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# Performance Analysis of Solar Air Conditioning System Using Liquid Desiccant – Research Article

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***Abstract* - Cooling demand for India increases to 8- 11 times the present year within a decade. Energy requirement for meeting the cooling demand also increases which lead to more consumption of non-renewable resources & emission related to it. Performances of cooling system have to improve to reduce the energy consumption. Upon usage of the low-grade heat and improved effectiveness in dehumidification, the liquid desiccant dehumidification technology is becoming more popular nowadays. By this technology air conditioning systems have been developed which is energy efficient, also demonstrated superiority over the traditional vapour compression system due to the controlling of temperature and humidity ratio independently.**

***Index Terms*-Liquid desiccant, Dehumidification, hybrid Liquid desiccant air conditioning (LDAC), multistage internal circulation liquid desiccant dehumidifier (MICLDD)**

## I.INTRODUCTION

Desiccants are chemical substance that absorbs water vapour (moisture) from ambient air due to vapour pressure difference between desiccant & air. Humidity ratio of air decreases as water vapour is absorbed, during the process latent heat of vaporization is released consequently the temperature of air may increase depend on rate of dehumidification.

Water vapour in the surrounding air is getting absorbed and adsorbed by the liquid desiccant until the desiccant vapour pressure attains pressure equilibrium with the ambient air. In case of liquid desiccant, there is exponential increase in the equilibrium vapour pressure with respect to the temperature of the desiccant. Desiccant will absorb water vapour to certain limit it becomes saturated for given condition, will not absorb furthermore. This moisture has to be removed from the desiccant to use for a cyclic process, this done by supplying heat energy by means of solar thermal collector or any other heat sources to desiccant will increase temperature consequently vapour pressure also increase. Due to pressure difference water vapour will transfer from desiccant to air, this process of removing water from desiccant using heat energy is known as Regeneration. Desiccant-based cooling systems are more economical than the conventional refrigeration systems which works at lower temperatures and lower humidity ratio.

A Desiccant dehumidification system is utilized in tropical and humid climatic conditions. Desiccant are classified into 2 types

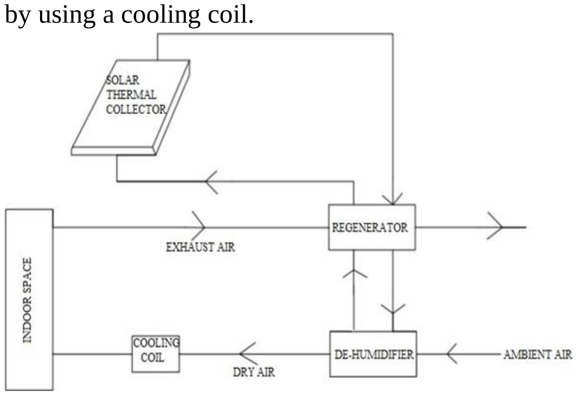
1. Solid Desiccant
2. Liquid Desiccant.

## II. METHODOLOGY

Liquid desiccant system is effective in the removal of latent and sensible load of air separately. In this research article a liquid desiccant dehumidification system is attached with a thermoelectric cooler (Peltier module) and real time experimental analysis is carried out. Duct of square cross section is attached with the refrigerated space, which is made to take the air from refrigerated space. Along the duct the air is made to get in contact with the liquid desiccant. For this purpose, a honeycomb type dehumidifier is made which has lower bypass factor and also it increases the effectiveness of dehumidifier.

In the dehumidifier the water vapour from the air is getting removed by the liquid desiccant by virtue of vapour pressure difference. Once liquid desiccant absorbs the water vapour from the ambient air, it attains a saturated condition, and the water vapour has to be removed from the liquid desiccant for the cyclic usage. So, a regeneration cycle is equipped with this system which removes the water vapour from the desiccant and again sent back to the duct.

In this regeneration cycle, Firstly the temperature of the liquid desiccant is increased to about 50˚C. To increase the temperature from ambient temperature condition to 50˚C Photovoltaic thermal collector (solar collector) is used. At the temperature of about 50˚C, the vapour pressure of the desiccant becomes greater than the vapour pressure of the surrounding air. Due to which the water vapour in the liquid desiccant is absorbed or adsorbed by the ambient air and hence the water vapour in the liquid desiccant is reduced. Then the liquid desiccant cannot be sent directly into the duct because it does not have the affinity to absorb the water vapour from the ambient as a result of higher vapour pressure. So, to reduce the vapour pressure in the liquid desiccant (considerably lesser than the air in the refrigerated space), the liquid desiccant is firstly cooled down to the ambient temperature by natural cooling and then it is cooled down to about 18 - 22˚C by using a cooling coil.



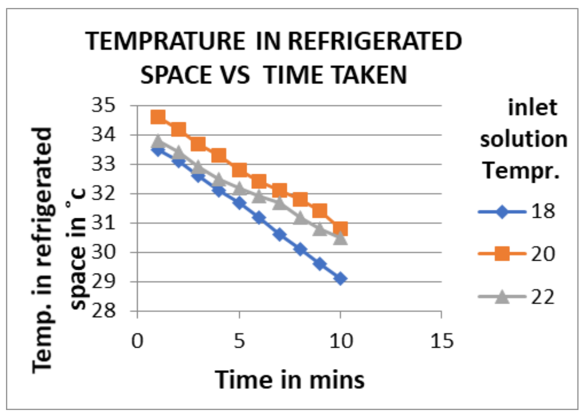

## III.RESULT

Performance analysis was carried out experimentally by two stages, first stage was without dehumidifier and in that first stage total work is supplied to attain cooling and dehumidification of the air in the refrigerated space. In second stage of experiment the air is dehumidified and cooled simultaneously by passing the air over the duct for dehumidification.

Initially time-based analysis was done by keeping cycle time as 10min, and the change in temperature was noted down. The variation between Temperatures is as follows.

As Plotted in the above graph the temperature difference attained without using dehumidifier (blue line) was around 3.1˚C in 10 mins of operation by thermoelectric cooler. Secondly the temperature difference attained with using dehumidifier (orange line) was around 3.8˚C in the same 10 mins of operation. So, from this graph it can be concluded that the temperature difference attained increases upon implementing a dehumidifier system along with a cooler. With the same work input the desired effect of the refrigerated space increases, thus increases the COP of the system.

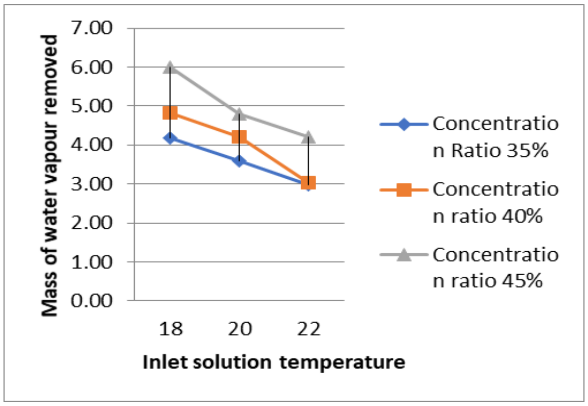
Then it is decided to improve the performance of the dehumidifier by varying the inlet solution temperature of the liquid desiccant. For this purpose, the liquid desiccant was cooled to about 18, 20, 22˚C Respectively. Firstly, the solution temperature at 18˚C is passed through the honeycomb type dehumidifier and the air is allowed to dehumidify, Then the cooler is switched ON and the temperature difference were noted down for the period of 10 mins. This same cycle is continued for the inlet solution temperature at 20 and 22˚C. The Variation between the temperatures in refrigerated space at the particular timing is noted down as follows.




From the above graph it is clear that the change in temperature in the refrigerated space increases as the solution temperature decreases. Initially for the inlet solution temperature being kept at 18˚C and the change in temperature was 4.4˚C. Then for the inlet solution temperature as 20 and 22˚C, the change in temperature was 3.8 and 3.5˚C.

This increase in temperature change of refrigerated space is due to the reduction in vapour pressure in the liquid desiccant when the temperature is being reduced. When the vapour pressure is reduced considerably lower than the ambient air, the affinity to absorb the moisture by the desiccant increases due to the pressure difference. Thus, more amount of mass of water vapour is removed from the air and the cooling load supplied to the cooler is completely used to decrease the temperature of air in the refrigerated space.

To find out the variation in performance of the dehumidifier upon varying the concentration ratio of the liquid desiccant, test were conducted and the mass of water vapour removed from the air is calculated.




From the above graph it is clear that higher the concentration ratio, higher is the concentration ratio then higher is the mass of water vapour removed. Also, higher the mass of water vapour absorbed by the liquid desiccant increases the dehumidifier performance. More the concentration ratio then more the vapour pressure difference between the liquid desiccant and atmospheric pressure, thus the liquid desiccant has the greater affinity to absorb the water vapour. Also, the variation according to the change in the inlet solution temperature is also considered to plot the graph.

As we kept the work constant in both the cases, we are now able to conclude that COP of system with dehumidifier will be higher than that COP of system without dehumidifier, since the desired effect is higher in first case because of its rate of temperature fall is higher.

## IV.PROBLEM IDENTIFICATION

To obtain the optimal result on liquid desiccant dehumidification and regeneration process, many problems were identified, and the main problems are summarised as follows.

1. Effect on the coefficient of performance of the refrigeration system upon adoption of separate hybrid Liquid desiccant air conditioning system (LDAC).
2. Effect on the dehumidification performance upon change in inlet solution temperature.

## IV.CONCLUSION

Based on the Experimental data, it is found that inlet humidity, inlet temperature of desiccant and air, mass flow rate of ambient air are major deciding parameter for an optimum dehumidifier performance. In case of regeneration, regeneration heating temperature and type of desiccant used will determines the effectiveness of regeneration process and the following points are concluded.

1. Hybrid system i.e. combining liquid desiccant dehumidification and vapour compression refrigeration has shorter payback period.
2. Rate of temperature fall in refrigerated space increases by using liquid desiccant dehumidifier.
3. inlet solution temperature is inversely proportional to change in enthalpy of air.
4. COP of desiccant dehumidifier combined evaporative cooling systems is greater than the reference system(conventional).
5. The regeneration performance is increased by increasing solution mass flow rate and regeneration temperature.
6. The amount of dehumidification increases by increase in solution concentration, air inlet moisture and solution flow rate.

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