Performance of Air Conditioning for 4-Seated Automobile Car

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Abstract— The Heating Ventilation and Air Conditioning (HVAC) system is arguably the most complex system installed in the car and is responsible for a substantial component of the total energy use. Maintaining optimal temperature and air circulation are the basis of a comfortable indoor environment. This role is played by HVAC (Heating, Ventilation and Air Conditioning) systems. Due to the increase and decrease of the customers regularly to the car. A Complete air conditioning system was designed to control the temperature, relative humidity, air movement etc. The layout of a 4-seated automobile car is made by Autodesk REVIT software after taking the plan, heating and cooling load calculations were taken by the design department. In this project calculations were done by using the Revit air conditioning software. The same values will be used in the Revit software at human comfort condition to get indoor temperatures DBT, WBT and MEAN RANGE VALUE.

Keywords: Heating Ventilation and Air Conditioning (HVAC), Air Conditioning System, Refrigeration Cycle

I. INTRODUCTION

A. *Heat Ventilation and Air- Conditioning system*

Air conditioning is used in most commercial properties, ranging from small shops and cafés to large office buildings and public spaces. To meet these diverse applications, air conditioning systems have different heating and cooling capacities and come with various setups and layouts.

Many of our homes and most offices and commercial facilities would not become fordable without control of the indoor environment. The "luxury label" attached to air conditioning in earlier decades has given way to appreciate it practicality in making our live healthier and more productive. Along with rapid development in improving human comfort came the realization that goods could be produced better, faster, and more economically in a properly controlled environment.

AutoCAD is the AutoCAD software for mechanical, electrical, and plumbing designers and drafters. Creation and coordination of construction documents is more efficient with AutoCAD more intuitive systems drawing and design tools. AutoCAD also assessing our vision and enhance our efficiency because of its purpose-built software for MEP designers and drafters.

With AutoCAD we are able to make changes much faster, thus help minimizing the financial impact, and make those changes in almost real time.

B. *History of HVAC*

In 1902, A 25 – year – old engineer from New York named Willis Carrier invented the first modern Air Conditioning system. The mechanical unit, which sent air through water-cooled coils, was not aimed at human comfort, however; it was designed to control humidity in the printing plant where he worked.

The first modern electrical Air Conditioning unit was invented by Willis Carrier in 1902 in Buffalo, New York. After graduating from Cornell University, Carrier found a job at the Buffalo Forge Company.

Heating, Ventilation and Air Conditioning (HVAC) is the technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality.

Air conditioners use chemicals that easily convert from a gas to a liquid and back again. This chemical is used to transfer heat from the air inside of a home to the outside air. The machine has three main parts. They are a compressor, a condenser and an evaporator.

1) *HVAC*

Heating, Ventilating, and Air Conditioning (HVAC) equipment perform heating and/or cooling for residential, commercial or industrial buildings. The HVAC system may also be responsible for providing fresh outdoor air to dilute interior airborne contaminants such as odors from occupants, volatile organic compounds (VOC's) emitted from interior furnishings, chemicals used for cleaning, etc. A properly designed system will provide a comfortable indoor environment year-round when properly maintained.

C. *Working of Air Conditioning System (AC)*

An air conditioner cools and dehumidifies the air as is passes over a cold coil surface. The indoor coil is an air-to-liquid heat exchanger with rows of tubes that pass the liquid through the coil. Finned surfaces connected to these tubes increase the overall surface area of the cold surface thereby increasing the heat transfer characteristics between the air passing over the coil and liquid passing through the coil. The type of liquid used depends on the system selected. Direct-expansion (DX) equipment uses refrigerant as the liquid medium. Chilled-water (CW) can also be used as a liquid medium. When the required temperature of a chilled water system is near the freezing point of water.

Freeze protection is added in the form of glycols or salts. Regardless of the liquid medium used, the liquid is delivered to the cooling coil at a cold temperature.

In the case of direct expansion equipment, the air passing over the indoor cooling coil heats the cold liquid refrigerant. Heating the refrigerant causes boiling and transforms the refrigerant from a cold liquid to a warm gas. This warm gas (or vapor) is pumped from the cooling coil to the compressor through a copper tube (suction line to the compressor) where the warm gas is compressed. In some cases, an accumulator is placed between the cooling coil and the compressor to capture unused liquid refrigerant and ensures that only vapor enters the compressor. The compression process increases the pressure of the refrigerant vapor and significantly increases the temperature of the vapor. The compressor pumps the vapor through another heat exchanger (outdoor condenser) where heat is rejected and the hot gas is condensed to a warm high-pressure liquid. This warm high-pressure liquid is pumped through a smaller copper tube (liquid line) to a filter (or filter/dryer) and then on to an expansion device where the high-pressure liquid is reduced to a cold, low pressure liquid. The cold liquid enters the indoor cooling coil and the process repeats.

D. Importance of HVAC

HVAC is an important part of residential structures such as single family homes, apartment buildings, hotels and senior living facilities, medium to large industrial and office buildings such as skyscrapers and hospitals, onboard vessels, and in marine environments, where safe and healthy building conditions are regulated with respect to temperature and humidity, using fresh air from outdoors.

Ventilating or ventilation (the V in HVAC) is the process of exchanging or replacing air in any space to provide high indoor air quality which involves temperature control, oxygen replenishment, and removal of moisture, odors, smoke, heat, dust, airborne bacteria, carbon dioxide.

E. Refrigerant

A refrigerant is a substance or mixture, usually a fluid, used in a heat pump and refrigeration cycle. refrigeration is a process of moving heat from one location to another in controlled conditions. The work of heat transport is traditionally driven by mechanical work, but can also be driven by heat, magnetism, electricity, laser, or other means in most cycles it undergoes phase transitions from a liquid to a gas and back again Many working fluids have been used for such purposes. Fluorocarbons, especially chlorofluorocarbons, became commonplace in the 20th century, gerents used in various applications are ammonia, sulfur dioxide, and non- halogenated but they are being phased out because of their ozone depletion effects. Other common refry hydrocarbons such as propane.

1) Types of Refrigerants:

The most common types of refrigerants in use nowadays are presented below

- Halocarbons
- Isotropic refrigerants.
- Zoetrope refrigerants.
- Inorganic refrigerants like carbon dioxide, ammonia, water and air.
- Hydrocarbon refrigerants.
- Halocarbons are generally synthetically produced. Depending on whether they include chemical elements hydrogen (H), carbon (C), chlorine (Cl) and Florine (F) they are named after as follows:
- CFCS(Chlorofluorocarbons): R11, R12, R113, R114, R115, HCFCS (Hydro chloroflurocarbons): R22,R123
- HFCS (hydro fluroocarbons): R134a, R404a, R407c, and R410a

F. Various Lines and Curves in Psychrometric Chart:

All the properties of air indicated in the psychometric chart are calculated at the standard atmospheric pressure. For other pressures relevant corrections have to be applied. The psychometric chart looks like a shoe. The various lines shown in the chart are as follows

1) Dry Bulb (DB) Temperature Lines:

The dry bulb temperature scale is shown along the base of the shoe shaped psychometric chart forming the sole. The DB temperature increases from the left to the right. The vertical lines shown in the chart are the constant DB temperature lines and all the points located along a particular vertical line have same DB temperature.

2) Wet Bulb (WB) Temperature Lines:

The outermost curve along the left side indicates the Wet Bulb (WB) temperature scale. The constant temperature lines are the diagonal lines extending from WB temperature curved scale downwards towards the right-hand side of the chart. All the points located along the constant WB temperature line have the same temperature.

3) Relative humidity:

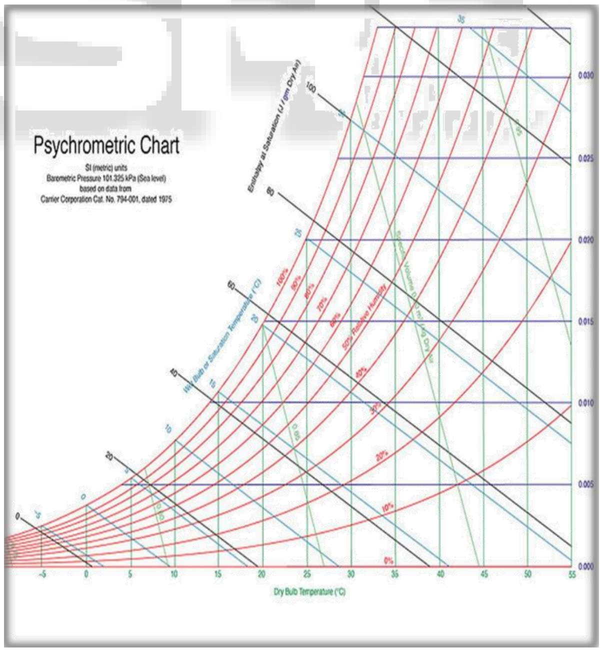
The ratio of the vapor pressure of moisture in the sample to the saturation pressure at the dry bulb temperature of the sample.

4) Dew Point (DP) Temperature Lines:

Since the dew point temperature of the air depends on the moisture content of the air, constant moisture lines are also constant DP temperature lines. The scale of the DP and WB temperature is the same, however, while the constant WB temperature lines are diagonal lines extending downwards, the constant DP temperature lines are horizontal lines. Thus the constant DP and WB temperature lines are different.

5) Humidity Ratio:

These are the horizontal lines on the chart. Humidity ratio is usually expressed as mass of moisture per mass of dry air (pounds or kilograms of moisture per pound or kilogram of dry air, respectively). The range is from 0 for dry air up to 0.03 (blew/lamb) on the right hand ω-axis, the ordinate or vertical axis of the chart.



G. Introduction of Air Conditioning System in Automobiles

Air-conditioning for automobiles came into wide use from the late twentieth century. Although air conditioners use significant power, the drag of a car with closed windows is less than if the windows are open to cool the occupants. There has been much debate on the effect of air conditioning on the fuel efficiency of a vehicle. Factors such as wind resistance, aerodynamics and engine power and weight must be considered, to find the true difference between using the air conditioning system and not using it, when estimating the actual fuel mileage. Other factors can affect the engine, and an overall engine heat increase can affect the cooling system of the vehicle.

The innovation was adopted quickly and new features to air conditioning like the Cadillac Comfort Control which was a completely automatic heating and cooling system set by dial thermostat was introduced as an industry first in the 1964 model year. By 1960 about 20% of all cars in the U.S. had air-conditioning, with the percentage increasing to 80% in the warm areas of the Southwest. American motors made air conditioning standard equipment on all AMC Ambassadors starting with the 1968 model year, a first in the mass market, with a base price starting at $2,671. By 1969, 54% of domestic automobiles were equipped with air conditioning, with the feature needed not only for passenger comfort, but also to increase the car's resale value.

H. Evaporative Cooling

A car cooler is an automobile evaporative cooler, sometimes referred to as a swamp cooler. Most are aftermarket relatively inexpensive accessories consisting of an external window-mounted metal cylinder without moving parts, but internal under dashboard or center floor units with an electric fan are available. It was an early type of automobile air conditioner and is not used in modern cars relying on refrigerate systems to cool the interior. To cool the air, it used latent heat (in other words, cooling by water evaporation). Water inside the device evaporates and in the process transfers heat from the surrounding air.

The cool moisture-laden air is then directed to the inside of the car. The evaporate "cooling" effect decreases with humidity because the air is already saturated with water. Therefore, the lower the humidity, such as in dry desert regions, the better the system works. Car coolers were popular, especially among summer tourists visiting or crossing the South western united states of California, Arizona, Texas, New Mexico, and Nevada.

Fig. 1.1: Car Cooler

I. Operating Principles

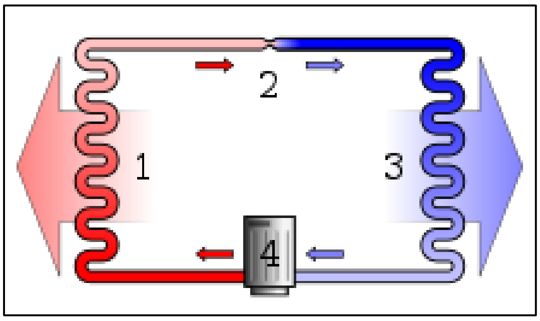


Fig. 1.2: Refrigeration Cycle

A simple stylized diagram of the refrigeration cycle:

1) Condensing coil
2) Expansion valve
3) Evaporative coil
4) Compressor

Fig. 1.3: Repassing the air conditioning of a Ford Focus

In the refrigeration cycle, heat is transported from the passenger compartment to the environment. A refrigerator is an example of such a system, as it transports the heat out of the interior and into the ambient environment.

Circulating refrigerant gas vapor (which also carries the compressor lubricant oil across the system along with it) from the evaporator enters the gas compressor in the engine bay, usually an axial piston pump compressor, and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed refrigerant vapor is now at a temperature and pressure at which it can be condensed and is routed through a condenser, usually in front of the car's radiator. Here the refrigerant is cooled by air flowing across the condenser coils (originating from the vehicle's movement or from a fan, often the same fan of the cooling radiator if the condenser is mounted on it, automatically turned on when the vehicle is stationary or moving at low speeds) and condensed into a liquid. Thus, the circulating refrigerant rejects heat from the system and the heat is carried away by the air.

The condensed and pressurized liquid refrigerant is next routed through the receiver-drier, that is, a one way desiccant and filter cartridge that both dehydrates the refrigerant and compressor lubricant oil mixture in order to remove any residual water content (which would become ice inside the expansion valve and therefore clog it) that the vacuum done prior to the charging process didn't manage to remove from the system, and filters it in order to remove any solid particles carried by the mixture, and then through a thermal expansions valve where it undergoes an abrupt reduction in pressure. That pressure reduction results in flash evaporative of a part of the liquid refrigerant, lowering its temperature. The cold refrigerant is then routed through the evaporator coil in the passenger compartment.

The air, often after being filtered by a cabin air filter, is blown by an adjustable speed electric powered centrifugal fan across the evaporator, causing the liquid part of the cold refrigerant mixture to evaporate as well, further lowering the temperature. The warm air is therefore cooled, and also deprived of any humidity (which condenses on the evaporator coils and is drained outside of the vehicle) in the process. It is then passed through a heater matrix, inside of which the engine's coolant circulates, where it can be reheated to a certain degree or even a certain temperature selected by the user and then delivered inside the vehicle's cabin through a set of adjustable vents. Another way of adjusting the desired air temperature, this time by working on the system's cooling capacity, is precisely regulating the centrifugal fan speed so that only the strictly required volumetric flow of air is cooled by the evaporator. The user is also given the option to close the vehicle's external air flaps, in order to achieve even faster and stronger cooling by recirculating the already cooled air inside the cabin to the evaporator. To complete the refrigeration cycle, the refrigerant vapor is routed back into the compressor.

The warmer the air that reaches the evaporator, the higher the pressure of the vapor mixture discharged from it and therefore the higher is the load placed on the compressor and therefore on the engine to keep the refrigerant flowing through the system.

The compressor can be driven by the car's engine (e.g. via a belt, often the serpentine belt, and an electromagnetically actuated clutch; an electronically actuated variable displacement compressor can also be always directly driven by a belt without the need of any clutch and magnet at all) or by an electric motor.

J. Power Consumption:

In a modern automobile, the A/C system will use around 4 Horse power (3 kW) of the engine's power, thus increasing fuel consumption of the vehicle.

II. DUCT SYSTEM

A. Duct:

Ducts are conduits or passages used in Heating, Ventilation, and Air Conditioning (HVAC) to deliver and remove air. The needed airflows include, for example, supply air, return air, and exhaust air. Ducts commonly also deliver ventilation air as part of the supply air. As such, air ducts are one method of ensuring acceptable indoor air quality as well as thermal comfort.

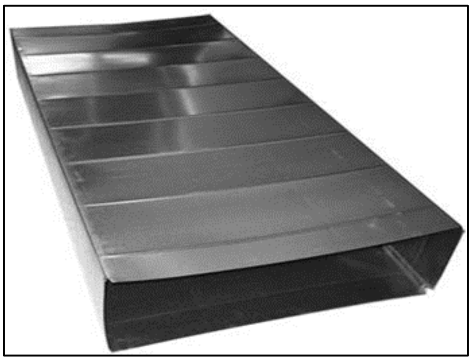


Fig. 1.4: Duct

Process duct work conveys large volumes of hot, dusty air from processing equipment to mills, bughouses to other process equipment. Process duct work may be round or rectangular. Although round duct work costs more to fabricate than rectangular duct work, it requires fewer stiffeners and is favored in many applications over rectangular ductwork.

The air in process duct work may be at ambient conditions or may operate at up to 900 °F (482 °C). Process ductwork varies in size from 2 ft diameter to 20 ft diameter or to perhaps 20 ft by 40 ft rectangular. Large process ductwork may fill with dust, depending on slope, to up to 30% of cross section, which can weigh 2 to 4 tons per linear foot. Round ductwork is subject to duct suction collapse, and requires stiffeners to minimize this. but is more efficient on material than rectangular duct work.

III. INTRODUCTION TO AUTODESK REVIT

Autodesk Revit is Building information modelling software for architects, landscape architects, structural engineers, mechanical, electrical and plumbing (MEP) engineers, designers and contractors. The original software was developed by Charles River Software, founded in 1997, renamed Revit Technology Corporation in 2000, and acquired by Autodesk in 2000. The software allows users to design a building and structure and its components in 3D, annotate the model with 2D drafting elements, and access building information from the building model's database. Revit is 4D building information modelling capable with tools to plan and track various stages in the building's lifecycle, from concept to construction and later maintenance and demolition

A. History

Charles Rivet Software was founded in Newton, Massachusetts, on October 31, 1997, by Leonid Raiz and Irwin Jungreis, key developers of PTC's Pro/Engineer's software for mechanical design, with the intent of bringing the power of parametric modelling to the building industry (PTC had previously tried and failed to market is recently acquired Reflex Software to the construction sector), With funding from venture capitalists Atlas Venture and North Bridge Venture Partners Raiz and Jungreis hired several software developers and architects and began developing Revit in C++ on the Microsoft Windows platform. In 1999, they hired Dave Lemont as CEO and recruitment board member Jon Hendrick founder of Solid works, and Arol Walford, founder of CMD Group.

From the outset, Revit was intended to allow architects and other building professionals to design and document a building by creating a parametric three-dimensional model that includes both the poetry and non-geometric design and construction information, which is also known as Building Information Modelling or BIM (1975 Eastman C). At the time, several other software packages such as ArchiCAD and Reflex provided a three-dimensional virtual building model, and let the user control individual component via parameters parametric components).two key differences in Revit were that users created parametric components in a graphical "family editor" rather than programming language, and the model captured all relationships between components, views, and annotations so that a change to any element automatically propagated to keep the model consistent. For example, moving a wall updated neighbouring walls, floors, and roofs, corrected the placement and values of dimensions and notes, adjusted the floor arcas reported in schedules, redrew section views, etc. so that the model remained connected and all documentation was coordinated.

The concept of bi-directional associativity between components, views and annotations was a distinguishing feature of Revit for many releases. The case of making changes inspired the name Revit, a contraction of Revise-Instantly. At the heart of Revit is a parameter change propagation engine that relied on a new technology, context driven parameter that was more scalable than the variation and history-driven parameter used in mechanical CAD software. The term Parametric Building Model was adopted to reflect the fact that changes to parameters drove the whole building model and associated documentation, not just individual components

B. Use and Implementation

Revit can be used as a powerful collaboration tool between different disciplines in the building in the building design sphere. The difference disciplines that use Revit approach the program from unique perspectives is focused on completing that disciplines task. Companies that adopt the software first examine the existing work flow process to determine such an elaborate collaboration tool is required.

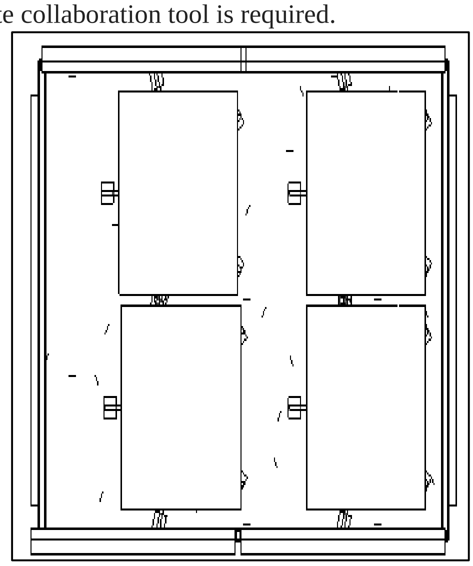


Fig. 3.1: Top View of Automobile 4 Seated Car

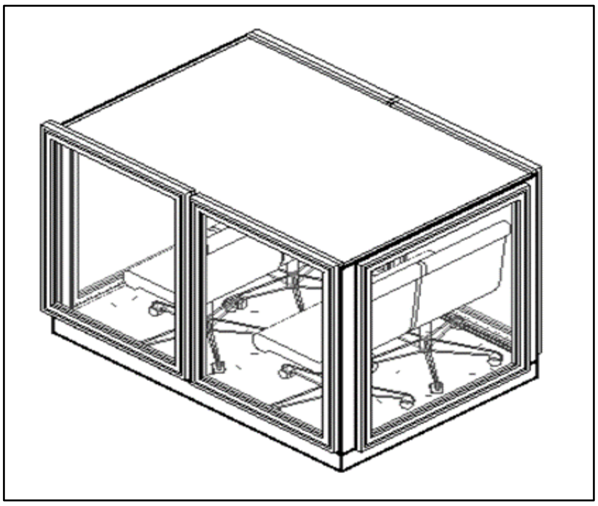


Fig. 3.2: 3D VIEW of Automobile 4 Seated Car

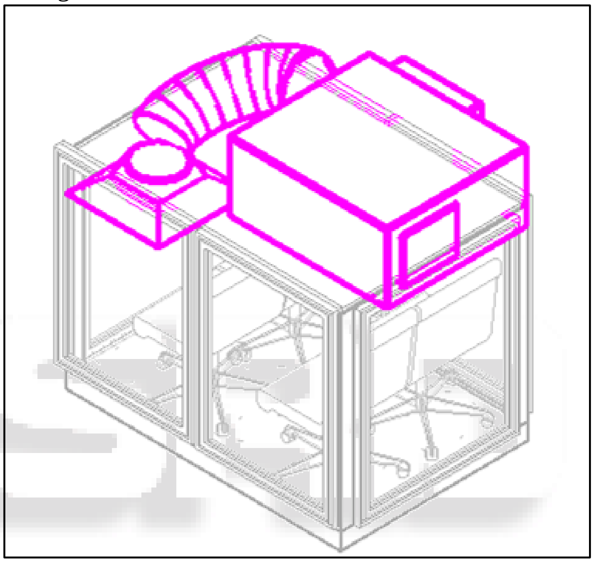


Fig. 3.3: Output Design of Automobile 4 Seated Car

C. Some of the Shortcuts used in the Software

CL [STRUCTURAL COLUMN]: Add a vertical load-bearing element to the car model.
CM [PLACE A COMPONENT]: Place a component.
DR [DOOR]: Adds a door to the room or building.
GR [GRID]: Places column grid lines in the building design.
LL[LEVEL]: Places a level in view.
RM [ROOM]: Creates a room hounded by model element and separation lines.
RP [REFERENCE PLANE]: Creates a reference line using drawing tools.
RT [TAG ROOM: ROOM TAG]: Tags the selected room.
SB [STRUCTURAL FLOORS]: Adds structural floors to a building model.
WA [ARCHITECTURAL WALL]: Creates a non-bearing wall or a structural wall in the building model.
WN [WINDOW]: Places a window in a wall or skylight in a roof.

Location and Weather	
Project	Project Name
Address	

Calculation Time	Saturday, June 15, 2019 3:20 PM
Report Type	Standard
Latitude	12.98°
Longitude	77.58°
Summer Dry Bulb	95 °F
Summer Wet Bulb	74 °F
Winter Dry Bulb	59 °F
Mean Daily Range	19 °F

Table 1: Project Summary

Inputs	
Building Type	Automotive Facility
Area (SF)	23
Volume (CF)	91.39
Calculated Results	
Peak Cooling Total Load (Btu/h)	190,102.9
Peak Cooling Month and Hour	April 4:00 PM
Peak Cooling Sensible Load (Btu/h)	190,090.2
Peak Cooling Latent Load (Btu/h)	12.7
Maximum Cooling Capacity (Btu/h)	190,102.9
Peak Cooling Airflow (CFM)	9,959
Peak Heating Load (Btu/h)	36,244.8
Peak Heating Airflow (CFM)	2,406
Checksums	
Cooling Load Density (Btu/(h·ft²))	8,320.61
Cooling Flow Density (CFM/SF)	435.87
Cooling Flow / Load (CFM/ton)	628.62
Cooling Area / Load (SF/ton)	1.44
Heating Load Density (Btu/(h·ft²))	1,586.40
Heating Flow Density (CFM/SF)	105.29

Table 2: Building Summary

Inputs	
Area (SF)	23
Volume (CF)	91.39
Cooling Setpoint	74 °F
Heating Setpoint	70 °F
Supply Air Temperature	54 °F
Number of People	1
Infiltration (CFM)	0
Air Volume Calculation Type	VAV - Single Duct
Relative Humidity	46.00% (Calculated)
Psychrometrics	
Psychrometric Message	None
Cooling Coil Entering Dry-Bulb Temperature	74 °F
Cooling Coil Entering Wet-Bulb Temperature	60 °F
Cooling Coil Leaving Dry-Bulb Temperature	54 °F
Cooling Coil Leaving Wet-Bulb Temperature	53 °F
Mixed Air Dry-Bulb Temperature	74 °F
Calculated Results	
Peak Cooling Load (Btu/h)	190,102.9
Peak Cooling Month and Hour	April 4:00 PM
Peak Cooling Sensible Load (Btu/h)	190,090.2
Peak Cooling Latent Load (Btu/h)	12.7
Peak Cooling Airflow (CFM)	9,959
Peak Heating Load (Btu/h)	36,244.8
Peak Heating Airflow (CFM)	2,406
Peak Ventilation Airflow (CFM)	0
Checksums	
Cooling Load Density (Btu/(h·ft²))	8,320.61
Cooling Flow Density (CFM/SF)	435.87
Cooling Flow / Load (CFM/ton)	628.62
Cooling Area / Load (SF/ton)	1.44
Heating Load Density (Btu/(h·ft²))	1,586.40
Heating Flow Density (CFM/SF)	105.29
Ventilation Density (CFM/SF)	0.00
Ventilation / Person (CFM)	0

Components	Cooling		Heating	
	Loads (Btu/h)	Percentage of Total	Loads (Btu/h)	Percentage of Total
Wall	178,585.7	93.94%	35,659.3	98.38%
Window	5,334.2	2.81%	527.5	1.46%
Door	0.0	0.00%	0.0	0.00%
Roof	397.9	0.21%	57.9	0.16%
Skylight	0.0	0.00%	0.0	0.00%
Partition	0.0	0.00%	0.0	0.00%
Infiltration	0.0	0.00%	0.0	0.00%
Ventilation	0.0	0.00%	0.0	0.00%
Lighting	61.8	0.03%		
Power	103.0	0.05%		
People	38.8	0.02%		
Plenum	0.0	0.00%		
Fan Heat	5,581.4	2.94%		
Reheat	0.0	0.00%		
Total	190,102.9	100%	36,244.8	100%

Table 3: Zone Summary – 1

Space Name	Area (SF)	Volume (CF)	Peak Cooling Load (Btu/h)	Cooling Airflow (CFM)	Peak Heating Load (Btu/h)	Heating Airflow (CFM)
car	23	91.39	184,521.5	9,959	36,244.8	2,406

Table 4: Spaces

Inputs	
Area (SF)	23
Volume (CF)	91.39
Wall Area (SF)	80
Roof Area (SF)	24
Door Area (SF)	0
Partition Area (SF)	0
Window Area (SF)	75
Skylight Area (SF)	0

Lighting Load (VA)	21
Power Load (VA)	34
Number of People	1
Sensible Heat Gain / Person (Btu/h)	250.0
Latent Heat Gain / Person (Btu/h)	200.0
Infiltration Airflow (CFM)	0
Space Type	Automotive Facility (inherited from building type)
Calculated Results	
Peak Cooling Load (Btu/h)	184,521.5
Peak Cooling Month and Hour	April 4:00 PM
Peak Cooling Sensible Load (Btu/h)	184,508.8
Peak Cooling Latent Load (Btu/h)	12.7
Peak Cooling Airflow (CFM)	9,959
Peak Heating Load (Btu/h)	36,244.8
Peak Heating Airflow (CFM)	2,406

Components	Cooling		Heating	
	Loads (Btu/h)	Percentage of Total	Loads (Btu/h)	Percentage of Total
Wall	178,585.7	96.78%	35,659.3	98.38%
Window	5,334.2	2.89%	527.5	1.46%
Door	0.0	0.00%	0.0	0.00%
Roof	397.9	0.22%	57.9	0.16%
Skylight	0.0	0.00%	0.0	0.00%
Partition	0.0	0.00%	0.0	0.00%
Infiltration	0.0	0.00%	0.0	0.00%
Lighting	61.8	0.03%		
Power	103.0	0.06%		
People	38.8	0.02%		
Plenum	0.0	0.00%		
Total	184,521.5	100%	36,244.8	100%

Table 5: Space Summary - 1 Car

IV. Conclusion

From the above calculations the estimated values the temperatures of car were find out and the project summary is provided and the temperature excel sheets and provided.

In this all the parameters were taken into consideration for high accuracy and proper estimation of cooling load.

Based on the obtained temperatures for car was done using Revit software. All the diagrams were shown in the civil plan. From this we can conclude that our estimated values are fair enough to establish the air conditioning system in the specified location. By using HVAC system energy consumption of the building is reduced as much as possible by avoiding unnecessary loses. This is one of the most well designed and most useful method in the present-day installations.

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