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Design, Fabrication and Performance Analysis of Vapor Absorption Refrigeration System Powered by Solar Using Nanofluid

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Abstract

This paper covers the application of the nanofluid into the vapor absorption refrigeration system. The ammonia water refrigeration system is works on the low grade energy. It is eco friendly refrigerants. But it has some drawbacks. This is mainly used for large applications more than 3000tons, lower COP, hazardus applications. Remembering this it has to revaluate its research. And performance should be increased. Owing to this aim the VARS is made for domestic purpose, and designed for such. The nanofluid is used to enhance the performance. The nanoparticles used in this paper is Al_2O_3.

Keywords: *Ammonia-Water, Solar energy collector, Nanofluid, nanofluid preparation, parabolic collector*

1. Introduction

Human life becomes luxurious. The refrigerant used in air conditioning and refrigeration system used now days are mostly CFCs and HCFC or HFC. They are so harmful to the earth's environmental health.

We have to thing and find a very eco-friendly refrigerant. Paper involves study and the solution for such environmental related problem created by the conventional refrigeration and AC systems. Now days human comfort and food preservation electronics equipment cooling are becomes challenging task. All the air conditioning systems and refrigeration works CFC refrigerants cycles. The refrigerant CFC and HFC contains the chlorine gas. The chlorine gas is huge threat to the ozone layer. Research shows that one chlorine atom deflects millions of the ozone (0_3) molecules. Its also cause to green house gas effect. Green gases absorb solar radiation (especially infrared radiation) and produces heat in earth's environment.

To minimize or overcome the problem of ozone layer depletion, the conventional refrigeration should be replaced by new one. The solution for this is the Vapor Absorption refrigeration System (VARS). The refrigerants used in VARS are NH_3, Water, LiBr which are not ozone layer threats. VARS has no moving parts and the refrigeration effect getting is economical. This works on the low grade energy like waste heat.

Most of our country region situated at remote area and isolated from developed region. Even electricity is problem. They have need of air comfort and refrigeration systems to keep their medicine or foodstuffs bellow spoiling temperature. Considering all the situations and Indian territory hot environment. It is need to develop a refrigeration system, which works on less energy consumption. The paper work proposed about cooling system is Vapor Absorption Refrigeration System (VARS).

VARS has some draw back. It has very low COP as compare to the vapor compression cycle. For increasing COP, the system should be well engineered and new technology should used. The technology discussed in this paper is to use nanofluid with the water-ammonia absorption system. Nanomaterial/ nanoparticles are added to fluid mixture called nanofluid. They are used to enhance the properties of the base fluid. Nanofluid has verity of applications. Some of thermal applications are as heat transfer intensification, electronic component cooling, automobile engine cooling, and solar application, Refrigeration application etc. this paper focused on the nanofluid used to enhance the performance of water-ammonia vapor absorption refrigeration systems. Some research about nanofluid discussed below: boiling heat transfer rate increased by 40% at nanoparticles adding in water by 1.25% of weight Al_2O_3 nanoparticles (02). Park found that using Carbon nanotubes (CNT), on nucleate boiling heat transfer rate of R123 and HFCl34a by 36.6% (03). Experimental result getting by the Saw that thermal conductivity is increased by 12.2 by mixing 1% of nano Cu powder in base material paraffin wax (04). This text involving design of vapour absorption system experimental setup, solar energy parabolic collector, use of nanofluid for performance enhancement.

2. Refrigeration

The refrigeration process can be defined as producing and maintaining temperature bellow the atmospheric temperature in confined space call as refrigeration. The melting of the ice or snow was one of the earliest methods of refrigeration and is same employed now days also. In this process the heat is extracted from confined space and pumped to the surrounding. The unit of refrigeration is ton of refrigeration, which able to produce 1 ton of ice within 24 hours from 32°F water conversion in to 32°F ice. ice TR equals to 3.5 kW. The earliest method of refrigeration was melts at 0^0C. So ice is placed in a given space wormer than 0^0C, heat flow into the ice and space is cooled or refrigerated. The latent heat of fusion of ice is supplied from the surroundings, and the ice changes its state from solid to liquid.

Now day the various methods are employed to produce refrigeration effect. The refrigeration Cycles are classified as follows

1. Thermal/work driven system
   - Absorption refrigeration cycle
   - Adsorption refrigeration cycle
   - Chemical reaction refrigeration cycle
2. Electricity (Photovoltaic) driven system
   - Vapor compression refrigeration cycle
   - Thermo-electric refrigeration cycle

Vapor compression refrigeration systems are the most commonly used among all refrigeration systems. As the name implies, these systems belong to the general class of vapor cycles, wherein the working fluid (refrigerant) undergoes phase change at least during one process. In a vapor compression refrigeration system, refrigeration is obtained as the refrigerant evaporates at low temperatures. The input to the system is in the form of mechanical energy required to run the compressor. Hence these systems are also called as mechanical refrigeration systems. Vapor compression refrigeration systems are available to suit almost all applications with the refrigeration capacities ranging from few Watts to few megawatts. A wide variety of refrigerants can be used in these systems to suit different applications, capacities etc. The actual vapour compression cycle is based on Evans-Perkins cycle, which is also called as reverse Rankine cycle. Before the actual cycle is discussed and analyzed, it is essential to find the upper limit of performance of vapor compression cycles. This limit is set by a completely reversible cycle.

The proposed refrigeration system is modified version of 'Einstein-Szilard refrigerator'. It is a three fluid system comprising of ammonia, water & hydrogen. Instead of a compressor it uses waste heat to run a generator, as opposed to a standard refrigerator. A low grade heat source heats up the absorber-absorbent pair releasing the refrigerant in vapour form. This vapor is air cooled to liquid state at the condenser. Finally hydrogen reduces the vapor pressure of the ammonia liquid entering the evaporator causing the liquid to boil absorbing heat from the cabin and in turn cooling it [10]

In the solar powered absorption air-conditioning system, the water storage is most require in this system the large storage gives the continuous and constant heat source to the generator. Also, it has been suggested that the nominal storage amounts for cooling purposes range from 80 kg/m2 of collector area to 200 kg/m2. A critical problem with the hot water storage tank is its heat loss to the surrounding area. Sometimes, the heat loss from the hot water storage tank could be equivalent to 2 h of operation per day of the solar air-conditioning system [05]. Similar to the hot water storage tank, a chilled water storage tank is often used in the solar powered air-conditioning system. While the hot water storage tank experiences considerable heat loss, the chilled water storage tank has a lower rate of heat gain because of the small temperature difference between the chilled water tank and its surroundings. Furthermore, if the chilled water storage tank is installed near the air-conditioned area, its heat gain could assist in cooling. Generally, a parallel auxiliary-heater arrangement is preferred to the series one. Since the chiller has the best performance at high temperatures, it is better to use the auxiliary heater directly to drive the chiller when the temperature in the hot water storage tank is lower than the required level. If the auxiliary heater is connected in series between the hot water storage tank and the chiller, water is often returned to storage hotter than it is taken out, which raises the storage temperature and decreases the collector efficiency. However, if the storage temperature is below the needed energizing temperature but above the return temperature from the generator, then, a series connection can be considered, since only a portion of energy need be supplied by the auxiliary heater to reach the energizing temperature. This method may be suitable in installations needing auxiliary energy only during short periods. In the heating season, the hot water is directly provided from the hot water storage to the fan-coil of the air-conditioned space, or/and to places where the heat is used for bathing or other domestic applications. The main parameter that governs the performance of the chiller is the chilled Water temperature. This is because, as the chilled water temperature decreases, the evaporator temperature decreases, thereby decreasing the pressure in the evaporator, all of which finally results in an increased concentration of the solution. This results in the possibility of crystallization of the solution. Also, with the decrease in evaporating temperature, the coefficient of performance (COP) of the chiller would decrease. [06]

3. Vapor Absorption Refrigeration System

The vapor absorption process works on the principle of the absorption / adsorption of one solution by another solution. These solutions have much affinity to each other. In vapor compression cycle the mechanically compression i.e. compressor is replaced by the thermal absorption process. The compressor is replaced by an absorber, generator and pump. The working fluid in an absorption refrigeration system is a binary solution consisting of refrigerant and absorbent. The most popular binary refrigerants-absorber solutions are ammonia-water and water-LiBr. Ammonia-water pair ammonia is refrigerant and water is absorbent. Likewise in water+-LiBr pair water is refrigerant and LiBr is absorbent.

The working principle of the VARS described bellow (07). The figure 1 (a) showing evacuated vessels are connected to each other. In left vessel liquid refrigerant poured and in the right vessel binary solution of absorbent/refrigerant. At low pressure, solution in the right vessel will absorb refrigerant from the left vessel. While the refrigerant vapor is being absorbed, the temperature of the remaining refrigerant will reduce as a result of its vaporization.

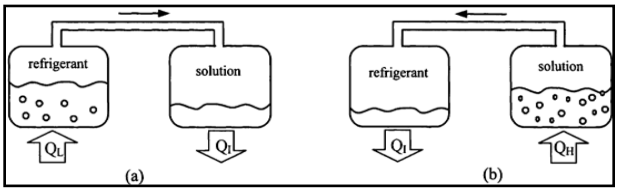


Figure1 Working principle of VARS

This causes a refrigeration effect to occur inside the left vessel. At the same time, solution inside the right vessel becomes more dilute/weak because of the higher content of refrigerant absorbed. This is called the "absorption process". Heat is rejected to surrounding for maintaining absorption capacity, the absorption process is exothermic. Whenever the solution cannot continue with the absorption process because of saturation of the refrigerant, the refrigerant must be separated out from the diluted solution. Heat is normally the key for this separation process. It is applied to the right vessel in order to dry the refrigerant from the solution as shown in Fig. 1(b).

Figure1. Working principle of VARS

The refrigerant vapor will be condensed by transferring heat to the surroundings. With these processes, the refrigeration effect can be produced by using heat energy. However, the cooling effect cannot be produced continuously as the process cannot be done simultaneously. Therefore, an absorption refrigeration cycle is a combination.

Separation process occurs in the right vessel as a result of additional heat from outside heat source. of these two processes as shown in Figure As the separation process occurs at a higher pressure than the absorption process, a circulation pump is required to circu- late the solution. The work input for the pump is negligible relative to the heat input at the generator, therefore, the pump work is often neglected for the purposes of analysis.

In figure

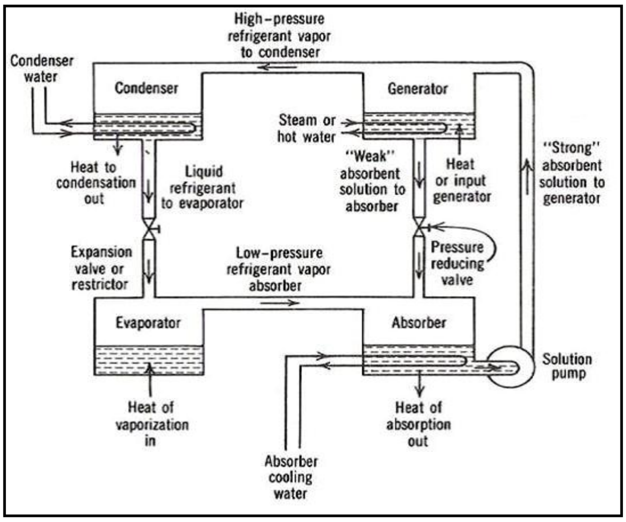


Figure 2 working setup of VARS

4. Design of VARS

The literature values for the design of the Aqua Ammonia vapour absorption system are (08)

Capacity of system = 3TR(10.548KW)

Concentration of NH3 in refrigerant, Xr = 0.98

Concentration of NH3 in Solution, Xs = 0.42

Concentration of NH3 in absorbent, Xw = 0.38

Temperature of the evaporator, TE = 2°C

Generator or condenser pressure, PH = 10.7 bar

Evaporator pressure, PL = 4.7 bar

Temperature of the Condenser, TC = 54°C

Temperature of the Absorber, TA = 52°C

Temperature of the Generator, TG = 120°C

5. Solar Energy

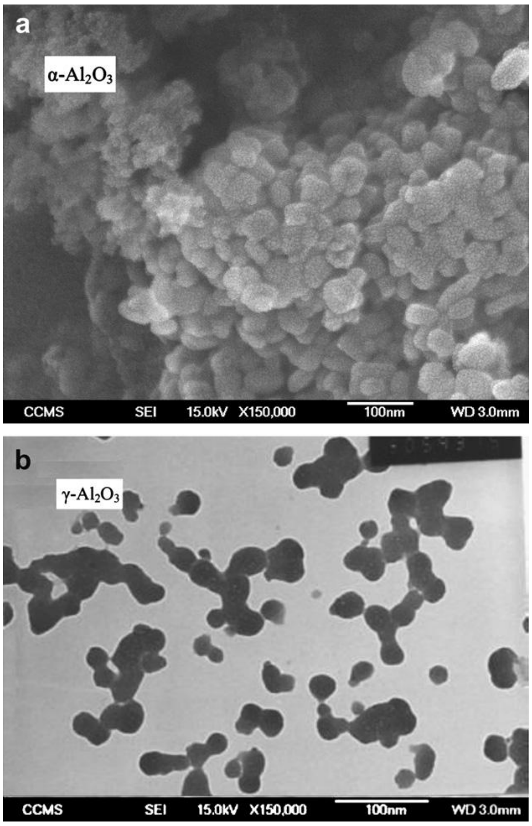
Solar power is the world's largest renewable energy source the sun. it is 99% of the world's available renewable energy sources. Increasing environmental and climate awareness, the use of solar energy has been growing explosively the past few years. However it has some technological and economical developments issues, the huge research has to be done on the same. Sun light comes on earth in two components. One is direct beam of light another diffused sun light. Direct beam of sunlight brings about 90% of the solar energy, and the diffuse sunlight carries the remainder. The diffuse portion is the blue sky on a clear day and increases proportionately on cloudy days. The most of the solar energy carries direct beam, so maximum collection of energy should collected in this phase.

In The proposed work of VARS setup is using parabolic Concentrator, which has 40% of efficiency

6. Nanofluid

Nanoparticles are crystalline having below 100 nm. This can be used to improve the base fluid property (Mechanical, thermal, physical, chemical etc). firstly, nanofluid ware developed by Choi (09) at Argonne National Laboratory. he defined as suspensions of nanoparticles into base fluids with the typical length scale of particles is 1–100 nm. K. Wang, G. Ding, W. Jiang, developed nanofluid for refrigerants. It can enhance the performance of a refrigeration system (10). By using nanoparticles in refrigeration system, three main advantages can be obtained (11); (i) nanoparticles increase the solubility between the refrigerant and lubricant. (ii) Thermal conductivity and heat transfer characteristics enhances. (iii) Nanoparticles dispersion into lubricant may decrease the friction coefficient and wear rate. However, there are contradictory results as well available in literature.

This paper focused on the use of the nano fluid in VARS to enhance its performance. The four types of anofluids in this study were prepared by mixing a-Al2O3 with PAA, a-Al2O3 with CTAB, g-Al2O3 with PAA and g-Al2O3 with SDBS in ammonia water base solution, respectively. Fig. 1 (a) and (b) shows the SEM image of a-Al2O3 and g-Al2O3 nanoparticles, respectively. The nano-particles are spherical or analogously spherical and the purity is more than 99.8% through the use of Ultraviolet emission spectrometer. The mean size of a-Al2O3 and g-Al2O3 nano-particles is less than 20 nm and 30 nm respectively. All the three kinds of surfactants used in the experiments are analytical reagent and the ammoni water is homemade. (14)



7. Conclusion

The project setup is ready to checking performance. But test of the Alumina is not done Using the nanoparticles of Al2O3 in VARS. By literature some conclusion is given bellow:

1. The dispersion of Al2O3 nanofluids firstly increases to a maximum and then decreases with the increase of surfactant mass fraction,
2. The stability of Al2O3 is improved with the increasing of the mass fraction of ammonia water.
4. The optimal dispersing condition of a-Al2O3 and a-Al2O3 nanofluids is 0.3% PAA in 25% ammoniaewater basefluid with 30 min supersonic vibration.

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