Heat Load Calculation and Duct Design of Seminar Hall

T.Pavan Kumar[1] Shaik Imran[2]
[1]Head of Dept. [2]Student
[1,2]Department of Mechanical Engineering
[1,2]NNRG, Hyderabad

Abstract— In this project importance of duct designing and human comfort has been analyzed which create an impact of system performance. Well known circular duct have low friction loss and easy to design but in practice rectangular duct is designed because of space availability. Now days various kind of tools are available for such work for energy efficient design of duct. Failure to correctly apply them to cooling spaces costs clients. This major missed opportunity is to a large extent a function of inadequate consideration given to the structure of ducts and the layout of the ducting system leading to problems such as uneven cooling across the cooling space, greater frictional losses, steeper installation costs & increased noise and power consumption levels. Aim is to design an air distribution system for a seminar hall using ducts. This project includes the heat load calculation of seminar hall i.e. Manually and design of duct using duct sizer and AutoCAD tool.

Key words: Heat Load Calculation, Duct Design

I. Introduction

Business Centre buildings are mostly multi-tenant; at times they may be occupied by a single tenant, a single organization. This aspect varies the approach to a solution of the problems. The multi-tenant building requires more exacting applications. Regardless of the occupancy most existing and some new buildings have the following basic areas to consider- the interior and the peripheral exterior areas. The interior areas are within the center of a building not influenced by outdoor elements, except the top storey under a roof. Areas around the periphery of a building (exterior zone) may extend from 12 to 20 feet inward from the outside wall. This zone is exposed to sun, wind, outdoor temperature and shading of the structural elements or neighboring buildings. There is an evident need for two different air conditioning systems to handle the two areas marked by loads of different behavior. An interior zone has a relatively constant load of light and people. Therefore a single all-air system is the most applicable. However with complications of scattered addition of electronic equipment and provisions to switch off lights within a fully partitioned space, the system grows more complex. There may appear a need for either a terminal reheat, volume control, or dual stream all air system. Occasionally there may be an application for a primary air-secondary water system, particularly if the wattage is high. The exterior zones have extensively varying load characteristics, from an extreme combination of sun gain through glass, maximum outside heat transmission, lights and people to no load during marginal weather and to a maximum negative transmission load in winter.

Although business centre buildings are occupied mainly for 8-10 hour periods and some business centre busy into the evening, the air conditioning equipment should usually operated for at least 16 hours. During peak design conditions the air conditioning system should operate for 24 hours. This contributes to a more economical selection of equipment.

This air conditioning system is carried out to provide customer comfort and to increase efficiency of customers who hires this business centre, since it is a business centre we use numbers of computers, servers etc.

It is a general practice that the computers should be placed in a cool and a dust free environment in order to perform its function efficiently, because it has several electronics components such as diodes which operates properly at certain temperatures so care must be taken that the temperatures should not increase a certain value.

II. Human comfort

The main purpose of most air conditioning systems is to provide an acceptable thermal environment for human beings. For the design and operation of such systems and for the thermal design of buildings, it is essential to quantify and specify these requirements for acceptable thermal environments.

We can define thermal comfort as:

"The state of mind which expresses satisfaction with the thermal environment"

This condition arises when a person feels thermally neutral and does not know whether he/she would prefer a higher or lower prefer a higher or lower ambient temperature. Thermal comfort does not necessarily mean the production of a relaxed environment – it is concerned with establishing an environment which is best suited to the special needs of the people occupying theatre. The consideration of thermal comfort levels must therefore take into account:

- The environment
- Clothing, including protective clothing worn
- Individual sensitivity to the environment
- Climatic needs in relation to the particular activity engaged in.

In practical engineering terms, the question of thermal comfort can be reduced to an energy balance equation relating personal factors, such as:

- Activity level
- Thermal insulation of clothing

And environmental parameters, such as:

- Air temperature
- Mean radiant temperature
- Air velocity
- Relative humidity

III. BUILDING SURVEY

This chapter is a first step in identifying the aims and objectives in this project by reviewing the latest research in design and analysis of HVAC systems. The previous researches show the findings of thermal comfort of the occupants based on the indoor and outdoor temperatures. The research findings show that there is a need to predict the comfort levels of the occupants in real time due to the complex heat flow patterns. This will be done by representing the actual site conditions and based on the real weather data to study the effect of environmental factors affecting the comfort levels checks will be made on the current environmental strategy to show it is feasible to maintain the comfort levels as specified in the ASHRAE standards.

A. Site Survey

An accurate survey of load components of the space to be air conditioned is a basic requirement for a realistic estimation of cooling and heating loads. The result and accuracy of this survey is the very foundation of the estimation, and its importance cannot be over-emphasized. Mechanical and architectural drawings, complete fields sketches and in some cases photographs, of important aspects are integral parts of a good survey. The following physical aspects must be considered.

- Orientation of building – location of the space to be air conditioned with respect to the major points of the compass.
- Use of space(s) – office, hospital, departmental store, specialty shop, machine shop, factory assembly plant, etc.
- Physical dimensions of spaces (s) – length, width and height
- Ceiling height - floor - to - floor height, floor to ceiling, clearance between suspended ceiling and beams.
- Columns and beams – size, depth.
- Construction materials – materials and thickness of wall, roof, ceiling floor and partition, and their relative position in the structure.
- Surrounding conditions – exterior color of walls and roof, shade from adjacent building or sunlight, space-unvented or vented, surrounding spaces conditioned or unconditioned – temperature often - conditioned adjacent spaces, such as furnace or boiler room and kitchens, floors on ground, crawl space and basement.
- Window – sized and location, wood or metal sash, single or double glaze; type of glass-single or Multiplan; type of shading device dimension of overhangs.
- Doors-location – type, size and frequency of use.
- Stairways, elevators and escalators-location temperature of space if open unconditioned area. Power of machinery, ventilated or not.
- People –number, duration of occupancy, nature of activity, any special concentration. At times, it is required to estimate the number of people on the basis of sq. m per person, or on average traffic.
- Lightening-wattage at peak, type – incandescent, fluorescent, recessed, exposed, if the lights are recessed, the type of air flow over the lights, exhaust, return or supply, should be anticipated. At times, it is required to estimate the wattage on a basis of watts per sq. m, due to lack of exact information.
- Appliances, business machine, electronic equipment- location, rate wattage.

Data obtained from the site is utilized in cooling load calculations, selection of machines and their location, duct sizing. For example the bottom of the beam and bottom of the duct establish in site survey will help in duct design and layout.

IV. MANUAL HEAT LOAD/COOLING CALCULATION

A. Working Area (Sensible Heat):

1) Solar Heat Gain through Wall (North)

Q = A xUxTΔ
= (65 x 12) x 0.35 x 37
= 6242 BTU/hr

2) North Glass:

Q = A xUx TΔ
= 6 x (5x 6) x 0.35 x 23
= 2164 BTU/hr

3) Solar Heat Gain through Glass (East)

Q = A xUx TΔ
= 2 x (5 x 6) x 0.56 x 163
= 403 BTU/hr

4) Solar Heat Gain through Wall
Q = A xUx TΔ
= (33x 12) x 0.35 x 23
= 5027 BTU/hr
5) Transmission Gain through All Glass
Q = A xUx TΔ
= 2 x (5 x 6)+6 x(5 x6) x 1.13 35
= 10563 BTU/hr

B. Internal Heat Gain:

1) Visitors Load
P = occupancy x activity (sensibleheat)
= 104x 400
= 25480BTU/hr
2) Light Load
Q = Watts/Sft x Total area in Sft x3.4
= 3 x 2145 x 3.4
= 9509 BTU/hr
3) Equipment Load
Q = No of computers x 0.2KW x3413
= 5 x 0.2 x 3413
= 3410 BTU/hr
4) Infiltrated Air Load:
Q = Cfm x T Δx B.F x S.H.C
= 429x 30 x 1.09 x 0.1
= 6476 BTU/hr

C. Latent Heat:

1) Visitors Load,
P = occupancy x activity (latent heat)
= 104 x 500
= 2132BTU/hr
2) Infiltrated Load,
Q = Cfm x Gr/Lb x L.H.C x C.F
= 429x 32 x 0.65 x 0.9
= 2029 BTU/hr
3) Total Sensible Heat (T.S.H)
=2164+403+6242+5027+6476+25480+9509+3410+10563+12701+30888
= 112863(+ 10%)
= 112863+11286
= 124149BTU/hr
4) Total Latent Heat (T.L.H)
= 2029+21320
= 23349 (+ 5%)
= 23349 + 1167
= 24516 BTU/hr
5) Total Effective Heat Load = T.S.H + T.L.H + Outside Air
= 124149+24516
= 148665 (+ 14.5%)
= 148665 + 20988.55+76543
= 246196.55BTU/hr
According to ASHRAE 1 tonne of refrigeration (TR) equal 12000 BTU/h
Hence to provide the cooling effect,
= 246196.55/12000
= 20.51 TR

D. Selection of Ductable Air Condition System

As Per Tonnage, Available Space, Economy, Client Requirement,
Selected machines are:
Calculated Tonnage for Ahu Room = 20.5 TR
Selected Tonnage for Ahu Room 1 = 22 TR

1) Total Ductable Machine Selected

a) Capacity Quantity

– 5.5TR (AHU ROOM)

– 4 No'S

– 4.2 Selection of Duct Size

Designing of ducts can be carried out on the software given by ASHRAE called as McQuay Duct sizer, By entering the required cfm calculated while performing heating/cooling calculations as shown below.

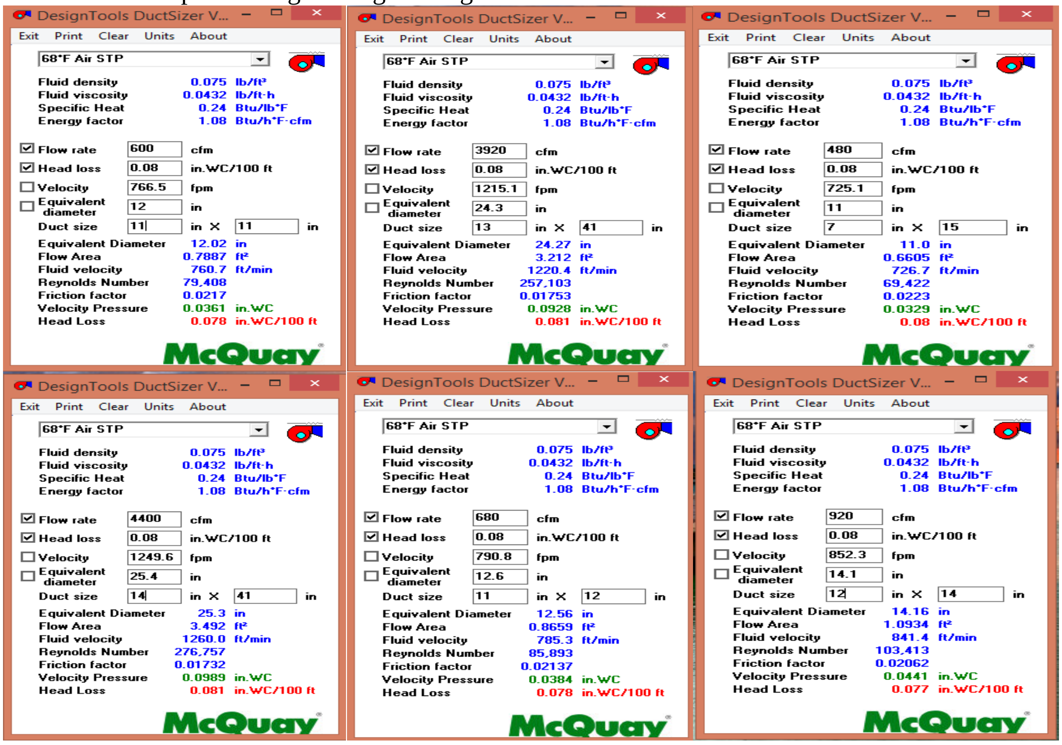

Fig. 1: Design tools

Note: All the duct dimensions after calculating in McQuay Duct size rare taken into consideration by making them to even.

E. Final HVAC layout

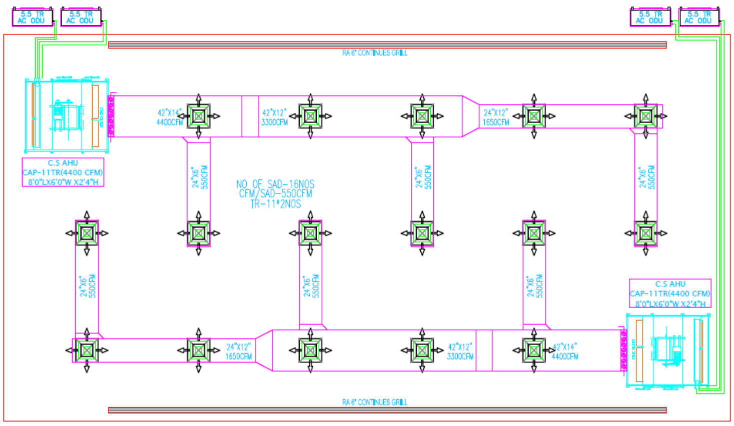

Fig. 2: duct dimensions

Note: All the duct dimensions after calculating in McQuay Duct sizerare taken into consideration by making them to even.

V. CONCLUSIONS

Theoretically it is known that the pressure drop for a typical system comprising of straight ducts, bends and diffusers is lower for a circular duct system than for a rectangular. Therefore one can very well conclude that by selecting a multiple duct system for the above application; great saving can be obtained in terms of operating costs (power consumed by the fan is directly proportional to the pressure drop). But the above methodology can also be extended further to explore the relative costs and benefits in selecting a particular section by using the pressure loss data obtained above to calculate the running costs and compare them to the installation costs.

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