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Design an Air Conditioning System for a 30 Bedded General Hospital

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Abstract -The substantial design of hospital is a necessary element of a hospital's contamination control policy, incorporating contamination control issues to minimize the risk of infection transmission. Hospital design therefore, needs to consider the separation of dirty and clean areas, sufficient exposure to air, lighting and storage facilities and plan of patient accommodation areas, including sufficient number of wash hand basins and single bed facilities. A 30 bed general hospital was designed keeping in view structural and intend elements necessary for success of a good infection control programme. Need for effective identification of potential infections, risks in the design of a hospital was stressed.

The responsibility of infection control in the plan of hospitals is increasing everyday with materialization of communicable diseases. A 30 bedded general hospital has been planned keeping in view essential design elements necessary for success of a good infection control programme. Planning of ward unit, ICU, OT, isolation ward and cubicles were reviewed keeping in view standard guidelines available.

1. INTRODUCTION

As it is clear from the name of the problem that it is a design work, under this problem I have to design the air conditioning body of a general hospital. And estimation of the expenses incurred in its installation. The thesis work on the Design of an air conditioning system for a 30-bedded general hospital capacity is totally depends on design work.

1.1 Meaning of Air-Conditioning

Air-conditioning is a process where we controlled the velocity of air humidity of air, Cleaning of air and oxygen supply with condition of need at any place the AC system are broadly classified into two groups.

Comfort AC
Industrial or commercial AC

1.1.1 Comfort AC

The comfort AC system is to provide an environment which is the comfort table to the major of the occupants the comfort AC system is established into three groups.

SUMMER AC - The problem encountered in AC is summer AC is to reduce the sensible heat and the water vapour content of the air by cooling and Dehumidification.

WINTER AC - The problem encountered in winter AC Is to increase the sensible heat and water vapour contains of the air by heating and dehumidification.

YEAR ROUND AC - This system assured the control of temperature and humidity of air in. And enclosed space throughout the year when the atmosphere conditions are changing as per season.

1.1.2. Industrial or Commercial AC

Industrial provided year at required temperature and humidity to perform specify industrial process successfully the design condition are not based on the feeling of the human being but purely on the requirement of the industrial process.

2. Requirement of Comfort AC

The comfort feeling of the people in an AC plant depends upon following five main factors.

Supply of Oxygen and removal of carbon dioxide.
Removal of body heat dissipated by the occupants.
Removal of body mixture dissipated by the occupants.
To provide sufficient air movement and air.
To maintain the purity of air by removing adore and dust.

These factors mentioned above are responsible for changing the optimum effective temperature and the see factor depends upon following factor.

Climate and seasonal difference.
Clothing.
Age and sex.
Activity.
Duration of stay.
Air velocity.

3. Types of AC System

Different types of systems are used for different types of load. Thus the following are the air conditioner systems as per load.

Window type air conditioner.
Package type air conditioner.
Central type air conditioner.

3.1 Window type air conditioner

Air conditioner is used domestically, it is of middle capacity.

3.2 Package type air conditioner

This type of air-conditioner is used in such buildings in which the total rooms are 3-5. In this type of AC cooled air from the Air conditioning unit supplied into the room. Generally the capacity of package type air conditioner is 3-10 tonnes. But now a day these AC's are available of 15 tonnes or 200 m^3/min of air flow capacity.

3.3 Central type air conditioner

Central type air conditioner is used in the big buildings and industries for full filling the need of the cooled air. The capacity of Central type air conditioner is more than 25 tonnes of refrigeration or 2500 m^3/min of conditioned air. Another method classifying of AC system is the type of fluid used for heating or cooling AC methods classified as per fluid used air.

Direct expansion system.
All water system.
All air system.
Air-water system.
Heat pump system.

4. Principle of AC Plant

Air conditioning plant mainly works on the principle of compression refrigeration system. Main parts of this system are following-

Compressor.
Expansion valve.
Condenser.
Flash chamber.
Evaporator.
Pressure balancing valve.
Inter cooler.

4.1 Compressor- The function of a compressor is to take the refrigerant at low pressure and low temperature.

4.2 Expansion Valve- The function of an expansion valve is to reduce the pressure of the liquid refrigerant keeping its total enthalpy constant.

4.3 Condenser- To function of condenser is to convert high pressure refrigerant vapour into high pressure refrigerant liquid.

4.4 Flash Chamber- In the flash chamber the refrigerant vapour is separated from refrigerant liquid and its prevent the flow of vapour into evaporator and allows liquid refrigerant to flow.

4.5 Evaporator- It is a refrigerator or actual cooler where the cooling is required heat remove from evaporator by the low temperature refrigerant into latent heat.

4.6 Pressure Expansion Valve- The function of the back pressure valve is to reduce the pressure of vapour from high pressure to low pressure.

4.7 Inter Cooler - The function of the inter cooler or heat exchanger is to despair heat the vapour coming from compressor in multi compressor. it reduce the work of compressor.

5. Components Used in AC Space

Generally these are the following components which used in the AC space-

1. Compressor2. Condenser3.Dryer 4.Damper 5. Duct

6. Evaporator 7. Expansion 8.Electric motor 9. Filter

10. Flash chamber11. Humidifier12.Pipe13. Muffler

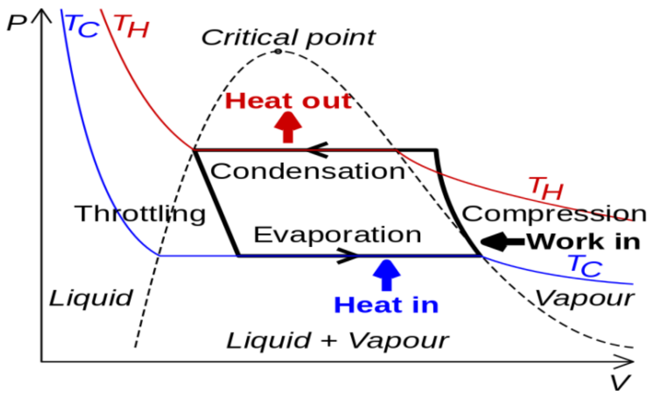
14. Receiver15. Blower 16.Accumulator17. Grill

18. Oil separator19. Stop valve20. Fans

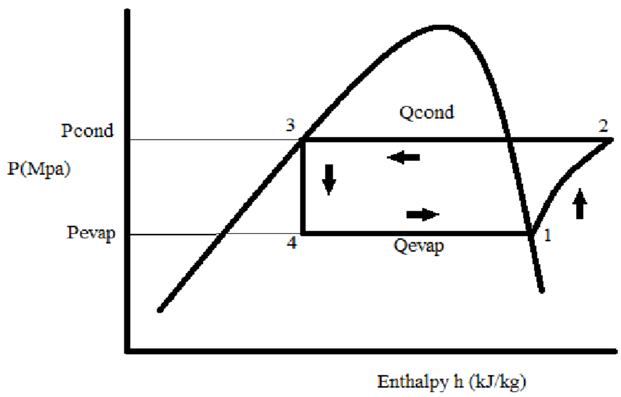
6. Process ofVapour Compression Cycle

Different process of vapour compression shown on the PH chart-

Process of the vapour compression cycle is shown in above figures-



{1. P-V diagram of vapor compression refrigeration cycle}



{2. P-h diagram of vapor compression refrigeration cycle}

1-2 isentropic compression

2-2'Desuper heating

2'-3 isothermal and isotropic condensations

3-4 adiabatic expansion

4-1 isobaric and isothermal evaporation

Symbolic presentation of vapour compression cycle we can divide this cycle in two parts.

High pressure side.
Low pressure side.

7. Design Condition

OUT SIDE CONDITION (In summer)

D.B.T -- 42°C **2.**W.B.T -- 22°C **3.** R.H -- 30°C

Hot and dry conditions *i.e.* inside condition (comfort feeling)

D.B.T -- 23°C **2.** R.H -- 60°C

Time G.A.M to G.P.M (May + June)

Latitude angle - 23°north location

LOAD CALCULATION

AIR CONDITIONING LOAD SOURCE

There are two types of load source-

External source 2. Internal source

EXTERNAL SOURCE- Heat transfer through building structure heat gain by solar radiation in titration load due to the leakage of outside air

INTERNAL SOURCE- Load by the occupant's electrical equipment heat load and product load.

The following data refers to air conditioning of a hospital hall-

Outdoor conditions = 40°C DBT, 20°C WBT.

Required comfort conditions = 20°C DBT, 50% RH.

Setting capacity of hall = 1000Amount of outdoor air supplies = 0.3m³/min/Person.

If the required condition is achieved air by adiabatic humidifying and then cooling air.

1) The capacity of cooling coil and surface temperature of the coil if the bypass factor is 0.25 and.

2) The capacity of the humidifier and its efficiency.

Calculation -

Given data-

DBT_1 = 40°C

DBT_2 = 20°C

WBT = 20 °C

RH= 50% = 0.5

Cooling capacity of cooling = $m(h_1-h_2)$

$m = v/\mu = (m^3/min)\times m^3$

Vol. = 0.89 m^3/kg

for P-chart-

$m = (0.3 \times 1000)/(0.89\times 60) = 5.81$ kg/sec.

from P- chart-

h_1=h_2 = 57.5 kj/kg

h_2= 39 kj/kg

Cooling capacity = m(h_1-h_2) = 5.61(57.5-39) = 103.63 kw

Given bypass factor =0.25

As we know that-

Bypass factor = (t_4-t_2)/(t_4-t_3)

0.25= (t_4-20)/(t_{4-}35)

t_4 = 14°C

Capacity of humedifier-

m(w_2-w_1) ; (w_2=w_3)

from P- chart

w_1 = 0.00645

w_2 = 0.0073

Now Capacity of humedifier = 5.61×(0.0073-0.00645) = 4.76×10^{-3} kg/sec = 4.76 gm/sec.

TYPES OF LOAD

There are two types of loads-

Sensible heat load **2.** Latent heat load.

SENSIBLE HEAT LOAD

Heat flow through the exterior walls, ceiling floor, windows, doors due to the temperature difference between their two sides.
It is due to solar heat radiation through (sun load) it is divided into two forms.
Heat transmitted directly by radiation through glass window and ventilators.
Heat from sun will be absorbed by roof and wall in conduction.
Heat received from the occupant.
Heat received from the different equipments which are commonly used in AC building.
Heat received from the unfiltered air from outside through cracks indoor, windows and ventilators and through their frequent opening.
Miscellaneous heat sources.

LATENT HEAT LOAD

The amount heat removed in the form of latent heat is known as latent heat. Latent heat is following types-

SUN LOAD- [Load due to direct radiation through glass]

The glass has high transitivity so that the considerable amount by heat is burned direct in the air conditioned space by the sun radiation through the glass. The amount of solar heat delivers to an AC space through the glass various from hour to hour from day to day from latitude to latitude.

LOAD FROM OCCUPANTS- The heat emitted from the bodies of the people also constitutes a major portiere of a summer cooling load.

The heat quantity given up by the occupants are dependent on activity of the person sex, age, and indoor D.B.T.

EQUIPMENT LOAD- The electric fan, hot plates and lighting equipment generator space, one of the major loads in much air conditioning system is the light load.

Equipment cooling load for electric appliances in term of **Kj/hr**is given by equipment.

Q = Kw×800×use factor for **KJ/hr**
The value of use factor residence commercial store and shop usually 1.
Use factor = actual voltage in use install voltage.
Kw = actual power transmitted to Driven shaft.

8. Practical analysis

FROM BUILDING STUCTURE

1. The thickness of the wall is approximately 23cm and a plaster layer is both sides of the wall.
2. The inside of the wall has a seat of 2.54 centimeters thermocol.
3. After thermocol, 1.27 cm thick gypsum board is installed
4. The roof of the building is of 10 cm thick cement concrete. After this, 1 cm thick application seat is installed, between these plaster and ply; there is a 2.54 cm thick thermocol seat, followed by 5 cm thick glass wood.
5. The plaster of the building is made of 10 cm concrete and 2.5 cm insulation.

Size of door	No of doors
2×2m²	04
Size of window	No of windows

$1.2\times1.2m^2$	16
$1.0\times0.9m^2$	15
$0.03\times0.4m^2$	04

TOTAL AREA OF WALL-

A = Total area of wall with door and window

[Total area of door + total is of window]

$A = [(11.5\times17) + (39.25\times11.5)] - [(2\times2)\times4 + (1.2\times1.2)\times16 + (1\times0.9)\times1 + (0.5\times0.4)\times4]$ m2

$A = 646.87 - 53.34$

$A = 593.53m^2$

Overall heat transfer coefficient for wall:

$[1/V = 1/F_0 + x/k + 1/F_i]$

Where-

F = Heat transfer coefficient on outer surface = 19.5 kcal/hr m^2 °k

F_i = Heat transfer coefficient on inner surface = 9 kcal/hr m^2 °k

S.no	Material	Thickness	Conductivity
1	Brick	23 cm = 0.23 m	0.697
2	Cement	1.25 cm = 0.0125 m	0.818
3	Thermocol	2.54 cm = 0.0254 m	0.027
4	Gypsum board	1.27 cm = 0.012 m	0.35

{1. Table - Overall heat transfer coefficient for wall}

$[1/V = 1/F_0 + x_1/K_1 + x_3/K_3 + x_4/K_4 + x_5/K_5 + 1/F_i]$

$1/V = 0.051+0.513+0.329986+0.013+0.0153+0.0363+0.941+0.125$

$1/V = 2.026886$

$1/V = 1/2.0269$

$V = 0.49337$ kcal/hr m^2 °k

$V = 0.49337\times4.2\times[(100\times60)/60]$

$V = 0.771$ w/m^2°k

Now heat transfer through wall-

$Q_w = A_w \times U_w \times \eth t$

$Q_w = 593.535\times0.771\times(42-23)$

$Q_w = 8694.69$

Heat transfer through roof

Area of roof = Area of (1) + Area of (2)

$= (39.25\times11.5) + (17.25\times11.5)$ m2

$= 451.375+198.375$

$= 649.75\ m^2$

Overall heat transfer coefficient for wall:

$[1/V = 1/F_0 + x/k + 1/F_i]$

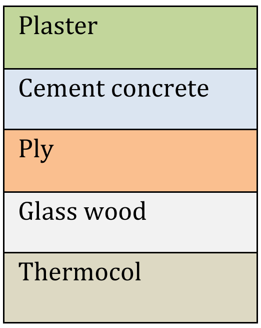
Where-

F_0 = Heat transfer coefficient on outer surface = 19.5 kcal/hr m^2 °k

F_i = Heat transfer coefficient on inner surface = 8 kcal/hr m^2 °k

S.no	Material	Thickness	Conductivity
1	Plaster	1.25 cm = 0.0125 m	0.18
2	Cement concrete	10.00cm = 0.1 m	0.52
3	Ply	1.00 cm = .01 m	1.42
4	Glass wood	0.05cm = 0.005 m	0.034
5	Thermocol	2.54cm = 0.0254 m	0.027

{1.1 Table - Overall heat transfer coefficient for wall}



{Fig:- Materials used in the building}

$[1/V = 1/F_0 + x_1/K_1 + x_3/K_3 + x_4/K_4 + x_5/K_5 + 1/F_i]$

F_0 = Air films coefficients (outside)

F_i = Air films coefficients (inside)

$1/V = (0.05128+0.01529+0.01023+0.012528+0.806+0.44) = 1.56$

$V = .063\times4.2\times[(1000\times60)/60]$

$V = 0.774 w/m^{2\circ}k$

Now heat transfer through the roof-

$Q_R = A_r \times u_r \times ðt$

$Q_R = 0.744\times650\ (42 - 2375)$

$Q_R = 11606.4$ w

Heat transfer through the floor-

Area of floor = Area of roof = 650 m^2

Overall heat transfer coefficient of floor

F_i = Heat transfer coefficient (inside) = 8 kcal/hr $m^{2\ \circ}k$

So

U = 1.1 $w/m^{2\circ}k$ coefficient with 25 insulation **(By C.P. Arora Book)**

So

$R_f = A_f \times U \times ðt$

$R_f = 660\times1.1\times[12\text{-}23\text{-}5]$

$R_f = 10164$ w

Heat transfer through the door and window-

Size of the door according to the outer wall is $2\times2m^2$ and number of doors is 4.

Area of total floor = $4\times2\times2 = 16m^2$

Size of glass in every door = $0.4\times0.2\ m^2$

Number of glass in every door = 4

So

Total area of glass in every door = $4\times0.4\times0.2 = 0.32\ m^2$

Total are of glass in 4 doors = $4\times0.32 = 1.28\ m^2$

Area of wood in 4 doors = 14.72 m^2

S.no	Size of window	No. of window	Area of window (m^2)	Size of glass (m^2)	No of glass	Area of glass (m^2)
1.	1.2×1.2	16	23.04	0.4×0.2	16×4 = 64	5.12
2.	1×0.9	15	13.50	0.3×.035	15×2 = 30	3.15
3.	0.5×0.4	4	0.80	0.2×.03	4×1 = 4	0.24

Total area of window = 37.34 m^2

Total area of glass = 8.51 m^2

Area of wood in window = Total area of window - area of glass

Area of wood in window = 37.34 – 8.51

Total area of wood which is connected to the wall = wooden area of door + wooden area of window

So,

Total area of wood which is connected to the wall = 14.72+2.3 = 43.55m^2

Total area of glass which is connected with window and door (outside) = [total area of glass in window + total area of glass (indoor)]

So,

Total area of glass which is connected with window and door (outside) = 8.51+1.28 = 9.7 m^2

Overall heat transfer through coefficient the glass-

h_0 = 19.5 Kcal/hr $m^{2\ \circ}k$

h_i = 8 Kcal/hr $m^{2\ \circ}k$

Thickness of wood = 4 cm

Conductivity of wood = 0.124 Kcal/hr $m^{2\ \circ}k$

$1/V = 1/h_0 + \times/K + 1/h_i$

$1/V = [(1/19.5) + \{4/(100\times0.120)\} + (1/8)]$

$1/V = 0.05128 + 0.325 + 0.125$

$1/V = 0.49886$

$V = 2.0045$ Kcal/hr m^2 $^\circ$k

$V= 2.00$ Kcal/hr m^2 $^\circ$k

$V = 2.005 \times 4.2 \times \{(100/60) \times (1/60)\}$

$V = 2.3386$ w/ m^2 $^\circ$k

Overall heat transfer through coefficient of glass-

$h_0 = 19.5$ Kcal/hr m^2 $^\circ$k

$h_i = 8$ Kcal/hr m^2 $^\circ$k

Thickness of glass = 0.4 cm

Conductivity of glass = 0.701 Kcal/hr m^2 $^\circ$k

$1/V = 1/ h_0 + \times/K + 1/ h_i$

$1/V = [(1/19.5) + \{0.4/ (100\times0.701)\} + (1/8)]$

$1/V = 0.05128 + 0.005706 + 0.125 = 0.18199$

$V = 5.495$ Kcal/hr m^2 $^\circ$k

$V = 5.495 \times 4.2 \times \{(100/60) \times (1/60)\}$

$V = 6.41$ w/ m^2 $^\circ$k

Heat transfer through wood –

$Q_{w1} = A_1 W_1 U_{W1}\ \eth t$

$Q_{w1} = 43.55 \times 2.437 \times (42-23)$

$Q_g = 1183.0236$ w

9. Final Result

Total heat transfer load through building structure-

$Q = Q_w + Q_r + Q_f \times Q_{w1} + Q_g$

$Q = 7158.3803 + 11606.4 + 1001 + 2016.49 + 1183.0236$

Q = 31974.23 w

SOLAR RADIATION

Solar radiation is an important factor for heat load AC space. Property of transitivity is in the glass. By which the solar rays that comes from sun does transmitted. Due to which the heat released from radiation for AC space is concede. This heat load changes with hour to hour, day to day and angle latitude to latitude.

The glass in the windows and doors of the nursing home, which appears to be double glass, is for layer insulation of 5 millimeters of air. The main condition for solar radiation is the latitude angle 23°C at time 6pm.

INTRODUCTION OF PACKAGE TYPE AIR-CONDITIONER

In package type air conditioning systems all conditioning equipment such as compressor condensers today are in a box. Thus the total assembly is known as package air conditioner. Package air conditioners are used wherever there is a shortage of space in big cities; it is economical with control air conditioning for the load of goods. The conditioner in the package system is primarily air-cooled and the compressor is a reciprocating compressor with an expansion device and an evaporator coil. Cold air from the evaporator's control is delivered to the ducts through air conditioning space with the help of a blower. Package type air conditioning units are small in size and have a capacity of 5 tonnes to 10 tonnes.

MAIN PARTS OF UNIT

1. Compressor

2. Condenser

3. Expansion device

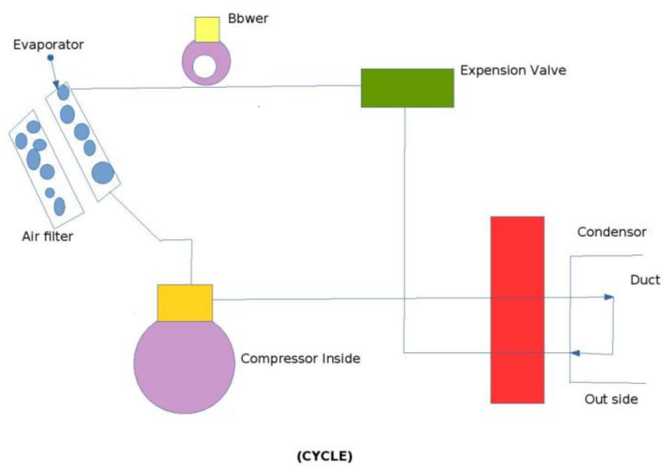
4. Evaporator coil

5. Fan

6. Blower

7. Duct

8. Filter



{Fig. main parts of unit}

DUCT DESIGN

The duct should be design to carry he required quantity of air from the 10 tonnes air conditioned space with minimum loses and its size should be must economical the velocities in the duct must be light enough to reduce the size of the ducts.

There are mainly 3 methods which are commonly used for duct design.

1. Equal friction loss (Pressure drop) method.
2. The static regain method.
3. Velocity reduction method.

EQUAL FRICTION LOSS (PRESSURE DROP) METHOD

The size of duct design to give equal friction loss per method of duct the advantage of this method or system are-

If the duct layout is symmetrical giving length in each run then no members are required to balance the system as this method gives equal pressure loss in various branches.

THE STATIC REGAIN METHOD

For the perfect balancing of duct layout system, the pressure at all outlets must be made same this is possible if the friction loss in each run is made equal to the pressure gain due to reduction in velocity the pressure gain (static pressure) is due to change in velocity is given by $[0.5\{(v_1^2-v_2^2)/2g\}]$.

Where 0.5 indicate the regain, the advantages of this system are-

1. It is possible to design long runs as well as shear runs (here the fan from complete regain).
2. It is sufficient to design the main duct for complete regain and use the pressure at outlet the branches.

VELOCITY REDUCTION METHOD

The duct designed in which a way that the velocity decrease as flow process the pressure drops are calculated from these velocities dispatch branches and main duct the fan is designed to overcome the pressure losses along any single run including the losses of main duct branch duct elbows, valves etc. the pressure outlet is adjusted by damper in the ducts.

ADVANTAGES OF THIS SYSTEM:

1. This method is easiest among method in sizing the duct diameters.
2. The velocities can be adjusted to avoid noise.

This is adopted only for simple system.

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