Solar Thermal Air Conditioner
Part I – Latent Cooling System

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***Abstract*— For long, people have been using the conventional air conditioners working on vapor compression systems that providing cooling using refrigerants. This has led to an increase in global warming due to the hydrofluorocarbons let out from these refrigerants in air conditioners. Secondly, although there have been stringent standards such as the five star rating system to control the power consumed by the conventional air conditioners, they still continue to consume a substantial amount of energy. These standards are known to improve year by year but the AC's still continue to consume a lot of electricity which is a precious resource. Although air conditioners have been known to provide comfort cooling quickly and reliably, not many are able to afford them. A solution to all these problems has long been overdue and it is now time. One solution to all the above addressed problems can be Liquid Desiccant Systems. An honest attempt has been made to develop such a system in this paper.**

***Keywords*—** *Liquid Desiccant Systems, Dehumidifier, Regenerator, Tri ethylene Glycol.*

I. Introduction

This paper is divided into two parts viz. Part I and Part II. This paper closely demonstrates the Part - I of this research. The first part includes latent cooling. Latent cooling is defined as the amount of energy required to dehumidify the air in a building regardless of outdoor humidity. Latent cooling refers to the wet bulb temperature.

The setup of this system (Liquid Desiccant System) for latent cooling includes Dehumidifier, Regenerator and a closed loop system of pipes and tanks for the liquid desiccant called as Tri Ethylene Glycol (TEG). A desiccant is simply a material that absorbs humidity from the air. A dehumidifier is a component in which the process of dehumidification of air takes place using desiccant. A regenerator is a component which helps to regenerate the desiccant after is has become dilute due to absorption of humidity in the dehumidification process. Regeneration is simply turning of dilute desiccant into concentrated one by the process of evaporation.

II. Model Development

The development of a model of this system includes the development of individual components such as the dehumidifier, regenerator and the heat exchanger. Detailed model development procedures are shown ahead.

A. Development of Dehumidifier

The flow of desiccant through dehumidifier must not be less than twice the air flow so as to not saturate. Jute material place parallel to the air flow allows for fast flow and does not compromise on the air pressure. Simultaneous dehumidification is possible if certain conditions were met.

1) Regeneration should take place at temperatures above 100°C

2) Desiccant must be cooled before entering the dehumidifier.

3) Air to desiccant flow rate must be close to 0.5

B. Development of Regenerator

The heated diluted desiccant needs to be regenerated before reusing. The surrounding air flowing through the regenerator allows the air to carry away the vaporized water

Fig. 1. Regenerator

within the desiccant. The flow of desiccant is by gravity and of the air is through a pump. It is important to know that the

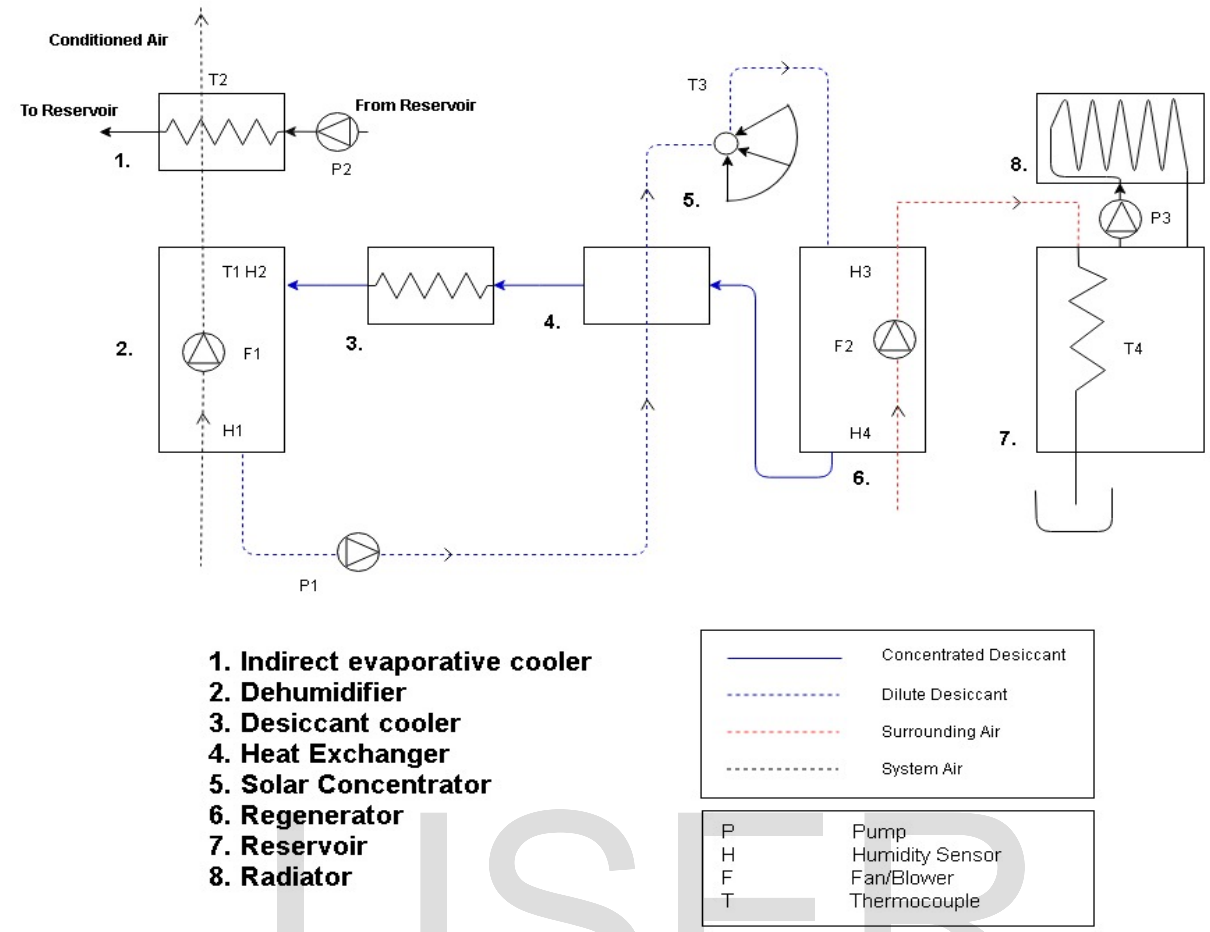

Fig. 2. Liquid Desiccant Cycle

air to desiccant flow rate ratio should be around 2. The steam produced can be condensed if the NSR is of high capacity allowing for Atmospheric Water Generation (AWG)

C. Development of Heat Exchanger

A heat recovery system can prove extremely vital in a solar operated system. Heat exchangers that are available in the market, although getting a good efficiency was not worth the cost. After two failed attempts due to ineffective sealing, a simpler heat exchanger was born. Size of the heat exchanger didn't matter as long as the exit temperatures were similar. Copper pipes were used concentric to PVC for external insulation and internal heat transfer.

Fig. 3. Heat Exchanger

III. LIQUID DESICCANT CYCLE

The desiccant cycle related to Part – I of this paper is explained in detail below. To begin with, the cycle is a closed loop cycle i.e. the desiccant TEG flows in a closed loop and is being reused. This helps in reducing cost of producing concentrated desiccant each time it is needed.

The cycle begins with the dehumidifier. Concentrated desiccant enters the dehumidifier and absorbs the moisture from the air which is to be cooled. The air which is dehumidified is passed further to Indirect Evaporative Cooler (IEC) which is explained in Part – II of this paper. The desiccant after it has absorbed the moisture from the air becomes dilute in nature and thus has to be regenerated to be reused. Regeneration takes place at a temperature of 100 ^{0}C in the regenerator. This temperature is achieved by using a Solar Concentrator (Part - II). After the regeneration has taken place due to the evaporation of water from the desiccant, the concentrated desiccant is now passed on to the heat exchanger where it rejects heat to the incoming dilute desiccant from the dehumidifier.

This desiccant now has to be further cooled down by the desiccant cooler (A combination of NSR, Radiator and Cooler explained in Part - II) and then passed on to the dehumidifier. The cooled desiccant now ensures effective dehumidification and thus the loop is completed.

IV. RESULTS

The dehumidifier shows promising results. The desiccant TEG used in the dehumidification process was found to be highly effective. It dropped the relative humidity (RH) from 75% to 65% when concentrated at a constant temperature of 28 ^{0}C.

Fig. 4. Dehumidifier

V. CONCLUSION

A rough model of liquid desiccant system was successfully prepared. Test's were carried out on the whole system including the dehumidifier and the regenerator. It was discovered that, in the dehumidifier, the air to desiccant flow rate must be 0.5. Also, in the regenerator the air to desiccant flow rate must be 2. Regarding the heat exchanger, construction of a cost effective, efficient as well as a small size heat exchanger is possible.

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