ABSTRACT

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The aim of the present study is to design and test the technical feasibility of a novel and simple continuous humidification/dehumidification system, suitable for solar energy operation, for space cooling in tropical climates. The attractiveness of the system under study lies in the fact that an absorbent solution is used for dehumidification which can be regenerated at temperatures appropriate to simple flat-plate collectors. In addition, the system has no moving parts except for the fans required for air movement and water pumps for circulating cooling water in the dehumidifier and heating water in the regenerator.

The system essentially consists of two vessels interconnected by two passages, an upper one filled with wick material and a lower one left unfilled. The vessels are filled to the top of the upper passage with an absorbent solution (in this case, calcium chloride solution). Provision is made for passing air over the solution in the two vessels. One vessel is fitted with a heating coil and the other with a cooling coil. In addition, the air to the vessel fitted with the heating coil can be heated prior to admission to the vessel.

The basic concept of the working of the system is that the air passing over the hot solution in one vessel (the regenerator)

will remove moisture from the solution while the air passing over the cool solution in the other vessel (the dehumidifier) will deposit moisture into it. Accordingly, one air stream becomes drier while the other becomes more moist. Meanwhile, the solution in the regenerator will become more concentrated while that in the dehumidifier will become less concentrated. Under the circumstances, there is a net transfer of moisture from the dehumidifier to the regenerator. The transfer is predominantly via the porous wick material. Therefore, for steady-state operation the rate of moisture removal in the regenerator must be equal to the rate of moisture addition tn the dehumidifier, the two in turn being equal to the rate of moisture transfer in the wick. The purpose of the lower open passage is to equalize the solution level on both sides.

Two modes of operation are investigated : one in which the regenerator air is heated prior to admission to the regenerator and the other in which the regenerator solution surface is heated while the air at inlet is at the same condition as the air entering the dehumidifier.

The system has been shown to be workable. Results indicate that the system works more effectively when the regenerator solution surface is heated instead of the regenerating air stream. For instance, for experiments with heated air, effective regeneration temperatures are between 55 ^{o}C - 70 ^{o}C while for regenerator solution surface heating, effective regeneration temperatures are between 50 ^{o}C - 60 ^{o}C — temperatures appropriate for simple flat-plate solar collectors.

It is shown that the primary parameters which influence the operation of the system are:-

i) the regenerator and dehumidifier solution surface concentration;

ii) the temperature in the regenerator and dehumidifier;

iii) the entering air absolute humidity and temperature;

iv) the ratio of the regenerator and dehumidifier air mass flow rates;

v) the properties of the porous material;

vi) the properties of the absorbent solution; and,

vii) the distance between the regenerator and the dehumidifier.

In addition, a COP is defined for the system. From the results of experiments conducted, it is shown that COP values of the order of 0.3 or more are possible when the regenerator solution surface is heated with hot water supplied at 50 ^{o}C.

For the purpose of airconditioning, the overall performance of the solar driven humidification/dehumidification

system is shown to be substantially better than the performance of absorption refrigeration systems, particularly at low collector temperatures.

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