Experimental Modelling of Liquid Desiccant Air - Conditioning System

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Abstract: In the present study, experiments have been conducted on an Indirect Contact Liquid Desiccant Vapour Compression Hybrid Air-Conditioner system, desiccants are coupled with vcrs cycle and the load of evaporator is shared by it, while the condenser heat is utilized for regeneration of the same. The energy efficiencies of conventional air conditioning and desiccant coupled air conditioning are evaluated. Various parameters like air specific humidity, air flow rate, desiccant flow rate and air temperature affect the system are done.

Key words: The system are done • In the present study

INTRODUCTION

In recent years, desiccant cooling systems have received considerable attention because of increased energy costs which has motivated a search for methods which conserve energy. Since air conditioning became one of the most essential parts of modern life, efforts are made to build a system which is energy efficient, environment friendly and affordable. It is known that, air quality increases with decrease in humidity [1]. Hence, humidity is considered as a pollutant and efforts are made to reduce it to comfort condition in a space provided in the present experimental set-up. Desiccants have the property of extracting and retaining moisture from the air brought into contact with them [2]. For dehumidification to occur, the liquid desiccant is used to absorb water vapour from air. Dehumidification of air by desiccant takes place due to the fact that; the partial pressure of water vapour in the air is greater than that of the water vapour in the desiccant. Desiccant can hold up water until the partial pressure of water in the desiccant and that of air are equalized. This water vapour removing capability of desiccants leads to the shifting of latent load from refrigerant cycle to desiccant cycle and to energy saving which is associated with the latent load. Desiccant cooling system is demonstrated to be effective when Sensible Heat Ratio (SHR) is very low [3].

Basic Vapour Compression Refrigeration Cycle:
Low-pressure liquid refrigerant in the evaporator absorbs heat from its surroundings, usually air, water or some other process liquid. During this process it changes its state from a liquid to a gas and at the evaporator exit is slightly superheated. The superheated vapour enters the compressor where its pressure is raised [4]. The temperature will also increase, because a proportion of the energy put into the compression process is transferred to the refrigerant. The high pressure superheated gas passes from the compressor into the condenser. The initial part of the cooling process de-superheats the gas before it is then turned back into liquid. The cooling for this process is usually achieved by using air or water. A further reduction in temperature happens in the pipe work and liquid receiver, so that the refrigerant liquid is sub-cooled as it enters the expansion devices. The high-pressure sub-cooled liquid passes through the expansion device,
which both reduces its pressure and controls the flow into
the evaporator [5]. The condenser has to be capable of
rejecting the combined heat inputs of the evaporator and
the compressor.

Desiccant: Desiccants attract moisture from the air by
creating an area of low vapour pressure at the surface of
the desiccant. The pressure exerted by the water in the air
is higher, so the water molecules move from the air to the
desiccant and the air is dehumidified. The essential
characteristic of desiccants is their low surface vapour
pressure. If the desiccant is cool and dry, its surface
vapour pressure is low and it can attract moisture from the
air, which has a high vapour pressure when it is moist.
After the desiccant becomes wet and hot, its surface
vapour pressure is high and it will give off water vapour
to the surrounding air. Vapour moves from the air to the
desiccant and back again depending on vapour pressure
differences [6].

Types of Desiccant:

- Solid desiccants
- Liquid desiccants

Solid Desiccant System: The common solid desiccants
available are: silica gel, zeolite, activated alumina and
carbon. Silica gel is a desiccant with high performance,
but it can be destroyed after rapid absorbing of great deal
of water and it is not a heat-resistant material [7].
Generally, solid desiccants can hold more water vapour
and they poses high drying capacity relative to liquid
desiccants

Liquid Desiccant Systems: The common liquid
desiccants available are: lithium chloride, lithium
bromide, calcium chloride and triethylene glycol.
Other desiccants include KCOOH, glycols like MEG
(mono-ethylene glycol), DEG (Di ethylene glycol),
propylene glycol and mixtures of desiccant LiCl + LiBr
or LiCl + CaCl2. This type of desiccant systems,
show several advantages like higher air
dehumidification, at the same driving temperature range of
solid desiccant cooling systems and the possibility of
high energy storage by storing the concentrated solution
[8].

In this project liquid desiccant used is calcium
chloride.

Factors for choosing calcium chloride is as follows:

- Low cost
- Less hazards effects when compare to other
desiccants when exposing continuously
- Less corrosive

Dehumidification: Dehumidification is the process of
removing water vapour from moist air. Here, absorption
method is used due to the easiness created
by the liquid desiccants. In absorption method of
dehumidification, desiccant solution absorbs the water
vapor in air.

The liquid desiccant solution is allowed to flow over
the desiccant arrangement, where cold and moist air
enters which interacts with the desiccant and looses the
moisture to the desiccant. As the desiccant absorbs
water, it gets diluted. To maintain the dehumidifying
capacity of the system, the absorbed water must be
removed from the desiccant. This is achieved by
regenerating the desiccant solution where the water in the
desiccant is evaporated.

Regeneration: A liquid desiccant is generally
regenerated by heating the desiccant solution which has
absorbed water vapour in air. As the temperature of the
desiccant increases, the water vapour pressure in the
solution increases. The moisture vapour pressure of the
desiccant decreases with increasing desiccant
concentration and increases with increase in desiccant
temperature. For air, the partial pressures of water vapour
increases with increasing air dry bulb temperature and
absolute humidity. When the vapour partial pressure of
the desiccant becomes higher than that of the
surrounding air, a desiccant system starts to work as a
regenerator and releases out all the water vapour
absorbed in air.

Layout of Liquid Desiccant Air Conditioning System:
In this system, liquid desiccant loop is superimposed over
the normal refrigerant loop. Liquid desiccant loop consists
of two parts, namely dehumidification and regeneration
part. In coconut fibre dehumidification unit atmospheric
air stream is passed over the fibres where the liquid
desiccant comes in direct contact with the air, the
moisture in the air is absorbed by the liquid desiccant and
then air is passed over the evaporator. Again the liquid
desiccant is passed over the condenser for regeneration
where the moisture in the desiccant is removed by the
condenser heat. Now solution has lower vapour pressure
than air and the solution can be used for dehumidifying
air in the cycle [8-17].
Desiccant Dehumidification: This process is mainly used to remove the latent and can also be used for some comfort air-conditioning installation requiring either a low relative humidity or low dew point temperature in the conditioned space. In this process the air is passed over the desiccant which has an affinity for moisture. As the air comes in contact with the desiccant the moisture gets diffused into it leaving its latent heat. Due to this the specific humidity decreases and dry bulb temperature increases. The path followed during this process is along the constant wet bulb temperature line or constant enthalpy line.

Desiccant Cycle:

(a) psychometric of desiccant cycle

For Desiccant Cycle:
Energy Efficiency Ratio (EER) = h4-h3compressor work done

h4 = enthalpy of air at desiccant outlet at temperature T, [(kJ/kg) of dry air]

h3 = enthalpy of air at evaporator outlet at temperature T, [(kJ/kg) of dry air]

For Conventional Systems
Energy Efficiency Ratio (EER) = h1-h3compressor work done+heater work done.

where,

h1 = enthalpy of air at evaporator inlet at temperature T, [(kJ/kg) of dry air]

h2 = enthalpy of air at evaporator outlet at temperature T, [(kJ/kg) of dry air]

h3 = enthalpy of air at heater outlet at temperature T, [(kJ/kg) of dry air]

Energy Efficiency Ratio Tabular Column

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<th>RH INLET%</th>
<th>DBT(EO)</th>
<th>RH%(EO)</th>
<th>DBT(DO)</th>
<th>RH%(DO)</th>
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CONCLUSION

From the observed readings, it is clear that desiccant air-conditioning system perform well in the hot climate when the relative humidity of air is kept constant with increase in its dry bulb temperature. Further, the desiccant air conditioning systems also seems to be good for same dry bulb temperature and increased relative humidity conditions in the humid climates. So, it is well and good to conclude that the DAC systems are the most suitable to be introduced at hot and humid climates. To achieve the indoor conditions by the desiccant processed air, the cooling capacity required by the evaporator is less than the capacity required by the reheater and the evaporator in the normal vapour compression refrigeration systems.

REFERENCES

10. file:///E:/PROJECT/basics%20of%20refrigeraton/Definitions.htm.