A Review on Managing Residential Air Conditioning System by Silica Gel Coated Heat Exchanger

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ABSTRACT

There has been a rising concern in reducing the energy consumption in buildings. Heating, ventilation and air-conditioning systems is the biggest consumer of energy in buildings. In this study, an investigation for comfortable environment, by managing air-conditioning system of a building has been carried out. In this, a heat exchanger with silica gel coated around is used and the system is operated for two modes one for cooling with dehumidification and second for heating with humidification and carried out in summer and winter respectively. The experimental results were and demonstrated that, for cooling with dehumidification the air is cooled by temperature of 8.5ºc and that for heating with humidification, the air is heated by temperature of 13.3ºc. [8].

Keywords: ***evacuated solar water heater; silica gel coated heat exchanger; cooling water; direct evaporative cooling unit; heat exchanger.***

1. INTRODUCTION

In recent years, with rapid growth in technology and society, there has also been a rapid rise in demand of air-conditioning in residential, commercial and industrial processes. This requirement of air-conditioning is fulfilled by conventional vapour compression systems. These conventional systems consume a huge amount of energy consumptions which has given rise to the risk of energy crises as well as to the environment. This has led to need of alternative air-conditioning systems. In recent years, numerous experiments have been carried out by various researchers to find the alternative solutions.

In very recent years, a new concept of desiccant coated heat exchangers has been developed. Dai et.al [1] did experimental comparison between silica gel and polymer coated fin tube heat exchanger. It was found that by using DCHE the system performance was improved. The SCHE performed better as compared to polymer coated heat exchanger. Dai et.al [2] to predict the performance of SCHE cooling system under ARI (American air-conditioning and refrigeration institute) developed a mathematical model. Dai et.al [3] by combining the mathematical model of different components proposed and developed a mathematical model of solar driven DCHE cooling system. To produce a continuous supply of air-condition with an optimum switch time of 2 minutes, two desiccant coated heat exchanger were used. The result provided satisfied cooling to indoor space. Dai et.al [4] for self-cooled solid desiccant cooling system by the combination of DCHE and regenerative evaporative cooler developed a mathematical model. In this different switch time period was 500-900 seconds. Dai et.al [5] investigated a solar driven SCHE, dehumidification unit along with this cycle time and ambient Conditions were also evaluated. The results obtained demonstrated that the required regeneration temperature was in the range of 50-80ºc. Dehumidification capacity and thermal coefficient of performance were increased with increase in the inlet air humidity ratio. Wang et.al [6] to evaluate the effect of water temperature, air temperature, air velocity on dehumidification rate experimentally investigated and analysed a SCHE. The results evaluated that the average dehumidification rate and coefficient of performance could be increased by pre-cooling of process air before dehumidification process. Sant and jiang [7] concluded that regeneration rate of the desiccant material can be increased by increasing the regeneration temperature. The main objective of this paper is to interpret the results and comparison of the system with DCHE and without DCHE and also to conclude the effect of silica coated heat exchanger on the performance of the system.

ISSN: 2321-8169
419 – 424

For this, Amitkumaret.al [8] had performed an experimental work in summer and winter season of northern India and also evaluated the cooling/heating capacity of the system.

2. WHAT IS SILICA GEL COATED HEAT EXCHANGER?

The construction of the system is similar to that of the normal air-conditioning system. The main components are:

1. Evacuated tube solar water heater.

2. Silica gel coated heat exchanger (SCHE).

3. Cooling tower.

4. Direct evaporative cooling unit (DEC).

5. Heat exchanger.

The main component of this review is silica gel coated heat exchanger. So total emphasis is put on this.

SCHE is similar to that of ordinary heat exchanger. But in addition to that, the heat exchanger is coated with silica gel. Amitet.al [8] has constructed a silica gel heat exchanger consisting of shell and tube type with water capacity of 17.3 litres as shown in the figure. This heat exchanger consists of 64 tubes made up of aluminium having a diameter of 25.4 mm. a silica gel desiccant material is used for coating of aluminium tubes. Firstly, the silica gel partials are coated on the aluminium tubes of heat exchanger and then these tubes are dried and soaked in the solution of silica gel repeatedly.

In addition of SCHE a basic heat exchanger is also used and it is placed before SCHE. The main purpose of adding basic heat exchanger in this system is, to provide sensible cooling of the process air before it is transferred to SCHE for dehumidification process. Its construction is similar to that of SCHE having shell and tube type structure. The water flows over the tubes of the heat exchanger and the process air is passed through the tubes. Figure 1, shows the schematic diagram of the experimental setup. And figures 2, shows the schematic and actual photographs of silica gel coated heat exchanger.

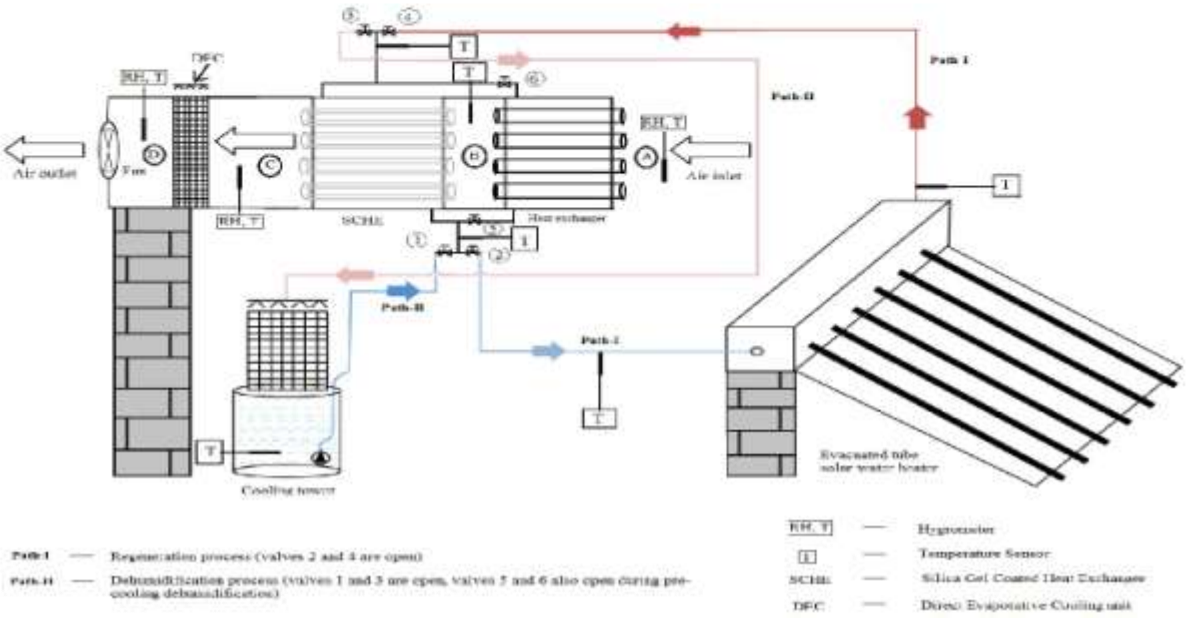


Fig-1: schematic diagram of experimental system

ISSN: 2321-8169
419 – 424

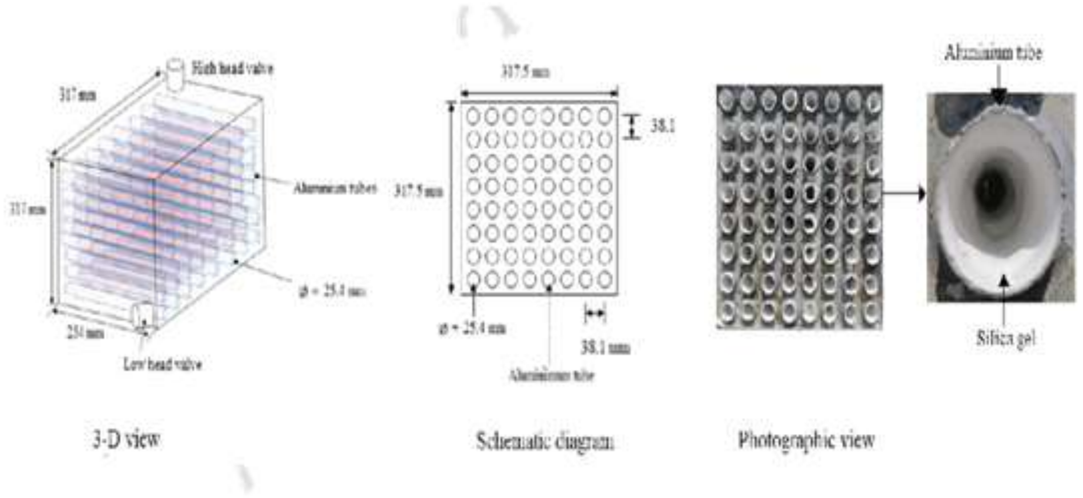
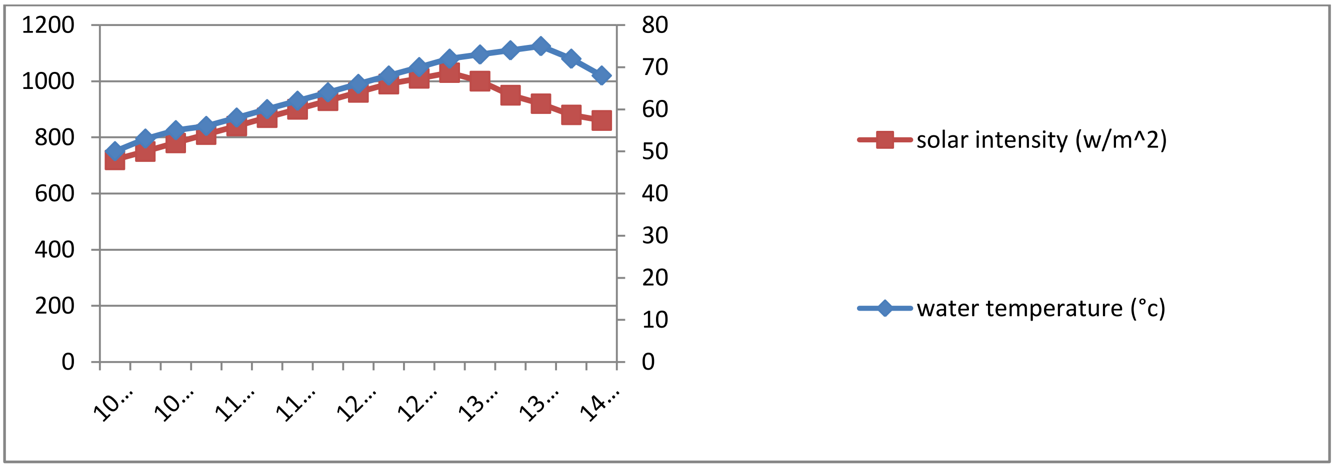


Fig-2:Three-D view, schematic diagram and photographic view of the SCHE

3. RESULTS OBTAINED BY ADDING SILICAGEL COATED HEAT EXCHANGER TO THE SYSTEM

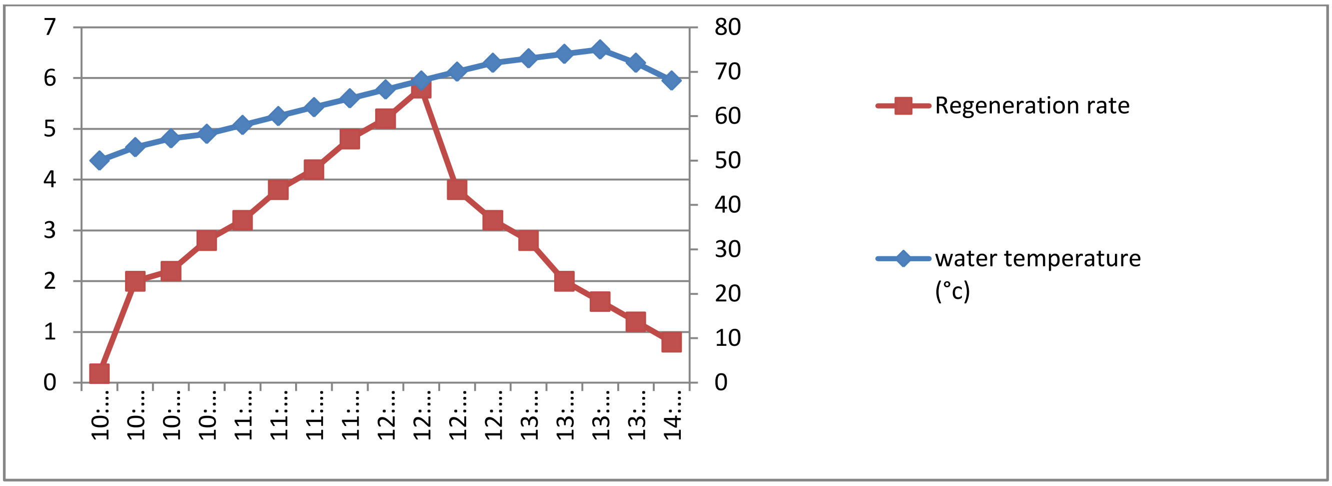
3.1 Cooling in summer

Figures 3 and 4 demonstrate the regeneration performance. The hot water temperature of the SCHE increases continuously to its maximum value 78.4°c and then slightly decreases at the end. The results show that the hot water temperature still increases with solar intensity, but after 12:45 hr. solar intensity decreases and hot water temperature still increases this is because of the collector temperature is higher than the water temperature. The average hot water temperature is 64.1°c with average intensity of 872 w/m^2 [8].



Time of day (hours)

Fig-3: Variation in hot water temperature of the SCHE and solar intensity with time.



Time of day (hours)

Fig-4: Variation in the regeneration rate of desiccant material and hot water temperature of SCHE with time.

The figures above indicates that, the regeneration rate of desiccant material increases with the hot water temperature and reaches to its maximum value of 0.57 kg/hr at highest intensity of sun. This occurs because, as the surface temperature of desiccant material increases, water vapour pressure in the pores of desiccant material also increases and this results in moisture transfer from desiccant material to regeneration air at high rate. But as the intensity of sun decreases, the water vapour pressure in the pores becomes low because of continuous transfer of moisture, and this results a continuous decrement in the regeneration rate irrespective of increase in the water temperature. Thus the result demonstrates a high potential of the system at domestic level during the summer, and even if the condition of air does not lies in the comfort zone. The process can also be shown on psychometric chart as shown below.

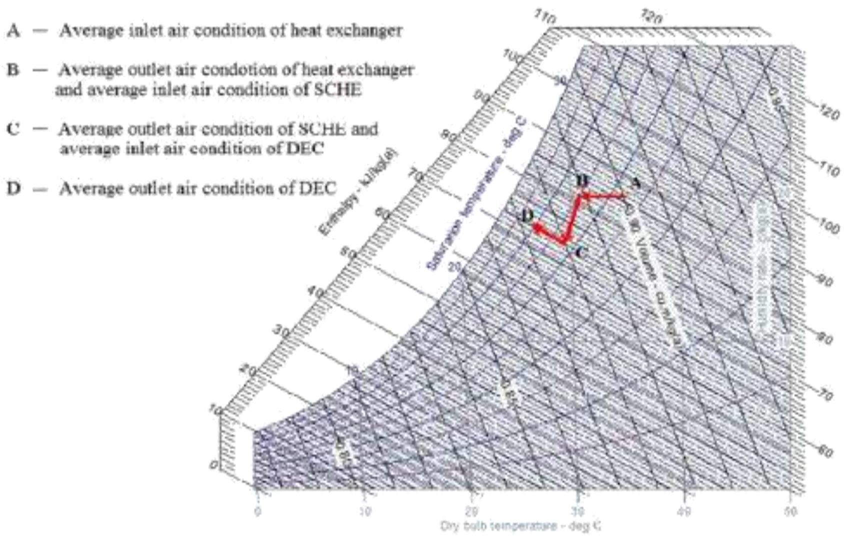


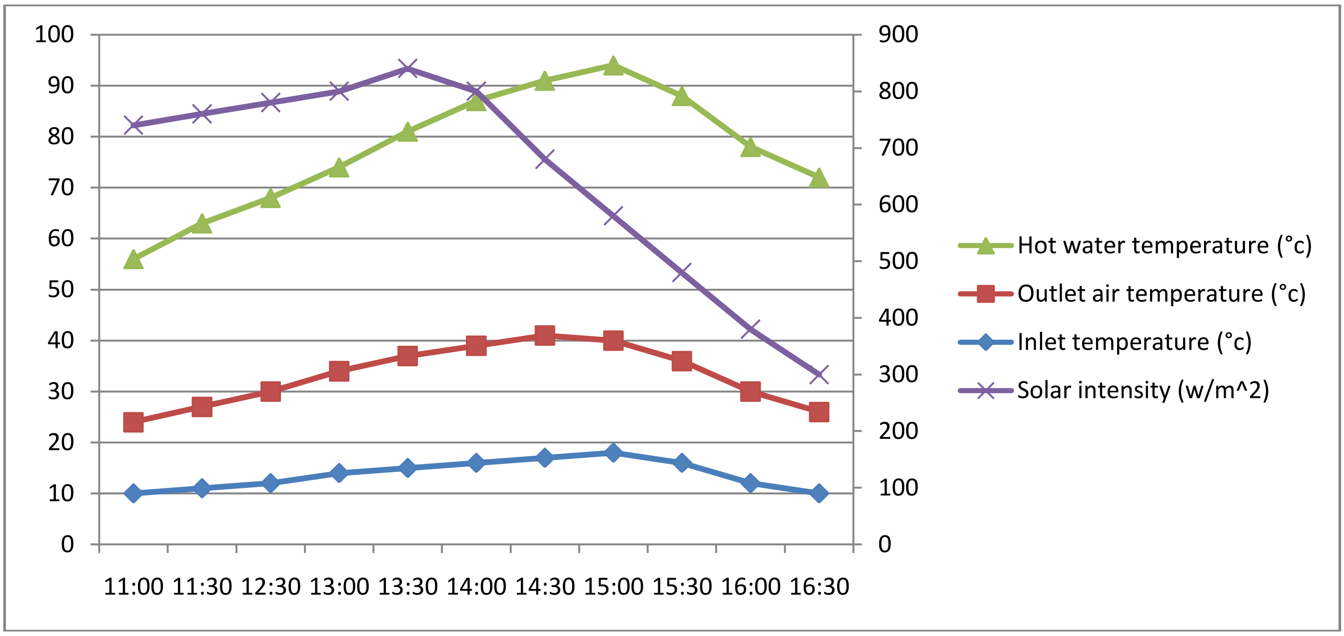
Fig-5:process on psychometric chart.

3.2 Heating in winter

It has been concluded by Dai et.al. [5] That heating with humidification supplied better comfort than direct solar heating thus for heating, the system has been only operated with humidification mode only. As compared to summer there is no significant change in the temperature with, so the readings have been taken after long interval of time approximately 30 minutes. The experiment was started in the evening and the adsorption rate of the desiccant material was 0.38 kg/hr.

This was because, water vapour pressure in the pores of the desiccant material is low so there high vapour pressure difference between pores and the air, this leads to moisture transfer rate.

From the recorded data it has been observed that with average solar intensity of 645 W/m^2, the average increment in process air temperature is 13.3ºc. The temperature difference between the process air and the ambient air depends on the hot water temperature of SCHE. Figure 6, shows the variation of hot water, solar intensity, and inlet and outlet air temperature with time.



Time of day (hours)

Fig-6: Variation in hot water temperature of SCHE, solar intensity and inlet and outlet air temperature with time.

4. CONCLUSION

In this study, the emphasis is put on the management of residential air-conditioning system. The aim of the system was to produce cooling effect in the summer and heating effect in the winter. The conclusion extracted from the study is as follows:

1. Depending upon the intensity of sun, the solar water heater produced hot water with an average temperature of 64.1ºc in summer season and 49.4ºc in winter season. The temperature of hot water required for regeneration of desiccant material was sufficient, so it can be seen that the temperature required for SCHE is low which makes it feasible in the regions where solar intensity is low. The regeneration rate of the desiccant material or humidification rate of process air depends upon the hot water temperature of SCHE.

2. The average adsorption rate of desiccant material is significantly higher in summer season as compared to the winter season. The regeneration and adsorption rate of the desiccant material depends upon the inlet air moisture content. As compared to summer with higher regeneration temperature, the average regeneration of desiccant material is higher in winter with lower regeneration temperature.

3. The SCHE has the ability to handle both latent loads and sensible loads with a good dehumidification capacity with the cooling water temperature of 27.6ºc. The average dehumidification rate of air is increased by 15.3%.

4. The results show that there was appreciable amount of comfort, in winter as well as summer season by using this system.

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419 – 424

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