Palestine Polytechnic University

College of Engineering and Technology
Mechanical Engineering Department

Graduation Project

Treatment of Green house effect in glass dome of "Fawzi Kawash Center"

Project Team

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Hebron-Palestine

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Palestine Polytechnic University
(PPU)
Hebron-Palestine

PROJECT NAME

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According to the project supervisor and according to the agreement of the Testing committee members, this project is submitted to the Department of Mechanical Engineering at college of engineering and technology in partial fulfillment of the requirements of (B.SC) degree.

Supervisor Signature

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Examine community Signature

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Department Head Signature

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June, 2010

Dedication

To our parents who

Spent nights and days doing their best

To give us the best

To all students and who

Wish to look for

The future...

To who love the knowledge and

Looking for the new

In this world

To who carry candle of science

To light his avenue

Of life

To our beloved country Palestine

To all of our friends

Talab Al-Tell

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To my great supervisor, who offered his best for this project to see light through his instructions and advices, Dr. Ishaq Sider with all his kindness and wisdom I thank him.

I would also like to thank every person who offered anything to make this work success; we sincerely believe that this work wouldn't exist without his inspiration. Great thanks to my college for the support and help, and anyone who helped me in my project.

Thanks to

My great Palestine Polytechnic University (PPU)

My College of Engineering and Technology (CET)

My Mechanical Department (MD)

Abstract

Treatment of Green house effect for a glass dome of building of
“Friends of Fawzi Kawash IT Center of Excellence”

Palestine Polytechnic University

2009

Dr. Ishaq Sider

The project aims to study the problem of Green house effect in the glass dome of building of “Friends of Fawzi Kawash IT Center of Excellence” That belongs to Palestine Polytechnic University, and offer solution for this problem then Implementation the ventilation method for this problem.

After selection the suitable Fans for the project we testing the devices, monitoring the state and give the recommendation of the project.

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General Introduction

- **General outlook**
- **Project Scope.**
- **Main Tasks and Activities.**
- **Time Planning**
- **Budget**

1.1General outlook

In this project, we mention to green house effect under the glass domes and in our case, we talking about the glass dome located in one of the facilities of the Palestine Polytechnic University which the Friends of Fawzi Kawash IT Center of Excellence in the Abu Roman

It is noticed that when you sit under glass dome and directly of sunlight on sunny day ,the interior of the dome gets much warmer than the air outside ,and you may have wondered why the place acts like a heat trap. The answer lies in the spectral transmissivity curve of the glass , ,as shown in the figure (1-1) . we observe from this figure that the glass at thicknesses encountered in practice transmit over 90 percent of radiation in the visible range and is practically opaque (nontransparent) to radiation in the longer –wavelength infrared region of the electromagnetic spectrum (roughly $\lambda > 3\ \mu m$).Therefore ,glass has a transparent window in the wavelength range $0.3\ \mu m < \lambda < 3\ \mu m$ in which over 90parcent of solar radiation is emitted .On the other hand , the entire radiation emitted by surface at room tempertature falls in the infrared region .Consequently ,glass allows the solar radiation to enter but dose not allow the infrared radiation from the interior surfaces to escape .This causes arise in the interior temperature as a result of the energy build-up in the hall under the dome .This heating effect ,which is due to the nongray characteristic of the glass (or clear plastic),is known as the greenhouse effect.

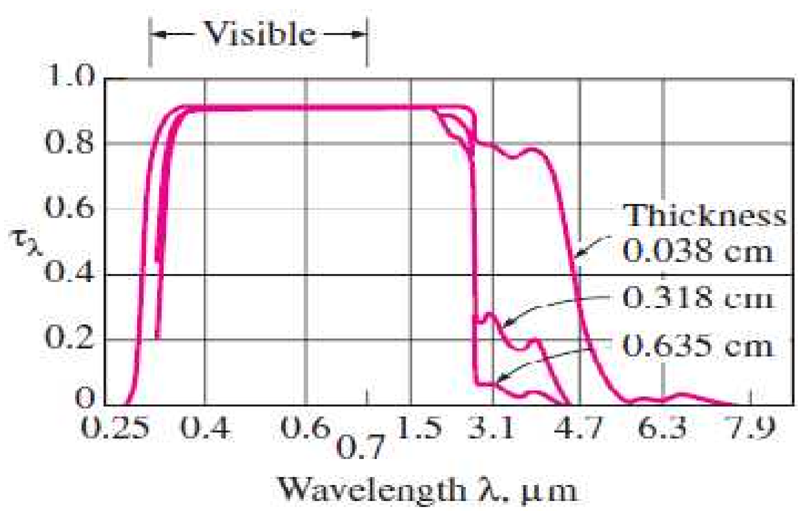


Figure (1-1) the spectral transmissivity of glass at room temperature for different thicknesses

The cause of green house effect, the incident under the dome is a large amount of glass, exposed to sunlight for a long time without an effective ventilation system. This project aims to examine this situation in the building and identify the underlying causes. And also to propose solutions to the problem as well as finding one of these solutions on the ground, and tested to work on during the peak periods of high temperatures and exacerbated the problem the solution going through several stages of the study on the ground and look at the schemes the building, and take statements from those responsible for the building and claimed that they want.

Figure (1.2) a photo of the glass dome of the building

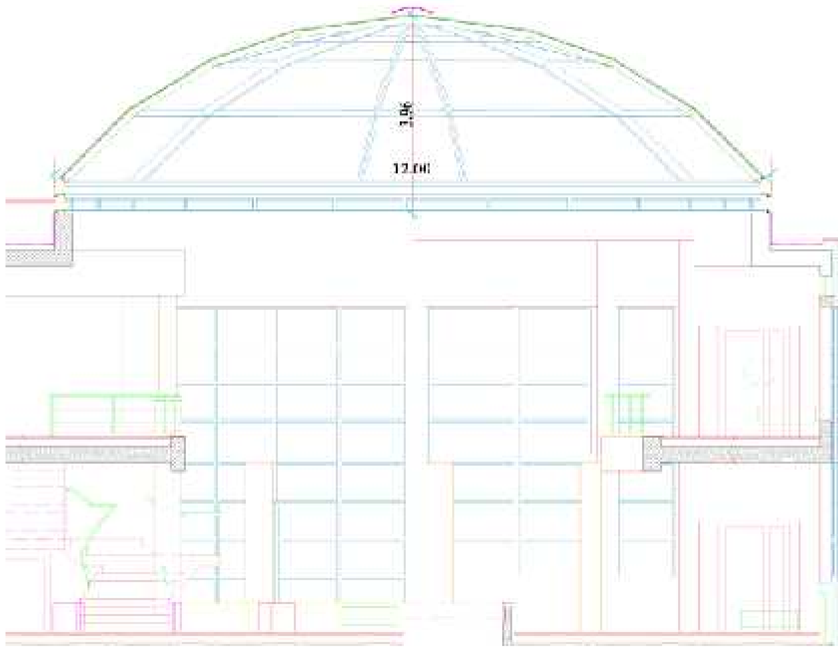


Figure (1.3) schematic drawing of the glass dome

In the greenhouse the sunlight, technically known as incoming solar radiation insulation, passes through the glass but 100% of the ultraviolet radiation is removed. This is why you cannot get a tan or even sunburn through glass. All the remaining sunlight strikes surfaces in the greenhouse and raises their temperature. The air in touch with the surfaces is heated and gradually the temperature of the greenhouse rises. The heat, known as sensible heat because a person can feel it, cannot pass through the glass. The glass has acted like a one-way valve letting sunlight in but blocking heat from escaping. As long as sunlight comes in the temperature will keep rising unless a window or door is opened.

The reason that glass is such a valuable material is that it exhibits a very low absorption of electromagnetic radiation in the visible part of the spectrum, which is a wordy way of saying that it is transparent. It is not, however, transparent either side of the visible range (ultra violet and infra red).when matter in general interacts with radiation it can absorb, reflect or transmit it. One of the basic principles in the understanding of energy is that it always degrades.. Thus the greenhouse glass acts as a one-way energy valve.

1.2 Project Scope

When you use the dome as an alternative to flat roof, the roof and increase the area of changing geometric properties which Increases the acquisition of solar, but notes that the size of the vacuum also changed, as changing the roof height increase (Half the width of the room in case of half spherical dome). This increase in size may be positive if found that the effect of a dome on the thermal gradient in the vacuum Increases the feeling of thermal comfort, or the presence of holes in the top of the dome to help out in the hot air. In this case, there is a corresponding performance may offset the negative impact of increased radiation acquisition of the dome, As in the case of air-conditioned spaces, increase in size adds a negative impact loads up a new air-conditioning.

1.3 Main Tasks and Activities

The main tasks include

.

- Studying previous cases that discussed this problem.
- Knowing why the greenhouse Phenomenon occurs in this dome.
- Applying the Air conditioning principles on the glass dome.
- Find the volume of the dome and the most appropriate way to resolve the problem.
- Account of convection resulting from the sunlight under the dome.
- Determine the characteristics of the ventilation system be appropriate and characteristics of objects used.

1.4 Time Planning

The project plan follows the following time schedule, which includes the related tasks of study and system analysis.

The following time plan is for the first semester

Selecting the project															
Reading															
Introduction Visiting the building															
Calculation the solar radiation and Selection the fans															
Printing the final report installation the fans, testing															
Project Documentation															

Table1.1: The first semester Time Plan

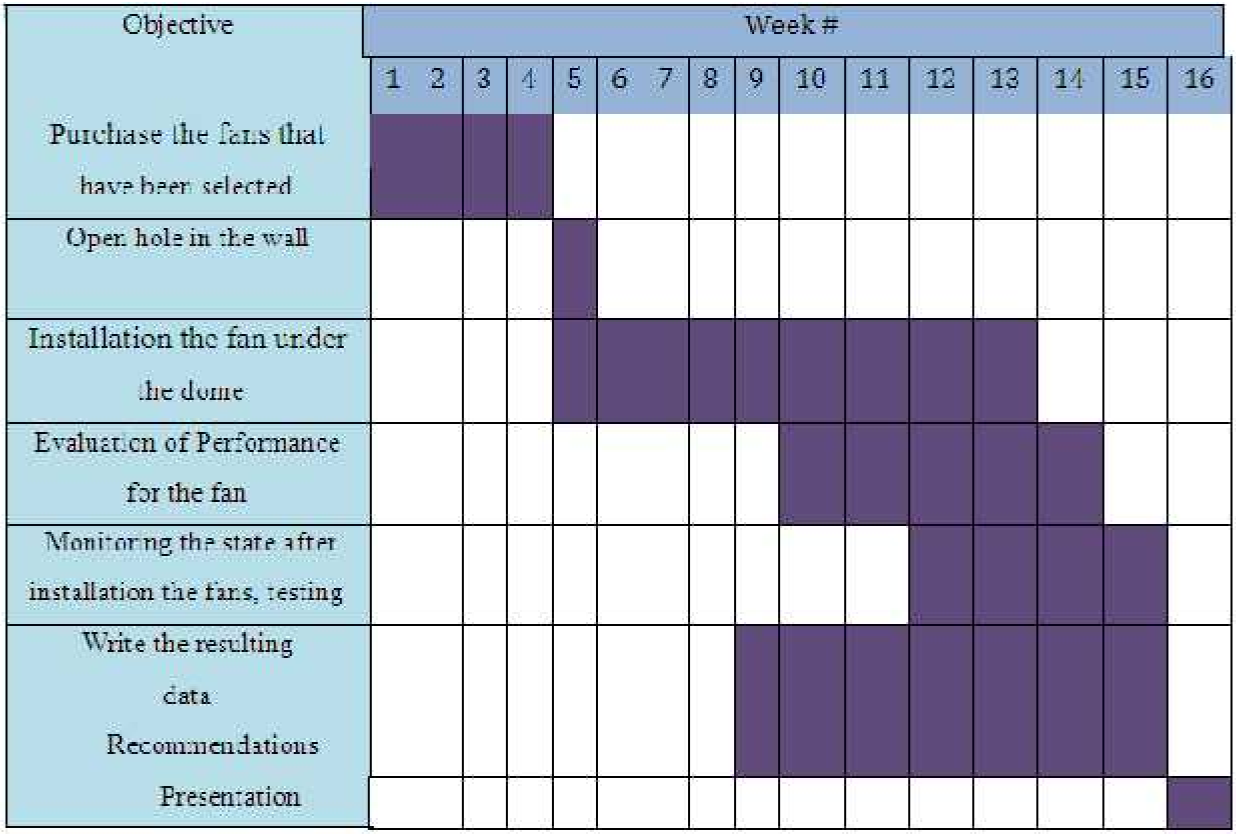


Table1.2: The second semester Time Plan

1.5 Budget

TASK	**COST** (NIS)
Researches and Internet	300
Transportations	200
Printing papers	120
Equipment	2430
Accessories of the project	700
TOTAL	**3750**

Table 1.3 Budget

Chapter Two

- **Previous Studies.**
- **Thermal comfort.**
- **Properties of Glass.**
- **Solutions proposed to solve the problem.**

2.1 Previous Studies

2.1.1 Berlin Parliament House

Lord Norman Foster's new Reichstag in Berlin combines unlike structural elements:. The building’s re-imagined dome is the central element in which all of these issues meld. It serves as a high-tech example of the stack effect seen in passive ventilation. The glazed dome is an architectural nod to the dome that was damaged during WWII, and it also serves as complex light funnel, bringing daylight deep into the building.

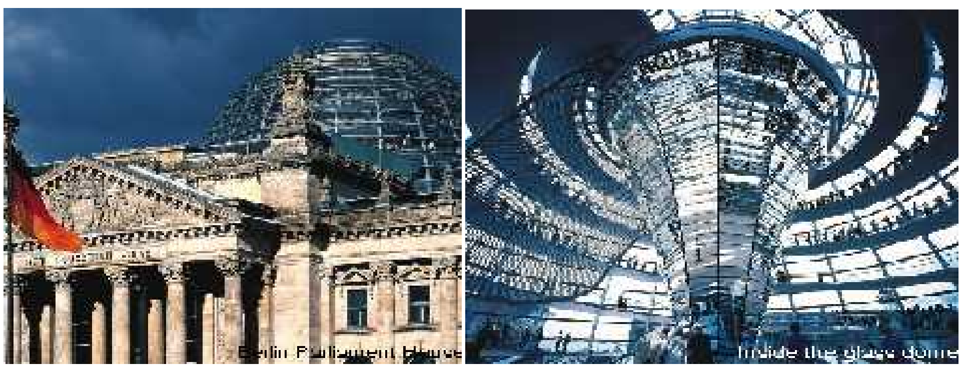


Figure (2.1): View of the Berlin Parliament House

Natural Ventilation and Lighting Concept Within the steel and glass dome, is an inverted conical structure, which performs dually in the passive ventilation of the Reichstag, and in a day-lighting capacity as well. The inverted cone, referred to as the ‘light sculptor’ is covered in reflective surfaces that bounce light from the horizon (as opposed to direct sunlight) into the assembly chambers. The light sculptor is effectively acting as a lighthouse in reverse.

In order to reduce glare and heat gain from the light sculptor's reflective surfaces, a rotating sun shade along the inside edge of the dome is operated by computer and follows the sun's course through the day. The light sculptor also funnels heat gain at its apex. The hot air within this cavity rises and is exhausted at openings at the top of the dome. This displaced air draws fresh air from intakes located at the perime.

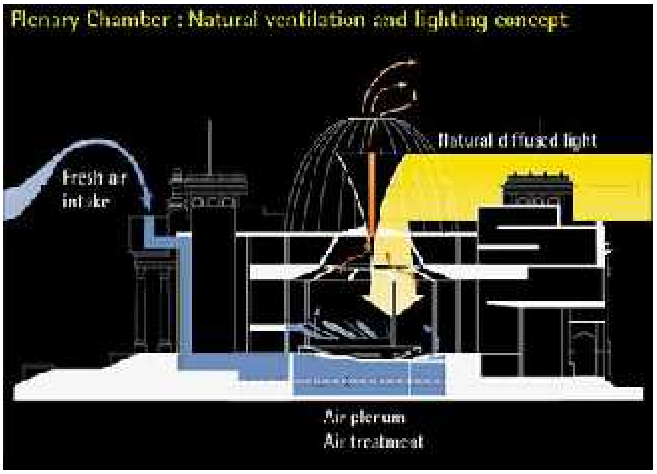


Figure (2.2): Natural ventilation and lighting concept the Berlin Parliament House

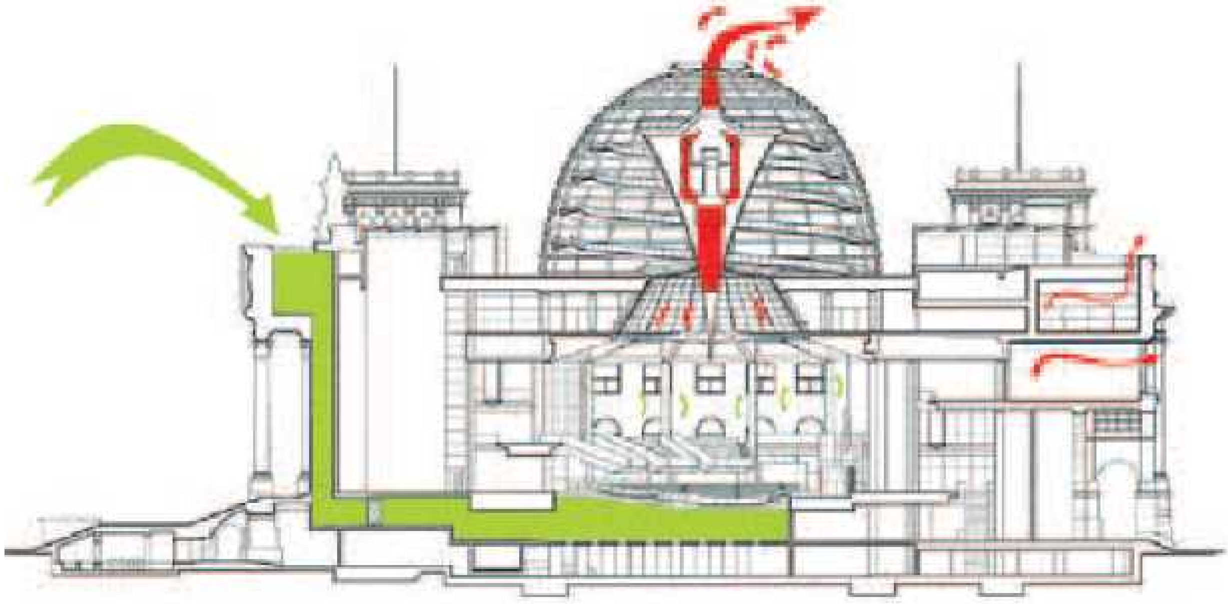


Figure (2.3): Natural ventilation and lighting concept the Berlin Parliament House

2.1.1.1 Ventilation

Ventilation air enters offices through grilles in the floor. When the vents in the facade are open, local cooling and heating systems are deactivated to minimize energy waste. During the winter, heat and moisture are recovered from the outgoing air, and hygroscopic thermal wheels condition incoming air.

2.1.1.2 Heating and Cooling

For cooling the building during warm weather, naturally chilled groundwater is brought up from the aquifer through holes bored through 410 feet (125 meters) of London clay. The water circulates through hollow structural members, and, without the need for mechanical chillers, the system uses far less energy than air conditioning units. After circulating, the groundwater is used to flush toilets, reducing the building's demand on the conventional city water supply.

Environmental control is provided throughout office areas by displacement ventilation and chilled beams. The vents around the perimeter are also open able to allow fresh air into the office space. The local heating is automatically shut off when a nearby vent is opened. These systems are simple, on troll able and represent good practice.

2. 2 Thermal comfort

Human thermal comfort is defined by ASHRAE as the state of mind that expresses satisfaction with the surrounding environment Maintaining thermal comfort for occupants of buildings or other enclosures is one of the important goals of HVAC design engineers.

Thermal comfort is affected by heat conduction, convection, radiation, and evaporative heat loss. Thermal comfort is maintained when the heat generated by human metabolism is allowed to dissipate, thus maintaining thermal equilibrium with the surroundings. Any heat gain or loss beyond this generates a sensation of discomfort. It has been long recognized that the sensation of feeling hot or cold is not just dependent on air temperature alone.[2]

2.2.1 Importance of thermal comfort

Thermal comfort is very important to many work-related factors. It can affect the distraction levels of the workers, and in turn affect their performance and productivity of their work. Also, thermal discomfort has been know to lead to Sick Building Syndrome symptoms. The US EPA BASE study found that higher indoor temperatures, even within the recommended thermal comfort range, increased worker symptoms. The occurrence of symptoms increased much more with raised indoor temperatures in the winter than in the summer due to the larger difference created between indoor and outdoor temperatures

2.2.2 Relative humidity

The human body has sensors that are fairly efficient in sensing heat and cold, but they are not very effective in detecting relative humidity. Relative humidity creates the perception of an extremely dry or extremely damp indoor environment. This can then play a part in the perceived temperature and their thermal comfort. The recommended level of indoor humidity is in the range of 30-60%.

A way to measure the amount of relative humidity in the air is to use a system of dry-bulb and wet-bulb thermometers. A dry-bulb thermometer measures the temperature not relative to moisture. This is generally the temperature reading that is used in weather reports. In contrast, a wet-bulb thermometer has a small wet cloth wrapped around the bulb at its base, so the reading on that thermometer takes into account water evaporation in the air. The wet-bulb reading will thus always be at least slightly lower than the dry bulb reading. The difference between these two temperatures can be used to calculate the relative humidity. The larger the temperature differences between the two thermometers, the lower the level of relative humidity.

2.3 Glass

Glass is a type of solid material which is typically brittle and optically transparent. Glass is commonly used for windows, bottles, or eyewear and examples of glassy materials include soda-lime glass, borosilicate glass, acrylic glass, sugar glass, Muscovy-glass, or aluminum ox nitride The term glass developed in the late Roman Empire. It was in the Roman glassmaking center at Trier, now in modern Germany, that the late-Latin term glues originated, probably from a Germanic word for a transparent, lustrous substance.

Strictly speaking, a glass is defined as an inorganic product of fusion which has been cooled through its glass transition to the solid state without crystallizing. Many glasses contain silica as their main component and glass former. The term glass is, however, often extended to all amorphous solids (and melts that easily form amorphous solids), including plastics, resins, or other silica-free amorphous solids. In addition, besides traditional melting techniques, any other means of preparation are considered, such as ion implantation, and the sol-gel method. Commonly, glass science and physics deal only with inorganic amorphous solids, while plastics and similar organics are covered by polymer science, biology and further scientific disciplines.

Glass plays an essential role in science and industry. The optical and physical properties of glass make it suitable for applications such as flat glass, container glass, optics and optoelectronics material, laboratory equipment, thermal insulator (glass wool), reinforcement fiber (glass-reinforced plastic, glass fiber reinforced concrete).

2.4 Solutions proposed to solve the problem

2.4.1 Window insulation film

Window insulation film is a plastic film which can be applied to glass windows to reduce heat transfer.

There are two types in common use designed to reduce heat flow via radiation and convection respectively.

2.4.1.1 Solar control film

This works by reflecting the infra-red component of solar energy (often 700W/sq M) and absorbing the UV component. Some films are also silvered or tinted to reduce visible light.

Typical absorption for a silvered film is 65% for visible and infra red with 99% for UV. This type of film sticks directly onto the glass.

2.4.1.2 Convection control film

This film is attached to the window frame using double sided pressure sensitive tape. The effect is to create a double glazed system with a still air layer about 0.5 inches thick between the film and the glass. This restricts the convective air flow which efficiently transfers heat onto the inside glass surface. The reduced heat flow also can prevent condensation which is triggered when the temperature of the inside surface falls below the dew point.
Assuming an outside temperature of 0C with wind velocity 15mph and inside temperature 20C condensation occurs at only 30%RH relative humidity with a single glazed system compared with 60%RH for a double glazed system [4]

Condensation also transfers an additional 2200 J/ml which is significant.

The film is a heat-shrink plastic which allows a hair dryer to be used to remove creases and improve optical clarity. Since the thermal conductivity of air (0.024 W/mK) is much less than glass (0.96 W/mK) the heat flow via conduction could be theoretically reduced by 97.5% though this is limited in practice by slow air movement in the convective cell formed between the film and the glass.

Solar control film is an effective way to control excessive sunshine during the summer months. Convection control film is often used in winter when the outgoing heat flow is more important, especially for single-glazed windows where the temperature difference is often sufficient to cause condensation.

2.4.2 Small patch of garden

Glass transmits the visible light radiated by the white hot sun but it absorbs the infrared light radiated by objects near room temperature. This selective absorption and transmission gives rise to the "greenhouse effect."

a small patch of garden is bathed in sunlight. The sun is transferring heat to this garden by radiation but the garden's temperature remains essentially constant. Why doesn't the garden get hotter and hotter.

The garden transfers heat elsewhere exactly as fast as heat arrives.

because the garden warms up until its rate of heat loss is exactly equal to its rate of heat gain. With as much heat leaving as arriving, there is no further change in the thermal energy content of the garden and its temperature remains constant.

If you cover the garden with a glass dome, what happens to the garden's ability to get rid of heat via radiation the garden has more difficulty getting rid of heat.

because Some of the thermal radiation emitted by the garden is absorbed by the glass. The glass gets hotter and it also emits thermal radiation. Some of this thermal radiation is sent back toward the garden.

The glass dome affect the garden's temperature by The garden's temperature rises because Since the garden is now receiving more thermal radiation than before, its temperature rises until it's able to eliminate heat as fast as that heat is arriving. And in our project the garden ready-made in the hall and we will study its effect on the "greenhouse effect.”

2.4.3 Thermal mass

A thermal mass in the most general term refers to any mass used to absorb and hold heat. Materials with high specific heat like stone, concrete, adobe or water work best.

Thermal mass is often confused with insulation, but is distinct from it.

Thermal mass is used in and around buildings to absorb or emit heat. Internal thermal mass in a well-insulated building, such as concrete or other forms of masonry, or water, reduces temperature swings in the interior. This reluctance to change temperature is related to the specific heat capacity of the mass. Water has a high specific heat and tanks of water are often used as a thermal mass.

Thermal mass is often used in solar heating systems to absorb heat during the day and release heat into the living area during the night. The thermal mass can also help over longer periods like an overcast day. In simple solar heating systems the thermal mass may directly absorb sunlight while in more complex systems moving liquid or air is used to move heat between the collectors, the thermal mass and the living area.

Earth sheltering is another important architectural means of using thermal mass. By placing exterior walls in direct juxtaposition to earth, the thermal mass of the earth provides a fairly constant, moderating temperature so that heat flow through the adjacent wall is greatly slowed.

2.4.4 Ventilation

Ventilation defined as "supply of fresh air to the conditioned space either by natural or by mechanical means for the purpose of maintaining acceptable indoor air quality". However, when outdoor conditions are suitable, the ventilation can also be used for cooling of the buildings, for cooling of the occupants or both.

When the ambient dry bulb temperature is lower than the building temperature, then the outdoor air can be used for cooling the building. Normally due to solar and internal heat gains, buildings can become hotter than the ambient air. This provides an opportunity for cooling the building at least partly, by using the freely available outdoor air. This can significantly reduce the load on air conditioning plants. Though the cooling of buildings during daytime may not be possible on all days, in an year there are many days during which outdoor air can act as a heat sink for the building. Greater opportunities exist for cooling the buildings especially during the night, when the outdoor air is considerably cooler. This is especially effective for hot and dry climates where the diurnal temperature variation is quite large.

Under certain circumstances, outdoor air can also be used very effectively for cooling the occupants of a building directly. By allowing the outdoor air to flow over the body at a higher velocity, it is possible to enhance the heat and mass transfer rates from the body, thus leading to a greater feeling of comfort. As a thumb rule, studies show that each increase in air velocity by 0.15 m/s will allow the conditioned space temperature to be increased by 1 ^oC. As mentioned before, maintaining the conditioned space at a higher temperature can give rise to significant reduction in the energy consumption of the air conditioning system. However, in general the air velocity if it exceeds about 1.0 m/s may give rise to a feeling of draft or irritation to the occupants.

The cooling effect provided by ventilated outdoor air is mainly sensible in nature, even though, it may also extract latent heat from the occupants if it is cool and dry. The sensible cooling rate provided by the outdoor air Q_v is given by:

$$\mathbf{Q_v = m_v \cdot c_p (T_{ex} - T_o)} \qquad \mathbf{(2.1)}$$

Where:

m.v is the mass flow rate of ventilated air

To and T_{ex} are the temperature of the outdoor air and temperature of the exhaust air, respectively.

Natural ventilation

The principle of natural ventilation is very well known and is widely studied. Most of the older buildings before the advent of electricity relied on natural ventilation for maintaining comfortable conditions. However, as mentioned before relying only on natural ventilation imposes several restrictions on building design. For example, windows on opposite walls have to be provided to all the rooms to meet natural ventilation requirements. As a result, large buildings have to be designed in simple T-, L- or H- shapes. The ceiling height has to be high to improve natural ventilation etc. In addition to this, the amount of airflow due to natural ventilation is also uncertain as it depends on:

a) Magnitude and direction of prevailing winds

b) Ambient air temperature

c) Landscaping and adjacent structures

d) Design of the building and position of windows, doors) Movement of the occupants,

Due to its uncertain nature, natural ventilation is treated as a secondary objective in the design of modern buildings. Natural ventilation, as discussed in an earlier chapter depends on wind effect and stack effect.

Forced ventilation using electric fans

As mentioned before, compared to natural ventilation, the use of fans for providing ventilation offers greater flexibility and control. Ventilation using electric fans is less sensitive to outdoor conditions, and hence is more certain. In general, depending upon the specific design, the fan-assisted ventilation can aid or oppose the natural ventilation. Obviously if the aim is to use outdoor air for cooling, then the design should be such that the mechanical and natural ventilations complement each other, rather than oppose. In general, the fan power consumption is quiet small and can be estimated using the equation

$$W_{fan}=\frac{Q'_{fan}*\Delta P_{fan}}{\eta_{fan}} \qquad \textbf{(2.2)}$$

Where: Wfan is the power consumption of the fan in Watts

Qfan is the air flow rate provided by the fan in m^3/s,

ΔP_{fan} is the pressure rise due to fan in Pascal's

η_{fan} is the efficiency of the fan.

The efficiency of the fan may vary from about 0.35 for small shaded pole, single-phase motor (≈1/6 HP) to about 0.85 for large, three-phase motors of about 5 HP capacities

Chapter Three

Calculation of Solar Heat Gain

- **Introduction.**
- **Heat Transmitted Through Glass Dome.**
- **Using the domes**
- **Transmition heat gain**
- **Convection Heat Gain**

3.1 Introduction

In areas with warm and sunny climate, as in Arabic area, it is better to have large windows to the north, to avoid the sun.

Conversely, the walls facing the south, should be more isolated and small windows that allow ventilation, but without introducing a large amount of the sun. In contrast, in cool regions such as Canada, you must choose the direction opposite to earn the largest possible quantity of heat.

In the existing situation we are vulnerable to heat the dome from the south are most influential and therefore be the largest convection enters through this period and the southern half of the dome exposed to the sun.

Therefore enables the expense of heat within the dome by monitoring the sun and find the period which the sun is at its highest radiation during the day

Thus, we can calculate the radiation passing through the dome of equations known in refrigeration books.

To calculate the heat load must be found the total vertical projection area of the glass and the assumption that the sun rays fall vertically on the dome

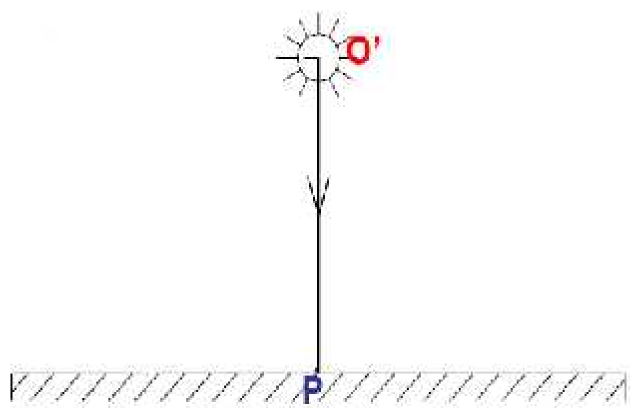


Figure (3-1) the sun over the vertical projection of dome

3.2 Heat Transmitted Through Glass Dome

Solar radiation which falls on the glass has three components which are

(1)Transmitted component: It represents the largest component, which is transmitted directly into the interior of the building or the space. This component represents about 42 to 87% of incident radiation, depending on the lasso's transmissibility value.

(2)Absorbed component: This component is absorbed by the glass its self and raises its temperature. About 5 to 50% of solar radiation it absorbed by the glass, depending on the absorbtivity value of the glass.

(3)Reflected component: This component is reflected by glass to the outside of the building; about 8% of the solar energy is reflected back by the glass.

If certain building has a large area of exposed clear glass then the solar radiation is considered a large part of the cooling load. The amount of solar radiation that can be transmitted through glass depends upon the following factors. [5]

1- Type of glass (single, double or insulating glass)and availability of inside shading (such as venetian blinds, construction overhangs ,wing walls, ect).
2- Hour of day, day of the month, and month of the year.
3- Orientation of glass area.(north, northeast ,east orientation)
4- Solar radiation intensity and solar incident angle.
5- Latitude angle of the location.

3.3 Using the domes

The building shape should allow for maximum volume and minimum heat loss area.
The building shape is a modified globe. Because of this, the surface of the building envelope is only 80% of that of a rectangular building with the same volume. The building shape should be optimized with regard to solar heat admittance.
The shape of the building is derived from a geo-metrically modified sphere, designed to minimize the surface area exposed to direct sunlight.

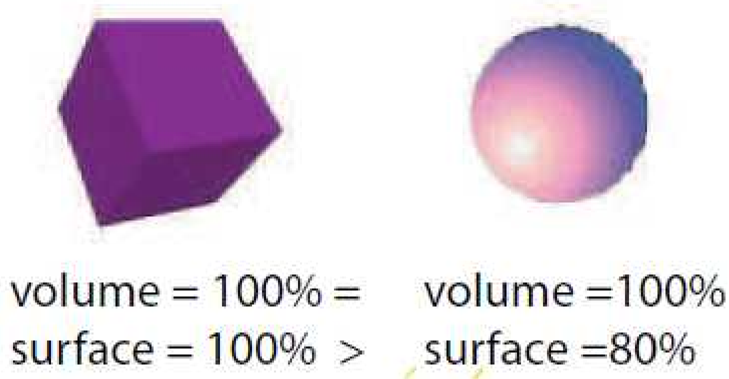


Figure (3-2) the difference between cubic and sphere

If you reduce the use of domes of the acquisition of heat to the bishop or aggravated. There are two views in this regard:
the first believe that the dome reduce the acquisition because the solar part of the roof being covered dome Of solar radiation, while the dome had a shadow over the rest, and the dome itself, not the entire exposed to radiation, The partly exposed to radiation while the other in the shade, Their use reduces the acquisition of the solar roof Planes. The form of the dome contains the largest volume of the void space of the lowest outer surface.
And the second believes that the use of the dome over the flat roof of the exhibition of radiation due to the increase dome flat Area of a circle on the flat roof covered by the (doubled in case of hemispherical dome), which Double acquisition of the solar radiation scattered and more than any savings in the acquisition of the direct rays A result of shades, but doubt the owners of this view that the acquisition of the direct rays less despite the lack of Exposed area of radiation, as a

result of radiation perpendicular to the surface of the dome hemispherical whatever its direction. Although both views start from the introductions to sound scientific, but they arrive in exactly two results contradictory,

Public opinion as a result not to account for the impact of each of them can be quantified for comparison .

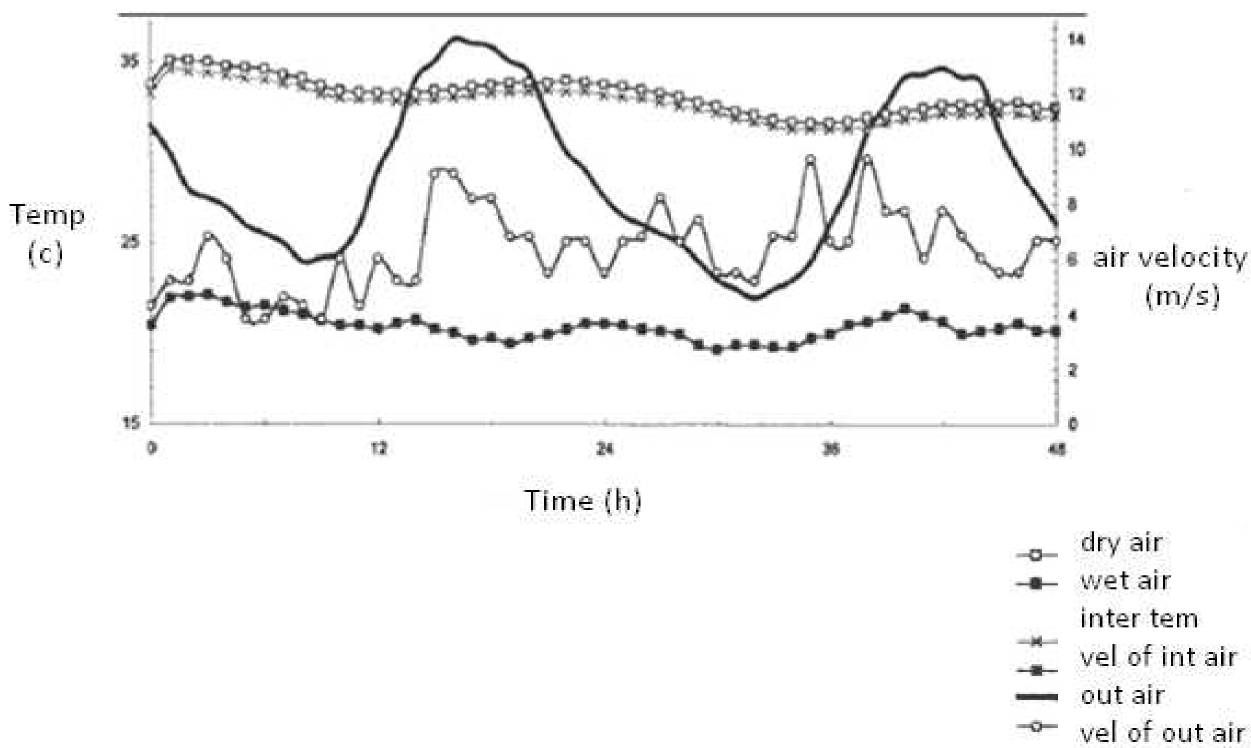


Figure (3.3) Changing of internal and external temperatures under dome

This figure shows Changing of internal and external temperatures under dome in balding at May noted the stability of the internal air temperature was around 33and 35 degrees Celsius, which is higher than the average and beyond the limits of thermal comfort at about 7 degrees Celsius

3.4 Transmition heat gain

Heat gain due to solar transmission through the glass window and is estimated by using Tables A-7 to A-11 where the following factors are selected:

- Solar heat gain factor (SGH):

This factor represents the amount of solar energy that would be received by floor, furniture and the inside walls of the room and can be extracted from Table A-7.

- Shading coefficient (SC):

It accounts for different shading effects of the glass window and can be extracted from Table A-8 for signal and double glass without inside shading or from Table A-9 for signal and double glass ,as well as ,for insulating glass with internal shading (venetian blinds ,curtains ,drapes, roller shading ,ect)

The shading coefficient SC is defined as the ratio of solar heat gain on glass window of the space to the solar heat gain of the double strength glass.

- Cooling load factor (CLF):

This represent the effect of the internal walls ,floor ,and furniture on the instantaneous cooling load ,and can be extracted from Table A-10 for glass without interior shading or from Table A-11 for glass with interior shading .It accounts for variation of SHG factor with time ,mass capacity of the structure and internal shading .The transmitted cooling load is calculated as Follows :

$$Q`_{tr} = A\ (SHG)\ (SC)\ (CLF) \quad \textbf{(3-1)}$$

Where: A: the total vertical projection area of the glass.

SGH: Solar heat gain factor.

SC: Shading coefficient.

CLF: Cooling load factor.

3.5 Convection Heat Gain

The convection cooling load by the glass is calculated from the equation :

$$Q`_{conv} = UA\ (CLTD)_{corr} \qquad \textbf{(3-2)}$$

Where:

$(CLTD)_{corr}$: correction cooling load temperature differences.

A: the total area of the glass.

U : the overall heat transfer coefficient of the glass.

And $(CLTD)_{corr}$ is calculated by using Eq.(3-3) the CLTD value for the glass is obtained from Table(A-12), the LM-month correction is also added to CLTD value if the month is different from 40° N and the month is not July. [5]

The maximum solar heat due to glass dome Q_g consist of transmitted $Q`_{tr}$ and convection $Q`_{conv}$ load as follows:

$$Q_g = Q`_{tr} + Q`_{conv} \qquad \textbf{(3-3)}$$

Where $Q`_{tr}$ is given by Eq. (3-1) as follows:

$A= (d^2/4)*\pi$

Where d: is the diameter of the dome.

$A=(12^2/4)*\pi$

$= 113.04\ m^2$.

The Factor	SGH	SC	CLF
Table	From Table (A-7)	From Table (A-8)	From Table (A-10)
value	361 W/m²	0.83 W/m².K	0.67

Thus, the transmittest load $Q`_{tr}$, for the dome is:

$Q`_{tr}$ = 113.04(171.4*0.83*0.67)=10.78 kW.

The convection load is obtained from Eq. (3-2)

A= 2πhr **(3-4)**

=2*π*(4)*(6)=150 m² .

U=3.5 W/m². °C Obtained From Table (A-13)

$(CLTD)_{corr}$ = (CLTD+LM) k

Where:

LM: is the latitude correction factor

A: is the total external surface area of the dome.

k :is the colour adjustment which equal k=0.5 for permanently light coloured

The Factor	CLTD	LM	k
Table	Table (A-12)	Table (A-9)	for permanently light coloured
value	7	-0.5	0.5

$(CLTD)_{corr}$ = (7- 0.5)*0.5

=3.25 C°

The convection load is obtained from Eq. (3-2) as follows

$Q`_{conv}$ =3.5*150*3.25

=1.715 kW.

Thus, the maximum value of the load due to dome is :

$Q_g = Q`_{tr} + Q`_{conv}$

= 10.78 + 1.715 =12.5 kW.

Insulation films

Type of glass or applied film	% of daylight through glass	% of solar energy through glass	Shading Coefficient *	Luminous efficacy constant**	% of Visible light reflectance interior/ exterior
1/4" clear glass	89	77	0.96	.93	7/7
1/4" clear glass with tinted film	37	64	0.74	.50	6/6
1/4" clear glass with reflective film	37	44	0.51	.73	18/28

Table (A-16) percentage of solar energy through glass when insulation films is used

The maximum value of the load due to dome is 24.405 Kw and when we use insulation films the maximum load decrees by 0.44%

Thus , maximum load equals 15KW

Item	Description	Quantity	Unit	Amount
	Supply , install insulation window films That put on the glass dome , of dimensions 300 x 200 cm for each part , with all necessary needed to complete the work . Price includes adhesives	150	M2	

Air conditioning method

Because the ventilation is not enough to give the human comfort we propose to insulation split unit are conditioning system.

From catalogue we select Model name [SPW] KR254GXH56B

And we take two units to absorb all cooling load .

Figure (4.24) Wall split type

Model name (SPW-)			KR74GXH56B	KR94GXH56B	KR124GXH56B	KR164GXH56B	KR184GXH56B	KR254GXH56B
Power source			220/230/240V, 1 phase 50, 60 Hz					
Cooling capacity		kW	2.2	2.8	3.6	4.5	5.6	7.3
		BTU/h	7,500	9,600	12,000	15,000	19,000	25,000
Heating capacity		kW	2.5	3.2	4.2	5.0	6.3	8.0
		BTU/h	8,500	11,000	14,000	17,000	21,000	27,000
Power input	Cooling	kW	0.031/0.033/0.035					0.049/0.052/0.055
	Heating	kW	0.031/0.033/0.035					0.049/0.052/0.055
Running amperes	Cooling	A	0.15/0.15/0.15					0.23/0.23/0.24
	Heating	A	0.15/0.15/0.15					0.23/0.23/0.24
Fan motor	Type		Cross flow fan *1					
	Airflow rate (H/M/L)	m³/min	10/8/6			12/10/8		16/14/10
	Output	kW	0.011			0.015		0.023
Power sound level (H/M/L)		dB(A)	47/43/39					53/49/45
Pressure sound level (H/M/L)		dB(A)	35/32/28					42/38/35
Dimensions	Height	mm	285					330
	Width	mm	995					1140
	Depth	mm	203					228
Piping connections	Liquid (Flare)	mm	6.35					9.52
	Gas (Flare)	mm	12.7					15.88
	Drain piping		VP-13					
Net weight		kg	14					21

Figure (4.25) Wall split type catalogue

Item no	Description	Quantity	Unit	Amount
1.	Supply and install air conditioning unit system. with the outdoor and indoor units, split unit Model name [SPW] KR254GXH56B , system with digital thermostat and all the needed necessary parts according to the drawings and specifications the price include all accessories needed for complete work	2		
2.	Connecting wires	30	m	
3.	metal Base	2		

3.6 Visibility study

1- For the windows film
Cast of one square meter 4 NIS, and the dome take 150 m^2

150 *4= 600NIS

Insulation cast 400 NIS

Ladder cast 400NIS

Total cost= 400+400+600=1400NIS

2- For air conditioning system:
Two devices each one has 7kW cooling capacity
And its need to work 8hours in day with26 day in month, it is take 600NIS as operating cast.
Total cost= initial cast +operation cast
=12000+600=12600NIS in the first month .

Chapter Four

<u>Selection of Fans</u>

- **Introduction.**
- **Types of Fans.**
- **Fan Operating Point.**
- **Evaluating the volume of the dome**
- **Selection of fanes.**

4.1 Introduction

A mechanical fan is an electrically powered device used to produce an airflow for the purpose of creature comfort (particularly in the heat), ventilation, exhaust, cooling or any other gaseous transport.

Mechanically, a fan can be any revolving vane or vanes used for producing air currents. Fans produce air flows with high volume and low pressure, as opposed to a gas compressor which produces high pressures at a comparatively low volume. A fan blade will often rotate when exposed to an air stream, and devices that take advantage of this, such as anemometers and wind turbines often have designs similar to that of a fan.

Typical applications include climate control, cooling systems, personal comfort (e.g., an electric table fan), ventilation (e.g., an exhaust fan), winnowing (e.g., separating chaff of cereal grains), removing dust (e.g. sucking as in a vacuum cleaner), drying (usually in addition to heat) and to provide draft for a fire. It is also common to use electric fans as air fresheners, by attaching fabric softener sheets to the protective housing. This causes the fragrance to be carried into the surrounding air. [6]

4.2 Important terms and definitions

Before types of fan are described it is important to first understand terms and definitions .

4.2.1 System characteristics

The term “system resistance “is used when referring to the static pressure. The system resistance is the sum of static pressure losses in the system the system resistance varies with square of the volume of air flowing through the system .For given volume of air the fan in a system with narrow ducts multiple short radius elbows is going to have to work harder to overcome garter system resistance than it would in system with larger ducts and minimum number of long radius turns. Thus the system resistances increase substantially as the volume of air flowing through the system increase square of the air flow.

4.3 Types of Fans

There exist two main fan types. Centrifugals fane used a rotating impeller to move the air stream

Axial fane move the air stream along the axial of the fane.

4.3.1 Centrifugal fans

Centrifugal fans increase the speed of an air stream with a rotating impeller .The speed increase as the reaches the ends of the blades and are then converted to pressure.

These fanes are able to produce high pressures, which makes them suitable for harsh operating condition, such as system with high temperature, moist or dirty air steam, and material handing.

4.3.2 Axial fans

Axial fans move an air along the axis of the fane .The way these fane work cane compared to propeller on an airplane ,the fan blades generate an aerodynamic lift that pressurize the air .They are popular to the industry because they are inexpensive compact and light . [7]

4.4 Fan Operating Point

An appropriate fan is selected based on the fan manufacturer's performance data. Usually, these data are provided in terms of multi-ratings tables published for each specific fan model and size. Based on these data it is possible to select a fan model, the specific model size, and the fan speed necessary to achieve the airflow rates and static pressure rise conditions necessary for the overall air pollution control system.

The match between the fan performance data and the system characteristic curve is illustrated in Figure 1for the specific fan rotational speed chosen. As long as both the overall system and the fan remain in good condition, the system will operate at the point shown in Figure 1. This point is termed the operating point.

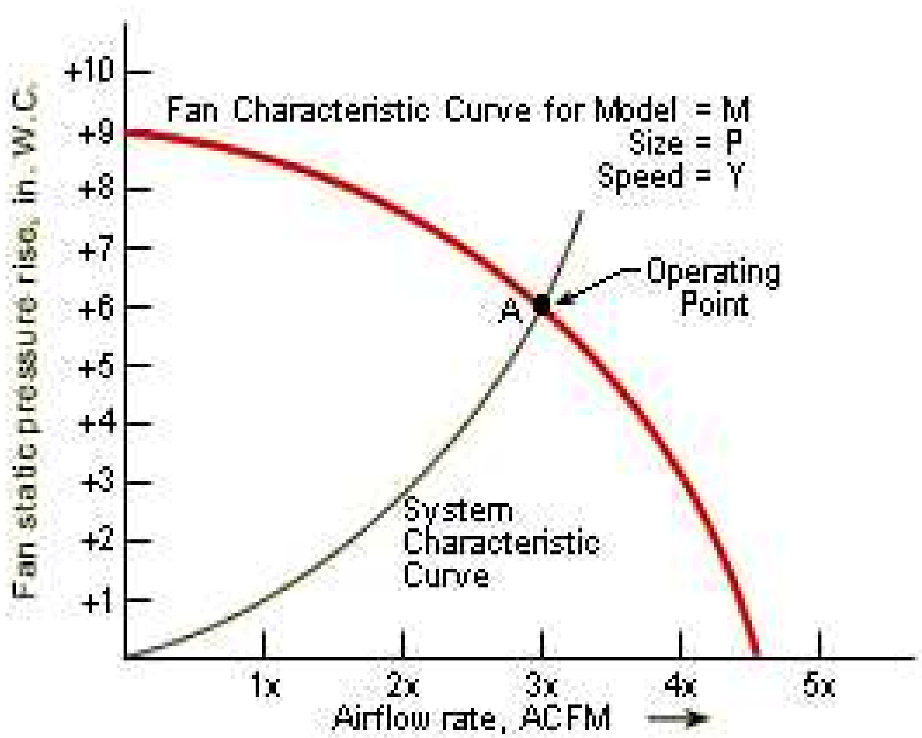


Figure (4-1): Fan Operating Point

After calculating the heat load resulting from the sun must find a way to solve our problem, we have formed is a change of hot air under the dome is located continuously in order to get rid of the amount of heat produced from the sun.

To got rid of hot air we can installation two fans under the dome in concrete interface located under the dome so that they are facing

One of the fans pull the hot air and the other providing space fresh air that temperature is less than the air located under the dome and by this way we can reach the temperature of the space under the dome to the temperature of the external environment and this way we can solve the problem.

4.5 Evaluating the volume of the dome

We can find the volume of the dome by using the "AutoCAD" program since the schematic drawing of the dome is on the "AutoCAD" we can using a function revolve to evaluate the volume of the dome.

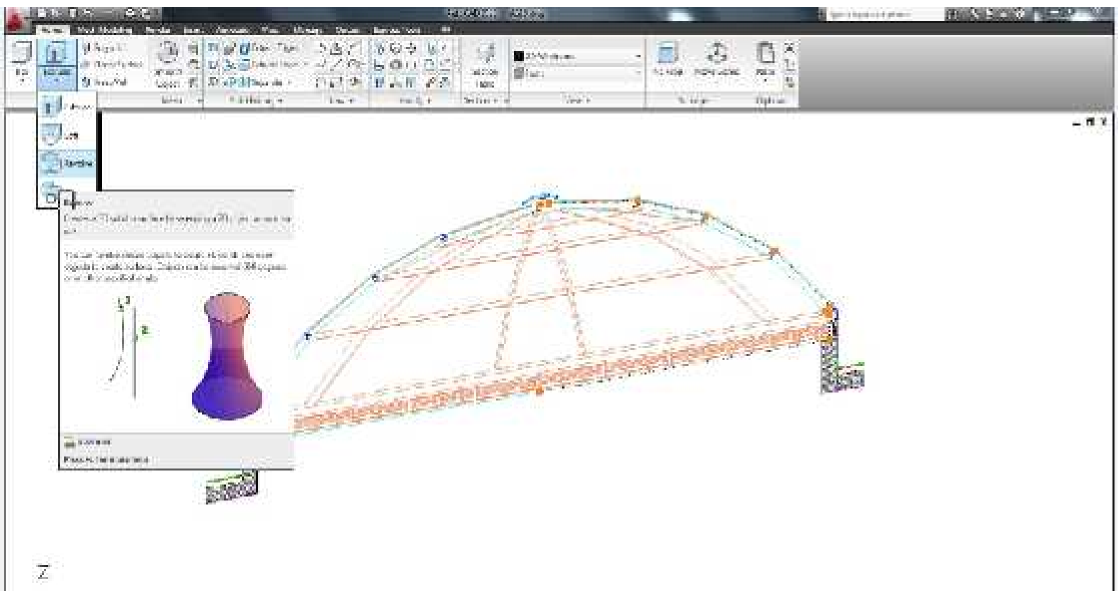


Figure (4.2) schematic drawing of the glass dome

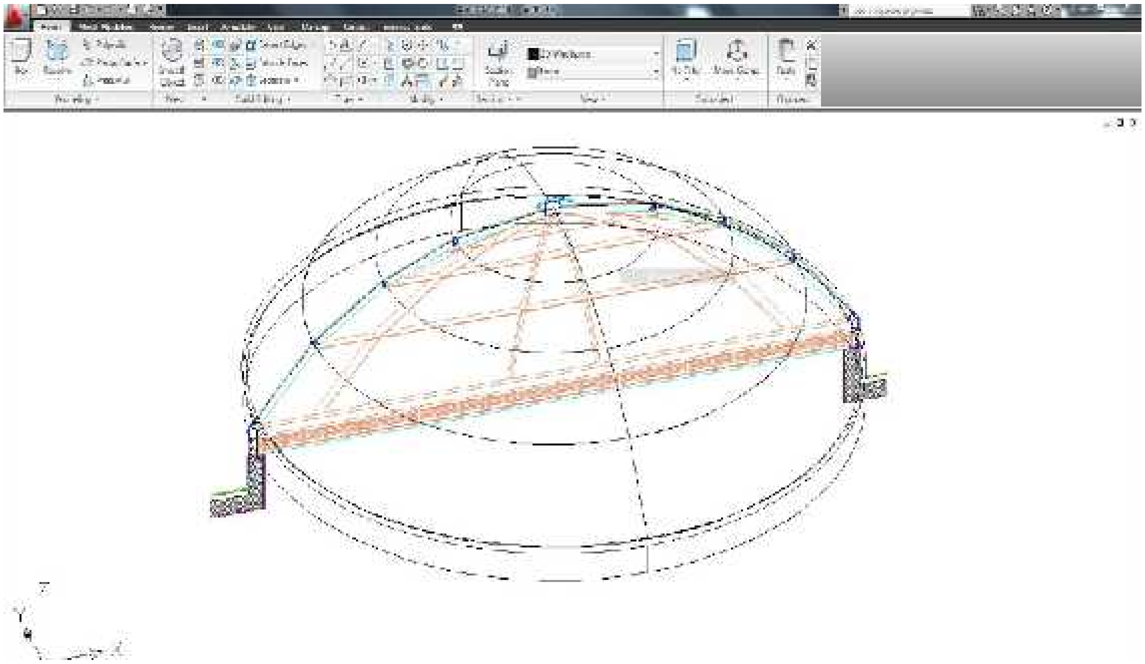
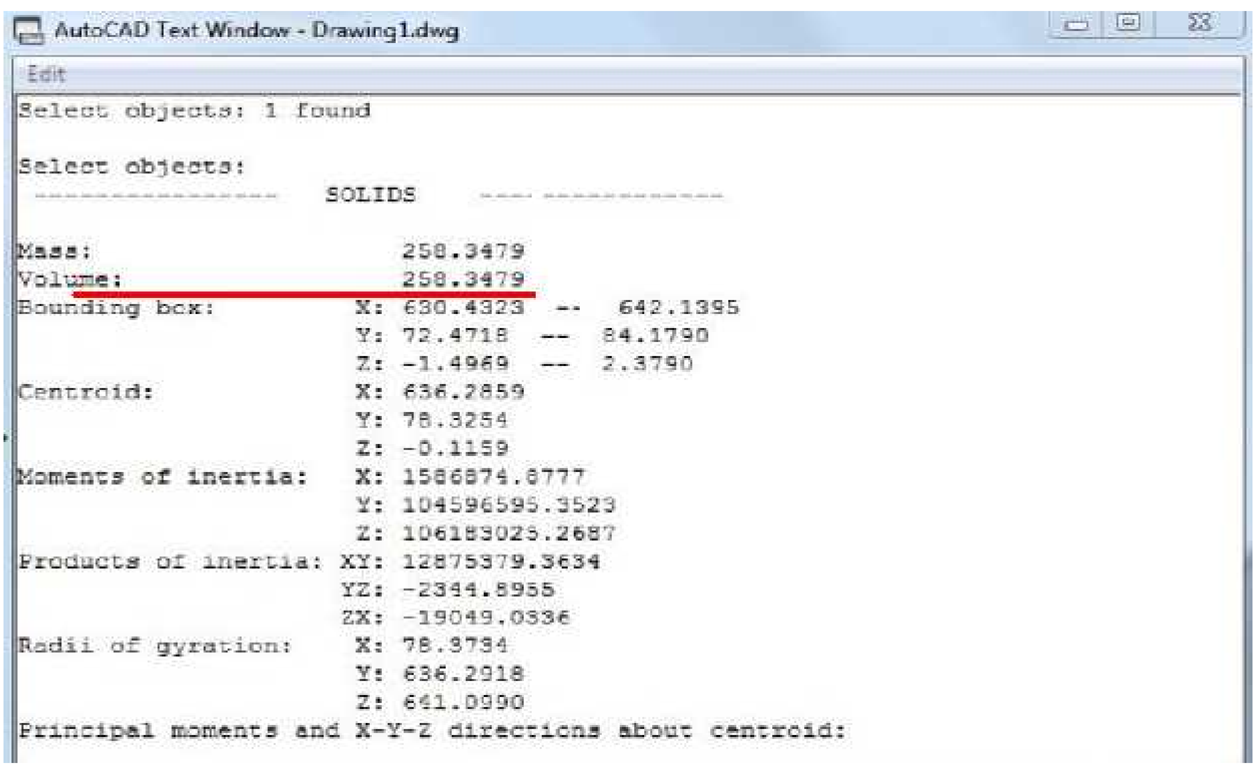


Figure (4.3) schematic drawing of the glass dome



AutoCAD Text Window - Drawing1.dwg

Edit

```
Select objects: 1 found

Select objects:
 ----------------     SOLIDS     ---------------

Mass:                     258.3479
Volume:                   258.3479
Bounding box:          X: 630.4323  --  642.1395
                       Y: 72.4718   --  84.1790
                       Z: -1.4969   --  2.3790
Centroid:              X: 636.2859
                       Y: 78.3254
                       Z: -0.1159
Moments of inertia:    X: 1586874.8777
                       Y: 104596595.3523
                       Z: 106183025.2687
Products of inertia:  XY: 12875379.3634
                      YZ: -2344.8955
                      ZX: -19049.0336
Radii of gyration:     X: 78.3734
                       Y: 636.2918
                       Z: 641.0990
Principal moments and X-Y-Z directions about centroid:
```

Table (4.1) some dimension of the dome

In this table appears some propitiates of the dome obtained from the AutoCAD functions. And the volume of the dome is 258.34 m^3.

4.6 Static head

Static head is the difference in height between the source and destination of the air .Static head at certain presser depends on the weight of the air and can be calculated by The head loss of fan Suction air system is the same as that produced in a straight pipe or duct whose length is equal to the pipes of the original systems plus the sum of the equivalent lengths of all the components in the system. This can be expressed as

$$h_{loss} = \Sigma\, h_{major\_losses} + \Sigma\, h_{minor\_losses} \quad (4.1)$$

where

h_{loss} = total head loss in the pipe or duct system

h_{major_losses} = major loss due to friction in the pipe

h_{minor_losses} = minor loss due to the components in the system

Major Losses

The major head loss for a single pipe or duct can be expressed as:

$$h_{major\_loss} = \lambda\, (l / d_h)\, (v^2 / 2\, g) \quad (4.2)$$

where

h_{loss} = head loss (m, ft)

λ = friction coefficient and its equal .035 from table (A-15)

l = length of duct or pipe (m)

d_h = hydraulic diameter (m)

v = flow velocity (m/s, ft/s)

g = acceleration of gravity (m/s^2, ft/s^2)

$h_{major\_loss} = \lambda\ (l\ /\ d_h)\ (v^2\ /\ 2\ g)$

$= 0.35*(1/0.3)*(10^2)/2*9.81=0.994m$

Minor head loss can be expressed as:

$h_{minor\_loss} = \xi\ v^2 /\ 2\ g$ (4.3)

where:

ξ = minor loss coefficient and its equal 0.2 from table (A-16)

$h_{minor\_loss} = 0.2*(10^2)/2*9.81= 0.208m$

$h_{loss} = \Sigma\ h_{major\_losses} + \Sigma\ h_{minor\_losses}$

$=0.992+0.208 = 1.2m$

4.7 Volumetric flow

To obtain volumetric flow of the fans we can use Table (A-14) in this table appears the minimum outside air required for mechanical ventilation. [8]

We need to change the air under the dome five times in the hour

4.8 Selection of fanes

To select the fans we can use a software program calls" Rosenberg RoVent ". And we required the static head and the flow rate of the air.

Assume static head equals 0.7 in and from Table (A-14) flow rate can be

Volumetric flow rate=V *5 times in hour

(258*5)/60=760 cfm.

And we but these data on the program and obtains the operation point.

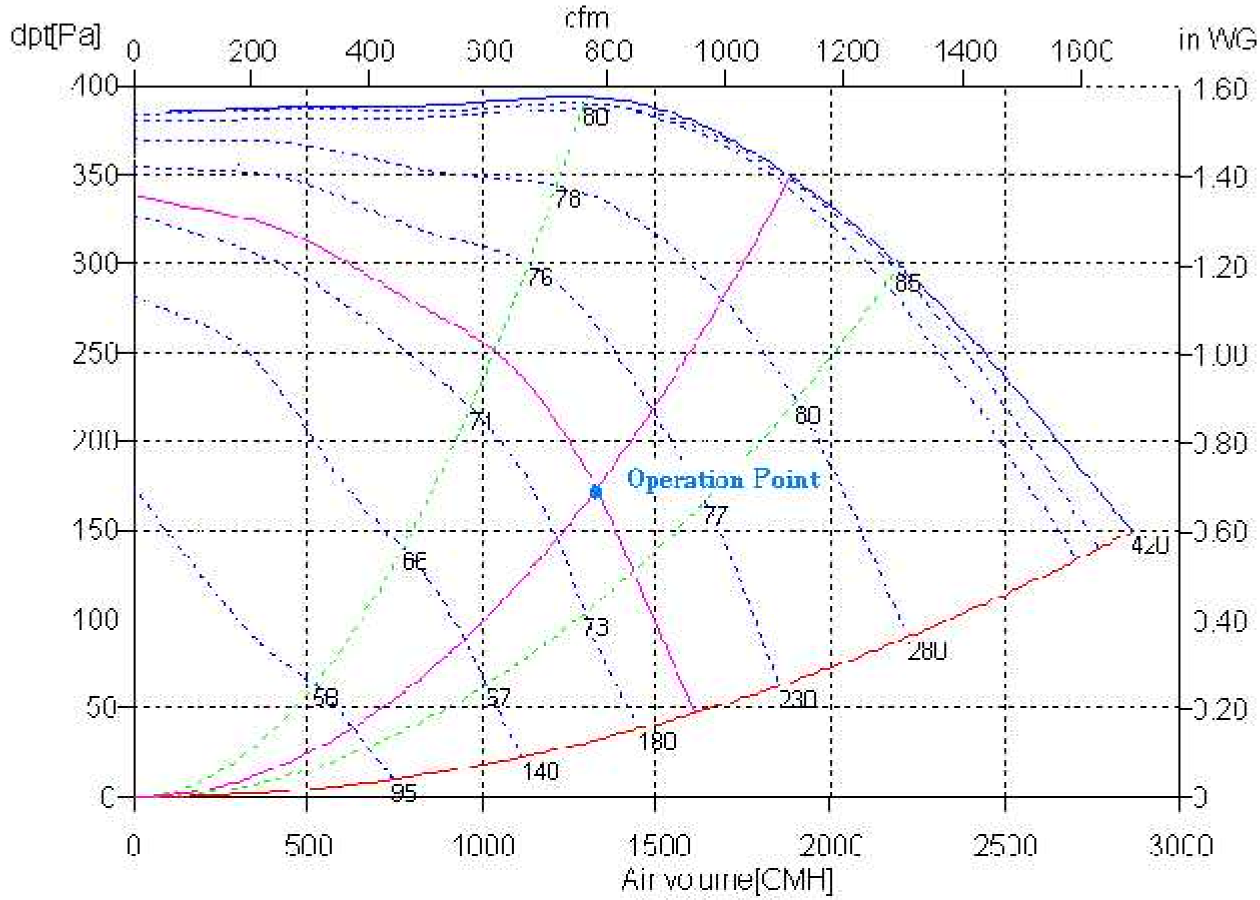


Figure (4-4): Fan Operating Point of our project

4.8.1 Casing and dimensions

The casing of the high efficiency radial fane are made of galvanized sheet steel and the side part of the scroll is assembled with nut sets the spirally shaped guide plate through a standing seam .

The side parts are product with nut sets to fix the mounting brackets which can be fixed in steps of 90°.

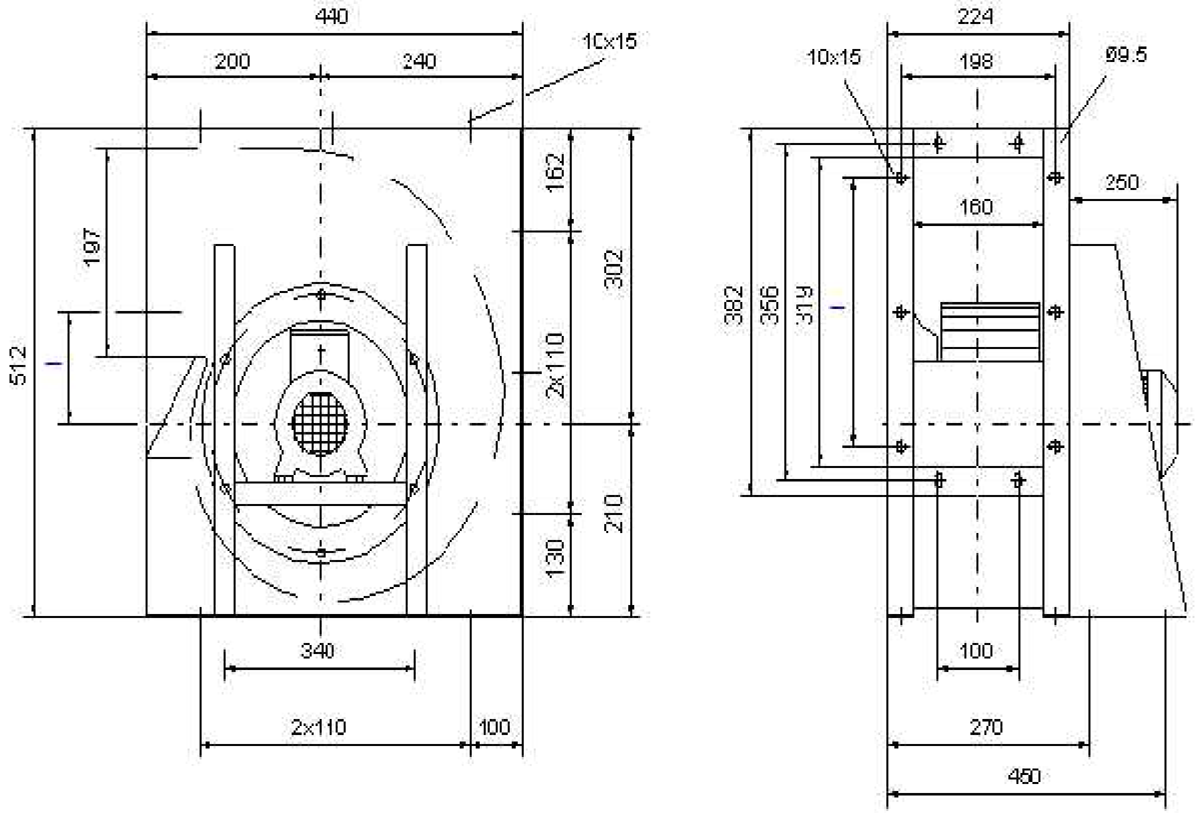


Figure (4-5): the dimensions of the fan

Characteristics of the fan at operating point are as shown below

DHAE 355-4

V[m³/h]	1093	U[v]	127	LwA[dBA]	67.8
dpt[Pa]	178	I [A]	2.29	N[1/min]	934
Dpdyn[Pa]	1.38	P[Kw]	0.287	Eta[%]	19.0

Table (4-2): characteristics of the fan by version DHAE 355-4

4.8.2 Installation of Centrifugal fans

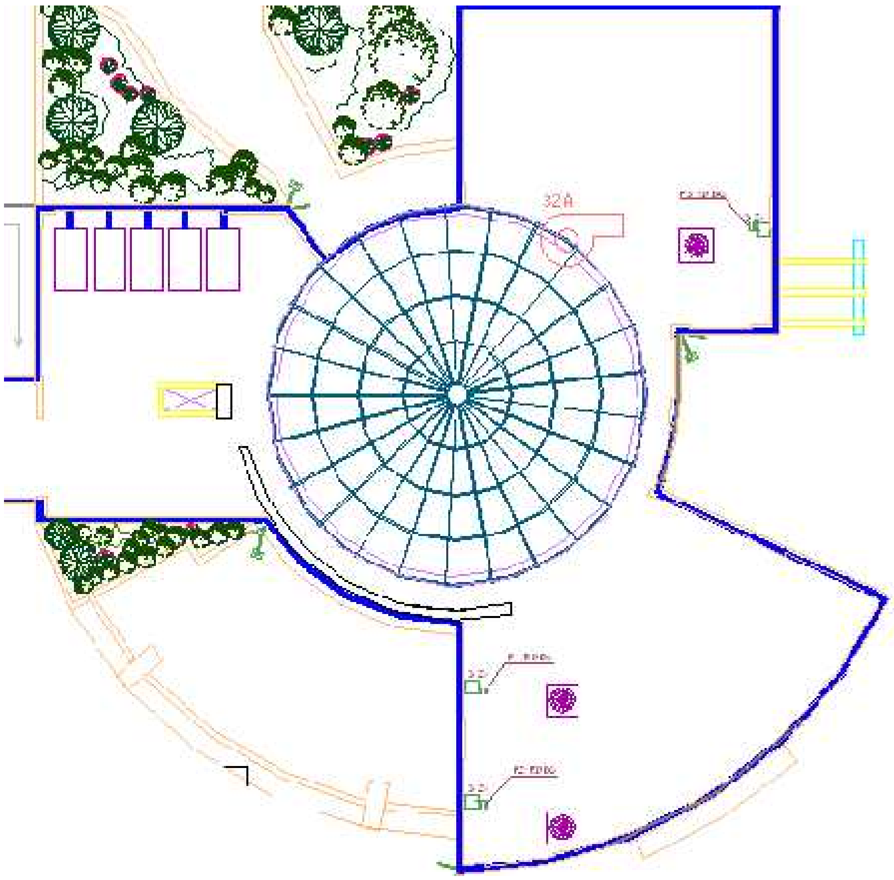


Figure (4-6) the Centrifugal fans as it appears on the Operational design

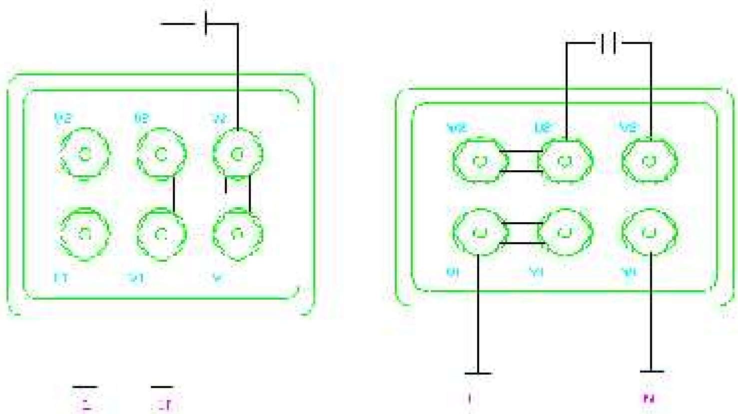


Figure (4-7): figure shows how the Centrifugal fans connected to electricity by using 1phas connection

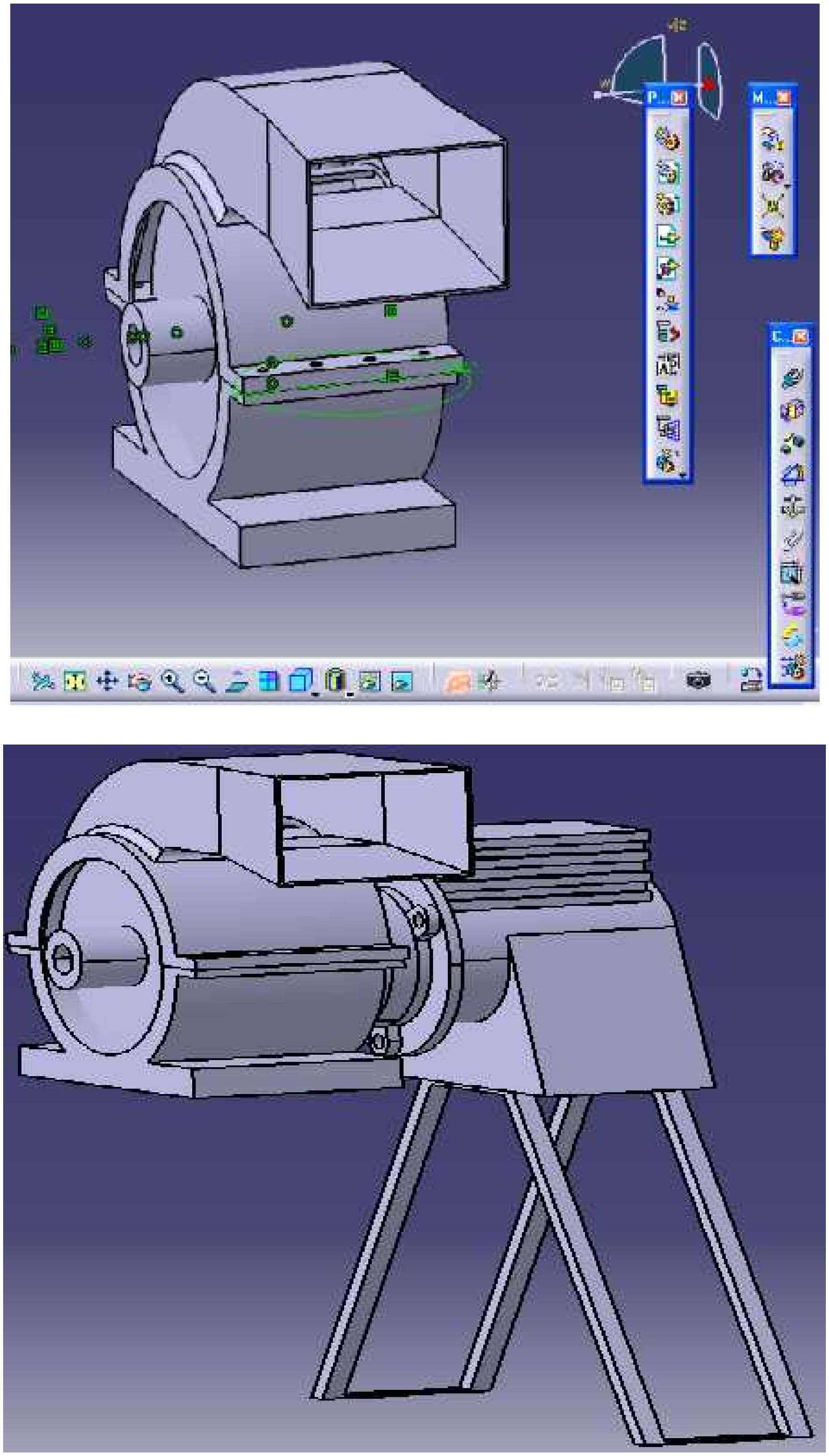


Figure (4-8): figure shows how the Centrifugal fans By CAD design

4.8.3 Reasons for selecting this fan

High Efficiency Radial Fane with backward curved radial impellers it characterized by several advantages as:

- Energy saving through concave impellers.

- The speed is 0-100% infinitely variable through auto transformers or electrical control

- Easy installation in any position.

- Compact and space saving design.

- Easy air volume adjustments via a large range of control products based on pressure and temperature.

- Extremely low starting current.

- The dimensions of the fan are suitable for our case.

Chapter Five

Recommendations

We measured the temperature in the hall under the glass dome without running the Centrifugal fan , measured temperature around the day to give of the biggest values of temperature as possible should have arrived within the dome .and Apparent the temperature in figure which show that the highest temperatures in the second hour in the afternoon.

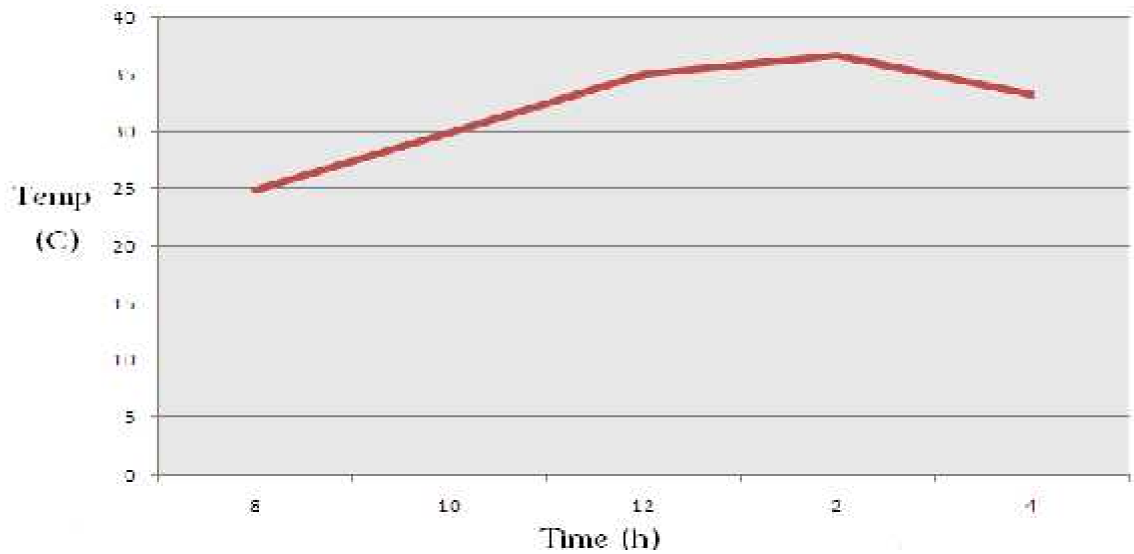


Figure (5-1): air temperature around the day

After running the Centrifugal fan for one hour, where the results show that temperatures dropped an average of three degrees for each hour were measured temperature

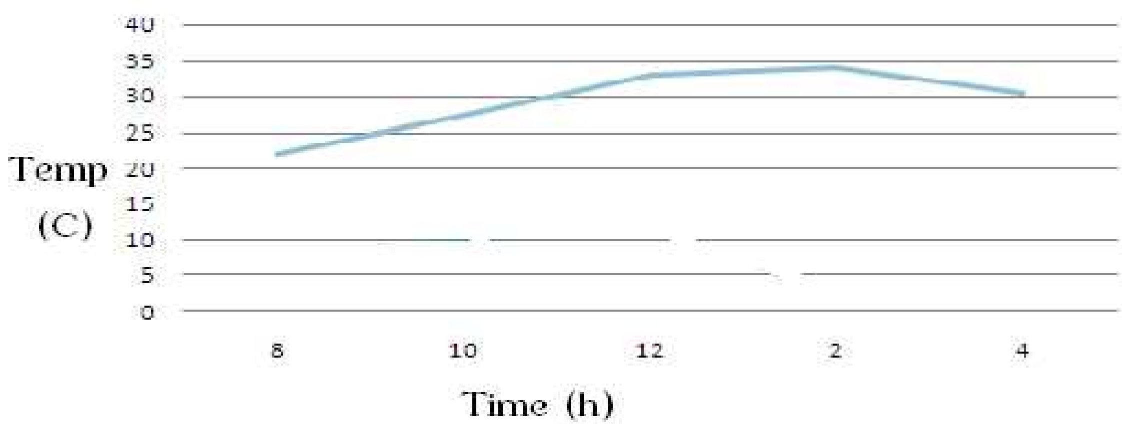


Figure (5-2): air temperature around the day where located the trees

When measuring the temperature in the region is located where the trees .show that the temperature drops by three degrees from areas away from trees, and in front of the sun

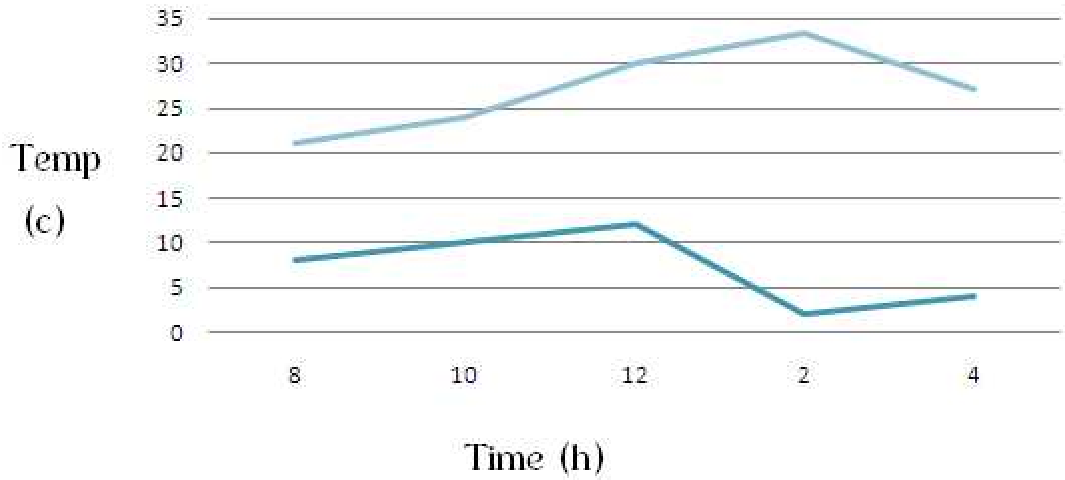


Figure (5-3): air temperature around the day with operation

From the figures above we can puts some recommendations to solve the problem in best way:

- This decrees in temperature in some days that the temperature about 36 C ,is not suitable for human comfort .
- There's halls around the wall that the dome placed on it make neutral ventilation. But also decrees in the performance of centrifugal fan
- To have internal temperature Suit with human comfort we must use air conditioning system in parallel with centrifugal fan.
- If we increase the trees in the hall that's make the temperature closer to human comfort.

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Books

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[2] Myhren, J. A., & Holmberg, S. (2008). Flow patterns and thermal comfort in a room with panel, floor and wall heating. Energy and Buildings, 40(4), 524-536.

[3] ^ ASTM definition of glass from 1945; also: DIN 1259, Glas – Begriffe für Glasarten and Glasgruppen, September 1986

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[6] Coolermaster Neon LED Case Fans Review". 2003-03-25.

[7] Rouse, H., ed. (1950). Engineering Hydraulics. New York: John Wiley and Sons Inc.

[8] Mohammed A.Alsaad, Mahmud A.Hammad, Heating and Air Conditioning, Jordan 2007, Third edition.

Hyper Links

[4] http://www.nytimes.com/2009/02/06/business/worldbusiness/06swiss.html?ref=busines

[6] http://www.overclockrsclub.com/reviews/coolermasterledcasefans/. Retrieved 2007-12-05.

Appendix

Table (A-1) Cooling Load temperature differences (CLTD) for sunlit roofs,C°

no	Roof Description of Construction	Um W/m^2 C	Solar Time ,h																							
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Without Suspended Ceiling																										
1	Steel Sheet With 25.4mmor 50.8mm insulation	1.209 0.704	0	-1	-2	-2	-3	-2	3	11	19	27	34	40	43	44	43	39	33	25	17	10	7	5	3	1
2	25mm Wood with 25.4mm insulation	0.963	3	2	0	-1	-2	-2	-1	2	8	15	22	29	35	39	41	41	39	35	29	21	15	11	8	5
3	101.6mm L.W concrete	1.209	5	3	1	0	-1	-1	-2	1	5	11	18	25	31	36	39	40	40	37	32	25	19	14	10	7
4	50.8mm H.W concrete 25.4mm	1.170 0.693	7	5	3	2	0	-1	0	2	6	11	17	23	28	33	36	37	37	34	30	25	20	16	12	10
5	25.4mm Wood with 50.8mm insulation	0.619	2	0	-2	-3	-4	-4	-4	-5	3	9	15	22	27	32	35	36	35	32	27	20	14	10	6	3
6	152.4mm L.W concrete	0.897	12	10	7	5	3	2	1	0	2	4	8	13	18	24	29	33	35	36	35	32	28	24	19	16
7	63.5mm wood with 25.4 mm insulation	0.738	16	13	11	9	7	6	4	3	4	5	8	11	15	19	23	27	29	31	31	30	27	25	22	19
8	203.4mm L.W concrete	0.715	20	17	14	12	10	8	6	5	4	4	5	7	11	14	18	22	25	28	30	30	29	27	25	22
9	101.6mm H.W concrete with 25.4 mm or 50.8 insul.	1.136 0.681	14	12	10	8	7	5	4	4	6	8	11	15	18	22	25	28	29	30	29	27	24	21	19	16
10	63.5mm wood with insulation	0.528	18	15	13	11	9	8	6	5	5	5	7	10	13	17	21	24	27	28	29	29	27	25	23	20
11	Roof terrace system	0.602	19	17	15	14	12	11	9	8	7	8	8	10	12	15	18	20	22	24	25	26	25	24	22	21
12	152.4mm H.W concrete with 25.4mm 50.8 ins.	0.664	18	16	14	12	11	10	9	8	8	9	10	12	15	17	20	22	24	25	25	25	24	22	20	19
13	101.6mm wood with 25.4 mm or 50.8 mm	0.602 0.443	21	20	18	17	15	14	13	11	10	9	9	9	10	12	14	16	18	20	22	23	24	24	23	22

Table (A-2) Latitude –Month correction factor LM,as applied to walls and horizantal roof

Lat.	Month	N	NNE NNW	NE NW	ENE WNW	E W	ESE WSW	SE SW	SSE SSW	S	Horizontal Roofs
16	December	-2.2	-3.3	-4.4	-4.4	-2.2	-0.5	2.2	5.0	7.2	-5.0
	Jan./Nov.	-2.2	-3.3	-3.8	-3.8	-2.2	-0.5	2.2	4.4	6.6	-3.8
	Feb./Oct.	-1.6	-2.7	-2.7	-2.2	-1.1	0.0	1.1	2.7	3.8	-2.2
	Mar./Sept.	-1.6	-1.6	-1.1	-1.1	-0.5	-0.5	0.0	0.0	0.0	-0.5
	Apr./Aug.	-0.5	0.0	-0.5	-0.5	-0.5	-1.6	-1.6	-2.7	-3.3	0.0
	May/July	3.3	2.2	2.2	0.5	-0.5	-2.2	-2.7	-3.8	-3.8	0.0
	June	3.3	2.2	2.2	0.5	-0.5	-2.2	-3.3	-4.4	-3.8	0.0
24	December	-2.7	-3.8	-5.5	-6.1	-4.4	-2.7	1.1	5.0	6.6	-9.4
	Jan./Nov.	-2.2	-3.3	-4.4	-5.0	-3.3	-1.6	-1.6	5.0	7.2	-6.4
	Feb./Oct.	-2.2	-2.7	-3.3	-3.3	-1.6	-0.5	1.6	3.8	5.5	-3.8
	Mar/Sept.	-1.6	-2.2	-1.6	-1.6	-0.5	-0.5	0.5	1.1	2.2	-1.6
	Apr./Aug.	-1.1	-0.5	0.0	-0.5	-0.5	-1.1	-0.5	-1.1	-1.6	0.0
	May/July	0.5	1.1	1.1	0.0	0.0	-1.6	-1.6	-2.7	-3.3	0.5
	June	1.6	1.6	1.6	0.5	0.0	-1.6	-2.2	-3.3	-3.3	0.5
32	December	-2.7	-3.8	-5.5	-6.1	-4.4	-2.7	1.1	5.0	6.6	-9.4
	Jan./Nov.	-2.7	-3.8	-5.0	-6.1	-4.4	-2.2	1.1	5.0	6.6	-8.3
	Feb./Oct.	-2.2	-3.3	-3.8	-4.4	-2.2	-1.1	2.2	4.4	6.1	-5.5
	Mar/Sept.	-1.6	-2.2	-2.2	-2.2	-1.1	-0.5	1.6	2.7	3.8	-2.7
	Apr./Aug.	-1.1	-1.1	-0.5	-1.1	0.0	-0.5	0.0	5.0	0.5	-0.5
	May/July	0.5	0.5	0.5	0.0	0.0	-0.5	-0.5	-1.6	-1.6	0.5
	June	0.5	1.1	1.1	0.5	0.0	-1.1	-1.1	-2.2	-2.2	1.1
40	December	-3.3	-4.4	-5.5	-7.2	-5.5	-3.8	0.0	3.8	5.5	-11.6
	Jan./Nov.	-2.7	-3.8	-5.5	-6.6	-5.0	-3.3	0.5	4.4	6.1	-10.5
	Feb./Oct.	-2.7	-3.8	-4.4	-5.0	-3.3	-1.6	1.6	4.4	6.6	-7.7

Table (A-3) Approximate CLTD values for sunlit roofs,C°

Solar Time	Roof Construction		
	Light	Medium	Heavy
10:00	5	----	----
11:00	12	----	----
12:00	19	3	0
13:00	25	8	2
14:00	29	14	5
15:00	31	19	8
16:00	31	23	10
17:00	29	25	12
18:00	24	26	14
19:00	19	25	15
20:00	11	22	16

Table (A-4)Cooling Load temperature differences(CLTD)for varios construction groups ,C°

	Group D Walls																											
N	8	7	7	6	5	4	3	3	3	3	4	4	5	6	6	7	8	9	10	11	11	10	10	9	21	3	11	8
NE	9	8	7	6	5	5	4	4	6	8	10	11	12	13	13	13	14	14	14	13	13	12	11	10	19	4	14	10
E	11	10	8	7	6	5	5	5	7	10	13	15	17	18	18	18	18	18	17	17	16	15	13	12	16	5	18	13
SE	11	10	9	7	6	5	5	5	5	7	10	12	14	16	17	18	18	18	17	17	16	15	14	12	17	5	18	13
S	11	10	8	7	6	5	4	4	3	3	4	5	7	9	11	13	15	16	16	16	15	14	13	12	19	3	16	13
SW	15	14	12	10	9	8	6	5	5	4	4	5	5	7	9	12	15	18	20	21	21	20	19	17	21	4	21	17
W	17	15	13	12	10	9	7	6	5	5	5	5	6	6	8	10	13	17	20	22	23	22	21	19	21	5	23	18
NW	14	12	11	9	8	7	6	5	4	4	4	4	5	6	7	8	10	12	15	17	18	17	16	15	22	4	18	14
	Group E Walls																											
N	7	6	5	4	3	2	2	2	3	3	4	5	6	7	8	10	10	11	12	12	11	10	9	8	20	2	12	10
NE	7	6	5	4	3	2	3	5	8	11	13	14	14	14	14	14	15	14	14	13	12	11	9	8	16	2	15	13
E	8	7	6	5	4	3	3	6	10	15	18	20	21	21	20	19	18	18	17	15	14	12	11	9	13	3	21	18
SE	8	7	6	5	4	3	3	4	7	10	14	17	19	20	20	20	19	18	17	16	14	13	11	10	15	3	20	17
S	8	7	6	5	4	3	2	2	2	3	5	7	10	14	16	18	19	18	17	16	14	13	11	10	17	2	19	17
SW	12	10	8	7	6	4	4	3	3	3	4	5	7	10	14	18	21	24	25	24	22	19	17	14	19	3	25	22
W	14	12	10	8	6	5	4	3	3	4	4	5	6	8	11	15	20	24	27	27	25	22	19	16	20	3	27	24
NW	11	9	8	6	5	4	3	3	3	3	4	5	6	7	9	11	14	18	21	21	20	18	15	13	20	3	21	18
	Group F Walls																											
N	5	4	3	2	1	1	1	2	3	4	5	6	8	9	11	12	12	13	13	13	11	9	7	6	19	1	13	12
NE	5	4	3	2	1	1	3	8	13	16	17	16	16	15	15	15	15	14	13	12	10	9	7	6	11	1	17	16
E	5	4	3	2	2	1	4	9	16	21	24	25	24	22	20	19	18	17	15	13	11	10	8	7	12	1	25	24
SE	5	4	3	2	2	1	2	6	10	15	20	23	24	23	22	20	19	17	16	14	12	10	8	7	13	1	24	23
S	5	4	3	2	2	1	1	1	2	4	7	11	15	19	21	22	21	19	17	15	12	10	8	7	16	1	22	21
SW	8	6	5	4	3	2	1	1	2	3	4	6	10	14	20	24	28	30	29	25	30	14	11	10	18	1	30	29
W	9	7	5	4	3	2	2	2	2	3	4	6	8	11	16	22	27	32	33	30	24	19	15	12	19	2	33	31
NW	8	6	4	3	2	2	1	1	2	3	4	6	7	9	12	15	19	24	26	24	20	14	12	10	19	1	26	25

Table (A-7) Solar heat gain factor (SGH)for sunlit glass W/m², for a latitude angle of 32°N

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
N	76	85	101	114	120	139	126	117	104	88	76	69
NNE/NNW	76	85	117	252	350	385	350	249	110	88	76	69
NE/NW	93	205	338	461	536	55	527	445	325	199	91	69
ENE/WNW	331	470	557	631	656	656	643	615	546	451	325	265
E/W	552	647	716	716	694	675	678	691	678	615	546	511
ESE/WSW	772	764	748	691	628	596	612	663	716	738	710	688
SE/SW	786	782	716	590	489	439	473	571	688	754	773	776
SSE/SSW	789	732	615	445	213	262	303	429	596	710	776	795
S	776	697	55	363	233	189	227	350	540	678	767	795
Horizontal	555	685	795	855	874	871	861	836	770	672	552	498

Table (A-8) Shading cofficient (SC) for glass without interior shading

Type of Glass	Nominal Thickness, mm	Solar Trans.	Shading Coefficient, W/m^2.K	
			h_0=22.7	h_0=17.0
Single Glass				
Clear	3	0.84	1.00	1.00
	6	0.78	0.94	0.95
	10	0.72	0.90	0.92
	12	0.67	0.87	0.88
Heat absorbing	3	0.64	0.83	0.85
	6	0.46	0.69	0.73
	10	0.33	0.60	0.64
	12	0.42	0.53	0.58
Double Glass				
Regular	3	----	0.90	----
Plate	6	----	0.83	----
Reflective	3	----	0.20-0.40	----
Insulating Glass				
Clear	3	0.71	0.88	0.88
	6	0.61	0.81	0.82
Heat absorbing	6	0.36	0.55	0.58

Table (A-9) Cooling Load Factor (CLF) for glass without interior shading,north latitudes

Glass Facing	Building Const.	Solar Time, h																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	L	0.17	0.14	0.11	0.09	0.08	0.33	0.24	0.48	0.56	0.61	0.71	0.76	0.80	0.82	0.82	0.79	0.75
N	M	0.23	0.20	0.18	0.16	0.14	0.34	0.14	0.46	0.53	0.59	0.65	0.70	0.73	0.75	0.75	0.74	0.75
Shaded	H	0.25	0.23	0.21	0.20	0.19	0.38	0.45	0.49	0.55	0.60	0.65	0.69	0.72	0.72	0.72	0.70	0.70
	L	0.06	0.05	0.04	0.03	0.03	0.26	0.43	0.47	0.44	0.41	0.40	0.39	0.39	0.38	0.36	0.33	0.30
NNE	M	0.09	0.08	0.07	0.06	0.06	0.24	0.38	0.42	0.39	0.37	0.37	0.36	0.36	0.36	0.34	0. 33	0.30
	H	0.11	0.10	0.09	0.09	0.08	0.26	0.39	0.42	0.39	0.36	0.35	0.34	0.34	0.33	0.32	0.31	0.28
	L	0.04	0.04	0.03	0.02	0.02	0.23	0.41	0.51	0.51	0.45	0.39	0.36	0.33	0.31	0.28	0.26	0.23
NE	M	0.07	0.06	0.06	0.05	0.04	0.21	0.36	0.44	0.45	0.40	0.36	0.33	0.31	0.30	0.28	0.26	0.24
	H	0.09	0.08	0.08	0.07	0.07	0.23	0.37	0.44	0.44	0.39	0.34	0.31	0.29	0.27	0.26	0.24	0.22
	L	0.04	0.03	0.03	0.02	0.02	0.21	0.40	0.52	0.57	0.53	0.45	0.39	0.34	0.31	0.28	0.25	0.22
ENE	M	0.07	0.06	0.05	0.05	0.04	0.20	0.35	0.45	0.49	0.47	0.41	0.36	0.33	0.30	0.28	0.26	0.23
	H	0.09	0.09	0.08	0.07	0.07	0.22	0.36	0.46	0.49	0.45	0.38	0.31	0.30	0.27	0.25	0.23	0.21
	L	0.04	0.03	0.03	0.02	0.02	0.19	0.37	0.51	0.57	0.57	0.50	0.42	0.37	0.32	0.29	0.25	0.22
E	M	0.07	0.06	0.06	0.05	0.05	0.18	0.33	0.44	0.50	0.51	0.46	0.39	0.35	0.31	0.29	0.26	0.23
	H	0.09	0.09	0.08	0.08	0.07	0.20	0.34	0.45	0.49	0.49	0.43	0.39	0.32	0.29	0.26	0.24	0.22
	L	0.05	0.04	0.03	0.03	0.02	0.17	0.34	0.49	0.58	0.61	0.57	0.48	0.41	0.36	0.32	0.28	0.24
ESE	M	0.08	0.07	0.06	0.05	0.05	0.16	0.31	0.43	0.51	0.54	0.51	0.44	0.39	0.35	0.32	0.29	0.26
	H	0.10	0.09	0.09	0.08	0.08	0.19	0.32	0.43	0.50	0.52	0.49	0.41	0.36	0.32	0.29	0.26	0.24

Table (A-12) Cooling Load temperature differences (CLTD) for convection heat gain for glass windows

Solar Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
CLTD C°	1	0	-1	-1	-1	-1	-1	0	1	2	4	5	7	7	8	8	7	7	6	4	3	2	2	1

Table (A-13) Overall Heat Transfer Cofficient for windows ,W\m².C°

	Wind Speed, m/s					
Material Type And Frames	Single Glass			Double Glass, 6 mm Air gap		
	<0.5	0.5-5.0	>5.0	<0.5	0.5-5.0	>5.0
Wood	3.8	4.3	5.0	2.3	2.5	2.7
Aluminum	5.0	5.6	6.7	3.0	3.2	3.5
Steel	5.0	5.6	6.7	3.0	3.2	3.5
PVC	3.8	4.3	5.0	2.3	2.5	2.7

Table (A-14) Minimum outside air required for mechanical vintelition

Application	Maximum Occupancy Per 100m^2	Ventilation Air Requirements	
		L/s/Person	L/s/m^2
Offices:			
Offices Space	7	10.0	2.5-10.0
Reception areas	60	8.0	3.5-7.5
Telecomm. Rooms	60	10.0	----
Conference rooms	50	10.0	----
Public spaces:			
Corridors	----	----	0.25
Public restrooms	100	25.0	----
Locker and dressing rooms	50	7.5-17.5	5-2.5
Smoking lounge	70	30.0	----
Elevators	-----	7.5	5.00
Laundries:			
Commercial laundry	10	13.0	----
Commercial Dry cleaner	30	15.0	----
Coin-operated laundries	20	8.0	----
Coin-operated Dry cleaner	20	8.0	----

Table (A-15) Minor Loss Coefficient

Component or Fitting	Minor Loss Coefficient - ξ -
90^{o} bend, sharp	*1.3*
90^{o} bend, with vanes	*0.7*
90^{o} bend, rounded radius/diameter duct <1	*0.5*
90^{o} bend, rounded radius/diameter duct >1	*0.25*
45^{o} bend, sharp	*0.5*
45^{o} bend, rounded radius/diameter duct <1	*0.2*
45^{o} bend, rounded radius/diameter duct >1	*0.05*
T, flow to branch (applied to velocity in branch)	*0.3*
Flow from duct to room	*1.0*
Flow from room to duct	*0.35*

Table (A-16) Minor Loss Coefficient depend on fitting

Type of Component or Fitting	Minor Loss Coefficient - ξ -
Tee, Flanged, Line Flow	0.2
Tee, Threaded, Line Flow	0.9
Tee, Flanged, Branched Flow	1.0
Tee, Threaded , Branch Flow	2.0
Union, Threaded	0.08
Elbow, Flanged Regular 90°	0.3
Elbow, Threaded Regular 90°	1.5
Elbow, Threaded Regular 45°	0.4
Elbow, Flanged Long Radius 90°	0.2
Elbow, Threaded Long Radius 90°	0.7
Elbow, Flanged Long Radius 45°	0.2
Return Bend, Flanged 180°	0.2
Return Bend, Threaded 180°	1.5
Globe Valve, Fully Open	10
Angle Valve, Fully Open	2
Gate Valve, Fully Open	0.15
Gate Valve, 1/4 Closed	0.26
Gate Valve, 1/2 Closed	2.1