Solar Thermal Air Conditioner
Part II – Sensible Cooling system and Concentrator

Naitik P. Patil
Student, Dept. Of Mechanical Engineering
Saraswati College of Engineering
Navi Mumbai, India
napr.patil@gmail.com

Vinay K. Chaudhari
Student, Dept. Of Mechanical Engineering
Saraswati College of Engineering
Navi Mumbai, India
vinaychaudhari1997@gmail.com

Umesh L. Gavit
Student, Dept. Of Mechanical Engineering
Saraswati College of Engineering
Navi Mumbai, India
umeshgavit007@gmail.com

Rahul S. Gangurde
Student, Dept. Of Mechanical Engineering
Saraswati College of Engineering
Navi Mumbai, India
tiger160507@gmail.com

Madan Jagtap
Professor, Dept. Of Mechanical Engineering
Saraswati College of Engineering
Navi Mumbai, India
jagtap.aero@gmail.com

***Abstract*— Conventional air conditioners are the first option people turn to when in need for cool air. They are known to provide quick and highly efficient cooling. However, there are three main shortcomings to a conventional air conditioner viz. high power consumption, high cost and global warming caused due to the refrigerants used in them. A sleek solution to these three problems can be Liquid Desiccant Systems. These systems do not use any harmful refrigerants, they contribute a very low load on the grid and cost less. The setup of these type of systems mainly consist of a Solar Concentrator, an Indirect Evaporative Cooler (IEC) and Night Sky Reservoir (NSR). The solar concentrator will heat the incoming liquid desiccant which is used for dehumidification of the air to be cooled. This heating is needed for the regeneration of desiccant which will be reused as the system is a closed loop system. The Indirect evaporative cooler is used to cool the dehumidified air. The IEC is known to provide cool air of about 21 degree Celsius without use of much electric power which reduces cooling load by about 40 percent as compared to conventional AC's. The Night Sky Reservoir is used to cool the stored water at night. The stored water is supplied to IEC and regenerated via atmospheric water regeneration. Thus the proposed system consumes low power, is environment friendly and cost efficient.**

Keywords*— *Indirect Evaporative Cooling, Night Sky Reservoir, Solar Concentrator, Liquid Desiccant Systems.

I. INTRODUCTION

This project is made in two parts namely Part – I and Part – II. This paper meticulously explains the Part – II of this research. This part includes the concept of Sensible Cooling and other closely related concepts to it concerning our project in detail. Sensible cooling of air is the process in which the sensible heat of air is removed. This reduces the temperature of the air but there are no changes in the moisture content of the air. Sensible cooling mostly related to the dry bulb temperature.

The setup of this system includes an Indirect Evaporative Cooler (IEC), Night Sky Reservoir (NSR) and solar concentrator. The system uses the desiccant Tri ethylene glycol (TEG) for dehumidification of air (Part - I). The IEC reduces the temperature of air flowing through copper pipes on which there is a damp cloth. The NSR helps to reduce the temperature of stored water required for IEC. This reduction in temperature is done in the night. The solar concentrators help in increasing the temperature of the dilute desiccant for the purpose of regeneration. This is done simply by concentrating the sunlight on a particular area.

II. MODEL DEVELOPMENT

The model development of this system includes individual development and assembly of components such as the IEC, solar concentrator and NSR.

A. Development of Indirect Evaporative Cooler

The IEC as name suggests cools the air by indirect evaporation of water in the component. Copper pipes of suitable diameter were selected and wrapped with absorbent material and placed at an angle for free flow of water down over the surface. Pipes have tiny holes made in them allowing the flow of high pressure dry air over them and increasing the rate of evaporation. Testing showed a constant drop in temperature.

Fig. 1. Indirect Evaporative Cooler

B. Development of Solar Concntrator

Solar concentrators of two types were developed. Circular and parabolic type.

1) Parabolic Type: The parabolic type concentrators are known to be highly efficient in concentration of sunlight.

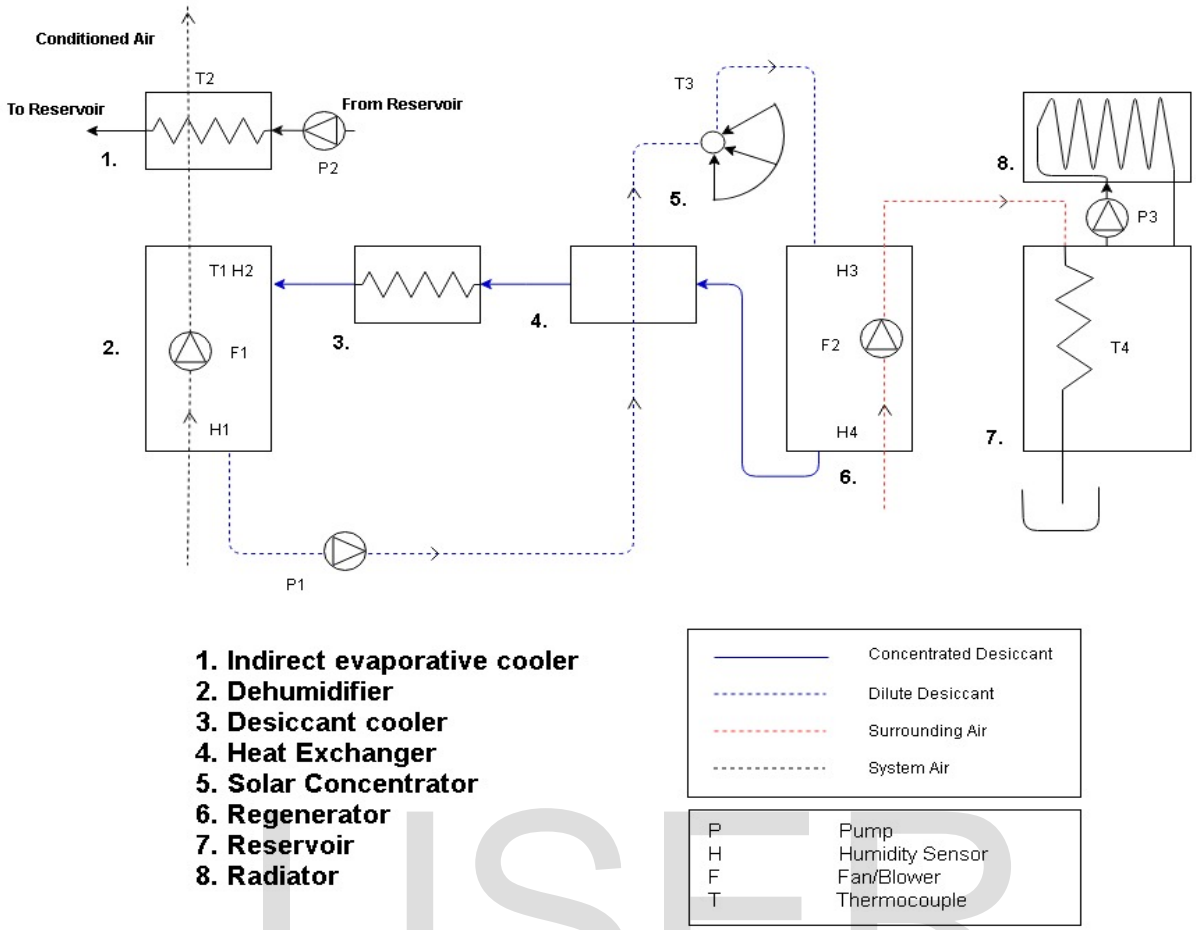

Fig. 2. Liquid Desiccant Cycle

They are highly sought after for the purpose of solar concentration. Parabolic radio dishes were used for the required reflective surface. Mylar was stuck over it and thus a highly efficient concentrator was made.

Fig. 3. Parabolic type solar concentrator

2) Circular Type: We used the most simple method to develop parabolas without any complex multiple equations. These parabolic structures proved difficult to produce due to the limited availability of such profile fabrication.We moved on to using circular half cut pipes in arrays A.K.A guttering. We found it much easier to attain a focal line and allows for increment of the size depending on the requirements.Due to poor efficiency of guttering, an additional parabolic concentrator was built with a thermal mass to hold the high temperatures.Both coupled in series can be very effective.

C. Development of NSR

The concentrator acts as a Night sky cooling radiator during the night time. Allowing for reduction in the temperature by utilization of the concentrator. Testing shows promising data comparable to previously done research.

III. Liquid Desiccant Cycle

The desiccant cycle related to Part – II of this paper is explained in detail below. The cycle comprise of a total of eight components; some of which are explained in Part – I and the others will be explained here. In order to reduce the costs inculcated in refurbishment of concentrated desiccant, the

system will be a closed loop system with regeneration of the liquid desiccant.

Dehumidification is the very first step in this system. It is explained in Part – I. After the air is dehumidified, it is passed on to the Indirect Evaporative Cooler where it is cooled and then this conditioned air is let out into the room where cooling is desired. The IEC contains of copper pipes wound with a black damp cloth. This cloth is kept damp with the help of continuously dripping water over it. Similar to out body, the water from the cloth evaporates carrying away the heat and thus cooling the copper pipes which in turn cool the air.

Now, the dilute desiccant due to dehumidification is passed on to the solar concentrator. The solar concentrator are of two types namely parabolic and circular. The concentrator uses mylar to reflect the sunlight incident on it and concentrate it on a sharp definite area. This will heat the dilute desiccant to a temperature of 100 ^{0}C. This heated desiccant will now move to the regenerator where it will lose its water content and become concentrated again. This will render it reusable. Further it will pass on to the heat exchanger where it will reject heat and enter into the desiccant cooler. The desiccant cooler is essentially a combination of NSR, radiator and cooler. The desiccant cooler will reduce the temperature of the desiccant to ambient temperature and this will help in proper dehumidification further. This completes the loop.

IV. RESULT

After careful tests on the IEC, NSR and Solar Concentrator rigs were carried out. Results were obtained. The data was carefully recorded and the following observations were made.

A. Results for Indirect Evaporative Cooler

Inlet Air Temperature to IEC was about 35 ^{0}C and the corresponding outlet temperature obtained was 25 ^{0}C. This suggests that the IEC can cool air by about 10 ^{0}C at a convenient flow rate.

B. Results for Solar Concentrator

The parabolic concentrator quickly managed to heat the dilute desiccant solution to 100 ^{0}C. On the other hand the circular type concentrator could heat desiccant from 30 ^{0}C to 60 ^{0}C i.e. a net rise of 10 ^{0}C. The circular concentrator takes time to heat desiccant and the flow rate of desiccant has to be kept low.

Fig. 4. Circular type Solar Concentrator

C. Results for Night Sky Reservoir

Tests on the NSR rig were carried out on 1st April, 2019. The NSR rig managed to reduce the temperature of water to a minimum of 25 ^{0}C at 6am when the ambient temperature was 23 ^{0}C. The results in a tabular format are shown below:

TABLE I. NSR READINGS

Sr. No.	Time	Atm Temp	NSR Temp
1	1.00 AM	27	30
2	1.30 AM	25.5	30.6
3	2.00 AM	25.5	29.6
4	2.30 AM	25.5	29.2
5	3.00 AM	23.9	28.6
6	3.30 AM	23.8	28.2
7	4.00 AM	24.2	26.8
8	4.30 AM	23	26.2
9	5.00 AM	23.3	26
10	5.30 AM	23	26
11	6.00 AM	23	25

(Note: All temperatures in ^{0}C)

V. CONCLUSION

Each and every component in the system functions as planned and further the results obtained from these observations are highly optimistic. The Indirect Evaporative Cooler (IEC) has managed to produce a maximum temperature difference of 10 ^{0}C. This means a reduction of about forty percent of energy load caused due to conventional air conditioners. The Night Sky Reservoir (NSR) helped achieve a temperature of 25 ^{0}C of stagnant water at night. The parabolic concentrator can heat the dilute desiccant up to 100 ^{0}C within 4 minutes while the circular concentrator takes slightly higher time than the parabolic one.

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