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Application of Evaporative Air Coolers Coupled With Solar Water Heater for Dehumidification of Indoor Air

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ABSTRACT

In this various parameter has recorded like temperature at the outlet water discharged from solar water heater, atmospheric humidity, inlet water temperature and outlet water temperature of Heat Exchanger, speed of the air flowing through the heat exchanger and percentage reduction in relative humidity before and after the heat exchanger.

Keywords: Parameters, Atmospheric Humidity, Relative Humidity.

I. INTRODUCTION

In the experimental part of this investigation, water from the storage tank of a solar water heater is circulated through the heat exchanger to heat the flowing air. The south faced solar water heater connected with the storage tank is installed in the open space. Hot water from the tank exit is pumped by a water circulating pump and is collected in insulating tank. Ambient air which is drawn through the cooler is used to heat the solution which is circulated in the heat exchanger. The solar heater is connected to water compensation line and it is equipped with an air vent near the top of the storage tank. PVC tubes are used to connect the indoor units (air cooler and heat exchanger) and the outdoor unit (solar heating system). To start the experiment, the water level in the hot water storage tank is checked, then water pump, solution pump and air fan are switched on. The following temperatures are recorded during the experiments: heating water at inlet and exit of the air heater; flowing air at inlet and exit of the heat exchanger. Also, the relative humidity of air at inlet and exit of the heat exchanger are recorded during the experiments. At the end of the experimental test, the mass and concentration of regenerated solution are evaluated and the mass of evaporated mass of water is determined. Thermometer is used to measure the temperature of water coming out of the heat exchanger; digital hygrometer having a resolution of 0.1% is used for measuring the relative humidity. The solution density is evaluated by measuring the mass and volume. An anemometer is used to check the temperatures of the tubes of the air heat exchanger and also the velocity of the air flowing through it.

II. METHODS AND MATERIAL

Data Analysis

1. Temperature vs. Relative Humidity

For each data set and Microsoft excel automatically calculated the nature of the graph achieved during temperature vs. the relative humidity. Information from the chart and average steady state temperatures were used in the analysis of the heat exchanger performance during the tests.

2. Temperature of Water vs. Temperature of air

In this set of different readings that we can determine the effect of increase of temperature of water vs. temperature of air.

3. Air velocity vs. Relative Humidity

So it is seen from the graph which is plot between the velocity of air and the relative humidity for the water as a working fluid gives the desired result that shows minimum air velocity gives the maximum relative humidity.

Heat Recovery Effectiveness and Safe Working Conditions

During the winter season, the considered exchanger operates in completely different conditions; therefore other efficiency factors need to be established for its analysis. It should be mentioned that safe operation is the priority in the winter season. Operation during winter conditions is connected with risks for any type of recuperator: when outdoor temperatures are very low, the frost can condensate on the plate surface of the heat exchanger (detail information about frost formation in recuperators in winter season can be found in). Frost on the plates can result in a decrease in the exchanger's efficiency and it can eventually damage the plates. Safe working conditions (i.e., lowest outdoor temperature which allows avoiding the frost formation under exhaust air temperature with known parameters depends on three main factors: temperature efficiency of the exchanger, return air temperature and return air relative humidity. There are two important efficiency factors which are included for the analysis of the winter operation.

Problems Associated with Round-Year Operation

The analysis of the previous section brings important conclusion: the high efficiency of the exchanger can lead to the additional energy consumption connected with providing safe operating conditions during winter season. On the other hand, in summer time high efficiency of the considered unit is well required and it is not connected with additional costs. The solution to the above-mentioned problem depends on the climate region, where such exchanger is applied. Systems operating in warmer regions are characterized with high cooling demand and low heating demand. The temperatures during the winter season in such climate conditions are usually above 0oC. This problem is even more complicated in the regions with temperate climate, where cooling demand in summer and heating demand in winter are similar. This problem can only be solved with compromise optimization method applied individually to each air-conditioning system. The size and type of the exchanger is determined on the basis of main source of heating and cooling power, outdoor and indoor conditions.

III. RESULTS AND DISCUSSION

In this section we are going to make a conclusion on the determined experimental value. And conclude that the water is best for different temperature range.

It can be observed that the minimum regeneration temperature increases with decrease in the room relative humidity, at constant values of ambient parameters (temperature and humidity). This can be explained by the need to a solution with higher concentration to absorb moisture from air with lower values of relative humidity at the same ambient temperature. In general, it can be stated that the temperature potential required to pump humidity from the room condition to the ambient air is directly proportional with the humidity potential between the room and the ambient air. On the other hand, an increase in the outdoor temperature increases the required regeneration temperature for constant values of room and outdoor humidity. An experimental test is carried out for a period of 6 hrs (from 8 am to 2 pm). For the first group of tests, the variation of water and air temperatures at inlet and exit of the heat exchanger and humidifier, respectively. The variation in heating water temperature is limited due to the use of hot water storage tank. The hot water accumulate the solar energy which is variable with time and supply the regeneration unit with water at an average temperature of 45 ˚C during the variation of solar radiation. One of the most important factors affecting the regeneration process is the temperature of air at humidifier (regenerator) inlet. For a regeneration period of 5 hours, solution concentration increases up to 38% as the regeneration of solution takes place for 8 hours and as a result, solution concentration reaches 48% at the end of regeneration process.

It was seen that as the temperature in the tank approaches towards the equilibrium temperature the humidity first tends to decreases and when the temperature of the water in the tank equals the temperature of water at outlet of heat exchanger the humidity increases drastically, so it is necessary to maintain the temperature of water in the tank as the humidity is totally depends upon the temperature of water. There is a variation in the temperature as well as the humidity present in the atmosphere just because of the variable speed of the evaporative air cooler as regulator is attached to it and the speed of the fan can be varied so as to have different humidity concentration at variable speeds.

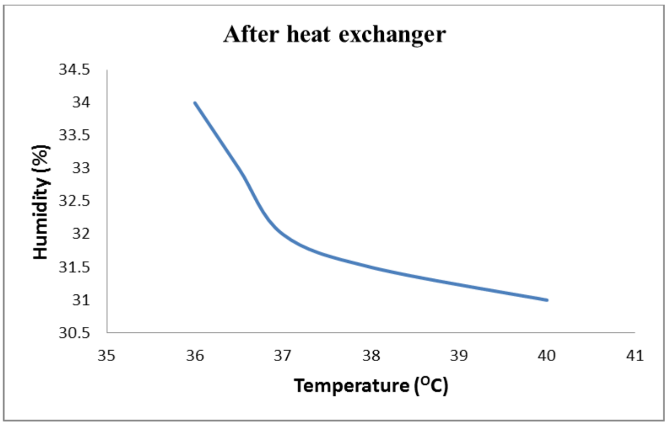

Figure 1: Temperature (˚C) vs. Humidity (%)

The figure shows variation in the plotted graph, the nature of the graph is deterministic with the increase of temperature of air after the heat exchanger its humidity decreases.

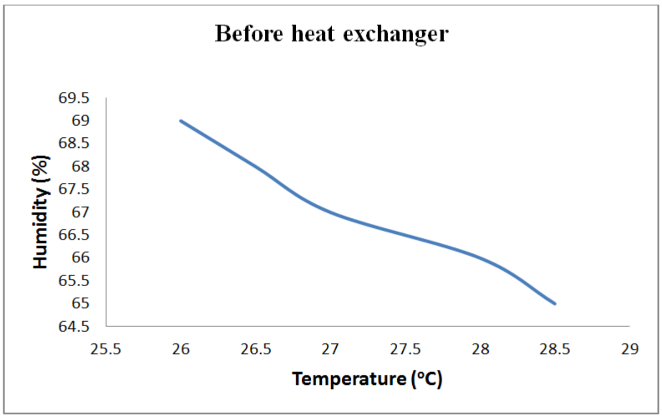

Figure 2: Temperature (˚C) vs. Humidity (%)

This figure shows the relationship between temperature and the humidity present before the heat exchanger. There is sudden increase in the humidity as the temperature decreases.

IV. CONCLUSION

The solar water heater coupled with evaporative air cooler for dehumidification purpose fabricated in this paper were successfully tested to determine the effect water on its performance. The performance was found to rely heavily on the relationship between temperatures of water drained from solar water heater and humidity.

So it is clear from the above results that the use of water as a working fluid yields a maximum efficiency as compared to other fluids in heat exchanging purpose by means of Heat Exchangers.

Novel design of solar powered desiccant operated humidity pump has been presented and analyzed. In the proposed design, air humidifiers are applied for dehumidification of processed air and regeneration of liquid desiccant. The effects of meteorological conditions and system design parameters are well defined. Also, system efficiency is defined in terms of operating cycle efficiency and system design parameters. Effect of indoor and outdoor parameters on the required regeneration temperature has been highlighted. The appropriate selection of desiccant concentration at the end of Sorption has been discussed. Based on the obtained simulation results, the following conclusions can be drawn: 1-Desiccant minimum regeneration temperature is proportional to the humidity potential between the indoor and outdoor conditions (temperature and humidity). 2-Stability of heating temperature is important. The application of storage tank coupled with the solar water heater limits the variation in the heating temperature in a range of 5oC in the specified experimental conditions. It is also concluded that the proposed model can be successfully used for predicting the overall performance of the system on the basis of experimental data collected for different system parts from the literature.

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