Vapour Absorption System (VAS) Assisted Air Cooler

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Abstract— In this paper we have considered use of Vapour Absorption System in conventional Air Cooler. The aim of our project is to minimize the power requirement and also increase cooling effect by using VAS system. As the power required for running an air conditioning is very high so everyone is not able to afford air conditioning. The function of domestic Vapour Compression Cycle (VCC) assisted Air cooler is of sensible cooling and humidification. As the VCC cycle consists of compressor, so the power required for the operation is large. In the VAS system, there are no moving parts like the compressor in VCC system. So the power required is reduced and also maintenance cost is reduced due to no wear and tear. The evaporator of the VAS will be used as the heat exchanger with Air cooler so that the water will be cooled more as per the simple Air cooler. As we are using VAS and Air cooler in combination so the advantages of both the system can be used effectively.

Key words: Vapour Absorption System, Vapour Compression Cycle, Air Cooler, Ammonia, Hydrogen, Water

I. Introduction

An evaporative cooler (also swamp cooler, Air cooler and wet air cooler) is a device that cools air through the evaporation of water. Evaporative cooling differs from typical air conditioning systems which use vapor-compression or absorption refrigeration cycles. Evaporative cooling works by employing water's large enthalpy of vaporization. The temperature of dry air can be dropped significantly through the phase transition of liquid water to water vapor (evaporation), which can cool air using much less energy than refrigeration. In extremely dry climates, evaporative cooling of air has the added benefit of conditioning the air with more moisture for the comfort of building occupants.

Evaporative coolers lower the temperature of air using the principle of evaporative cooling, unlike typical air conditioning systems which use vapor-compression refrigeration or absorption refrigerator. Evaporative cooling is the addition of water vapor into air, which causes a lowering of the temperature of the air. The energy needed to evaporate the water is taken from the air in the form of sensible heat, which affects the temperature of the air, and converted into latent heat, the energy present in the water

Vapor component of the air, while the air remains at a constant enthalpy value. This conversion of sensible heat to latent heat is known as an adiabatic process because it occurs at a constant enthalpy value. Evaporative cooling therefore causes a drop in the temperature of air proportional to the sensible heat drop and an increase in humidity proportional to the latent heat gain. Evaporative cooling can be visualized using a psychometric chart by finding the initial air condition and moving along a line of constant enthalpy toward a state of higher humidity.

In the Vapour Absorption Refrigeration (VAR) system, a physicochemical process replaces the mechanical process of the Vapour compression refrigeration (VCR) system by using energy in the form of heat rather than mechanical work. The main advantage of this system lies in the possibility of utilizing waste heat energy from industrial plants or other sources and solar energy as the energy input.

The VAR systems have many favourable characteristics. Typically a much smaller electrical input is required to drive the solution pump, compared to the power requirements of the compressor in the VCR systems, also, fewer moving parts means lower noise levels, higher reliability, and improved durability in the VAR systems

A vapour absorption refrigeration system is a heat operated unit which uses refrigerant (NH3) that is alternately absorbed by and liberated from the absorbent (water). The vapour absorption system uses heat energy, instead of mechanical energy as in vapour compression system, in order to change the condition of the refrigerant required for the operation of the refrigeration cycle. In this system, the compressor is replaced by an absorber, a pump, a generator, and a pressure reducing valve. These components in the system perform the same function as that of compressor in vapour compression system. The vapour refrigerant from evaporator is drawn into an absorber where it is absorbed by the weak solution of refrigerant forming a strong solution. This strong solution is pumped to the generator where it is heated by utilizing electric energy. During the heating process, the vapour refrigerant is driven off by the solution and enters into the condenser where it is liquefied. The liquid refrigerant then flows into the evaporator and thus the cycle is completed.

II. Methodology

A. Two-Stage Indirect and Direct Evaporative Cooling

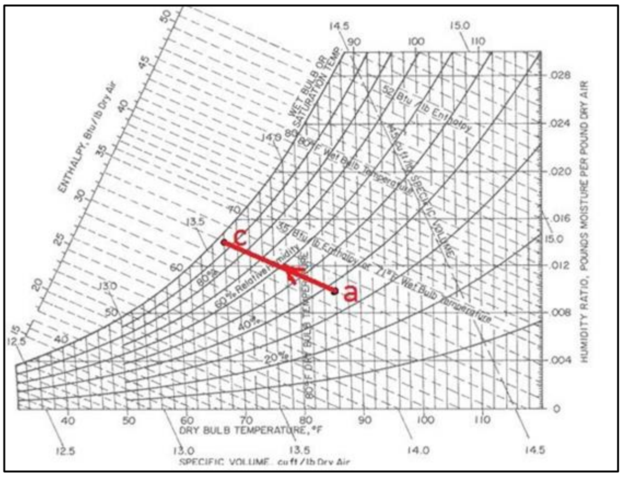

Fig. 1: Indirect Evaporative Cooling

The System Consist of two types of cooling i.e. Indirect Evaporative Cooling and Direct Evaporative Cooling. Two stage evaporative coolers combine indirect with direct evaporative cooling. This is accomplished by passing air inside a heat exchanger that is cooled by evaporation on the outside. In the second stage, the pre-cooled air passes through a water-soaked pad and picks up humidity as it cools. Because the air supply to the second stage evaporator is pre-cooled, less humidity is added to the air, whose affinity for moisture is directly related to temperature. The two-stage evaporative cooling provides air that is cooler than either a direct or indirect single-stage system can provide individually. In many cases, these two-stage systems provide better comfort than a compressor-based system, because they maintain a more favourable indoor humidity range.

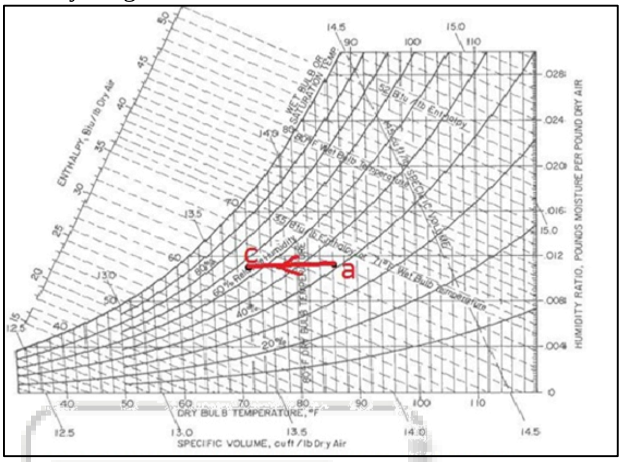

Fig. 2: Direct Evaporative Cooling

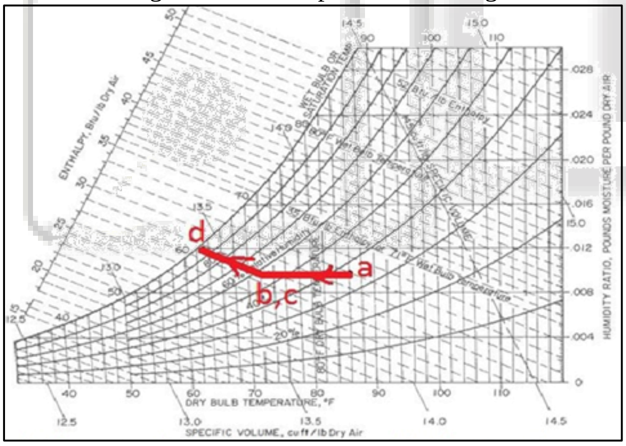

Fig. 3: Two Stage Indirect and Direct Evaporative Cooling

B. Electrolux Refrigerators

Fig.4 shows a schematic diagram of an "Electrolux refrigerator". It is a domestic refrigerator and is the best known absorption type of refrigerator. Here pump is dispensed with. The small energy supply is by means of a heater which may be electric or gas.

The principle involved makes use of the properties of gas-vapour mixtures. If a liquid is exposed to an inert atmosphere, it will evaporate until the atmosphere is saturated with the vapour of the liquid. This evaporation requires heat which is taken from the surroundings in which the evaporation takes place. A cooling effect is thus produced. The partial pressures of the refrigerant vapour (in this case ammonia) must be low in the evaporator, and higher in the condenser. The total pressure throughout the circuit must be constant so that the only movement of the working fluid is by convection currents. The partial pressure of ammonia is kept low in requisite parts of the circuit by concentrating hydrogen in those parts.

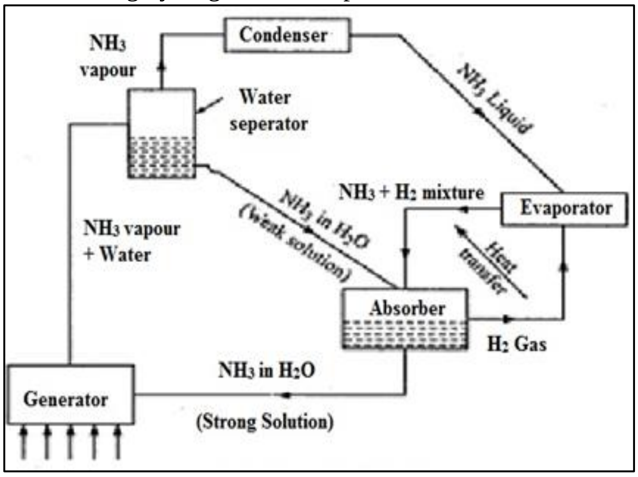

Fig. 4: Basic Electrolux VAS System

The ammonia liquid leaving the condenser enters the evaporator and evaporates into the hydrogen at the low temperature corresponding to its low partial pressure. The mixture of ammonia and hydrogen passes to the absorber into which is also admitted water from the separator. The water absorbs the ammonia and the hydrogen returns to the evaporator. In the absorber the ammonia therefore passes from the ammonia circuit into water circuit as ammonia in water solution. This strong solution passes to the generator where it is heated and the vapour given off rises to the separator. The water with the vapour is separated out and a weak solution of ammonia is passed back to the absorber, thus completing the water circuit. The ammonia vapour rises from the separator to the condenser where it is condensed and then returned to the evaporator.

The actual plant includes refinements and practical modifications (which are not included here). The following points are worth noting:

The complete cycle is carried out entirely by gravity flow of the refrigerant.

The hydrogen gas circulates only from the absorber to the evaporator and back.

With this type of machine efficiency is not important since the energy input is small.

It has not been used for industrial applications as the C.O.P. of the system is very low.

C. Role of Hydrogen:

By the presence of hydrogen it is possible to maintain uniform total pressure throughout the system and at the same time permit the refrigerant to evaporate at low temperature in the evaporator corresponding to its partial pressure. Thus the condenser and evaporator pressures of the refrigerant are maintained as below:

In the condenser only ammonia is present, and the total pressure is the condensing pressure.

In the evaporator hydrogen and ammonia are present; their relative masses are adjusted such that the partial pressure of ammonia is the required evaporator pressure.

These are achieved without the use of pumps or valves.

D. *Vapour Absorption System (VAS) Air Cooler*

As stated above in the working of Electrolux System the ammonia refrigerant is cooled in the condenser which is then passed through the evaporator coils. As it passes through the evaporator coils ammonia evaporates by taking latent heat from the water present in the air cooler. Water is thus cooled by giving its latent heat to ammonia present in VAR System. This cooled water is pumped back to cooling pads through water tubes. Simultaneously blower sucks air from outside and throws on cooling pads. The cold water absorbs heat from the air and increases humidity of the air thus supplying the cold and humidified air to surrounding.

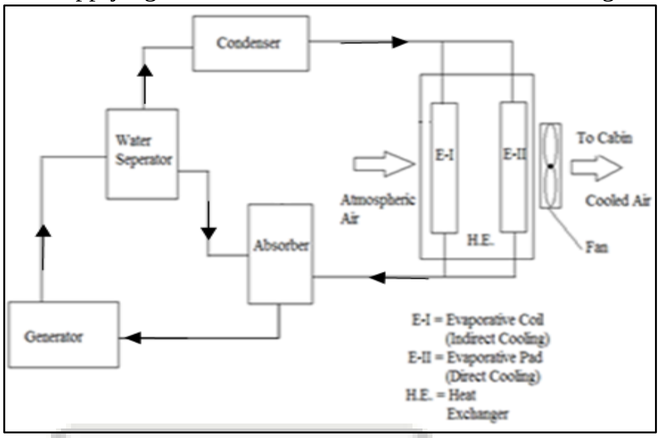

Fig. 5: Block diagram of VAS Vapour Assisted Air Cooler

III. ADVANTAGES AND LIMITATIONS

A. *Advantages*

Since it does not have a compressor, its capital cost is not prohibitive.

- As the components used are a fan, small pump and pads, its repair and maintenance is cheap and easy.
- Less expensive to install: Estimated cost for installation is about half that of central refrigerated air conditioning.
- No mechanical troubles, maintenance cost is low.
- No lubrication problem; no wear and tear.
- No chance of pressure unbalancing and no need of valves.
- System may be designed to use any available source of thermal energy-process steam, exhaust from engines or turbines, solar energy etc.
- Easy control, simply by controlling heat input.
- Less expensive to operate. Estimated cost of operation is 1/8 that of refrigerated air. Power consumption is limited to the fan and water pump.

B. *Limitations*

- As the process of cooling is isenthalpic process, the lowest temperature of air that can be achieved is Wet Bulb Temperature of outside air. So to get adequate amount of cooling there should be large difference between Dry Bulb Temperature and Wet Bulb Temperatures of outside air. This means it is most effective only in areas of dry climate. So its use in Coastal areas of high humidity is very limited.
- The actual temperatures that could approach Wet Bulb temperature would depend upon extent of evaporation surface of water. So the quantity of pad over which water is spread would decide the extent of cooling or effectiveness of cooler.
- More complicated in construction and working.
- C.O.P is very low.
- The major disadvantages of this type of refrigerator are that if it is spoiled once, it cannot be repaired and has to be replaced fully
- High humidity in air accelerates corrosion, particularly in the presence of dust. This can considerably reduce the life of electronic and other equipment.
- High humidity in air may cause condensation of water. This can be a problem for some situations (e.g., electrical equipment, computers, paper, books, and old wood).

IV. CONCLUSION

- Two-stage (Indirect/Direct) Evaporative Cooling is more effective than only direct or indirect cooling.
- Both DBT and WBT get reduced in this process.
- Power Consumption significantly reduces for same cooling effect achieved by air conditioner.
- Humidity And Air Flow can be adjusted using controls in cooler.
- COP is less as compare to VCC system but can be neglected due to reduced power consumption.

V. FUTURE SCOPE

We can use solar energy to heat generator, also to provide energy to desert cooler so to get cool air for no cost.

We can make desert cooler more compact by eliminating some unnecessary parts with further study.

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