Experimental investigation on thermal environment in a ceiling based supply air distribution system for commercial basis

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Abstract

In the air conditioning systems the variations in temperature is most important part for loading calculations, India is a tropical country where variations in environmental temperature is between 0°c to 45°c . In corporate sector the load calculations for air conditioner inside glass chamber & variation in temperature at different duct altitude of chamber is latest trend. It is also very much require to calculate the heat effect of computer for proper load calculations. In this research work, I have been investigated the effect on comfort conditioning inside the glass chamber having two personal computers. The variation in temperatures with respect to horizontal distance & vertical distance at particular heights of duct has been investigated for properly sealed glass chamber. The experiment has been investigated inside 2.6 x 3.4 x 2.7m3 glass chamber using thermocol insulated roof & according to inside variable temperature I have been calculated the essential load for conditioner neglecting humidity effects inside the glass chamber at fixed altitude of air conditioning duct.

Keywords

comfort conditioning, Load calculations, Duct design, Air distribution, Cooling.

1.Introduction

1.1Air conditioning

Air conditioning is the removal of heat from indoor air for thermal comfort. another sense, the term can refer to any form of cooling, heating, ventilation, or disinfection that modifies the condition of air. An air conditioner (often referred to as AC or air con) is an appliance, system, or machine designed to change the air temperature and humidity within an area (used for cooling as well as heating depending on the air properties at a given time), typically using a refrigeration cycle but sometimes using evaporation, commonly for comfort cooling in buildings and motor vehicles[1-5].

1.2Air conditioning system

1)Compressor: Compressor compresses the refrigerant and increases its pressure before sending it to the condenser. The size of the compressor varies depending on the desired air conditioning load. In most of the domestic split air conditioners hermetically sealed type of compressor is used. In such compressors the motor used for driving the shaft is located inside the sealed unit and it is not visible externally.

2) Condenser: The condenser used in the outdoor unit of split air conditioners is the coiled copper tubing with one or more rows depending on the size of the air conditioning unit and the compressor. Greater the tonnage of the air conditioner and the compressor more are the coil turns and rows. The high temperature and high pressure refrigerant from the compressor comes in the condenser where it has to give up the heat.

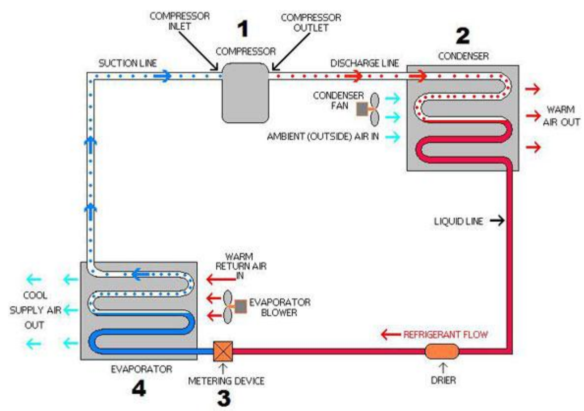


Figure 1 Desired air conditioning load

3) Condenser Cooling Fan: The heat generated within the compressor has to be thrown out else the compressor will get too hot in the long run and its motor coils will burn leading to complete breakdown of the compressor and the whole air conditioner. Further, the refrigerant within the condenser coil has to be cooled so that after expansion its temperature become low enough to produce the cooling effect. The condenser cooling fan is an ordinary fan with three or four blades and is driven by a motor.

4) Expansion Valve: The expansion valve is usually a copper capillary tubing with several rounds of coils. In the split air conditioners of bigger capacities thermostatic expansion valve is used which is operated electronically automatically. The high pressure and medium temperature refrigerant leaves the condenser and enters the expansion valve, where its temperature and pressure drops suddenly.

1.3Energy use

In a thermodynamically closed system, any power dissipated into the system that is being maintained at a set temperature (which is a standard mode of operation for modern air conditioners) requires that the rate of energy removal by the air conditioner increase. This increase has the effect that, for each unit of energy input into the system (say to power a light bulb in the closed system), the air conditioner removes that energy. In order to do so, the air conditioner must increase its power consumption by the inverse of its "efficiency" (coefficient of performance) times the amount of power dissipated into the system. As an example, assume that inside the closed system a 100 W heating element is activated, and the air conditioner has an coefficient of performance of 200%. The air conditioner's power consumption will increase by 50 W to compensate for this, thus making the 100 W heating element cost a total of 150 W of power[6-8].

1.4Air distribution system

The conditioned air from an air conditioning equipment must be properly distributed to the application area when conditioned air can not be directly supplied from the air conditioning equipment, ducts are installed. Ducts supply air to the conditioned space and distributed it in the room with the help of diffusers.

Central heating and cooling systems use an air distribution or duct system to circulate heated and/or cooled air to all the conditioned rooms in a house. Properly designed duct systems can maintain uniform temperatures throughout the house, efficiently and quietly.

1.5Object of air distribution

The objective of an air distribution system is to create a proper combination of temperature, humidity, air motion in the occupied zone of the conditioned room the comfort conditions for the occupants must be met.

2.Cooling load calculation & experimental setup

2.1Historical development cooling load calculations

The 1930s, Houghton et al. introduced the analysis of heat transmission through the building Envelope and discussed the periodic heat flow characteristics of the building envelope. In 1937, ASHVE Guide introduced a systematic method of cooling load calculation involving the division of various load components. In the ASHVE Guide, solar radiation factors were introduced and their influence on external walls and roofs was taken into consideration. Both the window crack and number-of-air-changes methods were used to calculate infiltration.

Mackey and Wright first introduced the concept of sol-air temperature in 1944. In the same Paper, they recommended a method of approximating the changes in inside surface temperature of walls and roofs due to periodic heat flow caused by solar radiation and outside temperature with a new decrement factor. In 1952, Mackey and Gay analyzed the difference between the Instantaneous cooling load and the heat gain owing to radiant heat incident on the surface of the building envelope. In 1964, Palmatier introduced the term thermal storage factor to indicate the ratio between the rate of instantaneous cooling load in the space and rate of heat gain. One year after, Carrier Corporation published a design handbook in which the heat storage factor and equivalent temperature difference (ETD) were used to indicate the ratio of instantaneous cooling load and heat gain because of the heat storage effect of the building structure. This cooling load calculation method was widely used by many designers until the current ASHRAE methods were adopted.

In 1967, ASHRAE suggested a time-averaging (TA) method to allocate the radiant heat over successive periods of 1 to 3 h or 6 to 8 h, depending on the construction of the building structure. Heat gains through walls and roofs are tabulated in total equivalent temperature differentials (TETDs). In the same year, Stephenson and Mitalas recommended the thermal response factor, which includes the heat storage effect for the calculation of cooling load. The thermal response factor evaluates the system response on one side of the structure according to random temperature excitations on the other side of the structure. This concept had been developed and forms the basis of the weighting factor method (WFM) or transfer function method (TFM) in the 1970s. In 1977.

2.2Experiment Apparatus

2.2.1Climate chamber

The test facility is located at the cad lab on the first floor of CME building . The test chamber has the inner dimension (length x width x height): 2.66 x 3.40 x 2.72 m, which is equivalent to a typical two-person office as showed in *Figure 2*

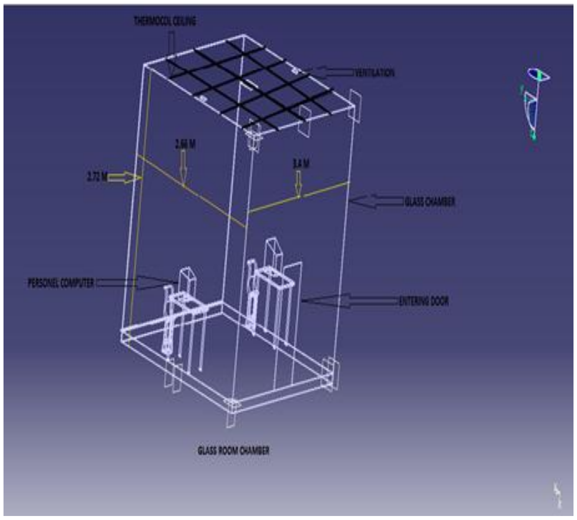


Figure 2 The test chamber has the inner dimension (length x width x height): 2.66 x 3.40 x 2.72 m

3.Experimental investigations and Results

The experiments are carried out in the Department of mechanical Engineering, LNCT bhopal The objective of this study is to evaluate the air distribution in a conditioned room. The experiment was based on the conditioned air distribution on through the supply air outlet placed at the ceiling of the room as used in a conventionally used air conditioning system.

Experiments is to evaluate the thermal comfort in a room equipped with a this type of ceiling as the air distribution terminal.. Furthermore the comfort condition are calculated both for seated and standing person in the occupied zone.

3.1Test condition

3.1.1 Experiment assumptions

In the early design stage, without experiment data support, some assumptions have to be taken based on the experience and similar studies done in this field. Following assumptions are applied in the investigation of experimental and numerical analysis.

- Metabolic rate and preference of closing in the office varies from the people to people. The standard values for metabolic rate and closing factor are used to calculate PMV/PPD. The activity of a sedentary occupant is estimated to be 1.2 met and the clothing insulation is 1.0 clo in winter and 0.5 clo in summer.
- Ventilation effectiveness for DCV is estimated to be 1.0, as it is for the mixing ventilation.
- The building is situated in a clean area with excellent air quality (0 dp)
- Thermocol ceiling are used for the suitable height for the room so from the ceiling heat transfer rate could be zero.

3.2 Experiment Method

The experiment has been carried out is such a manner that a room was design of given dimensions and assembly are done. the room was assembled such a way that it looks like a ordinary small office room for the two person doing moderate work test location has been marked in the room for recording the temperature of the room in various points so room has been divided in to five test point [A, B, C, D, E].all the four corner are name as a [A] [B] [C] [D] and a centre [E].all the four point taken 0.20m from the corner of the room wall. And centre is situated at the 1.3m from the front side. After all the arrangement the stand having the 13 thermocouples are placed at different test point and record the data by using switch changer and temperature indicator. After all the set-up varying the position of duct the air is distributed in to the room. When the air distributed inside the room at varies height of duct over the ceiling the circulation of the air inside the changes so the temperature distribution through out the room changes so the study has been done to record that temperature distribution over the room and get the result to find the temperature variation so can estimate the required room condition and the comfort for the working environment.

Figure 3 Centrally Duct Arrangment Setup

3.3Experiment Results

The main results of experiments are presented by the table data. As shown in figure. The above experiment is conducted in a space where five test locations has been made for analysis the vertical temperature differences in all the test point at different position of duct height for air distribution in the conditioning space. The below temperature distribution analysis shown in the figure. The meruserment of various temperature of different test location are measured by thermocouple which gives the result of temperature variation along the vertical height[9-10].

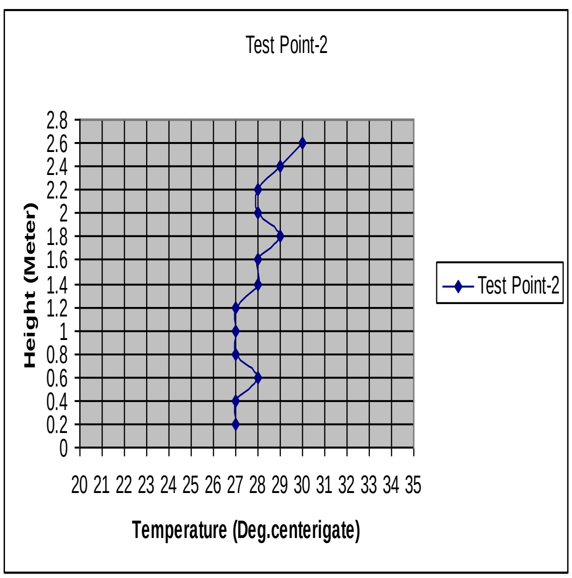
The different temperature data has been recorded and mentioned in the Table.

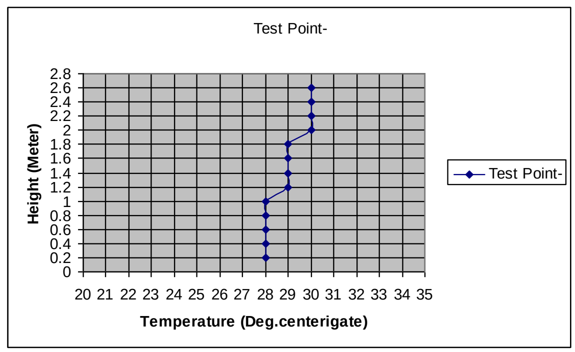
Table 1 Variation of temperature with height

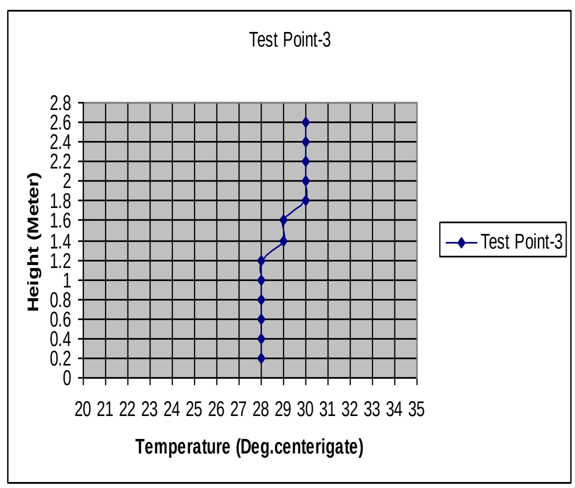
S. NO.	HEIGHT (m)	TP-1(A) (°C)	TP-2(B) (°C)	TP-3(C) (°C)	TP-4(D) (°C)	TP-5(E) (°C)
A	0.2m	28	27	28	29	28
B	0.4m	28	27	28	28	28
C	0.6m	28	28	28	28	28
D	0.8m	28	27	28	28	28
E	1.0m	28	27	28	29	28
F	1.2m	29	27	28	29	27
G	1.4m	29	28	29	29	27
H	1.6m	29	28	29	29	27
I	1.8m	29	29	30	29	26
J	2.0m	30	28	30	29	25
K	2.2m	30	28	30	30	24
L	2.4m	30	29	30	30	23
M	2.6m	30	30	30	30	20

3.4graphs prepration

Following are the graphs are generated on the basis of the above table which shows the temperature changes along the vertical height of the varying duct height the graphical data gives the information of the changing the temperature at different points in the conditional space when supply of the air inside the room.







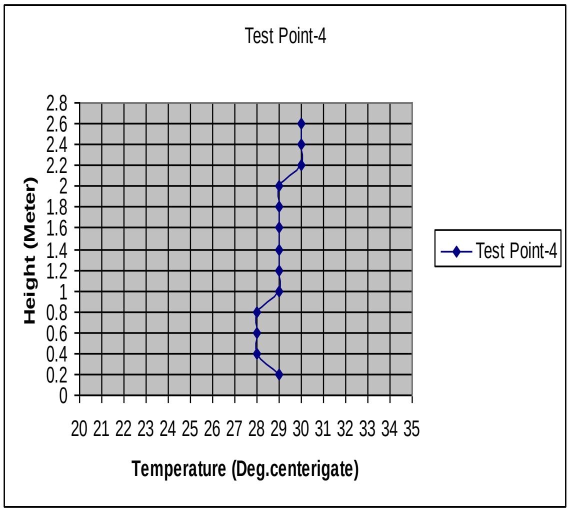


Figure 4 Variation of temperature with height

4.Conclusion

In the above Investigation work it has been found that in proper sealed glass chamber with two computers. The maximum comfort obtained at the centre of the room. The variation obtained at the horizontal distance towards corner of the room. The maximum variation obtained at a horizontal distance of 1.2 m from the centre towards corner, when we placed duct height 2.6 metres.

Also the changes obtained in the vertical height of the room is almost uniform but at the height of 1 m maximam variation obtained. This work is very beneficial for comfort glass.

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