Design of Air Conditioning System for College Application using Indirect Evaporative Cooling System

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Abstract - The main aim is to design an air conditioning system for college application such that not only it consumes less energy but also environment friendly with having same air properties to conventional air conditioning system, this thing is possible by using the indirect evaporative cooling system. Normal air conditioning systems uses electrical energy as power and using refrigerant as heat carrying medium to remove heat from conditioning space. This refrigerant is basically had some bad effect on environment and the power of this system is normally wasted on evaporator coil during the air cooling process, as air passes over cooling coil some of the air moisture convert into water and this condensation consumes lot more energy than simply sensible cooling process. This conventional air conditioning normally uses about 40% energy of the building total energy. Whereas the indirect evaporative air conditioning system uses sensible cooling of air for cooling the space and the indoor air properties are even better to normal air conditioning system. As this system gives 100% fresh air and the relative humidity and dry bulb temperature are similar to normal system. The main thing of this system is that it uses about 20% energy of the normal air conditioning system.

Keywords: Evaporative cooling; Environment friendly; Dry bulb temperature; Dew point; Low energy consumption

1. INTRODUCTION

The indirect evaporative cooling system uses one of the oldest methods of cooling and that is evaporative cooling. This method of cooling had used by ancient Egyptian [1]. In this method of cooling the air is cooled by passing through the cooling pads, this pad increases the surface area of water and due to this the evaporation of water increases. As the water changes its phase from liquid to vapour its absorbs the energy from the air which is passing through the cooling pads and the air after losing its heat becomes cool and this air then supplied to the conditioned space [2].

2. LITERATURE REVIEW

This method is very simple, environment friendly as water is used for cooling and also uses very less energy compare to normal air conditioning system which is nothing but compression refrigeration system. This method of cooling is only applicable in dry and hot climate conditions [3]. The working process and the psychrometric chart for simple evaporative cooling are given in below Fig. 1 and Fig. 2.

Fig. 1 Simple Evaporative Cooling System [4]

Fig. 2 Evaporative Cooling Process on Psychrometric Chart

The simple evaporative cooling system is modified and named it as indirect evaporative cooling system. This indirect evaporative cooling system overcomes the humidity problems of simple evaporative cooling system. There are many types of indirect evaporative air conditioning system but here only some important systems are explained, only those system which are commonly in use and easily available in market [5].

The simple indirect evaporative cooling system is modification of direct evaporative cooling system. The modification is one heat exchanger is adopted which is dry channel to cool the secondary air stream.
[6]. The cooling system consists of one dry channel and one wet channel. The wet channel used for evaporative cooling and the dry channel is used for cooling the air that is going to cool the space [7-10]. In wet channel the dry hot air enter as 1 and gets humidified and cools due to evaporative cooling represented as 2 [11-15]. The second channel also takes the hot and dry air as 3 and this air is cooled due to the heat exchanged of hot dry channel and cool wet channel and thereby only sensible cooling of air takes place and no humidity is added and represented by 4 [16]. Then this cool and dry air is introduced into the cooling space. This method is very simple but the cooling temperature is maximum to entering dry bulb temperature of outside air is shown in Fig. 3 and Fig. 4 [17].

![Fig. 3 Simple Indirect Evaporative Cooling](image1)

![Fig. 4 Different Process of Indirect Evaporative Cooling](image2)

The regenerative indirect evaporative cooling is also the modification of direct evaporative cooling system with only one heat exchanger but the result of this cooling system is totally different compared to simple indirect evaporative air conditioning system. The regenerative cooling system is also consisting of two channels wet and dry. The arrangement is little different [18-20]. The dry hot air is first enter into dry channel as 1 and gets cooled due to the heat transfer from dry to wet side and then some amount is send to air condition space and some amount of enters into the wet channel as 2 and the humidification starts and at the end of the channel the air is humidified and warm as at 3. This air then released into atmosphere. In this type of cooling system the air is cooled beneath the wet bulb temperature of the atmospheric air. The working and the cooling process of this system is shown in below Fig. 5 and Fig. 6 [21-24].

![Fig. 5 Regenerative Indirect Evaporative Cooling System](image3)

![Fig. 6 Cooling process of Re-generative System](image4)

Note: The indirect evaporative air conditioning system is only applicable in hot and arid or moderately dry climatic conditions. The cooling effect of this system is significantly affected by the humidity of the ambient air. This system is nearly failed in hot and dry humid climatic conditions [25].

3. METHODOLOGY

The designing of air conditioning is done on the building which is used for college purpose. This building is located in Hyderabad and its major door is facing towards North side is shown in Fig. 7. The building consist of two floors i.e. ground floor and first floor [26-30]. the ground floor consist of departments, labs and auditorium and the first floor consist of class rooms for B.Tech and M.Tech courses, counseling room and scholarship department. The total area of the building is 62405 square feet out of which the area where air conditioning is provided is 44210 square feet. There are 20 spaces on ground floor and 26 spaces on first floor. The maximum occupancy of the building is around 1250 persons [31].
4. CALCULATIONS

4.1 Heat load calculation

The heat load calculation is done to measure the quantity of heat to be removed from the controlled space [32]. In this calculations heat load is divided as sensible heat load and latent heat load. The basic formula used for heat load calculation is given as

\[ Q = UA (t_1 - t_2) \]  
\[ U = \frac{1}{R} \]  
\[ \frac{1}{R} = \frac{1}{f_i + \frac{1}{K} + \frac{1}{f_o}} \]

where,

- \( U = \) Overall heat transfer coefficient of wall
- \( A = \) Outside area of the wall
- \( T_1 = \) outside temperature
- \( T_2 = \) inside temperature
- \( f_o = \) outside film conductivity
- \( f_i = \) inside film conductivity
- \( X = \) thickness of the wall
- \( K = \) thermal conductivity of wall
- \( R = \) thermal resistance of wall

The Heat load calculation is done by using hourly analysis program (HAP). This is standard software used for heat load calculation it is not only gives the tonnage of the building but also the cubic feet of air required for air condition space. The software gives approximate values using ASHRAE ventilation standard 62.1-2007 and ASHRAE energy standard 90.1-2007 [33]. The result values obtained using HAP software for college building are 132 Tr for ground floor with 59863 cubic feet of maximum air per minute and 172 Tr for first floor with the 70966 cubic feet of maximum air per minute [34].

4.2 Machine selection

The air conditioning machine is selected after the heat calculation based on given parameters

- Energy consumption
- Affect on Environmental using cooling machine
- Cooling capacity

As the indirect evaporative air conditioning machine uses less energy for air conditioning and also it is environmental friendly. So the machine is selected based on the air required which is cubic feet per minute as the operating temperature and humidity are similar to any machine used for modern days air conditioning system [35].

5. RESULTS AND DISCUSSION

Ducts are the medium through which the conditioned air is supplied from machine to conditioned space without losing its thermal and physical properties. This duct are design using many methods, among them equal friction method is used for duct designing and the basic formula for duct designing is given as

\[ Q = AV \]

Where

- \( Q = \) quantity of air in cubic feet per minute
- \( V = \) velocity of air in feet per minute
- \( A = \) area of duct in inches and

The duct designing is done by using Mc Quay duct sizer, this is software especially design for duct sizing and the things which are considered in duct designing.
are the aspect ratio should be in range of 1:4 (height/width) and the friction pressure loss should below 0.08 inch of water gauge per 100 feet of duct length [36].

Table 1 Cost comparison of indirect evaporative cooling to a typical air conditioning system

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Type of cost</th>
<th>Indirect evaporative cooling system</th>
<th>Air cooled chilled water system</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Initial cost</td>
<td>Rs. 2,650,000</td>
<td>Rs. 28,865,500</td>
</tr>
<tr>
<td>2</td>
<td>Operating cost per month</td>
<td>Rs. 1,93,500</td>
<td>Rs. 81,783</td>
</tr>
<tr>
<td>3</td>
<td>Energy consumption per month</td>
<td>19,350 kw</td>
<td>81,783 kw</td>
</tr>
</tbody>
</table>

6. CONCLUSION

In this air conditioning design system of the indirect evaporative air conditioning system it is found that the initial cost of the indirect evaporative cooling is only about 9% of the air cooled chilled water system and the indirect evaporative cooling system consumes about 23% energy of the total energy consume by air cooled chilled water system. Furthermore the indirect evaporative cooling system supplies the air is 100% fresh outside air that improves the indoor air quality. The indirect evaporative air conditioning system is also environmental friendly as it uses water for removing the heat from the conditioned space.

REFERENCES


