

Review on Artificial Neural Network and its Application in the Field of Engineering

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Abstract - The Simulations of evaporative cooling powered by desiccant dehumidification systems in hot and humid climate was carried out by using TRNSYS. The moisture level of process air was substantially controlled by the use of the rotary solid desiccant dehumidifier to provide thermal comfort to the indoor space. The simulation results mainly give the output parameters or the system performance varying over a selected cooling during cooling season from March to October. One needs to fix up the time for getting the output or performance at that instant during the selected cooling period. Design engineers can exploit the use of TRNSYS by considering the extreme range of parameters in their designs to know further applicability of the hybrid cooling system for different climatic conditions. Also, the overall system performance can be predicted for variable climatic conditions for different cities in India. Solid desiccant powered evaporative cooling systems are found reliable in performance, environment-friendly and capable of improving indoor air quality using diversified renewable or waste energy resources. Because of high accuracy and short computing time, this methodology can be useful to simulate the performance of desiccant-assisted HVAC systems at different operating conditions in different climatic zones.

Keywords - adsorption rate, desiccant powered evaporative cooling, regeneration temperature, TRNSYS simulation.

INTRODUCTION

Generally for the cooling purpose in buildings, offices, industries and many areas where cooling effect with controlled humidity is desired we use the conventional air conditioning systems like vapour compression system or evaporative coolers. This is because these systems are easily available in the market at competitive price range. The vapour compression system is a compact device, requires very less maintenance and provides optimum thermal comfort. Now a day the demand of vapor compression cooling system is being increased continuously due to temperature rise in outdoor environment due to global warming. The main drawback of vapour compression system is that it discharges the halogenated organic compound like CFC during leakage or maintenance. These organic compounds are severely affected to the ozone layer and main cause of depletion of this layer and hence leave the harmful impact on our environment line global warming which further increases load on cooling system. It has been observed that the condensed water on the coil surfaces offered a breeding atmosphere for the micro-organisms like bacteria that may be a cause of health problem due to wet environment. Moreover, the traditional air conditioners suffer from performance degradation especially in humid conditions. This is due to the fact that the excess moisture level in ventilation air considerably increases latent cooling load of the space to be conditioned due to high human occupancy or large space. The use of desiccant coupled sensible cooling system can alleviate this problem by controlling the temperature and humidity separately into cooling coil and dehumidifier respectively. It also reduces energy consumption for obtaining the desired thermal comfort by putting off individual component operation under achieving target for temperature or humidity control [1].

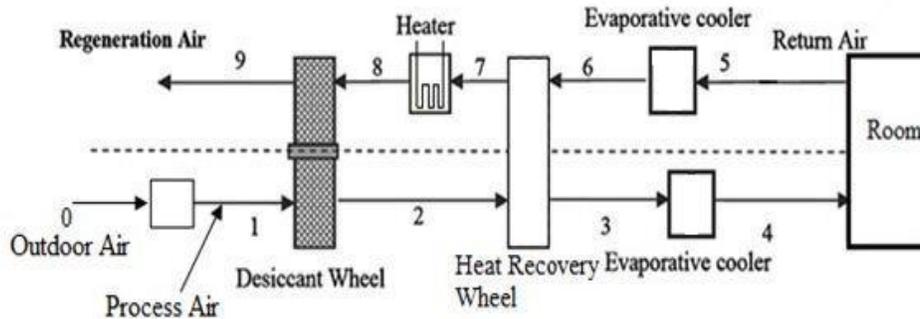
A desiccant is a hygroscopic material that sustains a state of dryness in its confined area in a moderately well-packed wheel. Desiccants are generally materials that have high affinity to moisture present in humid environment. It may be exists either in solid state or liquid state according to nature and its type. Commonly used desiccant materials are solids, and work by absorption of water [2-4]. Desiccants may be also used in other form, and may give performance with other applications, such as chemical bonding of water molecules. Sealed desiccant is most frequently used to take away unnecessary moisture that would generally degrade or even pull down products sensitive to wetness. When used like a food preservative, the desiccants have the cause of maintaining the food substance moist. The desiccant powered conventional evaporative cooling system (liquid/solid) is the one of the method to achieve comfort cooling condition in humid outdoor climate [5-7]. This system is the combination of several components like a desiccant coated dehumidifier wheel, a heat recovery wheel for energy conservation, evaporative coolers for sensible heat exchange and generator or heater etc for reactivating dehumidifier for continually work in cycle. The desiccant based hybrid air conditioning system is very effective and efficient in moisture control during hot and humid climate. In the present study, TRNSYS simulation studio project is developed to perform simulations of a desiccant powered conventional evaporative cooling system for hot and humid climatic conditions. Measurements are also carried out to observe the

influence of operating parameters on the system performance. The obtained results show that the proposed system has ensured a substantial reduction in process air humidity at the dehumidifier exit while maintaining the conditioned room indoor thermal comfort.

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DESCRIPTION OF THE SYSTEM

Outdoor air enters into the solid desiccant wheel at point 1 where the moistures in the air is absorbed substantially by the desiccant material like silikagel used in dehumidifier and gets dehumidified to make the outcoming air dry. Half portion of the wheel is in contact with outdoor air is called process air section while other half with regenerative air is called reactivation air section. The temperature of the process air increases due to dehumidification while exiting the dehumidifier. This dehumidified air enters into the heat recovery wheel at point 2. The heat is transferred from hot dehumidified process air to regenerative air resulted to energy conservation in cycle. As a result of this the air gets sensibly cooled. Also, there is no direct contact between process air and the regenerative air inside the heat recovery wheel. After sensible cooling the air enters into the evaporative cooler at point 3 where it is further cooled by evaporative cooling and the air send inside the room at point 4 in conditioned state. After leaving the room (at point 5) the air enters into another second evaporative cooler in reactivation process air side where it is cooled by evaporative cooling and exits at point 6. The air enters in the heat recovery wheel and gets partially heated by the process air from the desiccant wheel and leaves at point 7. Furthermore, this air is heated upto desorption temperature govern by desiccant material type and requirement for adsorption rate into the secondary heater. The heat source to the heater may be conventional or non conventional (solar energy, waste energy etc) which are eco friendly and also reduces the operating cost of the system. At point 8, the regeneration air again enters into the desiccant wheel, where it is utilized to regenerate the dehumidifier and finally exited to the atmosphere at point 9. A schematic view of the solid desiccant cooling



system and processes involved in this is shown in Fig.1.

Fig. 1. Solid desiccant assisted dehumidification and cooling systems.

SYSTEM MODELING

The following assumptions have been considered in the present analysis;

- The air flow in the desiccant wheel is incompressible.
- The desiccant wheel is fully conserved and no heat transfer with surrounding.
- The regeneration temperature of desiccant wheel is 80°C.
- Effectiveness of desiccant wheel is 70% to 90%.
- Effectiveness of direct evaporative cooler is 80% to 90%.
- Effectiveness of heat recovery wheel 80% to 90%.

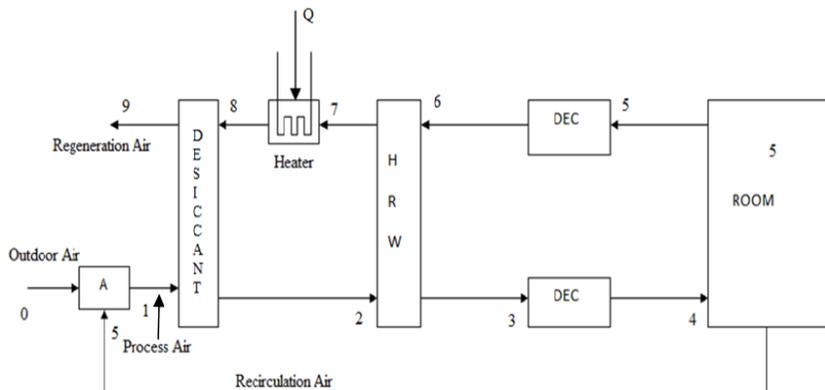


Fig. 2. Desiccant cooling system with recirculation mode.

At point 1;

$$T1 = xT1 + (1-x) T5 \quad \dots\dots\dots (1)$$

$$w1 = xw0 + (1-x) w5 \quad \dots\dots\dots (2)$$

$$m1 = xm0 + (1-x) m5 \quad \dots\dots\dots (3)$$

Since there is a mixing of two air stream at 'A', therefore

$$\frac{m0}{m5} = \frac{h1 - h5}{h0 - h1} = \frac{w1 - w5}{w0 - w1} \quad \dots\dots\dots (4)$$

At point 2;

According to Daou et al. [1], the effectiveness of the desiccant wheel can be given by,

$$\epsilon_{DW} = \frac{T2 - T1}{T8 - T1} \quad \dots\dots\dots (5)$$

According to Daou et al. [1] another relationship of effectiveness is given by,

$$\epsilon_{DW} = \frac{W2 - W1}{W1 - W2,ideal} \quad \dots\dots\dots (6)$$

At point 3;

The effectiveness of the heat recovery wheel [8-10] is given by

$$\epsilon_{HRW} = \frac{\text{Actual heat transfer}}{\text{Max. heat transfer}} \\ \epsilon_{HRW} = \frac{T2 - T3}{T2 - T6} \quad \dots\dots\dots (7)$$

$$T3 = T2 - \epsilon_{HRW}(T2 - T6) \quad \dots\dots\dots (8)$$

T6 can be determining by eq. (12).

& w3 = w2 (sensible cooling).

At point 4;

The effectiveness of DEC is defined as

$$\epsilon_{DEC} = \frac{\text{Actual drop in DBT}}{\text{Ideal drop in DBT}} = \frac{\text{Actual drop in sp. humidity}}{\text{Ideal drop in sp. humidity}} \\ \epsilon_{DEC} = \frac{T3 - T4}{T3 - T3w} \quad \dots\dots\dots (9)$$

$$T4 = T3 - \epsilon_{DEC}(T3 - T3w) \quad \dots\dots\dots (10)$$

w4 can be determined from psychrometric chart at T4 and T4W. Since 3-4 is evaporative cooling process therefore WBT will constant.

At point 5;

T5 & Ø5 are the design points.

At point 6;

$$\epsilon_{DEC} = \frac{T5 - T6}{T5 - T5w} \quad \dots\dots\dots (11)$$

$$T6 = T5 - \epsilon_{DEC}(T5 - T5w) \quad \dots\dots\dots (12)$$

w6 can be determining from Psychrometric chart at T6 and T6W.

At point 7;

Applying energy balance on HRW

$$(mCp)6 (T6 - T7) = (mCp)2 (T3 - T2) \quad \dots\dots\dots (13)$$

$$T7 = T6 + (T2 - T3) \quad \dots\dots\dots (14)$$

Since sensible heating of air between point 6 to 7, therefore w7 = w6.

At point 8;

$T_8 = 800C$ (Regeneration temperature)

& $w_8 = w_7$

At point 9;

Applying energy balance on desiccant wheel

$$(mC_p)_8 (T_9 - T_8) = (mC_p)_1 (T_1 - T_2) \dots\dots\dots (15)$$

$$T_9 = T_8 + (T_1 - T_2) \dots\dots\dots (16)$$

Total cooling load;

$$TCL = SHL + LHT \dots\dots\dots (17)$$

$$SHL = m_4 C_p (T_5 - T_4) \dots\dots\dots (18)$$

$$LHT = m_4 h_{fg} (w_5 - w_4) \dots\dots\dots (19)$$

Sensible Heat Factor (SHF);

$$SHF = \frac{C_{pg}(T_5 - T_4)}{(h_5 - h_4)} \dots\dots\dots (20)$$

Heat supply to the air at point 7 i.e. regeneration heat;

$$Q = m_7 C_p (T_8 - T_7) \dots\dots\dots (21)$$

Coefficient of performance (COP) of the system is defined as;

$COP = \text{Cooling effect} / \text{Regeneration heat}$

While the thermal COP is defined as

$$COP = \frac{m_p (h_5 - h_4)}{m_R (h_8 - h_7)} \dots\dots\dots (22)$$

The temperature and specific humidity at each point of solid desiccant cooling system have been calculated [11-14] by the proposed mathematical modeling and the results are presented on psychrometric chart as shown in Fig. 3.

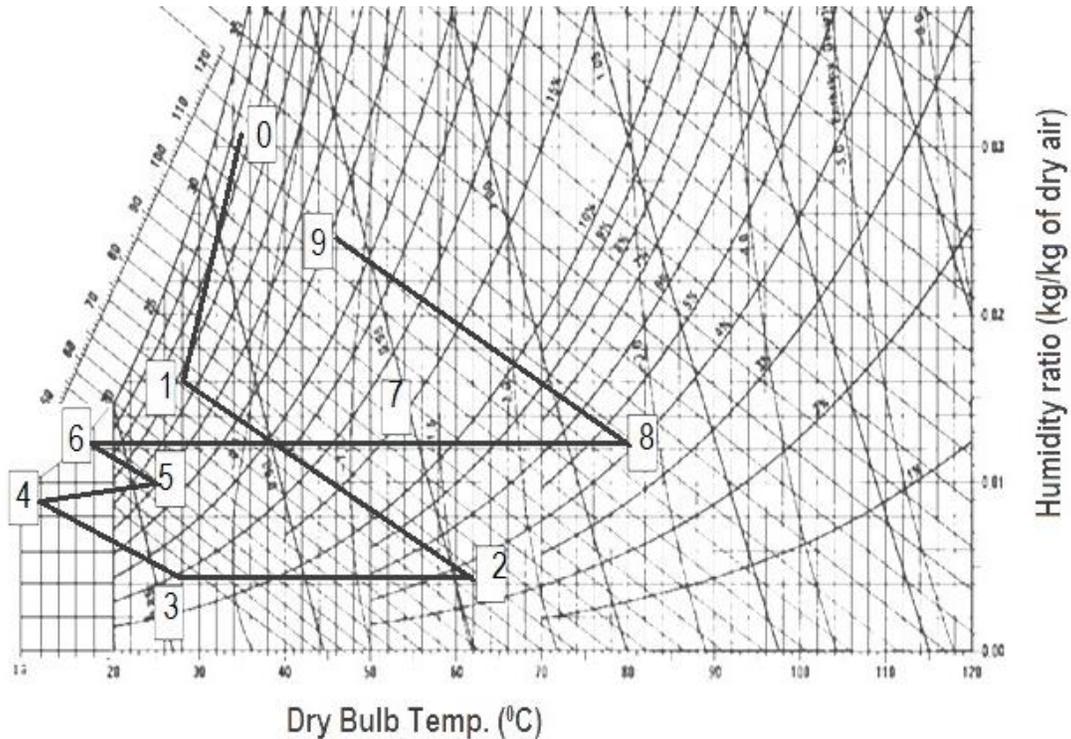


Fig. 3. Psychrometric chart.

TRNSYS SIMULATION

Schematic diagram of system, created in TRNSYS is as shown in Fig. 4. After preparing the model in TRNSYS simulation was carried out for the cooling season and, the results are obtained in the form of graph. These graphs represent the temperature,

humidity at different points.

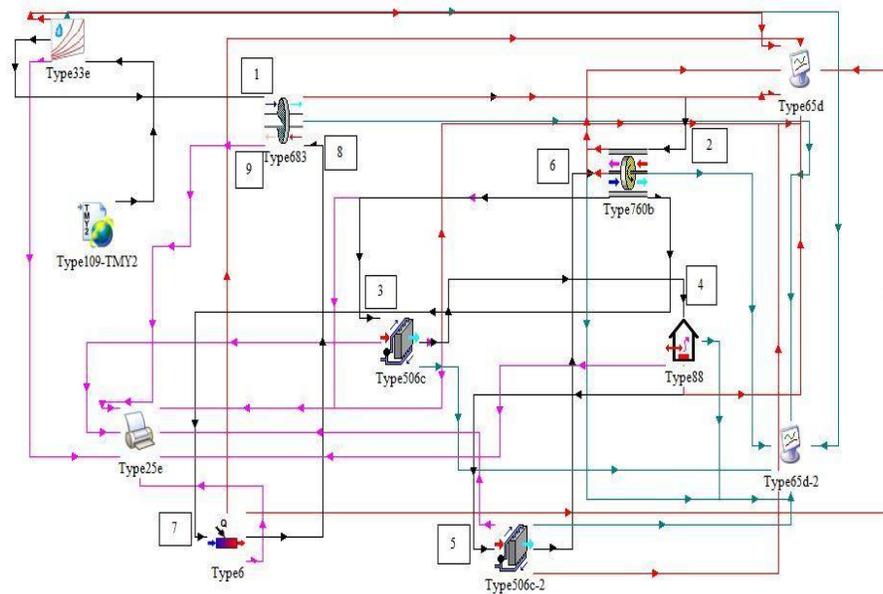


Fig. 4. TRNSYS simulation studio project.

Fig. 5 shows simulation results for variation of temperatures in the desiccant-assisted HVAC system. So, lower energy is required in heater to obtain the desired regeneration air temperature for desorption of desiccant wheel in low ambient humidity condition. Fig. 5 also depicts changes in outdoor DBT, room supply air conditions and dehumidifier process air outlet temperature and test room internal temperatures. Variations in the humidity ratio of ambient air, process air at the outlet of desiccant wheel, room air and supply air are shown in Fig. 6 [15-17]. Humidity ratio is the main parameter indicating the removal of moisture from the room in terms of latent heat to obtain the desired comfort conditions inside the room. Temperature and specific humidity variations at important state point of desiccant-assisted HVAC system are studied for the cooling and dehumidification of air conditioning system using TRNSYS 16 simulation software [18-20]. It is observed that coefficient of performance (COP) for the system depends on the requirement of reactivation temperature for efficient desorption of dehumidifier, which is ultimately governed by existing ambient conditions in terms of its ambient humidity and temperature.

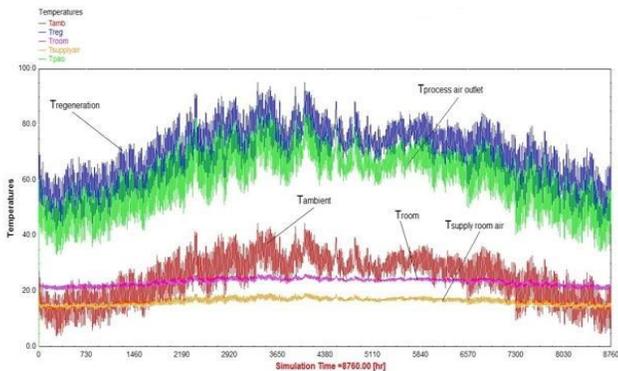


Fig. 5. Variation in temperature at important state points in the system.

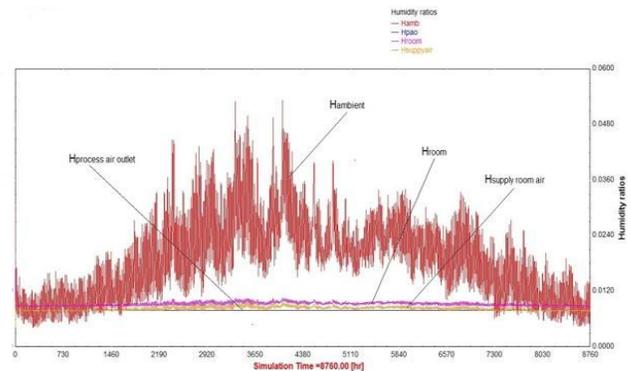


Fig. 6. Variation in humidity ratio at important state points in the system.

CONCLUSIONS

The simulation results obtained by the use of TRNSYS for the solid desiccant-assisted conventional evaporative cooling system highlight good performance in hot humid climate. The moisture level of process air was substantially lowered by the use of solid desiccant-based rotary dehumidifier. The simulation results mainly give the output parameters or the system performance varying over a particular period. One needs to fix up the time for getting the output or performance at that instant. De-

sign engineers can exploit the use of TRNSYS by considering the extreme range of parameters in their designs. Also, the performance can be predicted for such extreme conditions. Solid desiccant cooling systems are found reliable in performance, environment-friendly and capable of improving indoor air quality at a reasonable cost. Because of high accuracy and short computing time, this methodology can be useful to simulate the performance of desiccant-assisted HVAC systems at different operating conditions. The performance of the solid desiccant-assisted HVAC system may be augmented by integrating it with the use of advanced desiccant materials, which can regenerate approximately at ambient conditions can save lot of primary heat for the desorption of rotary dehumidifier.

Nomenclatures

T = temperature (°C)
RH = relative humidity (%)
 ω = humidity ratio (gm/kg dry air)
 ϵ = effectiveness
COP = coefficient of performance

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