APPLICATION OF SOLAR ENERGY IN VAPOUR ABSORPTION REFRIGERATION SYSTEM

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Abstract— As the energy is the backbone of the technology it affects the price of product as well as the overall economy of the industry. Energy is the most important factor in industrial production as well as in the domestic use eco friendly system as it uses solar power. As sun is the huge source of energy solar energy is the perfect alternative for some energy sources such as electricity, petroleum .In India the large part of the solar energy is wasted because of lack awareness about the solar energy. Mostly the solar energy is used to dry the food grains and mostly to dry the cloths. But last few years are the most memorable years for the India from the last few years most of the peoples decide to install the solar units. We are focusing on the need of the alternatives for the conventional energy source. we are using the vapour absorption refrigeration system operated by using solar power, in this we are using R-717 as refrigerant and water as working fluid. 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.

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

I. INTRODUCTION

Refrigeration is the process of removing heat from enclosed system or space and rejects it to the another system or surrounding. The refrigeration is used to lower the temperature of the enclosed system. A vapour absorption refrigeration system is similar to a vapour compression refrigeration system. The vapour absorption system comprises of all the processes in the vapour compression refrigeration system like compression, Condensation, expansion and evaporation. In the vapour absorption system the refrigerant used is ammonia-water or lithium-bromide. The refrigerant gets condensed in condenser and evaporated in evaporator. The refrigerant produces cooling effect in the evaporator and release the heat to the atmosphere through the condenser. The difference between the two systems is the method of the suction and compression of the refrigerant in the VARS cycle. In the vapour compression system, the compressor sucks the refrigerant from the evaporator and compress it to the high pressure. The compressor is also enables the flow of the refrigerant through the complete refrigeration cycle. In the vapour absorption cycle the process of suction and compression are carried out by two different devices called as absorber and generator. Thus the absorber, generator and the pump replace the compressor in the vapour absorption cycle.

The absorbent enable the flow of refrigerant from the absorber to the generator by absorbing heat. In the vapour absorption system the energy input is in the form of heat this can be from the excess system from the process or hot water. The heat can be created by another source like natural gas, kerosene, heater etc .Though these sources are only in the small system.

The above sources are conventional and are being used extensively in such way that their known reserves have been depleted to a great extent. At same time it is becoming increasingly difficult to find and exploit their new deposits of petroleum on our country will get exhausted by the few decades and their reserves are expected to last for another some years. But here we are using the solar energy to heat the water. Because the solar energy the abundant source of energy. Solar energy systems allow you to absorb free sunlight and convert it into usable power in your system. Unlike conventional power, solar produces no harmful emissions that hurt the environment. Solar energy will save your money each month. In addition, the investment that you made in solar, will improves property value. Vapour absorption system is basically uses the low grade energy such as waste heat and solar energy coming in the nature from thousands of years.

II. 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 vaporise 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 40^0C(degree celcious) and generator temperature of 90^0C.

Tarik A. Shaikh, Yogesh J. Morabiya done the mathematical modelling 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 LiBr– H_2O solution as working fluid. The condition of hot water entering to the desorber and leaving the desorber, 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 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 desorber, 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 concen¬trated 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)

III. HISTORY OF SOLAR VAPOUR ABSORPTION REFRIGERATION

Attempts have been made to run vapour absorption systems by solar energy with concentrating and flat plate solar collectors. Several small solar absorption refrigeration systems have been made around 1950s in several countries. Professor G.O.G. Lf of America is one of the pioneers in the area of solar refrigeration using flat plate collectors. A solar refrigeration system that could produce 250 kg of ice per day was installed in Tashkent, USSR in 1953. This system used a parabolic mirror of 10 sq m area for concentrating the solar radiation. F. Trombe installed an absorption machine with a cylindro-parabolic mirror of 20 sq m at Montlouis, France, which produced 100 kg of ice per day.

Serious consideration to solar refrigeration systems was given since 1965. Due to the scarcity of fossil fuel based energy sources. LiBr-water based systems have been developed for air conditioning purposes. The first solar air conditioning system was installed in an experimental solar house in University of Queensland, Australia in 1966. After this several systems based on solar energy were built in many parts of the world including India. In 1976, there were about 500 solar absorption systems in USA alone. Almost all these were based on LiBr-water as these systems do not require very high heating temperatures. These systems were mainly used for space air conditioning.

Intermittent absorption systems based on solar energy have also been built and operated successfully. In these systems, the cooling effect is obtained during the night time, while the system gets "charged" during the day using solar energy. Though the efficiency of these systems is rather poor requiring solar collector area, they may find applications in remote and rural areas where space is not a constraint. In addition, these systems are environment friendly as they use eco-friendly refrigerants and run on clean and renewable solar energy.

IV.COMPONENTS OF VAPOUR ABSORPTION

REFRIGERATION 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 NH_3 vapour is absorbed by the weak solution of NH_3 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 vapours. 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 flowingthrough the tubes. The solution absorbs heat from the warmersteam or water, causing the refrigerant to boil (vaporize) andseparate 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 plantsand other heat exchange system.

The purpose of condenser is to condense the refrigerant vapours. 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 tubesurfaces. 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 cause 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 pressureliquid refrigerant flows through the expansion device, itcauses a pressure drop that reduces the refrigerant pressure tothat of the evaporator.

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

E. 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 pressure of the solution.

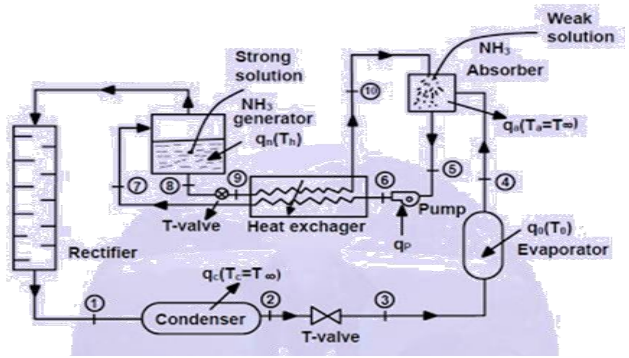

Fig. 1: Schematic Diagram of Vapour Absorption Refrigeration System.[7]

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, analyser, a rectifier, heat exchangers.

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.1. 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.

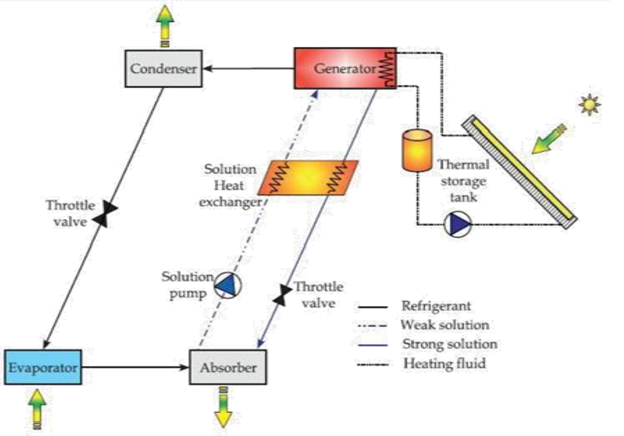

Fig. 2: Schematic Diagram Of Solar Absorption Refrigeration System[2]

V.SOLAR VAPOUR ABSORPTION REFRIGERATION SYSTEM METHODOLOGY

The absorption cycle powered by solar energy is illustrated in Fig.2 Low-pressure refrigerant vapour from the evaporator is absorbed by the liquid strong solution in the absorber.The pump receives low-pressure liquid weak solution from the absorber, elevates the pressure of the weak solution and delivers it to the generator. By weak solution (strong solution) is meant that the ability of the solution to absorb the refrigerant vapour is weak (strong). In the generator, heat from a high-temperature source by solar energy(solar collector)drives off the refrigerant vapour in the weak solution.

A. Solar Collector:

Solar Collectors are either non-concentrating or concentrating. In non-concentrating type, the collector are is the same as the absorber area. In this types the whole solar panel absorbs light. Concentrating collector have a bigger interceptor than absorber.

A solar thermal collector collects heat by absorbing sunlight. A collector is a device for capturing solar radiation. solar radiation is energy in the form of electromagnetic radiation from the infrared (long) to the ultraviolet (short) wavelengths. The term "Solar Collector" commonly refers to solar hot water panels, but may refer to installation such as solar parabolic troughs.

The liquid strong solution returns to the absorber through a throttling valve whose purpose is to provide a pressure drop to maintain the pressure difference between the generator and the absorber. The high-pressure refrigerant vapour condenses into liquid in the condenser and enters the evaporator through a throttling valve, maintaining the pressure difference between the condenser and the evaporator. In order to improve cycle performance, a solution heat exchanger is normally added to the cycle.

VI.CONCLUSION

Vapour absorption refrigeration system with R-717 as refrigerant and water as working fluid have been studied theoretically. Consistently increasing CO2 emission and ozone depletion from CFC's are serious environmental issues challenging scientific community. In conventional refrigeration system, compression machines are employed, which requires high-grade energy as input and this is in the form of electricity. Therefore it is better to use the Vapour absorption refrigeration system which gives scope of utilizing low grade energy source i.e. solar panel for generating cooling effect which is dominated by high grade energy driven compression technology. Absorption refrigeration system provides large potential for reducing heat pollution of the environment. Therefore, in future it is decided to compare the performance between conventional systems and vapour absorption system using solar thermal energy.

VII.SCOPE FOR THE 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 ($LiBr-H_2O$) where water vapour is the refrigerant and ammonia-water (NH_3-H_2O) 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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