Estimation of Heat Load for Air Conditioning System of JMI Library

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Abstract: ***Refrigeration and air conditioning system covers a wide variety of cooling applications, using both standard and custom-made equipment. Central air conditioning is more reliable to operate for easy operation with a low maintenance cost. Refrigeration and Air-conditioning accounts for a significant portion of the energy consumption in various manufacturing industries (like pharmaceuticals, chemicals, dairy, food etc.), agricultural & horticultural sectors (mainly cold stores) and commercial buildings (like hotels, hospitals, offices, airports, theatres, auditoria, data processing centers, multiplexes, telecom switching exchanges etc.). Educational and research institutions also need human comfort, as the population of student community increase year by year. The effective design of central air conditioning can provide lower capital cost, power consumption and improve air purity of a building. This paper establishes the result of cooling load calculations of varying climatic conditions by using CLTD method for a multi-story JMI library which is a part of an institute. Cooling load items such as, lighting heat gain, people heat gain, infiltration and ventilation heat gain can easily be putted to the E 20 MS-Excel program. The E 20 MS-Excel program can also be used to calculate cooling load due to walls and roofs. And results were compared with the standard data given by ASHRAE and CARRIER Fundamental Hand Books, and results are satisfactory. It also seen that comfort air-conditioning generally implies relative humidity in the range of 50% to 60% and cooling of room air to about 25°C. Industrial process air conditioning and precision air conditioning may require temperatures ranging from 19°C to 23°C with relative humidity values ranging from 50% to 60%.***

Keywords: CLTD, Cooling Load, Human comfort, Air conditioning.

1. Introduction

The main purpose of air conditioning system is to provide a comfortable environment for people or machines (computer centers, library, metrology laboratories….) inside a closed space. Therefore, cooling (decrease the temperature of the room air), cooling and heating load calculations are carried out to estimate the required capacity of cooling and heating systems, which can maintain the required conditions in the conditioned space. To determine the required cooling or heating capacities, one has to have information related to the design of indoor and outdoor conditions, specifications of the building premises, specifications of the conditioned space (such as the activity level, occupancy, various appliances and equipment used etc.) and any requirements of the particular application. For comfort applications, the requisite indoor conditions are fixed by the criteria of thermal comfort, while for commercial or industrial applications the required indoor conditions are fixed by the particular products being stored or the processes being performed. As discussed above, the design outdoor conditions are chosen based on design of dry bulb and wet bulb temperatures for summer, monsoon or winter months for cooling and heating load calculations, respectively.

1.1 Abbreviation

A/C	Air-conditioner
A	Body surface area, ft^2 (m^2)
HVAC	Heating, ventilating, and air-conditioning
W	Useful rate of working.
Q_E	Heat loss by evaporation
Q_S	Heat stored in the body.
Q_R	Heat loss and gain by radiation.
Q_C	Heat loss and gain by conduction and convection.
T_b, T_s	Temperature of the body and surrounding.
U	Heat transfer coefficient on body surface.
h_i	Indoor surface heat transfer coefficient, Btu/ (h. ft^2 ^OF) [W/ (m^2 K)]
h_O	Outdoor surface heat transfer coefficient, Btu/ (h. ft^2 ^OF) [W/ (m^2 K)]

1.2 Cooling load Calculation

The cooling load experienced by a building changes in magnitude from zero (no cooling required) to a maximum value (maximum load). The design cooling load is a load near the maximum magnitude, but is not actually the maximum load. Design cooling and heating load takes into account all the loads experienced by a particular building under a specified set of assumed conditions.

The assumptions considered in design cooling load are as follows:

1) The load on the building due to solar radiation is determined for clear sky conditions.
2) Design outside conditions are extracted from a long-term statistical database. The conditions will not necessarily represent any particular year, but are representative of the location of the specific building. Design data for outside condition for various locations of the world have been collected and are represent in tabular form in various handbooks.
3) The occupants in the building is assumed to be *at full load capacity*.
4) All building appliances and equipment are considered to be operating at a reasonably representative capacity.

The total building cooling load consists of heat transfer through the building enclosed area (windows, doors, floor, walls, roof, etc.) and heat generated by equipment, occupants and lights. The load due to heat transfer through the surroundings is called as external load, while all other loads in the building envelope are called as internal loads. The percentage of internal versus external load varies with, site climate building type and building design. The total cooling load on any building consists of both latent as well as **sensible** load components. The latent load affects the moisture content, while the sensible load affects dry bulb temperature of the conditioned space.

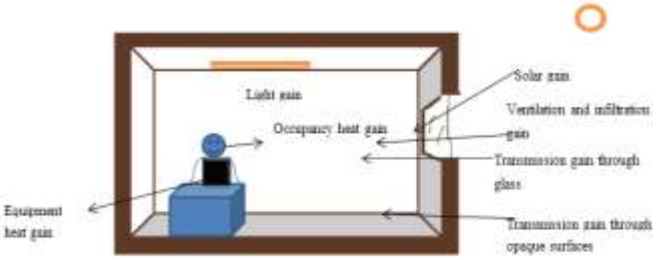

Figure 1: Calculation of various load

1.3 The Software: E 20 Excel Sheet

E 20 excel sheet is a computer tool produced by Excel, a company providing solution for heating, air conditioning and refrigeration. The aim of this program is to assist engineers to design HVAC systems for commercial and industrial buildings. It presents two tools in one: estimation of the loads and design system, and calculation of the energy usage and calculation of energy costs.

E 20 excel sheet is able to perform the following tasks:

- To determine be the optimum rate at which heat needs to be removed from space to establish a pre-determined inside conditions & maintain thermal equilibrium.
- To estimate peak design loads (heating / cooling).
- To estimate capacity or size of plant/equipment.
- To provide information for HVAC designs e.g. load profiles and graphs.
- To form the basis for building load capacity analysis.

2. Literature review

Wong et al. [1] for estimating the HVAC energy consumption in buildings these method and results were very useful. Analyzed the development of a new example weather year and generated the mathematical model to estimate occupants load profiles using Monte Carlo simulation method for subtropical climate.

Francesco Causone [2] they used heat balance method and time series method to calculate the cooling load and proposed a simplified procedure to determine the magnitude of the solar heat load and estimated and designed radiant cooling load systems for removal of solar heat gain.

Fernando et al [3] proposed a new method based on a stochastic simulation method for uncertainty in peak cooling load estimation. The stochastic solution was compared with the actual solutions, and a universal sensitivity method was assumed to identify the most important uncertainties.

Christian Ghiaus et al [4] an unconstrained optimal control algorithm was proposed which used feed-forward method to compensate the weather conditions and model predictive programming (MPP) for set-point tracking and reported that the estimation of optimal thermal loads of intermittently heated buildings.

Yang et al [5] they found that when using the average outdoor temperature and film coefficients of the special building cooling load component can be obtained properly. He investigated the heat transfer through a photovoltaic (PV) wall to determine the cooling load component added by building-integrated PV walls.

3. Theoretical Analysis

The configuration of the building as shown in figure and for finding the overall heat transfer coefficient (U) we use below equation

$$Q_M - W = Q_E \pm Q_S \pm Q_R \pm Q_C \quad (1)$$

$$Q_R = \sigma A\,(Tb^4 - Ts^4) \quad (2)$$

$$Q_E = CdA\,(Ps - Pv)\,Cc.hfg \quad (3)$$

$$Q_C = UA\,(T_b - T_s) \quad (4)$$

$$CLTDcorr = (CLTD + LM)\,K + (25.5 - Ti) + (To - 29.4) \quad (5)$$

$$Q = UA\,(CLTD)\,corr \quad (6)$$

$$Q = AxSCxSHGF\,max.xCLF \quad (7)$$

$$Qs,\,person = N\,xCLF\,x\,qs,\,person \quad (8)$$

$$RTH = RLH + RSH \quad (9)$$

Amount of infiltrated air (Vinf) = Volume of Space X Ac m^3/hour
Qequipment = Total wattage of equipment X Use factor X CLF
Q light = Total wattage of light X Use factor X Ballast factor
Latent heat gain due to the infiltration, Qs, inf = 50000X Vinf X (To – Ti) watts
Sensible heat gain due to the infiltration, Qs, inf = 20.44 X Vinf X (To – Ti) watts

4. E 20 Excel Sheet

This program is released as two separate parts, but they have same products. The "**E** 20 Excel Sheet for design load" program provides system design and load calculating features. The full "E 20 excel sheet" program provides the similar system design capabilities plus energy analysis features.

4.1 E 20 Excel Sheet features

E 20 Excel Sheet determines design heating and cooling loads for industrial and commercial buildings in order to estimate required size for HVAC system components. Ultimately, the program provides information regarding to specification and selection of equipment. The program performs the various tasks including cooling and heating loads.

5. Result and Discussions

The results show the cooling load calculation of different climate conditions by using CLTD E 20 excel sheet method for a JMI Library which is a part of a JMI institute. Cooling load items such as infiltration, lighting, people and ventilation can easily be entered to the E 20 EXCEL SHEET MS-Excel program.

5.1 Building Parameters

City: JMI Library, New Delhi
Length of the room = 13.70 m
Breadth of the room = 6.00 m
Height of the room = 4.26 m

5.2 Window Specifications

Height =1.67 m
Width =1.35 m
No of windows = 4

5.3 Door Specifications

Height =2.56 m
Width =1.40 m
No of door = 2

5.4 Electrical Equipment

No of fans = 8
No of tube lights = 24
Energy Units: Watt (W)
Calculation Method: **E 20 Excel Sheet**

6. Conclusion

In this study, Refrigeration and Air conditioning of JMI Library in Engineering Department building located in New Delhi was considered for calculation of cooling loads. The hand calculation features and accuracy make it sufficient for actual design of HVAC systems.

The main conclusions can be drawn from the results of calculation of the present work are:-

1) The total cooling load for the Air conditioning of the JMI Library by hand calculation requirement is 6.30 TR and total cooling load for E 20 excel sheet programs requirement is 6.25 TR.
2) By hand calculation method it is found that each TR can cover 1000 m² floor area.

Table 1: Input parameters of installation for air conditioning system

				Package AC	[illegible]	[illegible]					
Job No. :	1		City:	New Delhi				Prepared by :	FAIZAN ALI		
Name of job :			Usage	[illegible] Library				Date :	07/03/2018		
Name of area :	ENGG LIBRARY			ESTIMATE FOR		Summer		BASIS OF DESIGN	Altitude (Ft)		708
Floor level :	Ground Floor								Outside	Space	Diff
								Deg F DB	110	74	36
Glass ht Ft :	5.48			Roof Temp :	Exposed to Sun		61	Deg F WB or RH	79	[illegible]	-
Room ht Ft :	13.9			Roof ins. :	Input 2 inch		0.12	Gr/Lb	74.7	69.1	[illegible]
Wall Th. inch :	9	0.30		Floor Tem.	Gr.Floor/Earth		10	Th	30.2	29.5	[illegible]
Floor Area SqFt :	1000							Occupancy (person)	40		
Ar Cavity Wall	RCC	0.41						Light load (Watts/SqFt)	2		
								Eq. Load (Watts/SqFt)	1		
Wall	L (Ft)	H (Ft)	Area (Ft²)	Net Ar (Ft²)	Factor	T.D.	Btu/hr	Total Equip Watt	-		
SPACE SENSIBLE LOAD								Air change/hour	1	212	
								Fresh air (CFM/pers.)	7.5	300	
N Wall	18	13.9	250	225	0.38	36	3081	Fresh air CFM / SqFt	0.12	129	300
N Glass	4.42	5.40	24					APPARATUS DEW POINT			
S Wall	22.4	13.9	311	287	0.38	30	3300	Sensible Heat Ratio	[illegible]		
S Glass	4.42	5.40	24					ADP	[illegible]		
E Wall								DPT	[illegible]		
E Glass								Summer Load	6.25	TR	
W Wall								Monsoon Load	6.55	TR	
W Glass								Winter Heat Load	0.62	TR	

Table 2: Cooling load sheet of 40 seated JMI engineering library

NE Wall							
NE Glass							
NW Wall							
NW Glass							
SE Wall							
SE Glass							
SW Wall							
SW Glass							
Floor	1000			1000	[illegible]	[illegible]	4100
Roof	1000			1000	0.42	61	7329
Partition	16	13.6		264	0.36	28	2608
Sunglass	(N,S,E,NE,SE)			48	1	12	581
Sunglass	(W)			0			0
Sunglass	(NW,SW)			0			0
All Glass				48	1.1	35	1918

CHECK FIGURES			Range
ft² / TON	160	OK	145 - 220
CFM/TON	371	OK	350 - 500
CFM / ft²	2.34	OK	2.0 - 4.0

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Table 3: Result obtained for air conditioning system

Lights	2		1000	2000	1.2	3.41	8184
Equipment	1		1000	1000	1	3.41	3410
People	40				1	230	9200
Venti			300	0.1	1.08	36	1166
			Space Sensible Heat				45507
	Duct Heat Gain + Fan H.P. + Safety Factor 10 %						4551
			Total Space Sensible Heat				50058
SPACE LATENT LOAD							
Venti			300	0.1	0.68	5.6	114
People	40				1	220	8800
			Space Latent Heat				8914
			Safety Factor 10 %				880
			Total Space Latent Heat				9794
			Total Space Sensible Heat				50058
			Total Space Heat				59852
VENTILATION AIR HEAT							
Venti. (Sensible)			300	36.0	1.08	0.9	10498
Venti. (Latent)			300	5.6	0.68	0.9	1028
			Refrigeration Sub Total				71378
		Return Heat Gain + Pump H.P. + Piping Gain (5%)					3569
			Refrigeration Total				74947
	TONS						**6.25**

Table 4: Temperature vs. humidity

Temperature	Humidity
30	0.004208
35	0.005212
40	0.006357
45	0.007722
50	0.009345
55	0.011268
60	0.01354
65	0.016217
70	0.019364
75	0.023057
80	0.027382
85	0.032442
90	0.038357
95	0.045266
100	0.053339
105	0.062774
110	0.073816

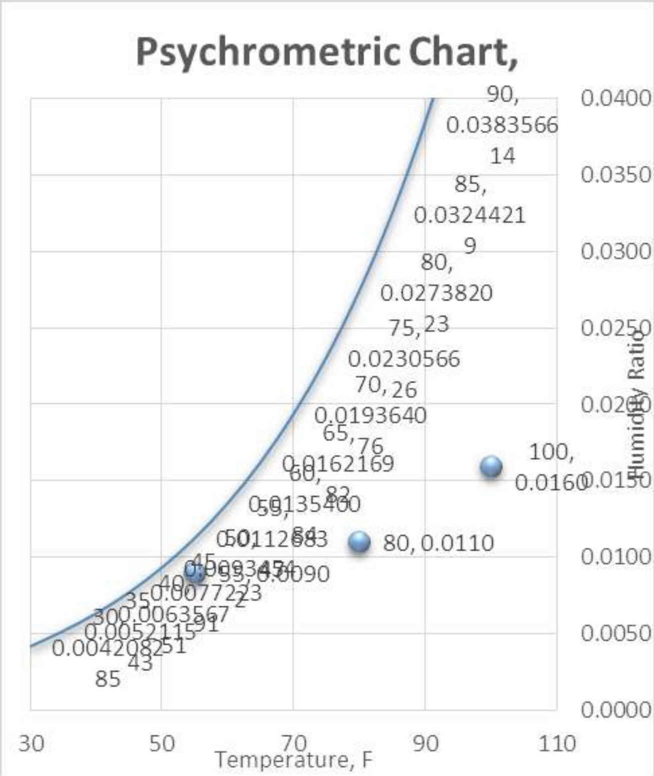

Figure 2: DBT vs specific humidity

Table 5: Load (TR) vs DBT

TR	DBT
0.41	75
0.45	80
0.48	85
0.51	90
0.55	95
0.58	100
0.61	105
0.65	110

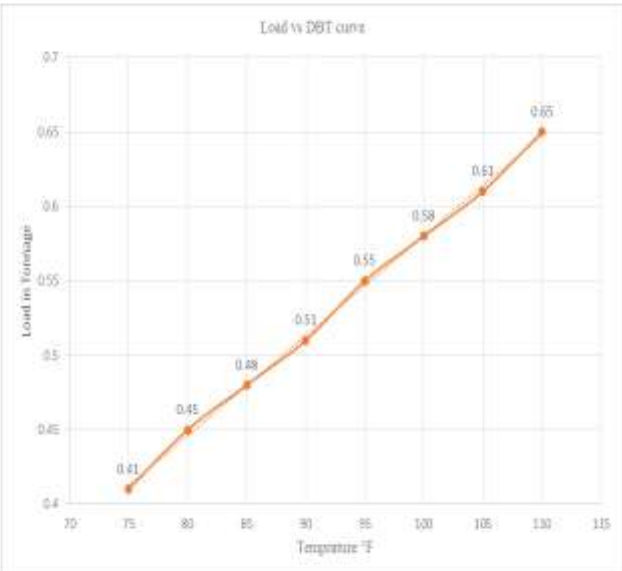

Figure 2: DBT vs. specific humidity

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Author Profile

Faizan Ali received the B.Tech degree in Mechanical Engineering from Amity University, India in 2015. M.Tech in Thermal Engineering from Jamia Millia Islamia, New Delhi India (May 2018). He is much interested in research and have good knowledge of HVAC (heating, ventilation and air conditioning. He wants to do further research in the same field. He is also a gold medalist (B.Tech) which shows his patience, hard-work and better understanding of basic concepts of his area.

Prof Mohammad Islam received PhD from Applied Mechanics Department, Indian Institute of Technology Delhi (IITD), New Delhi. Presently, he worked as Professor in JMI, New Delhi India.. He has more than thirty years of teaching experience. He has many publications in reputed National and International Journals.

Muhammad Asfar experienced HVAC (heating, ventilation and air conditioning) with a demonstrated history of working in the design industry. Skilled in AutoCAD, HVAC, Microsoft Excel, Customer Service, and Heat Loads. Strong engineering professional completed M.Tech in Thermal Engineering from Jamia Millia Islamia, New Delhi India. Currently running an MEP and structure consultancy.