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COOLING LOAD CALCULATION FOR SEMINAR HALL MED, MMMUT GORAKHPUR

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Abstract:

Nowadays air conditioner is crucial equipment of our life because day by day increasing environment temperature. To install the air conditioners, it is necessary to know the correct cooling load for maintaining the cooling effects according to the human comfort. Without knowing cooling load if anyone install the air conditioner, it may be oversize and undersize. This research paper is presenting calculation of cooling load of Vikram Sara Bhai seminar hall of mechanical engineering department, Madan Mohan Malviya University of Technology Gorakhpur by using the method of Cooling Load Temperature Differential/Cooling Load Factors (CLTD/CLF). These methods are obtained from transfer function method (TFM) which are well documented in ASHRAE fundamental handbook. CLTD was calculated for every part of room which is simplified way of hand calculation of cooling load and gives the acceptable result and when compared with refrigeration and air conditioning book by C P ARORA, ASHRAE and CARRIER handbooks, and results are satisfactory.

Keywords: Cooling load, Transfer Function Method, CLTD

1. Introduction

In present days air conditioners is becoming more important equipments of human life. Nowadays environmental problem is one of the most sedate problems. About 72% of global energy is spent by commercial buildings, industries, market and residential houses, but 60% of total energy needed in the complex is allocated for the air conditioning system for cooling purposes (s k Sahu, 2014). For reducing the energy consumption, correct calculation of cooling load is mandatory to get proper heat ventilation air-conditioning (HVAC) system. Designing is also an important factor for making more effective operating cost and energy consumption because Larger size air-conditioners is not better (J. Protor *et al*, 1995). The oldest methods of cooling is evaporating cooling, and had been used by man since 2500 B.C (Harris C. N, 1983). The cooling load calculation is used to find that how much heat is needed that would be extracted from cost with cooling. With the help of correct cooling load calculation, it is easy to procreate a system and structure having good efficiency to minimize cooling cost. Because Without proper calculating air conditioner become less efficient if it is undersize then insufficient cooling problem occur if it is oversize means again less efficient because it will consume more power. There are some major factors which affects the cooling load are outdoor weather condition such as temperature, humidity and solar radiation. There are so many methods and concepts are available in different books for calculating the cooling and heating load. Calculating the cooling load by hand calculation method there is some error found but this error can be minimizing by using computer programs such as CARRIER programs (Ujjwal Kumar Sen *et al*, 2016). This type of program due to sophisticated data input and consume long time, is not much popular so we used hand calculation

method because it is easier to cooling Load calculation. Cooling load Temperature Differences (CLTD), Cooling Load Factor (CLF) and Solar Cooling Load Factor (SCL) is important method for cooling load calculation. In this paper we are going to calculate the cooling load of seminar hall in mechanical engineering department, Madan Mohan Malvina University of Technology Gorakhpur by using the method of Cooling Load Temperature Differences (CLTD). By using this method one factor is important to study that latitude must not be less than 24 ºN. The latitude of this seminar hall is 27 ºN.

2. Methodology

2.1 heat gain from solar transmission

There are mainly three basic mode of heat transfer happens by conduction, convection and radiation.in any building Heat transfer taking place due to solar radiation through walls, roof, windows and doors. There is some formula which is used to determine heat gain through solar radiation.

Solar and Transmission gain through walls and roof:

Q =UA (CLTD)

Overall heat transfer coefficient (U) may be calculated by:

$$\frac{1}{U} = \frac{1}{fo} + +\Sigma\frac{\Delta x}{k} + \Sigma\frac{1}{C} + \frac{1}{fi}$$

f_o and f_i is outside and inside film coefficient

k = conductivity of material

c = conductance

CLTD = cooling load temperature difference (ºC)

A = surface area (m^2)

Solar gain through glass:

$Q = A\times SHGF$max

$SHGF$max = maximum solar heat gain factor (W/m^2)

2.2 Internal heat gain through people or occupant:

Every human body lose heat to their surroundings. It is sensible heat or latent heat. This heat besmeared to calculate the cooling load. The sensible is due to the temperature difference between body and environment, while the latent heat is released by means of breathing and sweating. Sensible heat gain from occupants is depend on sensible heat load/person and no of people similarly, for latent heat:

Internal heat gain through people or occupant is determined by following equations:

Sensible heat gain from occupants:

Qs, person = SHL× N

Latent heat gain from occupants:

Q_l , person = LHL × N

Where,

N = total number of people present in hall

SHL = sensible heat load/person (W)

LHL = latent heat load/person (W)

2.3 Internal Heat Gain Due to Electric Equipments:

Qequipement = Total wattage of equipment × Use factor ×CLF

CLF = 1.0, if operation is 24 hours or of cooling is off at night or during weekends.

2.4 Heat Gain due to Infiltration:

Amount of infiltrated air = $\frac{volume\ of\ space \times Ac}{60}$ m^3/min

A_c is number of air changes value/ hour

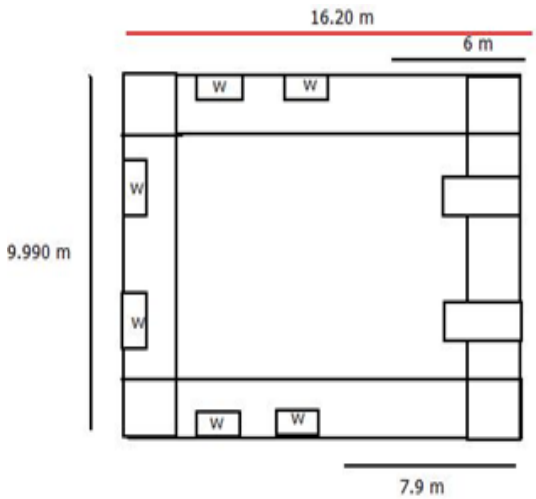
3. Cooling load Calculation of seminar hall

The final calculation sheet of cooling load of 100 people capacity seminar hall by simple way of hand calculation using Cooling Load Temperature Differential (CLTD) method is given below.

Table 1.1 Calculation sheet for cooling load estimation.

SPACE USED FOR HALL Size = 16.20 × 9.990 = 161.838 m² × 3.4442m = 557.4024 m³						
ESTIMATE FOR 5 P.M. LOCAL TIME HOURS OF OPERATION DAY TIME						
Condition	DB	WB	%Rh	DP	h, KJ/kg	w, kg/kg
OUTDOOR	45	28	30	23.40	85	0.016
ROOM	25	18	50	15.7	50.85	0.01
DIFFERENCE	20				34.15	0.006
100 PEOPLE × 0.28 cmm/PERSON = 28 cmm VENTILATION cmm = 28						
DOORS = 2 × 3.555 m² × 1.9813 cmm/m² = 14.08 cmm CRACK = 43.68 × 2.5/60 = 1.82cm INFILTRATION cmm = 14.08 + 1.82 = 15.9						
SENSIBLE HEAT						
		SOLAR GAIN-GLASS				
E-N GLASS	5.952 m2	28		_		166.656
N-W GLASS	5.952 m2	486		_		2892.67
S-W GLASS	5.952 m2	196		_		1166.59
LOAD CALCULATIONS						
ITEM	AREA OR QUANTITY	SUN GAIN OR TEMP. DIFFERENCE OR HUMIDITY DIFF.			FACTOR	Watt
SOLOR TRANSMISSION GAIN – WALL AND ROOF						
N-W WALL	34.385 m²	13.93			2.91	1393.84
N-E WALL	35.315 m²	14.87			2.91	1528.14
S-W WALL	28.4026 m²	19.58			2.91	1618.31
ROOF SUN	161.838 m²	29.40			5.31	25279.45
TRANSMISSION GAIN – OTHERS						
ALL GLASS	17.77 m²	20			5.9	2096.86
DOORS	7.11 m²	20			0.63	89.586
PARTION	81.75 m²	15.5			2.36	2893.95
FLOOR	161.838 m²	2.5			3.78	1529.29
INFILTRATION	15.9 m²	20			20.4	6487.2
INTERNAL HEAT GAIN						
PEOPLE	100	_			75	7500
LIGHTS	1080 W	_			1.25	1350
PROJECTOR	400 W	_			1.25	500
UPS	400 W	_			1.25	500
WIRELESS RECIVER	3.6 W	_			1.25	4.5
SUB TOTAL						56997.04
FOS					5%	59846.89

OUTDOOR AIR BY PASSED	28cmm	20	20.40 × 0.15	1713.6
EFFECTIVE ROOM SENSIBLE HEAT				61560.49
		LATENT HEAT		
PEOPLE	100	_	55	5500
INFILTRATION	15.9	0.006	50000	4770
SUB TOTAL				10270
FOS		-	5%	10783
OUTDOOR AIR BYPASSED	28cmm	0.006	50000×0.15	1260
EFFECTIVE ROOM LATENT HEAT				12043
EFFECTIVE ROOM TOTAL HEAT = ERSH + ERLH =				73603.99
OUTDOOR AIR TOTAL HEAT				
SENSIBLE	28cmm	20	20.4(1-0.15)	9710.4
LATENT	28cmm	0.006	50000(1-0.15)	7140
GRAND TOTAL				90454.39(25TR)



This is the sketch diagram of the seminar hall with all details, the latitude of seminar hall is 27◦ because seminar hall is situated in Gorakhpur. For calculation data is taken from C P ARORA book of refrigeration and air conditioning and ASHRAE handbook.

Length of the hall = 16.20 m

Width of the hall = 9.990 m

Height of the hall = 3.442 m

Area of seminar hall = 16.20 × 9.990 = 161.838 m^2

Volume of hall = 16.20 × 9.990 × 3.4442 = 557.4024 m^3

No of the doors = 2

Total Area of the doors = (1.5×2.37) ×2= 7.11 m^2

No of the glass windows = 6

Total area of windows = (2.40×1.24) ×6=17.856 m^2

Partition wall area:

ES wall = 9.990 × 3.442 34.185 m^2

NE wall = 6 × 3.442 = 20.53 m^2

SW wall = 7.9 × 3.442 = 27.191 m^2

Outside wall area:

NW wall = 9.990 × 3.442 = 34.385 m^2

NE wall = 10.320 × 3.442 = 35.315 m^2

SW wall = 8.300 × 3.442 = 28.4026 m^2

Wall construction:

Outside wall = 22.86 cm bricks, 1.8 cm plaster, 1 mm inside paint film thickness

Partition wall = 22.86 cm bricks, 1.8 cm plaster, 1 mm both side paint film thickness

Thermal conductivity of brick = 1.32 W/m-K

Thermal conductivity of plaster = 8.65 W/m-K

Thermal conductivity of concrete = 1.73 W/m-K

Thermal conductivity of paint = 0.495 W/m-K

Outside film coefficient = 23 W/m2-K

Inside film coefficient = 8.5 W/m2-K

Density of brick = 2000 kg/ m^3

Density of concrete = 1900 kg/ m^3

Density of plaster = 1885 kg/ m^3

Density paint = 1198 kg/ m^3

Mass of outside wall = 526.25 kg/ m^2

Mass of partition wall = 526.25 kg/ m^2

Mass of roof = 381.19 kg/ m^2

Occupancy load:

No of occupancy = 100

SHL =75 w/person

LHL = 55 w/person

Ventilation rate for seminar hall:

Q/person = 0.28 cmm

Q_v = 0.28×100 = 28 cmm

No of air changes of ventilation air = $\frac{28 \times 60}{557.4024}$ = 3.031

Infiltration rate:

Wind velocity is 11 kmph

▲p $0.00047(11)^2$ = 0.057 cm H_2O

Infiltration rate for window according to the 0.11 cm wind pressure = 2.5 m^3/h/m

Length of crack for 6 window = 43.68 m

3.21The general step by step procedures for calculating the total heat load are as follows:

A room sensible load:

1. Calculate solar heat gain and transmission gain through wall, roof, glass etc.
2. Find transmission gain through ceiling, floor, partition wall etc.
3. Infiltration.
4. Calculate the heat gain through people, power, light, appliances etc.
5. Extra heat gain, factor of safety etc.
6. Bypassed outside air load.

The sum of 1 to 6 is called effective room sensible heat (ERSH).

A room latent heat:

1. Infiltration.
2. Calculate the heat gain through people, steam, appliances etc.
3. Extra heat gain, factor of safety etc.
4. Bypassed outside air load.

The sum of 1 to 4 is called effective room latent heat (ERLH). Sum of ERSH and ERLH is called effective room total heat (ERTH).

All The details of calculations of cooling load, 100 seated seminar hall is given on the calculation sheet in table 1.1.

4. Results and discussion:

In this study Vikram Sara Bhai seminar hall an integrated part of mechanical engineering department in Madan Mohan Malviya University of technology Gorakhpur is considered for cooling load calculation. There is used cooling load temperature difference (CLTD) method for calculation of cooling load in month of June. The results show that the seminar hall required about 90454.39 Watt or 25 TR (Ton of Refrigeration) for 100 people in the seminar hall. This value of cooling load is calculated at peak load condition.

5. Conclusion:

The main objective of this cooling load calculation, providing uniform comfortable ambient for students and professors to increase their studying and teaching capacity. In this study cooling load temperature difference (CLTD) simplified method of hand calculation of cooling load is used. This CLTD method is also used in duct design and pressure drop (Deepak V K, *et al*, 2015). This study is also useful for seminar hall of other engineering colleges and universities.

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