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"Design of Duct for Air Cooling System"

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ABSTRACT

This paper focus on study of design of duct for air cooling system in which all air flow features related to the duct system efficiency. Adequate tools and methods are required to design the air cooling duct system. For the purpose of designing a ducting system, we first collected the dimensions of our class room and decided upon the various instruments that can be used as well as available to fulfil our purpose. Our concentration was manly towards the efficiency of the design, while giving highest priority to uniform distribution of cooling air and minimizing the pipe friction loss. After a series of calculation and designing the outcome was a possible solution for an optimum ducting system for our class room. This paper will be study about velocity distribution of air in the duct at various sections, pressure difference at various outlets and distribution of air flow for different load conditions.

Keywords: Air duct, Mech. Building, Heat load, Duct design, velocity method

I. INTRODUCTION

Earlier the use of air cooling duct for comfort purpose was considered a luxurious but now-a-day, it has been a necessity in extreme climatic conditions, such as extreme cold and hot in western countries. Window air cooling duct are preferred for office rooms while large centralized units are installed for cooling the auditorium, hospitals etc.

The correct estimation of cooling load of large area is very complicated due to many factors such as outdoor temperature, humidity, air leakage into the conditioned space. The Climate condition at workplace like offices, hotels, workshops are also important factor While selecting the optimum design for cooling duct. Which results in comfort condition.

A normal healthy person feels comfortable at 25°C DBT, 50% RH with 9 to 12m/min air velocity. Human comfort is influenced with the physiological conditions determined by the internal heat generation. Ducts are used in heating, ventilation, and air conditioning (HVAC) to deliver and remove air. These needed airflows include, for example, supply air, return air, and exhaust air. Ducts also deliver, most commonly as part of the supply air, ventilation air As such, air ducts are one method of ensuring acceptable indoor air Quality as well as thermal comfort. Ducts can be further used to transfer cooled air for long distances. The main objective of our project is to provide efficient air cooling.

Theory

Cooling Load Temperature Difference(CLTF), Cooling Load Factors is used to calculate the cooling load of building. The conditioned air (cooled or heated) from the air conditioning equipment must be properly distributed to rooms or spaces to be conditioned in order to provide thermal comfort condition. When the conditioned air cannot be supplied directly from the air conditioning equipment to the spaces to be conditioned, then the ducts are installed. The duct systems convey the conditioned air from air conditioning equipment to proper air distribution points or air supply outlets in the room and carry the return air from the room back to the air conditioning equipment for reconditioning and recirculation.

The conditioned air (cooled or heated) from the air Conditioning equipment must be properly distributed to rooms or spaces to be conditioned in order to provide comfort conditions. It may be noted that duct system for proper distribution of conditioned air cost nearly 20 to 30% of total cost of equipment required Duct material is usually made from galvanized iron sheet metal, Al sheet metal or black steel. But now a day, the use of non-metal ducts has increased. The resin bonded glass fibre ducts are used because they are quite strong and easy to manufacture according to desired shape and size. They are used in low velocity applications less than 600m/min and for static pressures below 5mm of water gauge.

It may be made in circular, rectangular or square shapes. From an economical point of view, the circular ducts are preferred because the circular shape can carry more air in less space. This means less duct material, less duct surface friction and less insulation is needed. For rectangular duct, Shape is determined considering minimum aspect ratio.

The pressure in duct is usually expressed in mm of water. Rise in pressure in fan is known as fan total pressure (FTP). FTP & supply air flow rate (in cmm) are used to select the fan. Here the Pressure is lost due to friction between the moving particles of fluid (i.e. air) and interior surface of duct. When the pressure loss occurs in a straight duct, it is usually termed as friction loss.

II. METHODOLOGY & MATERIAL DESCRIPTION

The schematic of air duct layout is shown in figure in which the supply air from the fan is distributed in two outlets which are located in two different zones. A-B is the duct running from the supply air fan to zone 1, A-B-C is the duct running from supply fan to conditioned zone 2. These are known as duct runs.

The purpose of the duct design is to select suitable dimensions of duct for each run and then to select a fan, which can provide the required supply airflow rate to each conditioned zone. The following methods are most commonly used in air flow ducting.

1. Velocity method
2. Equal Friction Method
3. Static Regain method

1. Velocity Method: The velocity method is one of the simplest type of designing the duct system for both supply and return air. The various steps involved in this method are:

i. Select suitable velocities in the main and branch duct.

ii. Find the diameters of main and branch duct from airflow rates and velocities for circular ducts. For rectangular ducts, find the Cross-sectional area from flow rate and velocity, and then by fixing the aspect ratio, find the two sides of the rectangular duct.

iii. From the velocities and duct dimensions obtained in the previous step, find the frictional pressure drop for main and branch ducts using friction chart or equation.

iv. From the duct layout, dimensions and airflow rates, find the dynamic pressure losses for all the bends and fittings.

v. Select a fan that can provide sufficient FTP for the index run.

vi. Balancing dampers have to be installed in each run. The damper in the index run is left completely open, while the other dampers are throttled to reduce the flow rate to the required design value.

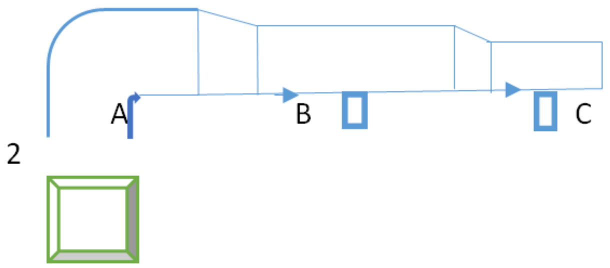

Figure 1. Air duct layout

1. Duct Material

The suitable duct material of our project are galvanize sheet material, aluminium sheet metal, black steel. Galvanised sheet metal is most commonly used because zinc coating prevents rusting and avoids cost of painting. GI duct thickness varies from 26 gauge (0.55mm) – 16gauge (1.6mm). Aluminium is used because of lighter weight and moisture resistance.

Figure 2. GI sheet

Black Sheet metal is always painted unless withstand high temperature. Resin bonded glass fibre ducts are used as they are quite strong and easy to manufacture. Cement asbestos duct may use for underground air distribution and wooden ducts are used where air has low motion contents.

Figure 3. different type of Air Duct

2. Air Cooler

Air cooler is an equipment used for air cooling. It is one type of heat exchange used to cool the air. A desert cooler is a device which cools air through the evaporation of water. It provides increase air flow and reduce temperature with the use of cooling fins, fans or finned coils that moves the heat out of room. It involves increase air flow over the target area that needs to be cool.

Figure 4. Air cooler

3. Fan

The fan is an essential and one of the most important components of air cooling systems. The centrifugal fan is most commonly used in air cooling systems as it can efficiently move large quantities of air over a large range of pressures. The centrifugal fan with forward-curved blades is widely used in low-pressure air conditioning systems. The more efficient backward-curved and air foil type fans are used in large capacity high pressure systems.

The important operating parameters of a fan are:
1. Density of air (ρ) which depends on its temperature and pressure
2. Operating speed of the fan (ω in rps), and
3. Size of the fan.

III. DESIGN OF DUCT

1. Rules for Design of duct

Air should be conveyed as directly as possible to save space, power and material sudden changes in directions should be avoided. When not possible to avoid sudden changes, turning vanes should be used to reduce pressure loss. Diverging sections should be gradual. Angle of divergence ≤ 20^0. Aspect ratio should be closest to 1.0. It should not exceed 4 air velocity should be within permissible limits to reduce noise and vibration.

2. Working Principal of Duct

The duct system is designed to supply the conditioned air in the room that is, cooled by the ducting equipment and to circulate the same volume of air. The duct system has two main air-transfer systems - supply and return. The supply side delivers the conditioned air to the home through individual room registers in which what you feel blowing out of the registers. The return side withdraws inside air and delivers it to the air handler of your central system. All of the air drawn into the return duct(s) is conditioned and should be delivered back through the supply registers.

The two factors are responsible for reducing the air flow in duct system .One is friction. As the air moves through a duct, it interacts with the surfaces. The smoother that inner surface is, the better it is for air flow. The rougher the surface, the more it slows down the air. The second factor is turbulence. This generally arises when you move air through fittings, or when you turn the air.

When air comes out of the air handler, it gets sent to the various rooms in the house. As it travels through a trunk-and-branch duct system, the quantity keeps diminishing because some of it gets diverted down each branch on the way to the end. Each section of duct, each fitting, each turn of the air adds resistance to that air flow because of friction and turbulence. Grilles and registers, filters, and balancing dampers also add resistance. That resistance results in decreases in the static pressure, or pressure drops. So, we begin at the blower with a high pressure. Then the air comes out of the supply vents, which pressure has dropped to zero (relative to room pressure).

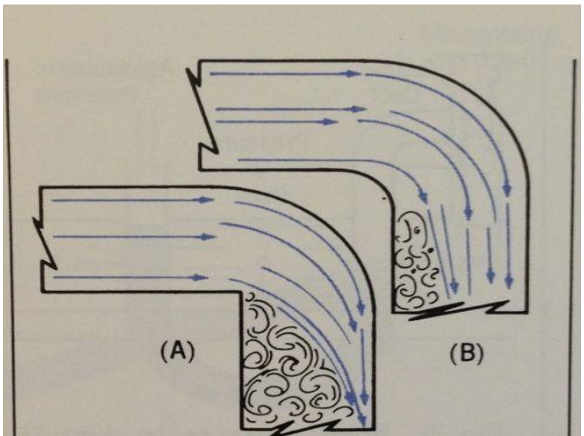

Fig. 3 Effect of elbow throat on turbulence within a duct system. The sharp throat of (A) creates more turbulence than the rounded throat of (B).

DUCT DESIGN CALCULATION	
METHOD USED FOR SIZING OF DUCT: VELOCITY REDUCTION METHOD Q=2.14m³/sec (Let velocity =6m/sec)	
For 1st outlet Q=AxV 1.5=Ax6 A= 0.25 m² Equivalent diameter=0.556m **L=22" & B=18"**	**For 2nd outlet** Q=AxV 0.64=Ax6 A=0.106m² Equivalent diameter= 0.35188m **L=16" & B=10"**

1. Heat load calculation

The purpose of heating and cooling load calculations then is to quantify the heating and cooling loads in the space to be conditioned. Rough estimates of load may be made during the concept of design phase.

The major components of load in buildings are due to the direct solar radiation through west glass transmission through fabric or structure and fresh air ventilation.

I. Heat Transfer through Building Structure:

The heat gain or losses to be considered in building is the heat transfer through walls, roofs, ceiling, floor, etc., the building structure. The load due to such heat transfer is often referred to as the fabric heat gain or loss. According to equivalent temperature differential method, the heat transfer is given by:

Q=UA (T2-T1)

U=over all heat transfer coefficient,

A=area of wall,

(T2-T1)=Equivalent temperature difference

II. Heat Gain by the Solar Radiation:

The glass has high transitivity so that considerable amount of heat is poured directly into the A/c space by sun through the glass. This amount varies from hour to hour, day to day, and latitude to latitude. The details of solar radiation with respect to time of day and situation of glass area given in the ASHRAE guides. Solar radiation is often the largest component of the room Sensible heat load for a building with considerable window area.

III. Solar Heat Gain through Glass:

Glass which is transparent allows the sunrays to pass through it. This results in heat dissipation inside the room. The amount of heat dissipated into room depend upon the glass area that is exposed to sun.

IV. Solar Heat Gain through Walls and Roofs:

Heat gain through the exterior construction (walls and roof) is normally calculated at the time of greatest heat flow. It is caused by the solar heat being absorbed at the exterior surface and by the temperature difference between the outdoor and indoor air. The heat flow through the structure may then be calculated, using the steady state heat flow equation with equivalent temperature difference (ETD).

Q = U*A*ETD

Q = heat flow rate KJ/Sec

U = transmission rate

A = Area of surface (Sq. m)

ETD= Equivalent Temperature Difference (K)

V. Heat Gain through Light & Appliances:

Lights generate sensible heat by the conversion of the electrical power input into light and heat. The heat is dissipated by radiation to the surrounding surfaces, by conduction into the adjacent materials and by convection to the surrounding air. Electric appliances contribute latent heat, only by virtue of the function they perform that is, drying, cooking, etc., whereas gas burning appliances , contribute additional moisture as a product of combustion.

Room: CAD Lab area 0	City:	NAGPUR DBT	WBT	RH	W(KJ/Kg of dry air)
0	ODC	43	27	29	0.016
Est. For : BUILDING PLAN (DESIGN CONDITION)	IDC Diff	25 18	18	50	0.01

NAGPUR ENVIRONMENT CONDITION (BY ISHRAE)

MAY 15

	SUMMER	WINTER	MONSOON
DBT	41.4	11.5	26.2
WBT	23.6	9.4	31.9

	L	B	H	Area (sq.ft)	Volume (ft.cb)	Occup.
Dimension	32	26	11	760	8360	45

SENSIBLE HEAT

LOAD	ITEM	AREA	TEMP. DIFF	FACTOR	WATTS
SOLAR GLASS GAIN	NORTH	7.0311	44	5.9	1825.27
SOLAR TRANSMISSION GAIN-WALL AND ROOF	NORTH WEST	32.20	10.6	2.8	955.7
	ROOF	76.0875	29.7	3.07	6937.58
TRANSMISSION GAIN	DOOR	2.4747	18	0.63	28.063
	ALL GLASS FLOOR	8.9531	18	5.9	950.819
		69.8375	2.5	6.05	1056.3
INTERNAL HEAT GAIN	PEOPLE	40	-	75	3000
	LIGHTS	3	40	1.25	150
	FANS	4	100	0.8	320
	COMPUTERS	32	150	0.8	3840
TOTAL ROOM SENSIBLE HEAT					**19063.73**
EFFECTIVE TOTAL ROOM SENSIBLE HEAT					**19063.73**

LATENT HEAT

ITEM	NOS	TEMP. DIFFERENCE	FACTOR	WATTS
PEOPLE	40	-	55	2200
APPLIANCES	32	150	0.07	336
SAFETY FACTOR		5%		126.8
TOTAL LATENT HEAT				**2662.8**
EFFECTIVE ROOM LATENT HEAT				2795
EFFECTIVE ROOM TOTAL HEAT				21859.66
GRAND TOTAL HEAT				**21859.66**
TONNS OF REFRIGERATION				**6.25**

CALCULATION OF MASS FLOW RATE			
Qtotal=m*Cp(T2-T1) 21859.66= m*1005x18 m*= 1.20kg/sec	Density =mass/volume Density=1.13@40°C volume=1.20/1.13 volume=1.07 m^3/sec	CFM=cubic feet per min Volume=1.07x(3.22)3x60 Volume=2265.46CFM	Consider factor of safety 2 Volume=2265.46x2 =4350.92 Volume=7704m^3/hr. Volume=2.14m^3/sec

DUCT DESIGN CALCULATION	
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IV. CONCLUSION

For designing the duct, building heating load, and air flow rate is calculated and duct design for building is done by velocity reduction method. This project work has given us opportunity for enrichment of our knowledge in area of R&AC and exposure to the practical field to learn the latest trends in this field and built our confidence to develop ourselves as an engineer.

It is used for testing, designing of air duct cooling system for office/residential building/auditorium with the help of load calculation.

V. ACKNOWLEDGEMENT

I would like to thanks of gratitude to my teacher **"Prof. Dr. Akash Langde"** who gave me the golden opportunity to do this wonderful project on the topic "Design of duct for air cooling system" which also helped me in doing of lot of research and I came to know about so many new things. I am really thankful to them. And I would also like to thank my friends which helped me out for proceeding of our project.

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