers from the refrigerant vapour to the water, refrigerant condenses on the tube surfaces. The condensed liquid refrigerant is collected at the bottom of the condenser before proceeding to the expansion valve.

D. Expansion Valve

It is used to control the amount of refrigerant flow into the evaporator. It causes a pressure drop (isenthalpic) of the working fluid. It cause sudden drop in temperature. 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. As the high pressure liquid refrigerant flows through the expansion device, it causes a pressure drop that reduces the refrigerant pressure to that of the evaporator.

E. Evaporator:

The refrigerant at very low pressure and temperature enters into the evaporator and produces the cooling effect. In the vapour absorption refrigeration cycle, refrigerant flows to the absorber that acts as the suction part of the refrigeration cycle.

At a lower pressure in the evaporator, the refrigerant gets evaporated by absorbing heat from the circulating water and the refrigerant vapors thus formed tend to increase the pressure in the vessel. With increase in pressure, the boiling temperature increases and the desired cooling effect is not obtained.

Therefore the refrigerant vapors are removed from the vessel into the lower pressure absorber. Most commonly the evaporator and absorber are contained inside the same shell, allowing refrigerant vapors generated in the evaporator to move continuously to the absorber.

F. Aqua Pump:

When the absorbent absorbs the refrigerant strong solution of refrigerant-absorbent (ammonia-water) is formed. This solution is pumped by the pump at high pressure to the generator. This pump increases the in a simple vapour absorption system ammonia is used as refrigerant and water is used as absorbent. It should be noted that solubility of ammonia in water is higher at low pressures and temperatures. Ammonia –water vapour absorption system consists of generator, condenser, expansion valve, evaporator coil, absorber, aqua pump, analyzer, a rectifier, heat exchangers.

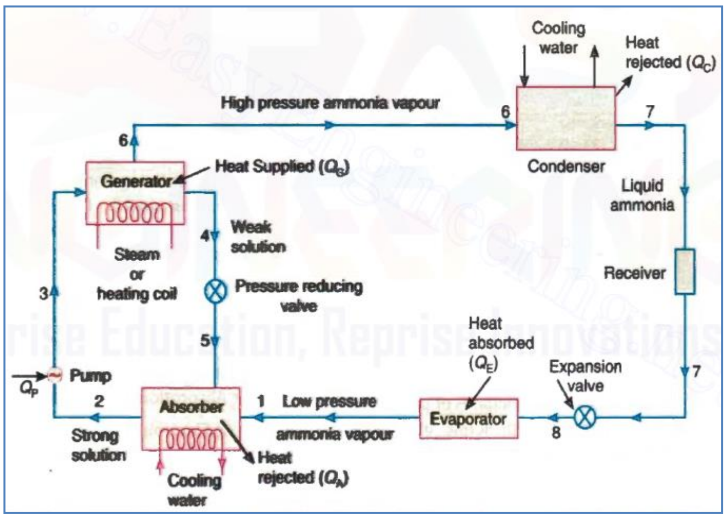

Fig.1 ***Schematic Diagram of Vapour Absorption Refrigeration System [10]***

Ammonia vapour is extracted from the NH3 strong solution at high pressure in the generator by an external heating source. In the rectifier, the water vapour which carried with ammonia is removed and only the dried ammonia gas enters into the condenser, where it's condensed. The pressure and temperature of cooled NH3 solution is then reduced by a throttle valve below the temperature of the evaporator. The NH3 refrigerant at low temperature enters the evaporator and absorbs the required heat from it, then leaves it as saturated vapour.

The low pressure NH3 vapour is then passed to the absorber, where it's absorbed by the NH3 weak solution which is sprayed also in the absorber as shown in Fig.6.7. After absorbing NH3 vapour by the weak NH3 solution (aqua–ammonia), the weak NH3 solution becomes strong solution and then it is pumped to the generator passing through the heat exchanger.

In the pump, the pressure of the strong solution increases to generator pressure. In the heat exchanger, heat form the high temperature weak NH3 solution is absorbed by the strong NH3 solution coming from the absorber.

As NH3 vapour comes out of the generator, the solution in it becomes weak. The weak high temperature NH3 solution from the generator is then passed through the throttle valve to the heat exchanger. The pressure of the liquid is reduced by the throttle valve to the absorber pressure, pressure of the solution.

4. Applications

This system has wide range of application like food storage and also for vaccine storage. In real, this technology can be used in rural areas where the accommodation of electricity is impossible. Uppal et al. [3] in 1986 constructed a small capacity solar-powered NH3–H2O absorption refrigerator to store vaccines in remote locations. In 1993, Sierra et al. [4] used a solar pond to power an intermittent absorption refrigerator with NH3–H2O solution. It is reported that generation temperatures as high as 73 ºC and evaporation temperatures as low as –2 ºC could be obtained. The COP under such working conditions was in between 0.24–0.28. Anyanwu and Ezekwe [5] also tested a solid absorption solar refrigerator using activated carbon–methanol as the working solution pair. Critoph [6] studied a rapid cycling solar/biomass-powered adsorption refrigeration system with activated carbon–ammonia as working pair. The thermal COP was about 0.3 when the initial generator temperature was about 50 ºC and evaporating temperature was about 0 ºC.

Avoid hyphenation at the end of a line. Symbols denoting vectors and matrices should be indicated in bold type. Scalar variable names should normally be expressed using italics. Weights and measures should be expressed in SI units. All non-standard abbreviations or symbols must be defined when first mentioned, or a glossary provided.

5. Result and Conclusion

From the previous study it's now quite clear that Vapour Absorption System has an upper edge over the Vapour Compression System taking in regard of the environment. In absorption systems there is no danger of depletion of ozone layer, all renewable sources of energy could be used such as, solar energy, wind energy, bio-gas etc. The system is also free compressor less, as a result of which the life span of system is longer than vapour compression one's. The only disadvantage with such system is low COP and requires longer time duration to perform the complete operation. Till date two "solution pairs" have been utilized in such systems and that are "NH3 - H2O &LiBr - H2O" and further research is going to in order to find some more alternate solution pairs that would b effective in during its operation and produces same amount of refrigeration effect. Some of them are "Ammonia Sodium Thiocyanate [NH3 – NaSCN], Ammonia Lithium Nitrate [NH3 – LiNO3], carbon methanol and many more.

Scope and future work

It is obvious from the introductory part of this paper, that the basic absorption refrigeration systems can be based either on lithium bromide-water (LiBr-H2O) where water vapour is the refrigerant and ammonia-water (NH3-H2O) systems where ammonia is the refrigerant. The future trends of research in this area would be on other refrigerant pairs which will be more effective and their main advantage is that they do not cause ozone depletion. Any change can be done that can bring an overall improvement in the system COP or material saving or more simple design procedure. The methodology described in this work can be adopted to design and develop a suitable system that can be most effectively and efficiently used maximum utilization of the solar power.

The major limiting factor at present is the availability of solar energy whenever it is required, for example at nights and extended cloudy days we cannot attain a high enough temperature and hence refrigeration is poor. Modifying the design of solar collector for wider acceptance angle and making generator tubes with material of higher thermal conductivity yield can be improved. There are many other achievements carried out by researchers, nevertheless, further improvements should be made to the solar powered refrigeration systems in order to compete with the conventional refrigeration systems. It is hoped that these results could serve as a source of reference for designing and selecting new absorption refrigeration systems, developing new working fluid pairs and optimizing suitable operating conditions.

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