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Study of Ammonia Water Vapour Absorption Refrigeration Chiller Run by Solar Thermal Energy

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Abstract: ***Now, most of the energies are used by the industries due to depletion of fossil fuels and continuous increases in the cost price and demand for energy has led to more research and development to utilize available energy resources efficiently by minimizing waste energy. For this Absorption refrigeration systems increasingly attract research interests because Absorption cooling offers the possibility of using heat to provide cooling. For this purpose solar heat can be used. Absorption system is divided into two categories depending upon the working. These two categories are the Libr-H_2O and NH_3-H_2O.In LiBr-H_2O system water is used as a refrigerant and Libr is used as an absorbent, while in NH_3-H_2O system ammonia used as an refrigerant and water is used as an absorbent, which used as in studying and developing a new absorbent refrigerant system. The objective of this review paper is to gives the fundamental knowledge and performance of Ammonia water (NH_3-H_2O) vapour absorption system run by solar energy. This system is eco friendly in nature.***

Keywords: Absorption Refrigeration, solar thermal Energy, Global warming, single stage refrigeration chiller

1. Introduction

In view of lack of energy production and fast increasing energy consumption, there is a need to minimize the use of energy and conserve it in all possible ways. Energy conservation is becoming a slogan of the present decade and new methods to save energy. Recovering energy from solar waste heat and from biogas utilizing for system efficiency improvement is fast becoming a common scientific temper and industrial practice now days. The present energy crisis has forced the scientists and engineers all over the world to adopt energy conservation measures in various industries. Refrigeration systems form a vital component for the industrial growth and affect the energy problems of the country at large. Therefore, it is desirable to provide a base for energy conservation and energy recovery from Vapour Absorption refrigeration System. In recent years, research has been devoted to improvement of vapour Absorption Refrigeration Systems.

The overall performance of the absorption cycle in terms of refrigerating effect per unit of energy input generally poor, however, solar waste heat such as that rejected from a power can be used to achieve better overall energy utilization. Ammonia/water (NH_3/H_20) systems are widely used where lower temperature is required. However, Lithium bromide/water (Libr/H_2O) system is also widely used where moderate temperatures are required and the latter system is more efficient than the former.

2. Literature Survey

SachinKaushik, Dr. S. Singh et al[1] investigated an absorption refrigeration cycle using an ammonia-water solution. The system is integrated with a marine diesel engine which provides waste heat at different temperatures levels. The system was theoretically investigated by calculating their performance using a thermodynamic model developed according to the first law of thermodynamic applied to each component of the system. The model was coupled to a set of equations of state allowing the reliable calculation of the thermodynamic properties of the binary mixture used. The thermodynamic study of the cycle was carried out for various operating conditions by varying generator, condenser, absorber and evaporator temperatures. It was found that high performance of the cycle is obtained at high generator and evaporator temperatures and also at low condenser and absorber temperatures. Furthermore, the increase in the solution heat exchanger effectiveness improves the coefficient of performance with no effect on the circulation ratio.

Dong-seonkim and Carlos et al[2] emphasised on the fast growing demand for air conditioning has imposed a significant increase in demand for primary energy. Electric utilities have their peak loads in hot summer days and in recent years they are barely capable of meeting the demand. With suitable technology, solar cooling can solve part of the problem. The fact that peak cooling demand in summer is associated with high solar radiation offers an excellent opportunity to exploit solar thermal technologies that can match heat-driven cooling technologies.

V.K. Bajpai et al[3] 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 .

SamehAlsaqoor, Khaled S. AlQdah et al[4] the possibility of having a refrigeration system driven by the solar energy is a huge advantage There are many circumstances where people do not have access to electricity or gas to power a refrigeration system. An absorption refrigeration cycle employing an ammonia-water solution as the working fluid has been investigated in this work. The cycle has been powered by three different power sources to providing a high temperature heat source for absorption cooling unit. Based on the results of the investigations performed in this study, the concluding remarks are as follows: the renewable energy resources like solar energy can contribute effectively to the supply of heat to the refrigeration load. The efficiency of absorption cooling based on a type resource of heat reliant on the temperature to be formed inside the generator, this temperature using to dominate the efficiency and coefficient of performance COP. for absorption refrigeration system. For this we find the best of efficiency and COP was found when using the electricity as a power source for the absorption cycle, after that using of methane instead of electricity but with its environmental impact and pollution. The clean and safe power source when we using solar thermal energy in spite of lower COP and efficiency. A number of equipment requirements and limitations must be considered in the analysis and design of powered absorption systems.

K Karthik et al [5]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.

Dillip Kumar Mohanty, AbhijitPadhiary et al[6] 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 400C (degree celcious) and generator temperature of 900C .

Tarik A. Shaikh, Yogesh J. Morabiya et al[7] 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 et al[8] 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 AMehrabian and A E Shahbeik et al [9]was developed a computer program for design and thermodynamic analysis of a single effect absorption chiller by means of LiBr– H2O 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 chillers 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.R. Ullah et al [10]more countries are endeavouring to exploit renewable energy than ever before. Pollution, higher expenses and limited resources are the main obstacles to the widespread use of fossil fuels. Therefore, renewable energy sources, such as solar energy, have been of considerable interest because of their promising advantages. Because of the year-round availability of sunshine, solar energy can be easily captured all over the world. Though the solar photovoltaic system can provide electricity as well as refrigeration, solar thermal refrigeration is much more efficient. Solar thermal cooling technologies are being used all over the world for industrial and home cooling purposes. These cooling systems are more applicable in remote areas or islands where conventional cooling is difficult and solar energy is always available. These systems are also more suitable than conventional refrigeration systems because pollution-free working fluids (instead of chloro-fluorocarbons) are used as refrigerants. This study also summarizes the different working fluids of solar absorption cooling systems and adsorption cooling systems, providing various results with their advantages and limitations. Though the coefficient of performance of absorption cooling systems is better than that of adsorption systems, the higher temperature issues can be easily handled with solar adsorption systems. Moreover, solar hybrid cooling systems can provide higher capacity and better coefficients of performance by eliminating some of the problems encountered with individual working pairs.

3. Working of Aqua Ammonia Single Tube Vapour Absorption Refrigeration Chiller

The most accepted refrigeration and air conditioning systems at current are those based on the vapour absorption refrigeration systems. These systems are well-liked because they are dependable, relatively low-cost and their technology is well recognized. A suitable working is possibly the single most significant factor in any refrigeration system. The cycle efficiency and process characteristics of an absorption refrigeration system depend on the properties of refrigerant, absorbent and their mixtures. The most significant thermo physical properties are: heat of vaporization of refrigerant, heat of solution, vapour pressure of the refrigerant and absorbent, solubility of refrigerant in solvent, heat capacity of solution, viscosity of the solution and surface tension and thermal conductivity of solution. Vapour Absorption Refrigeration Systems belongs to the class of vapour cycles analogous to vapour absorption refrigeration systems. However, dissimilar to vapour absorption refrigeration systems, the requisite input to absorption systems is in the form of the heat. Hence these systems are also known as heat operated or thermal energy driven systems. Both vapour absorption and absorption refrigeration cycle achieve the removal of heat through the evaporation of a refrigerant at low pressure and the dismissal of heat through condensation of refrigerant at a higher pressure.Some liquids like water have a great tendency for absorbing large amount of certain vapours (NH3) and reduce the total volume quite. The absorption chiller refrigeration system differs basically from vapour compression system only in the method of compressing the refrigerant. In the absorption refrigerating system, the compressor is replaced with an absorber, generator and pump. Figure 6.7 shows the schematic diagram of a vapour absorption refrigeration system. 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 NH_3 solution is then reduced by a throttle valve below the temperature of the evaporator. The NH_3 refrigerant at low temperature enters the evaporator and absorbs the required heat from it, then leaves it as saturated vapor.The low pressure NH_3 vapour is then passed to the absorber, where it's absorbed by the NH_3 weak solution which is sprayed also in the absorber as shown in. After absorbing NH_3 vapour by the weak NH_3 solution (aqua–ammonia), the weak NH_3 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 NH_3 solution is absorbed by the strong NH_3 solution coming from the absorber. As NH_3 vapour comes out of the generator, the solution in it becomes weak. The weak high temperature NH_3 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.

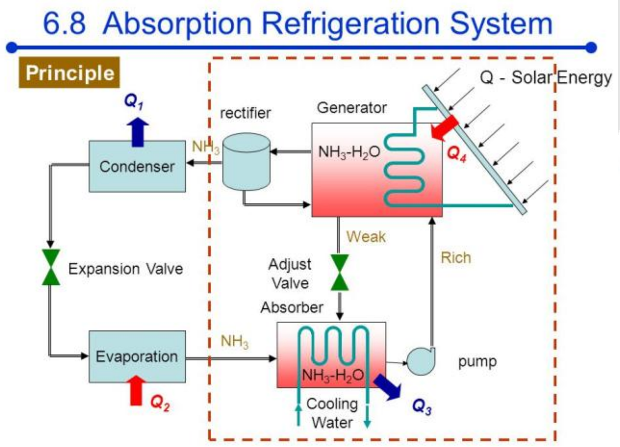

Figure 1: Schematic diagram of solar based Aqua ammonia absorption refrigeration chiller

3.1The primary components of the vapour absorption refrigeration system:

3.1.1 Generator:

The purpose of the generator is to deliver the refrigerant vapour to the rest of the system. It accomplishes this by separating refrigerant from the solution. In then 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

3.1.2 Absorber

Inside the absorber, the refrigerant vapour is absorbed by the solution. As the refrigerant vapour is absorbed, it condenses from a vapour to a liquid, releasing the heat it acquired in the evaporator. The heat released from the condensation of refrigerant vapours by their absorption in the solution is removed by the cooling water circulating through the absorber tube bundle. The weak absorbent solution is then pumped to the generator where heat is used to drive off the refrigerant. The hot refrigerant vapours created in the generator migrate to the condenser. The cooling tower water circulating through the condenser turns the refrigerant vapours to a liquid state and picks up the heat of condensation, which it rejects to the cooling tower. The liquid refrigerant returns to the evaporator and completes the cycle.

3.1.3 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 connected to a cooling tower.

3.1.4 Evaporator

The purpose of evaporator is to cool the circulating water. The evaporator contains a bundle of tubes that carry the system water to be cooled/chilled. At low pressure existing in the evaporator, 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. Physically, the evaporator and absorber are contained inside the same shell, allowing refrigerant vapours generated in the evaporator to migrate continuously to the absorber.

3.1.5 Pump

A pump is a device that moves fluids (liquids or gases, or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps. Pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work by moving the fluid. Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power, come in many sizes, from microscopic for use in medical applications to large industrial pumps.

3.1.6 Rectifier

A rectifier is an electrical device composed of one or more diodes that converts alternating current (AC) to direct current (DC). A diode is like a one-way valve that allows an electrical current to flow in only one direction. This process is called rectification. A rectifier can take the shape of several different physical forms such as solid-state diodes, vacuum tube diodes, mercury arc valves, silicon-controlled rectifiers and various other silicon-based semiconductor switches.

4. Indian and Global Market Scenario

Global demand for refrigerant is expected to achieve $21 Billion by 2020 at a CAGR of 6.0% from 2015 to 2020.The growth of refrigerants is driven my various factors such as increasing demands of refrigerant in Asia-pacific, increasing demand of cooling products and increase in global cold chain market. The growing user industries such as construction, automobile, oil & gas and food also driving the refrigerant market.

This report approximate the refrigerant market for 2014, and projects its expected demand till 2020. It also provides a detailed qualitative and quantitative analysis of the market. Various secondary sources, such as directories and databases have been used to identify and collect information that is useful for this broad commercial study. The primary sources for the report included experts from related industries and suppliers who have been interviewed to obtain and verify critical information as well as to assess the future scenario of the market.

Competitive scenarios of the top players in the refrigerant market have been discussed in detail. We have also profiled the leading players of the industry with their recent developments and other planned industry activities.

5. Conclusion

This paper presents an extensive review of several kinds of vapour absorption systems, their thermodynamic aspects and performance assessment. Specifically vapour absorption refrigeration by solar thermal heat is concentrated. Requirement for the working pairs have also been discussed, over the last few decades, a lot of research work still need to be done. Here feasibility of solar thermal chiller is studied with aspects of thermodynamics and economically along with eco friendly in nature.

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