Solar Based Refrigeration and air Conditioning By Ejector Based and LDAC Approach: A Review

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***Abstract**: The environmental benefits of New and Renewable energy sources have evolved very few devices which are functioning without producing pollutions. Usually while utilizing the solar application day timing is constraint. The need of refrigeration and air conditioning increases with increase in the intensity of sun. This advantage depicts importance of development of ejector based air conditioning and Liquid desiccant air conditioning. The power consuming device i.e. compressor in traditional VCR is replaced by ejector assembly in Ejector Based Air Conditioning. The Liquid Desiccant Air Conditioning can be used for cooling in summer and heating in winter.*

Keywords -Solar Based AC EBAC Ejector Based A LDAC

I. INTRODUCTION

Ejector based cooling introduced 10 decades back, originally developed forevacuating air from condensers of steam engines power plants. A moderate vacuum is created by ejector in conjunction with boiler which utilizes low pressure steam. Refrigerating effect is generated by evaporator with the help of steam based ejector by extracting vapour refrigerant from it.In late 1910 to 1930's ejectors were typically used to produce refrigerating effect where availability of common places and unutilized energy from low pressure steam like ships and motels .Their popularity increased due to No maintenance over decades.

In the late 1930's, the innovation of CFC refrigerant evolved the use of heat pump driven by electricity to houses where heat source is not available. The pronounced effect of Heat pump is sound thermal performance and safer operations. Till now the heat pump utilization in air conditioning dominating the market. The environmental degradation by production of electricity leads to rethink on these source of energy and forcing to replacing it with the cleaner source.

II. *EJECTOR BASED RAC*

The thermally driven ejector is a nothing but the compressor. Traditionally used compressors which consume electrical energy are replaced by the ejectors which use thermal energy instead of electrical to produce compression effect (figure 1a). The Ejector based Cooling is attractive for commercial manufacturing with inherent benefits of no moving parts, simple and reliable. To operate in heat pump utilities these technique needs large solar collectors and condensers for efficient working. For commercial performance the saving in electricity should be more than the costing of solar collectors.

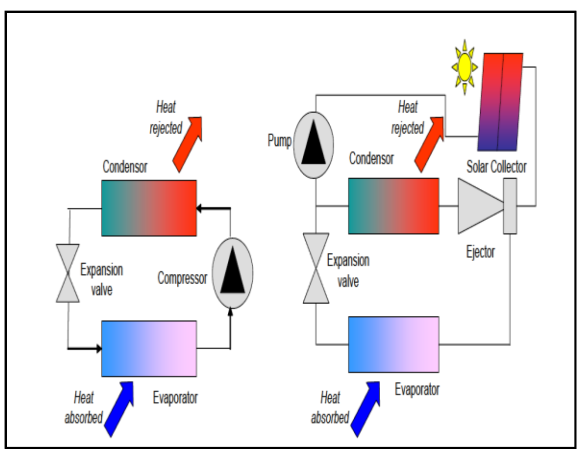

Fig.1.a): Traditional Refrigeration Fig.1.b): Solar Refrg. System

An ejector system having two converging-diverging nozzles (figure 1b). A supersonic jet is produced by the primary nozzle which has a small throat diameter from the generator flow. From essentially stagnation conditions the flow has accelerated at the nozzle entrance to such high velocity. Due to conservation of energy its pressure and temperature must drop (figure 1b). Thus the key function of the primary jet is to produce the suction Similar to the Compressor which is electrically driven.

when the secondary pressure goes down below the vapour pressure refrigerant is withdrawn from the evaporator at the evaporator temperature (figure 1 b). The evaporator flow is comes into the annular space of the primary jet and the ejector mixing duct wall. The diameter of this duct is carefully design by keeping in view that the sufficient condensing pressure should be achieved. Secondary flow passes through the annulus which is designed to be choked at optimal operation conditions. However, the secondary flow can be calculated from the area of the annulus by assuming choked flow conditions.

A single flow is formed when the primary and secondary flows undergo turbulent shear whose properties can be calculated by the equations of the conservation of mass, momentum and energy. According to the condensing conditions, the mixed flow is supersonic and unstable. It experiences an irreversible supersonic compression shock by which its temperature and pressure is elevated. It is the second ejector effect that is of compression relative to the evaporator state. Finally, enthalpy from the kinetic energy is recovered by a subsonic diffuser which further increases the pressure and temperature.

Air-Conditioning Cycle

The figure 2 representing the simple ejector based cooling system and its representation on log(P)-h graph. The liquid refrigerant is passed to the generator through the pump (point 8). The solar energy from solar heater or waste heat utilized to heat the liquid in the generator. saturated vapor produces as a result of first stage heating, which is then heated upto superheated condition (point 1). Generator capacity as well as mass flow is key parameters to produce the degree of superheat. When superheated vapour comes into nozzle of the ejector it undergoes an expansion from the generator pressure p_g to the lower pressure, which is nothing but the evaporation pressure p_e (point 2). The ejector sucks in the refrigerant from the evaporator (point 7), and mixes it with expanded vapor (point 2) and as a result of mixing the mixed vapor in state 3 is produced. The pressure of the working fluid rises in both ways initially rises slightly as a result of the momentum exchange, and then it raises more in the diffuser up to the point 4, which is a level of the the condensation pressure p_c. After that the Compressed vapor comes into the condenser, where it condenses or may subcool depending on the conditions of the cooling. The refrigerant leaves the condenser at state 5 (point 5). The flow is divided into two parts: one part flows into the generator through the pump and the remaining part flows into the evaporator by passing through the expansion valve (throttling valve), it is throttled to the evaporation pressure which is denoted as p_e, which is the condition of wet vapor (point 6). The working fluid absorbs cooling capacity *Qo* from the refrigerated medium through the boiling in the evaporator.This is may be utilized in the air circulating in the air-conditioned room or ice water.

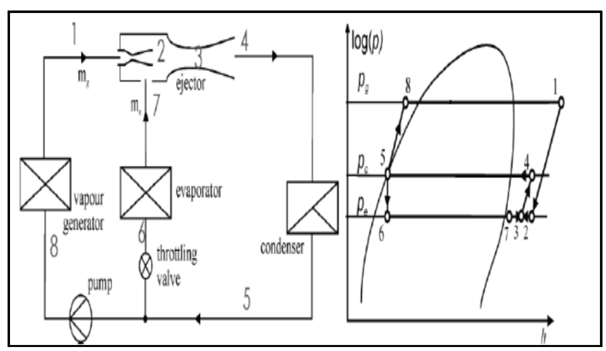

Fig. 2 : Schematic diagram of ejector device and ejector cycle in log(*p*)-*h* co-ordinates.

The significant difference between ejector based refrigeration cycle and the reverse Rankine cycle (conventional refrigeration cycle) is not only replacement of a compressor but also three heat sources at different temperatures

TABLE I. PERTICULARS OF COMPONENTS ON LOG P-H DIGRAMM.

S.N	Component	Points on Diagram.	Temp (°C)
01	Generator level	(8-1)	70-100°C,
02	Condensing level	(4-5)	Ambient temperature of 25-35°C
03	Evaporator Level	(6-7)	approx. 5-8°C.

Advantage

- Energy Cost (/ hr) which is associated with the Electricity Consumption (Kw) is No More or less than compared to Vapour Compression Cycle.
- Annual energy cost, Service Interval, Estimated Service Cost, Annual Service Cost and Annual running Cost are negligible compared to VCR.
- The Ejector based system has no moving parts, simple and highly reliable.

Disadvantage

- Higher Investment in Initial phases of Installation.
- The need of Auxiliary devices for Efficient Working.
- The operation Becomes Complicated In Night Hrs.
- Set Points of Ejector Assembly are complicated in performance.
- The thermal efficiency is less and Large solar collectors are required

III. LDAC RAC

In the Liquid Desiccant Air Conditioner (LDAC), Process air is passed through liquid desiccant material which extracts moisture, latent heat and may be sensible heat from it. The examples of Liquid Desiccant Materials are lithium Chloride (LiCl).In the Unit, the concentrated and cooled liquid desiccant sprayed from top and flows down thorough a granule particals packaged bed (See Figure 3 a) . The concentrated and cooled liquid desiccant absorb both the moisture and latent heat of counter flowing return air which is flowing in opposite direction from Bottom to top. After absorbing the moisture the concentrated and cooled liquid desiccant diluted and from bottom of the packaged bed it flows to the regenerator.

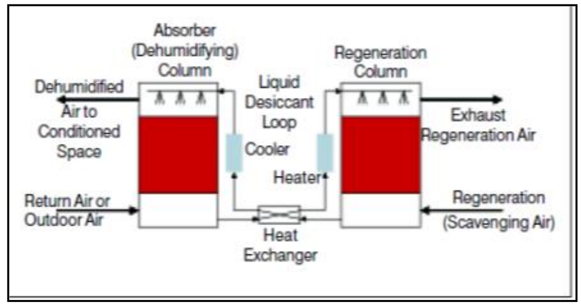

Fig.3.a: Basic Configuration of desiccant dehumidifier.

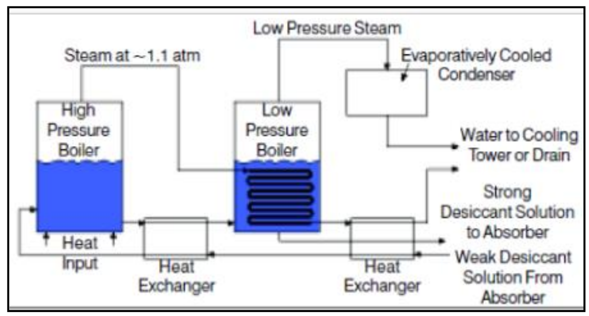

Fig.3.b: Double effect LDAC

The construction and working of regenerator loop is very simple. The heat source utilizes the energy of gas, oil fired, waste heat and solar etc. In the regenerator heating of the diluted liquid desiccant solution is done, by spraying on another packed bed. A counter-flowing scavenger airstream absorbed moisture of the the heated solution of diluted liquid desiccant and regenerate into concentrated liquid desiccant solution. A cooling tower or chiller used to cool the return feed from regenerator and thus the cool and concentrated liquid desiccant is regenerated. The cool and concentrated liquid desiccant is send back to Absorber to complete the loop. To reduce significant amount of heating and cooling heat exchanger may be installed between the absorber and regenerator with the basic configuration. Industrial market needs deep drying and precise humidity control. Many firms manufacturing LDAC but they are having very small market share.

Liquid desiccant units have better potency of precise humidity control than traditional systems they extract moisture without cooling air below saturation temperature which helps to keep the supply duct dry and prevent bacteria and mold formation. The indoor air quality would also be improve by the operation of the scavenging action of liquid desiccant systems which remove contaminants. To put on hold on commercial market many modification are required to compete with commercial units. The use of liquid desiccant medium i.e.LiCl tends to corrode the metal along with desiccant carry over which may cause health issues. LiCl corrosion may prevent by using Stainless steel and plastic parts . A research laboratory runs over months with zero desiccant carryover. Without spraying liquid desiccant it is directly onto absorber surface with low flow rate.

Advantage

- The System removes moisture without cooling the air below saturation temperature which prevent Growth of mold and bacteria formation in supply duct.
- The whole Assembly with little change can be used for winter as well.
- The System is Effective and Efficient for Commercial uses with little Modifications.

Disadvantage

- Desiccant Carry Over
- Corrosion of Components after some days due to use of licl

CONCLUSION

Traditional refrigeration systems consume electricity which creates pollution and other environmental problems can be replace by the Solar refrigeration systems examples Ejector based refrigeration system and Liquid Desiccant Air Conditioning. The Ejector based system has no moving parts, simple and highly reliable. Ejector based cooling is looks attractive for commercial production if we overcome limitations of the low thermal efficiency and requirement of large solar collectors. Liquid Desiccant Air Conditioner (LDAC) Extract moisture without cooling the air below saturation temperature which prevent the growth of bacteria an mold in supply ducts. LDAC can be used commercially with little modifications of Desiccant carry over and Corrosion prevention. LDAC can be used for both the season's winter and summer. The more Concentration of Researchers needs to improve these technique and to make it more commercial.

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