Cooling Load Calculation for an Auditorium

Deepanshu Prasad
Department of Mechanical Engineering
Chhattisgarh Swami Vivekanand Technical University C.G-India 491001

Abstract— This research with the cooling load calculation for an Auditorium, commercial complex, etc., using central air conditioning system which includes the study of auditorium layout, determination of cooling load, and distribution of cool air. The auditorium requires a conditioned air of certain quality. The cooling load calculation will be done by considering the ambient temperature as 32 °C which is temperature encountered in the winter season in this local area. The compressor capacity will be found after determination of cooling load required.

Key words: Cooling Load, Ambient Temperature, Centralized Air Conditioning

I. INTRODUCTION

Air Conditioning is a process which heats, cools, cleans, and circulates air and controls its moisture content. It also includes odor removal, gas removal bacteria removal. Air conditioning is generally categorized as comfort and industrial. Briefly, an air conditioning is necessary for the following reasons. Heat gain from the sunlight and electric lighting, in particular, may cause the unpleasantly high temperature in the room unless the window is opened. If windows are opened then excessive droughts noise and dirt enter and objectionable.

The essential feature of comfort condition is that it aims to produce an environment which is comfortable to the majority of the occupants, in case of industrial and conditioning purpose for conditioning is different.

II. PROBLEM IDENTIFICATION

Extreme hot or cold weather is not only uncomfortable but also unhealthy. It may promote the growth and spread of microorganisms, such as Legionella pneumophilia, the infectious agent responsible for Legionnaire's disease, or thermophilic, actinomycetes. Conversely, air conditioning (includes filtration, humidification, cooling, disinfection etc.) it can be used to provide a clean, safe, hypoallergenic atmosphere in Auditoriums and other environments (hospitals auditoriums, multiplexes, shopping malls etc.), where an appropriate atmosphere is critical to student's safety and well being. The heat produced by human body due to an increased blood circulation through the arteries and veins of the body surface. This puts a greater load than the normal on the heart and this is dangerous for heart patients.

III. EFFECTIVE TEMPERATURE

The degree of hotness and coldness mainly depends upon the factors:

A. Dry Air

The dry air is the mixture of various gases in the absence of water vapour.

B. Moist Air

It is a mixture of dry air and water vapour.

C. Saturated Air

The presence of water vapours in air depends upon the temperature of the air. The air is said to be saturated air at a particular temperature when it holds the maximum possible amount of water vapour in it. It should be noted that the saturation pressure corresponding to the temperature of the saturated air as determined from a steam table will represent the vapour pressure of moisture in the air in case the temperature of the mixture of air and water vapours is above the saturation temperature of water vapours the vapors is called superheated vapour.

D. Dry Bulb Temperature (tb)

The temperature of air measured by ordinary thermometer when placed in the air is called dry bulb.

E. Humidity Ratio/Specific Humidity

It represents the mass of actual water vapour mixed with one kg of dry air.

F. Relative Humidity

It is defined as the ratio of an actual mass of water vapour in a certain volume of moist air at a given temperature to the mass of water vapour in the same volume of saturated air at the same temperature.

IV. PSYCHROMETRIC FOR HEATING AND COOLING PROCESS

Latent Heat (Lf): It is defined as the heat which when supplied or removed from a substance, produces a change of state without any change of state without any change in temperature. It can be either latent heat of fusion or latent heat of vaporization, while the former (Lf) is the heat which must be added to 1kg of solid already at its melting point to change its state to liquid at the same temperature and later is the heat which must be added to a kg of liquid already at its boiling point to change its state to vapour at the same temperature.

A. Sensible Heat (Sh)

It is defined as the heat which when supplied to or removed from a substance produces a sensible effect on the substance i.e., a change of temperature which is measurable by a thermometer.

V. PSYCHROMETRIC PROCESSES

There are various processes used in summer and winter air conditioning practices which are as follows.

a) Sensible heating or cooling
b) Humidification and dehumidification
c) Heating and humidification
d) Cooling and dehumidification
e) Chemical dehumidification

A. Sensible Heat Factor

The thermal properties of air can be latent and sensible heat. The term sensible heat factor is the ratio of a sensible to the

total heat where total heat is the sum of the sensible heat and the latent heat.

B. Bypass Air

Bypass air is that which flows through a coil but does not contact with the coil surface. The velocity of air passing through the coil surface is low, and then more of the air contact the surface and when the velocity is high, fewer amounts of air comes in contact with coil surface. It is measured in terms of bypass factor (BF).

VI. SURVEY OF AN AUDITORIUM

Data Collection has been done to determine the best possible air conditioning system and best method of installing that system. The completeness and accuracy of this survey is the foundation of the estimate.

In Auditorium survey, the following physical aspects must be considered:

a) An orientation of Auditorium
b) Physical dimension of the space: Length, width, and Height etc.
c) Construction material: The material of wall and ceiling.
d) Windows: Size and number of windows and type of glass in a window.
e) People: Number of seats in auditorium.
f) Doors: Size of the door.
g) Lightning: Types and the number of lights.

VII. HEAT TRANSFER ANALYSIS

The heat is transferred from one system to another by the means of conduction, convection, radiation. The cooling and heating load depends upon the various factor such as local climate, thermal characteristics of material and building type. For the calculation of cooling load various software's are available such as DOE 2.1E, BLAST, Elite.

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

a) Select inside design condition (Temperature, relative humidity).
b) Select outside design condition (Temperature, relative humidity).
c) Determine the overall heat transfer coefficient of wall, ceiling, floor, door, windows, below grade.
d) Calculate the area of wall, ceiling, floor, door, windows.
e) Calculate heat gain from a transmission.
f) Calculate solar heat gain.
g) Calculate sensible and latent heat gain from ventilation, infiltration and occupants.
h) Calculate lighting heat gain.
i) Calculate total heat gain.
j) Calculate TR.

VIII. COOLING LOAD ESTIMATION PRESENTED ON THE WORKSHEET

The cooling load calculation of an auditorium is represented on the worksheet.

The worksheet carries the various source of heat gain from the body and the materials.

Project :COOLING LOAD CALCULATION OF AN AUDITORIUM				Area –BHARTI COLLEGE OF ENGINEERING DURG CHATTISGATH		
Space-90 SEATS (AUDITORIUM NO-1008)						
Length (m)=15.5m		CONDITION	DBT	WBT	%RH	
Width (m) =7.6m		Outside	45	26	28	
Height (m)=3m		Inside	25	18	50	
Area (m^2)=117.8		difference	20			
Volume(m^3)=353.4						
SUMMER						
SOLAR HEAT GAIN FROM WINDOW						
SIDE	w/m^2k	(m^2)	Δte	Q		
GLASS(E)						
GLASS(W)						
GLASS(N)	6.461	2.375	20	51.1495		
GLASS(S)	6.461	2.375	20	255.7475		
TOTAL				306.897 W		
SOLAR HEAT GAIN BY THE DOOR						
SIDE	w/m^2k	(m^2)	Δte	Q		
PLY (S)	12.54	2.438	20	75.09W		
TOTAL				75.09W		
TRANSMISSION HEAT GAIN THROUGH WALL AT DIFFERENT HOURS						
DIRECTION	1PM	2PM	3PM	4PM	5PM	

EAST	1229.58	1162.35	1072.44	1024.41	962.00	
SOUTH	2885.28	3066.24	3169.27	3214.65	3194.32	
WEST	756.70	800.82	923.63	1028.91	1200.00	
NORTH	1465.02	1548.10	1619.82	1685.07	1742.18	
TOTAL	6336.55	6577.51	6785.2	6953.04	7098.5	
TRANSMISSION LOAD IS MAXIMUM AROUND 5PM =7098.5						
SENSIBLE HEAT LOAD			SAFETY FACTOR FOR SENSIBLE HEAT			
FABRIC	Watt					
WALL	7098.5		Sensible heat		18103.23 W	
CEILING	652.612		Safety factor (5%)		862.05 W	
FLOOR	2346.576					
FAN	360		SAFETY FACTOR FOR LATENT HEAT			
LIGHT	27.5					
PEOPLE	6750		People		4950 W	
TOTAL	17241.18		Latent heat		5197.5 W	
			Safety factor (5%)		247.5 W	

TOTAL HEAT GAIN			
LOAD	Watt		
Sensible heat gain	18103.3	Total effective room heat	25630.803 W
System losses(10% safety)	1810.323	Room sensible heat factor(RSHF)	0.776
Effective room sensible heat	19913.553	Total tonne of refrigration load Tone (W/3500)	7.32 TR ≈8TR
Latent heat gain	5197.5		
System losses(10% safety)	519.75		
Effective room latent heat	5717.25		

IX. RESULTS

The calculation was carried out using the above data and the following result appeared:

Load through glass = 306.897 W
Load through ceiling = 2346.576 W
Load through floor = 2346.576 W
Room sensible heat gain = 18103.3 W
Room latent heat = 5197.5 W
Total effective room heat = 25630.803 W
Room sensible heat factor (RSHF) = 0.776
Total tons of refrigeration load = 7.32 TR
= 8TR

X. CONCLUSION

In this study, the auditorium which is the integrated part of the research is located in durg city and considered for the calculation of cooling loads. The cooling load temperature difference method is used to find the cooling load.

The result shows that the 8TR of a compressor is used for the cooling process of the auditorium in Bharti College of Engineering Durg Chhattisgarh for the month of summer (month of April).

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