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VAPOUR ABSORPTION SYSYTEM (VAS) SUPPORTED DESERT COOLER

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ABSTRACT

Air Conditioner gives superior cooling effect than any other cooling device but it comes with a huge cost and power requirement. It's not easily affordable by everyone. Alternatively, a domestic Desert Cooler supported by VCC gives cooling temperature in the range of 22°C to 25°C, though it generates humid air but it serves the purpose economically when compared to an Air Conditioner. As the Vapour Compressed Cycle (VCC) consists of compressor, the power required for its operation is high. In order to minimize the cost, power requirement and also to increase the cooling effect of a domestic Desert Cooler, Vapour Absorption System (VAS) is used for achieving the aforementioned purposes. In the VAS, there are no moving parts like the compressor and pump as in VCC system, thereby reducing the power consumption and also due to no wear and tear, the maintenance cost is insignificant. The evaporator of the VAS will be used as a heat exchanger in line with the desert cooler to increase the cooling effect. Solar Energy, an alternative energy source, can also be used to further reduce the cost. This paper is an attempt to highlight the advantages and viability of using VAS along with a Desert Cooler pertaining to the cost, power requirement and size of the cooler

1. OBJECTIVE:

To improve the cooling effect of Desert Cooler:

- By using VARS as a heat exchanger.
- To develop an eco-friendly Desert Cooler (by eliminating refrigerants like CFCs / HFCs).
- To design the cost-effective and viable size of heat exchanger.

2. PRESENT THEORY AND PRACTICES:

3.1 Desert Cooler (Evaporative Cooler)

An air conditioner ensures proper comfort conditions in the space but its capital cost and running cost is significant. So an alternative, even if giving only relief from heat at lower cost was the requirement, then the Evaporative cooler can serve this purpose.

Working:

A schematic diagram showing the essential parts of evaporative cooler is given below (Fig-1). The outside air is pulled by a fan over wetted pads. The hot air when in contact with water surface transfers heat to the water and evaporates it. A tiny pump ensures wetting of pad. This cool air then is supplied to the space for cooling it. However, the vapour formed mixes with the air and so air supplied has greater humidity than outside air. Since the cooling of air is due to evaporation of water, this is known as evaporative cooler. In this process the heat transfer is within the system of air i.e. sensible heat given out by air is received back as latent heat. Therefore, it is also known as adiabatic cooling or isenthalpic cooling.

Fig - 1

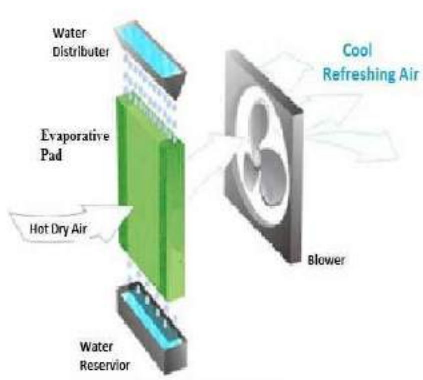

Fig.1 Block diagram of Desert Cooler

Advantages:

1. Since it does not have a compressor, its capital cost is not expensive.
2. It uses air and water which are readily available resources.
3. Supply of cool air from cooler gives relief from hot air outside and heat coming in through walls and roof.
4. As the components used in it are a fan, small pump and pads, its repair and maintenance is cheap and easy.

Disadvantages:

1. As the process of cooling is isenthalpic, the lowest temperature of air that can be achieved is the Wet Bulb Temperature of outside air. So to get adequate amount of cooling there should be large difference between the Dry Bulb Temperature and Wet Bulb Temperature of outside air. This means it is most effective only in dry climate areas. So its use in coastal areas, which have high humidity, is very limited.
2. The actual temperatures that could approach Wet Bulb Temperature would depend upon the extent of evaporation from the surface of water. So the quantity of pad over which water is spread would decide the extent of cooling or effectiveness of the cooler.
3. This process is used in hot and dry climates of Northern region of India even for large industrial spaces. In such systems two or three nozzles are used to give a spray through which air is passed. This cooler has very high efficiency.

3.2 Domestic Electrolux Refrigerator

The domestic absorption type refrigerator was developed by Carl Munters and Baltzer Von Platen. This system is often called as “Munters Platen System”.

This type of refrigerator is also referred to as “Three Fluids Absorption System”. The three fluids used in this system are Ammonia (NH_3), Hydrogen (H_2) and Water. Ammonia is used as a refrigerant because it possesses most of the desirable properties. Though it is toxic, and not otherwise preferred in domestic appliances, but due to the absence of any moving parts in the system there is a very little chance of any leakage and hence considered to be safe for usage.

Hydrogen being the lightest gas, is used to increase the rate of evaporation (the lighter the gas, faster is the evaporation) of the liquid ammonia passing through the evaporator. Hydrogen is non-corrosive and insoluble in water. Water is used as a solvent because it has the ability to absorb Ammonia readily.

Principle and Working of Electrolux Refrigerator:

Fig.2 shows a schematic diagram of an Electrolux Refrigerator. It is a domestic refrigerator and is the best known Absorption Type Refrigerator.

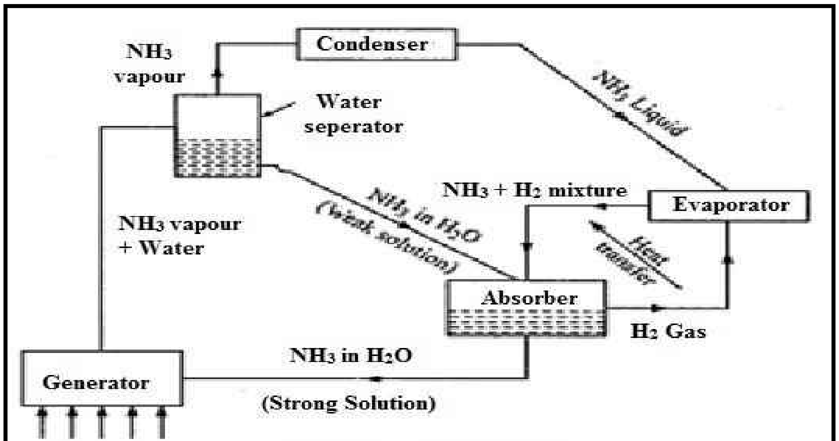

Fig - 2

The principle involved in this makes use of the properties of gas-vapour mixtures i.e. 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. 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.

Working:

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 water is also admitted. The water absorbs the ammonia in the absorber and forms a strong solution, whereas the hydrogen returns to the evaporator. This strong solution passes on 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, the 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.

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 hence 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.

Advantages:

- No pump or compressor or valve is required.
- No mechanical troubles, maintenance cost is low.
- No lubrication problem; no wear and tear.
- Completely leak proof.
- Noiseless.
- No chance of pressure unbalancing
- System may be designed to use any available source of thermal energy like Process steam, exhaust from engines or turbines, solar energy etc.
- Easy control (simply by controlling heat input).

Disadvantages:

- More complicated in construction and working.
- C.O.P is very low.
- Major disadvantage of this type of refrigerator is that if it is spoiled once, it cannot be repaired and has to be replaced fully.

3. CALCULATIONS AND RESULTS:

4.1 Temperature reduction achievable using Direct Evaporative Cooling (Fig-3)

Temp drop achievable = (dry bulb - wet bulb) x (efficiency of the media)

⇨ (86°F - 66°F) x 90% = 18°F

Achievable temp = dry bulb - temp drop achievable

⇨ 86°F - 18°F = 68°F

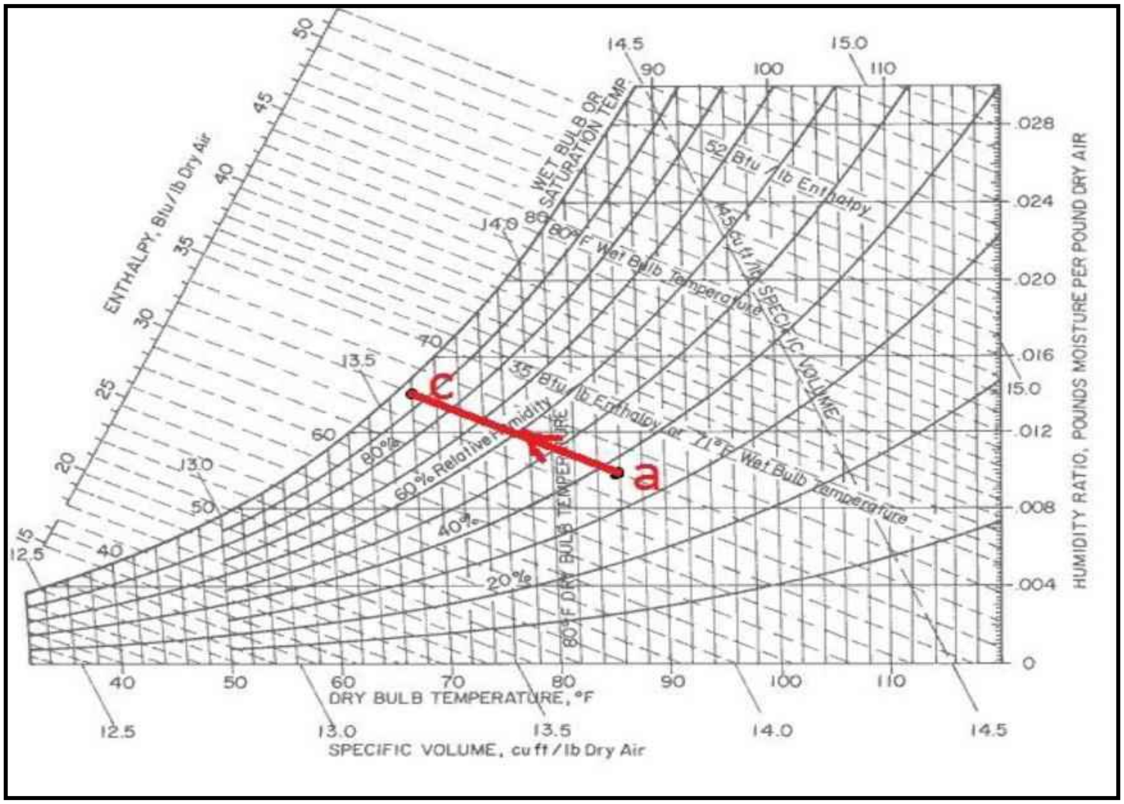

Fig - 3

Results:

Starting DB: 86°F & Ending DB: 68°F

Starting WB: 66°F & Ending WB: 66°F

4.1.2 Temperature reduction achievable using Indirect Evaporative Cooling

(Fig-4)

Temp drop achievable = (dry bulb – wet bulb) x (efficiency of indirect module)

⇨ (86°F - 66°F) x 70% = 14°F

Achievable temp = dry bulb – temp drop achievable

⇨ 86°F – 14°F = 72°F

Results:

Starting DB: 86°F & Ending DB: 72°F

Starting WB: 66°F & Ending WB: 61.4°F

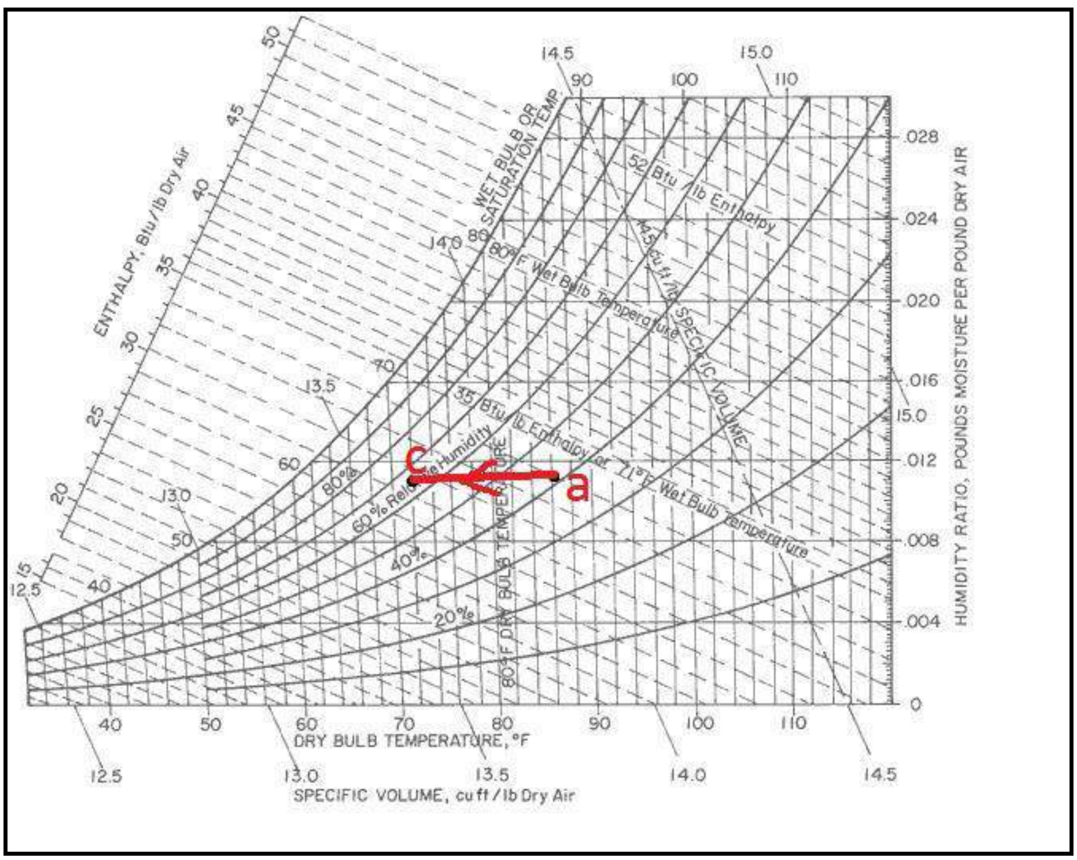

Fig - 4

4.1.3 Temperature reduction achievable using Two-stage Indirect/Direct Evaporative Cooling (Fig – 5)

First calculate the dry bulb and wet bulb temperatures achievable with indirect evaporative cooling:

Temp drop achievable = (dry bulb - wet bulb) x (efficiency of indirect module)

⇨ (86°F - 66°F) x 70% = 14°F

Achievable temp = dry bulb - temp drop achievable

⇨ (86°F – 14°F) = 72°F

Result after Stage -1 (Indirect cooling)

Starting DB: 86^{o}F & Ending DB: 72^{o}F

Starting WB: 66^{o}F & Ending WB: 61.4^{o}F

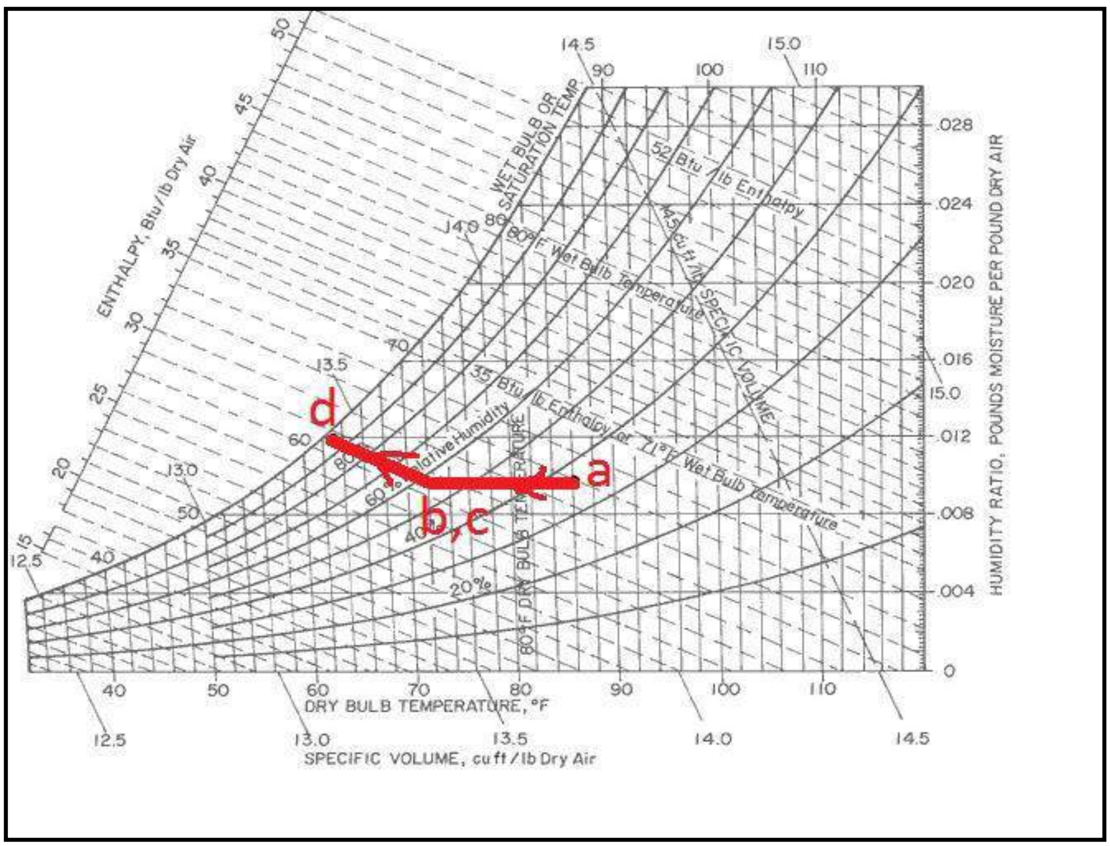

Fig - 5

Then use the dry bulb/wet bulb values from step 3 to calculate the dry bulb/wet bulb temperatures achievable with direct evaporative cooling:

Temp drop achievable = (dry bulb - wet bulb) x (efficiency of the direct module Media)

$= (72^o F - 61.4^o F) \times 90\% = 9.5^o F$

Achievable temp = dry bulb - temp drop achievable

$= 72^o F - 9.5^o F = 62.5^o F$ DB

Result after Stage -2 (Direct cooling)

Starting DB: 72^o F & Ending DB: 62.5^o F

Starting WB: 61.4^o F & Ending WB: 61.4^o F

Final Result after Stage-1 & Stage-2 cooling:

Starting DB: 86^oF & Ending DB: 62.5^oF

Starting WB: 66^oF & Ending WB: 61.4^oF

So, Heat Exchanger has to be designed which will provide the required indirect cooling for the cooler before direct cooling.

4. CONCLUSIONS:

1. The capital and installation a Desert Air Cooler is way cheaper as compared to an Air Conditioner.
2. Desert Air Cooler consumes less electricity as compared to an Air Conditioner.
3. As the system does not contain any refrigerants like CFCs or HFCs, it is eco-friendly.

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