Retrofitting of Backup Air-Conditioning System In Air- Conditioned Vehicle

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Declaration

We hereby, declare that the work presented in this project is the outcome of the investigation and research work performed by us under the supervision of ***Mr. Shuvo Biswas Topu**,* **Lecturer, Department of Mechanical Engineering, Sonargaon University (SU).** We also declare that no part of this project and thereof has been or is being submitted elsewhere for the award of any degree.

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Approval

This is to certify that the project on ***"Retrofitting of backup Air-conditioning system in Air-conditioned vehicle"*** by (Md. Mizanur Rahman, ID- BME1601008159, Md. Masudur Rahman Tipu, ID-BME1601008173, Md. Tanjil Mahmud, ID- BME1601008174, has been carried out under our supervisor. The project has been carried out in partial fulfillment of the requirement for the degree of Bachelor of Science (BSc) in Mechanical Engineering of the year 2019 and has been approved as to its style and contents.

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ABSTRACT

This thesis has been performed for the design of backup air conditioning system of interior of the car. Air conditioning system is mainly used in passenger and commercial vehicle. The purpose of this system is to make comfortable environment in terms of desired temperature, humidity, air flow, indoor air quality, filtration, and other environmental parameter for the occupants, equipment's as well as to save fuel consumption. In this thesis cooling load is calculated for Mercedes-Benz E250 sedan car. This car interior consists of five section having an area of $3.972m^3$ .To calculate the cooling load (Without Load), to calculate the cooling load (With Load), Comparison Electrical consumption Without Load and With Load. To calculate the System Thermal Efficiency, Overall efficiency, To calculate of project volume & real car volume, To calculate the cooling time of project & cooling time of real car without passenger, To calculate the cooling time of real car with passenger. To calculate the cooling rate of the system, to calculate the system capacity. The results showed that the total cooling time taken 3.96 Minutes found of this backup system for interior of the car with passengers. That's why we can take decision to use backup Air-conditioning system in vehicle. In automobiles, a Stop-start backup Air-Conditioning system manually shut down the internal combustion Engine to reduce the amount of time the engine spends idling, thereby reducing fuel consumption and emissions. The engine goes off when the vehicle is stationary and back on again when the switch is off. The objective of this thesis is to make effective air-conditioning by using Battery Energy for Backup Air-Conditioning System in Air- Conditioned Vehicle. Brief information and comparisons of different air-conditioning cycle has been presented in this report. By investigating, backup Air-conditioning system saves fuel and reduces the vehicle's emissions by shutting off the engine in situations where the vehicle is not in motion, When use backup Air-conditioning system on the car, the fuel consumption is zero of the Engine with no emission because whereas Engine start is switched off. That is to say no need to start an Engine for using backup Air-conditioning system. During this period all passenger is feel comfort temperature in the interior of the car. Stop-start backup Air-Conditioning system technology is one of the fuel economy car technologies to help reducing CO_2 emissions. It plays a key role in the way to achieve emission regulation whilst reducing fuel consumption, and a low temperature heat source can be used to drive the air-conditioning system.

The final section of this thesis will be the key component of the backup Air-Conditioning System in Air- Conditioned Vehicle system.

ACKNOWLEDGEMENT

The authors want to express gratefulness, regards, gratitude and sincere thanks to supervisor ***Mr. Shuvo Biswas Topu,*** **Lecturer, Department of Mechanical Engineering, Sonargaon University (SU).** For his guidance and valuable counsel in execution and completion of the study without which it would be impossible to carry out the work. Also, thanks to ***Md. Mostofa Hossain***, **Associate Professor and Head of the Department of Mechanical Engineering, (SU)** for giving permission to use laboratory facilities of the department.

Authors grateful to the teachers who helped us directly or indirectly which was very necessary to complete the thesis work.

Finally, we are also grateful to the **Vice Chancellor** of Sonargaon University (SU) for his overall support to finish the project works.

"The Authors".

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Nomenclature

V = Volume of Air (m^3)

M = Mass (kg)

ρ = Density of Air (kg/m^3)

Cp = Specific Heat (Constant Pressure) (kg/m^3°K)

Q = Heat Energy (J)

η = Efficiency

T = Temperature (℃)

AH = Ampere Hour

I = Ampere (Current)

$A_{Du} = DuBois\ Body\ surface\ area\ (m^2)$

CHAPTER 1

INTRODUCTION

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INTRODUCTION

1.1 Introduction

Retrofitting of backup Air-conditioning system in Air-conditioned vehicle in automobiles, a Stop-start backup Air-Conditioning system manually shut down the internal combustion Engine to reduce the amount of time the engine spends idling, thereby reducing fuel consumption and emissions. When use backup Air-conditioning system on the car, the fuel consumption is zero of the Engine with no emission because whereas Engine start is switched off. That is to say no need to start an Engine for using backup Air-conditioning system. During this period all passenger is feel comfort temperature in the interior of the car.

1.2 Aim of the Project

To analyze and construct reducing the fuel consumption and emission. Its main purpose of save the fuel consumption with less emission and to make comfortable environment in terms of desired temperature to the interior of the car for the passengers of backup Air-conditioning System in Automotive car is on standing condition whereas Engine start is switched off.

1.3 Objectives

i. To reduce fuel consumption and emission by using Stop-start backup Air-Conditioning system while manually shutting down the internal combustion Engine.
ii. To use the backup Air-conditioning system without the necessity of starting the internal combustion Engine when Traffic is heavy on the road.
iii. To make effective backup Air-conditioning system by using Battery Energy.
iv. To make Pollution Free system by using it.
v. To make backup Air-Conditioning system to feel comfort temperature for the passenger in the interior of the car.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2
LITERATURE REVIEW

2.1 Air conditioning System:

All air-conditioning systems utilize a specific material to undergo the phase conversion process. This material is called a refrigerant, and is contained within tubing which runs throughout the air-conditioning system. The refrigerant is pulled into the system's compressor in the form of a warm vapor after leaving the evaporator coil.

The compressor increases the density of the incoming refrigerant vapor, causing it to increase in pressure and temperature. This is normally accomplished using a centrifugal system, where a series of spinning blades rapidly forces the vapor to the outside of the compressor chamber, at which point it exits. This hot, high-pressure vapor then travels to the air conditioner's condenser where it moves through a series of coils with thin metal fins attached. A fan blows air over the fins, and heat moves from the refrigerant to the fins and into the air stream, very similar to the method a radiator uses to remove heat from the coolant circulating within in a car engine. The air that is run over the condenser coils is vented to the building exterior and is released to the atmosphere.

This trip through the condenser causes the vapor to lose a significant amount of heat and it subsequently changes phase from a gas to a high temperature liquid. The liquid refrigerant is then forced through an expansion valve which is basically a pinhole that causes the liquid to form a mist. A sudden pressure drop and material expansion when the liquid turns into a mist results in a rapid cooling of the fluid as it throws off heat energy. This cold mist travels through the evaporator coil which is located directly in the air stream of a circulation fan which pulls air from within the building. The fan pushes the air across the cold coils, which pulls heat from the air, causing the air to cool. The transfer of heat to the refrigerant causes it to change back into a warm vapor and it enters the compressor to begin the cycle again. [1]

2.2 Types of Air-Conditioning System:

- Orifice Tube System.
- Expansion Valve System.

2.2.1 Orifice Tube System:

The orifice tube systems are commonly found in General Motors (GM) and Ford models. The orifice tube is located in the inlet tube of the evaporator or in the liquid line. The orifice tube is no longer than 3 inches. It is made up of small brass tubes surrounded by plastic, covered with a filter at each end. Disadvantages of the orifice tube system include clogging caused by debris and high costs of repairing or replacing the tube. To avoid the clogging of debris in the orifice tube system, install a larger pre-filter in front of the orifice tube. [2]

2.2.2 Expansion Valve System:

The expansion valve system is generally used on after-market systems. This system is efficient at regulating refrigerant to the evaporator. It is located at the firewall, between the evaporator inlet and outlet tubes and the liquid and section lines. It may clog with debris. Additionally, the valve contains small moving parts that may stick together or malfunction because of corrosion. [2]

2.3 History:

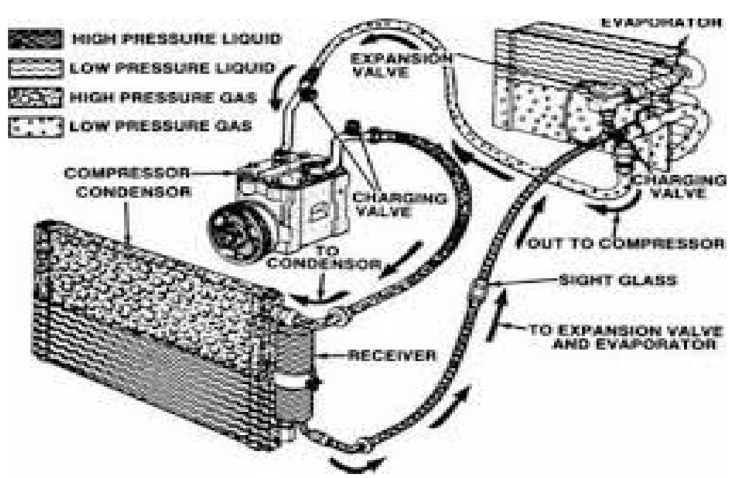

Fig 1: Air-Conditioning System

A company in New York City in the United States first offered installation of air conditioning for cars in 1933. Most of their customers operated limousines and luxury cars.

In 1939, Packard became the first automobile manufacturer to offer an air conditioning unit in its cars.[2] These were manufactured by Bishop and Babcock Co, of Cleveland, Ohio. The "Bishop and Babcock Weather Conditioner" also incorporated a heater. Cars ordered with the new "Weather Conditioner" were shipped from Packard's East Grand Boulevard facility to the B&B factory where the conversion was performed. Once complete, the car was shipped to a local dealer where the customer would take delivery.

Packard fully warranted and supported this conversion, and marketed it well. However, it was not commercially successful for a number of reasons:

The main evaporator and blower system took up half of the trunk space (though this became less of a problem as trunks became larger in the post-war period).

It was superseded by more efficient systems in the post-war years.

It had no temperature thermostat or shut-off mechanism other than switching the blower off. (Cold air would still sometimes enter the car with any movement as the drive belt was continuously connected to the compressor—later systems would use electrically operated clutches to remedy this problem.)

The several feet of plumbing going back and forth between the engine compartment and trunk proved unreliable in service.

The price, at US $274 ($4,692.12 in 2014 US dollars), was unaffordable to most people in depression/pre-war America. The option was discontinued after 1941.

The 1953 Chrysler Imperial was one of the first production cars in twelve years to offer modern automobile air conditioning as an option, following tentative experiments by Packard in 1940 and Cadillac in 1941. Walter Chrysler had seen to the invention of Air temp air conditioning in the 1930s for the Chrysler Building, and had offered it on cars in 1941-42, and again in 1951-52.

The Air temp was more advanced than rival automobile air conditioners by 1953. It was operated by a single switch on the dashboard marked with low, medium, and high positions. As the highest capacity unit available at that time, the system was capable of quickly cooling the passenger compartment and also reducing humidity, dust, pollen, and tobacco smoke. The system drew in more outside air than contemporary systems; thus, reducing the staleness associated with automotive air conditioning at the time. Instead of plastic tubes mounted on the rear window package shelf as on GM cars, small ducts directed cool air toward the ceiling of the car where it filtered down around the passengers instead of blowing directly on them, a feature that modern cars have lost. Cadillac, Buick, and Oldsmobile added air conditioning as an option on some of their models in the 1953 model year.

All of these Frigidaire systems used separate engine and trunk mounted components.

In 1954, the Nash Ambassador was the first American automobile to have a front-end, fully integrated heating, ventilating, and air-conditioning system. The Nash-Kelvinator corporation used its experience in refrigeration to introduce the automobile industry's first compact and affordable, single-unit heating and air conditioning system optional for its Nash models. This was the first mass market system with controls on the dash and an electric clutch. This system was also compact and serviceable with all of its components installed under the hood or in the cowl area

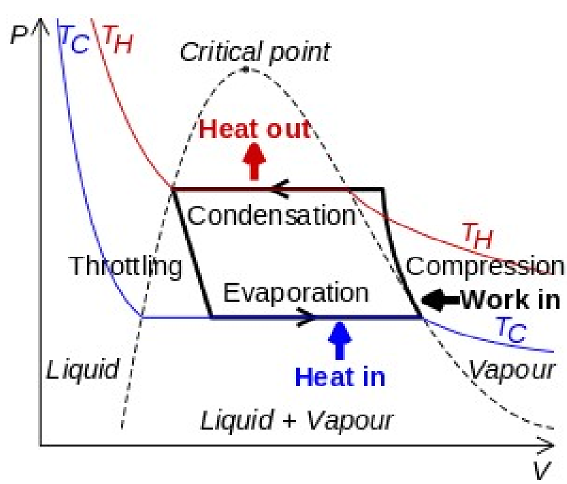

Figure 2: Pressure-Volume Diagram for an Air-Conditioning Cycle

The condensed liquid refrigerant, in the thermodynamic state known as a saturated liquid, is next routed through an expansion valve where it undergoes an abrupt reduction in pressure. That pressure reduction results in the adiabatic flash evaporation of a part of the liquid refrigerant. The auto refrigeration effect of the adiabatic flash evaporation lowers the temperature of the liquid and vapor refrigerant mixture to where it is colder than the temperature of the enclosed space to be refrigerated. The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the cold refrigerant liquid and vapor mixture. That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to the desired temperature. The evaporator is where the circulating refrigerant absorbs and removes heat which is subsequently rejected in the condenser and transferred elsewhere by the water or air used in the condenser. To complete the refrigeration cycle, the refrigerant vapor from the evaporator is again a saturated vapor and is routed back into the compressor. [3]

2.4 Thermodynamic Analysis of the System:

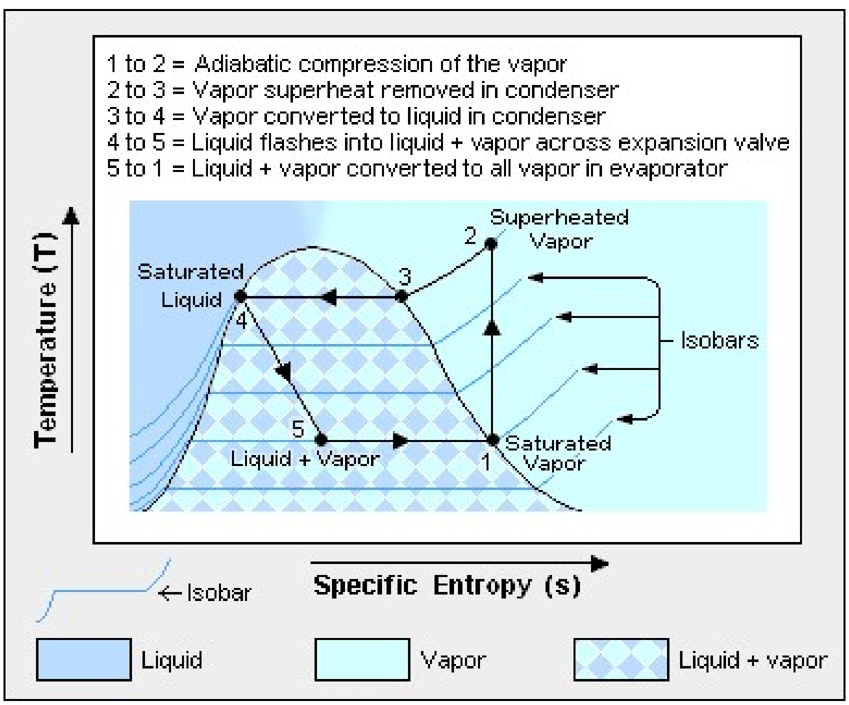

Figure 3: Temperature-Entropy Diagram for a Typical Refrigeration Cycle

The thermodynamics of the vapor compression cycle can be analyzed on a temperature versus entropy diagram as depicted in Figure 2. At point 1 in the diagram, the circulating refrigerant enters the compressor as a saturated vapor. From point 1 to point 2, the vapor is isentropic ally compressed (compressed at constant entropy) and exits the compressor as a superheated vapor. From point 2 to point 3, the vapor travels through part of the condenser which removes the superheat by cooling the vapor. Between point 3 and point 4, the vapor travels through the remainder of the condenser and is condensed into a saturated liquid. The condensation process occurs at essentially constant pressure. Between points 4 and 5, the saturated liquid refrigerant passes through the expansion valve and undergoes and abrupt decrease of pressure. That process results in the adiabatic valve and undergoes an abrupt decrease of pressure. That process results in the adiabatic flash evaporation and auto-refrigeration of a portion of the liquid (typically, less than half of the liquid flashes). The adiabatic flash evaporation process is isenthalpic (occurs at constant enthalpy).

Between points 5 and 1, the cold and partially vaporized refrigerant travels through the coil or tubes in the evaporator where it is totally vaporized by the warm air (from the space being refrigerated) that a fan circulates across the coil or tubes in the evaporator. The evaporator operates at essentially constant pressure and boils off all available liquid there after adding 4-8 kelvins of superheat to the refrigerant as a safeguard for the compressor as it cannot pump liquid. The resulting refrigerant vapor returns to the compressor inlet at point 1 to complete the thermodynamic cycle.

It should be noted that the above discussion is based on the ideal vapor-compression refrigeration cycle which does not take into account real world items like frictional pressure drop in the system, slight internal irreversibility during the compression of the refrigerant vapor, or non-ideal gas behavior (if any). [4]

CHAPTER 3

WORKING PRINCIPLE OF AUTOMOTIVE AIR-CONDITIONING SYSTEM

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3.1 How Does Air-conditioning System Work in a Car?

The automotive air conditioning system includes the compressor, condenser, evaporator, receiver-dehydrator and connecting lines which includes expansion valve, orifice tube, suction throttling valve, positive operating absolute valve, evaporator pressure regulator valve, thermal sensor, high pressure cut off switch and cycling compressor switch. In old days Freon 12 was used as refrigerant but now it is replaced by alternative refrigerant like R134a.

The working of automotive air condition system is similar to all other air conditioning system. The refrigerant vapor from the evaporator is compressed to high pressure by the compressor. The compressor is driven by the engine through a belt drive. It is connected by a electromagnetic clutch witch serve engage and disengage the compressor required. A variable displacement AC compressor is sometime used to match compressor capacity to varying cooling requirement. Refrigerant pressure and temperature increases in the compressor and convert it into vapor form. This high pressure and temperature refrigerant vapor from the compressor then discharge to the condense, which is a heat exchanger situated in front of vehicle. In the condenser the refrigerant liberate heat and convert into liquid form. Sometime the ram air is not sufficient so an extra engine or electric driven fan is used to cool down the refrigerant. This cooled but high pressure refrigerant allow to pass form dehydrator to extract any moisture. Dry refrigerant liquid is then made to pass through expansion valve mounted at the inlet side of the evaporator. The expansion valve allows the refrigerant liquid to expand to low pressure in the evaporator. The process of expansion to low pressure makes the refrigerant to evaporate and thereby cool the evaporator. A sensing devices, called temperature tube signals the diaphragm in the expansion valve to vary orifice size depending upon the refrigerant temperature at the evaporator outlet, thus achieving automatic temperature control. The evaporator is similar in construction to the condenser. [5]

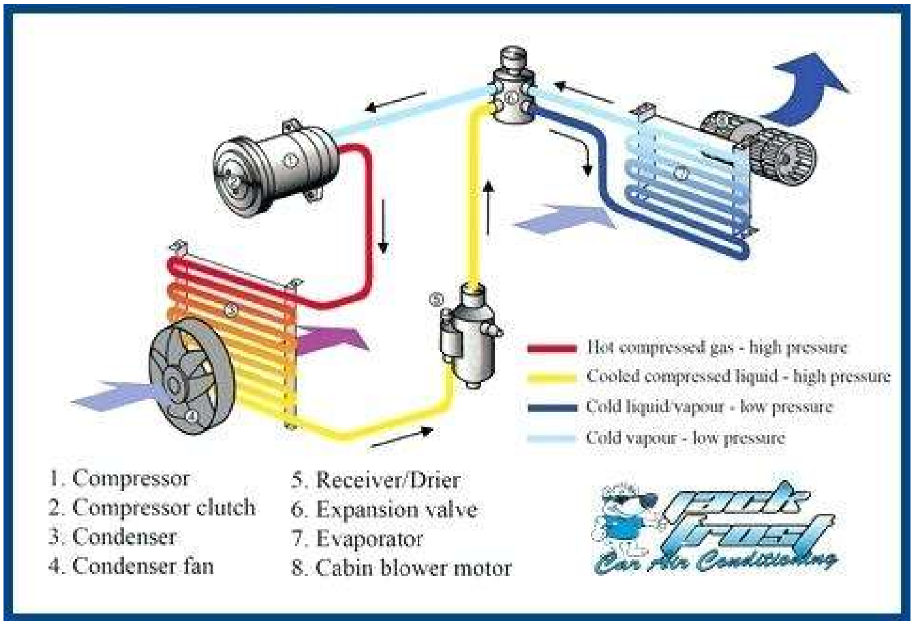

Figure 4: Vehicle air conditioning cycle

3.2 Main Parts of a Car air conditioning System:

A refrigerator consists of a few key components that play a vital role in the Car air conditioning process:

3.2.1 Compressor:

A/C Compressor: The compressor is to circulate the refrigerant in the system under pressure, this concentrates the heat it contains.

At the compressor, the low pressure gas is changed to high pressure gas.

The cycle begins when the compressor draws in cool, low-pressure refrigerant gas from the indoors. The motor-driven compressor's sole function is to "squeeze" the refrigerant, raising its temperature and pressure so that it exits the compressor as a hot, high-pressure gas. [6]

Figure 5: A/C Compressor

3.2.2 Condenser:

A condenser is simply a heat exchanger, the purpose of a condenser in the cycle of compression refrigeration is to change the hot gas being discharged from the compressor to a liquid prepared for use in the evaporator.

Inside the condenser, the refrigerant vapor is compressed and forced through a heat exchange coil, condensing it into a liquid and rejecting the heat previously absorbed from the cool indoor area. The condenser's heat exchanger is generally cooled by a fan blowing outside air through it. [6]

Figure 6: Condenser

3.2.3 Expansion Valve:

The main function is to remove pressure from the liquid refrigerant in the system. This allows for expansion, and then converts the refrigerant from liquid to vapor inside the evaporator. And also controlling the refrigerant flow, called metering. Inside of the valve is a moveable rod that moves up and down. This enables it to open and close the passageway inside, allowing refrigerant to enter, or not. At any given time it can accurately meter the precise amount of refrigerant that's needed. [6]

Figure 7: Expansion valve

3.2.4 Evaporator:

Evaporator: The evaporator works the opposite of the condenser, here refrigerant liquid is converted to gas, absorbing heat from the air in the compartment. When the liquid refrigerant reaches the evaporator, its pressure has been reduced, dissipating its heat content and making it much cooler than the fan air flowing around it.

Evaporator is an important component together with other major components in a refrigeration system such as compressor, condenser and expansion device. The reason for refrigeration is to remove heat from air, water or other substance. It is here that the liquid refrigerant is expanded and evaporated
[6]

Figure 8: Evaporator

3.2.5 Condenser Fan: The outdoor unit works to keep the air conditioning unit cool when it is running. The condenser fan motor is what runs to turn the fan blades and blow air across the condenser coil, where it cools the refrigerant from a hot gas into a liquid. [6]

Figure 9: Condenser Fan

3.2.6 Blower Motor: A blower motor is also found vehicles, and is the part of that system responsible for pushing the hot air throughout your vehicle when you are running the heating system. It also blows through the vehicle's AC evaporator in order to provide cool air when the air conditioning system is running. [6]

Figure 10: A/C Blower Motor

3.2.7 Refrigerant:

The type of refrigerant used in automotive air conditioning systems is changing. Although R-134a refrigerant is still used in many late model vehicles, most new cars and light trucks are now being equipped with A/C systems that use R-1234yf refrigerant. Other refrigerants are still being considered as alternatives down the road, but for now it looks as if R-1234yf will be the primary refrigerant.

The Europeans phased out R-134a in new vehicles in 2017. European rules require any new refrigerants to have a global warming potential of less than 150. The U.S. EPA also wants car makers to use R-1234yf to lower the overall carbon emissions of the vehicle fleet.

The latest EPA rules say vehicle makers must discontinue using R-134a in new vehicles built for the North American market after model year 2021. R-134a can still be used for some export vehicles, but only until 2025. After that, R-134a will be discontinued in new vehicles - although production will continue for servicing older vehicles that have R-134a A/C systems. [7]

Figure 11: Refrigerant

3.2.8 Backup Air-conditioning system by Battery Energy:

The renewable energy (RE) source (PV, wind, or hydro) produces the energy, and the battery stores it for times of low or no RE production. Most batteries employed in renewable energy systems use the same electro-chemical reactions as the lead-acid battery in the car.

Backup Air-conditioning system by Battery Energy is the cleanest and most available renewable energy source. The Modern technology can harness this energy for a variety of uses, including producing electricity, providing light and heating water for domestic, commercial or industrial application.

Now Battery use to backup Air-conditioning system on the car, the fuel consumption is zero of the Engine with no emission because whereas Engine start is switched off. That is to say no need to start an Engine for using backup Air-conditioning system. During this period all passenger is feel comfort temperature in the interior of the car.

Stop-start backup Air-Conditioning system technology is one of the fuel economy car technologies to help reducing CO_2 emissions. It plays a key role in the way to achieve emission regulation whilst reducing fuel consumption, and a low temperature heat source can be used to drive the air-conditioning system.

Figure 12: Backup Air-conditioning system by Battery Energy.

3.2.9 Battery Types: As mentioned earlier, the majority of today's emergency power systems make use of two types of batteries, namely, lead-acid and nickel-cadmium (NiCad). Within the lead-acid family, there are two distinct categories, namely, flooded or vented (filled with liquid acid) valve-regulated lead acid (VRLA, immobilized acid). Lead-acid and NiCad batteries bust be kept dry at all times and in cool locations, preferably below 70°F, and must not be stored for long in warm locations. Material such as conduit, cable reels, and tools must be kept away from the battery cells.

3.3 Function of Vehicle Air Conditioning System:

The purpose of the vehicle air conditioning system is to cool the air entering the passenger compartment and remove the moisture from the air so it feels more comfortable in the vehicle. In many vehicles, air conditioning also cycles during the defrost setting, pulling the humidity from the windshield to improve visibility.

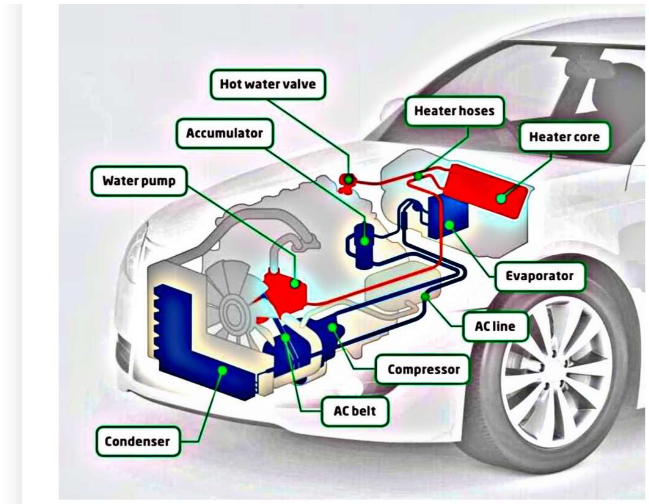

Figure 13: Vehicle Air Conditioning System

Automotive air-conditioning (A/C) or mobile air-conditioning (MAC) systems have played an important role in human comfort and to some extent in human safety during vehicle driving in varied atmospheric conditions. It has become an essential part of the vehicles of all categories worldwide. After discussing the basic operation of the A/C system, a brief summary is provided on historical development of the vehicular A/C system, with refrigerant history from the inception of the A/C system to future systems: R12, R134a, and enhanced R134a A/C system, and next-generation refrigerants having no ozone depletion potential in the stratosphere and global warming potential less than 150. The discussion also includes an enhanced MAC system with R134a, and the direct and indirect emissions from vehicles impacting global warming due to the use of the A/C system. This would explain why we continue to change the refrigerants in the automotive A/C system in spite of billions of dollars of cost for the previous refrigerant change (from R12 to R134a). The system design considerations are then outlined for minimizing the impact of A/C operation on the vehicle fuel consumption. Finally, new concepts of design of A/C system and vehicle heat load reduction ideas are discussed to further minimize the impact of A/C system operation on the environment without impacting human comfort. It is anticipated that this article will provide the overall and detailed prospective of the A/C system developments and provide an opportunity to the researchers to accelerate research and development for the refrigerant changeover and A/C system and component optimization and cost reduction. [8]

CHAPTER 4

COOLING LOAD CALCULATION

CHAPTER 4
COOLING LOAD CALCULATION

4.1 Basic Design Data from the project:

Readings from the project:

Initial Temperature in Refrigerant system of project: 70 ℃

Outside Temperature: 26 ℃

Initial Voltage: 48V

On load Voltage: 47.84V

On load current: 15.01A

No load current Consumption (Compressor): 5.8A at this time battery voltage is 48.82 V

Evaporator Blower Current consumption: 2.8A at this time battery voltage is 10.7V

Condenser Fan current consumption: 7.943A at this time battery voltage is 10.7V

Current consumption in Total system: 5.9A at this time battery voltage is 48.66V

System project Temperature after 1 minute run: 26℃

System project Temperature after 2 minute run: 7.7℃

System project Temperature after 2.30 minute run: 7.4℃

System project Temperature after 3 minute run: 7.2℃

4.2 Dimensional Analysis of Model:

Cabin Volume: Length (L) =584.2 mm
Width (W) =365 mm
Height (H) =660.4 mm

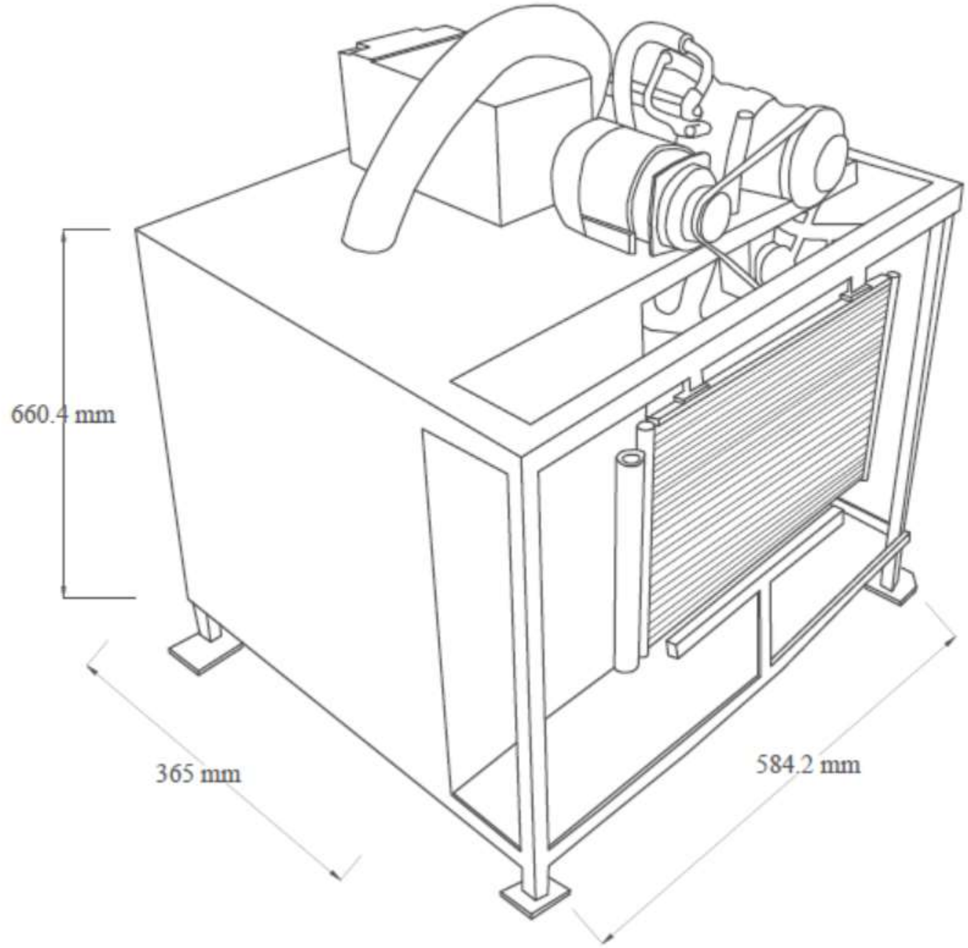

Figure 14: Backup Air-Conditioning system

Volume Calculation of Model:

$$= (L \times W)H$$

$$= (584.2 \times 365)660.4\ mm^3$$

$$= \frac{140819073}{1000 \times 1000 \times 1000}\ m^3$$

$$= 0.1409 m^3$$

$Volume\ of\ Air,\quad V = 0.1409\ m^3$

$Density\ of\ Air\ at\ 26°C, \rho = 1.184\ kg/m^3$ $\quad Where, \rho = 1.184\ kg/m^3$[10]

Mass of air available in our designed area,

m= Volume of Air × Density of Air Where, m=mass (kg)

$m = V\rho$ V=Volume (m^3)

$= 0.1409 \times 1.184$ $\quad \rho = Density\ (kg/m^3)$

$= 0.1668\ kg$

Heat removed from our designed backup Air-Conditioning system,

Q = mC_p (T_2-T_1) [∵ Q= Heat Energy & Specific Heat Constant pressure, Cp=1.006 kg/m^3°K] [10]

$Q = 0.1668\ kg \times 1.006 kJ/kg \times (70 - 26)°C$

= 7.3832 kJ

= 7383.23 J

System cooling rate $= \frac{7383.23\ J}{60\ sec}$ $\quad [\because when\ t = 60sec]$

= 123 J/S

$= 123\ Watt$ [∵1 J/S= 1 Watt]

Wastage of Electrical Energy:

i. Compressor no load Power $= VI$

$= 48.82 \times 5.8$

$= 283.15\ W$

ii. Compressor power consumption on load $= VI$

$$= 47.84 \times 15.01$$

$$= 718.07W$$

iii. Evaporator Blower Power $= VI$

$$= 10.7 \times 2.8$$

$$= 29.96\ W$$

iv. Condenser Fan Power Consumption $= 10.7 \times 7.943$

$$= 84.990\ W$$

Total Power taken during load $(P_1) = (718.07 + 29.96 + 84.99)$

$$= 832.95\ W$$

i. Electrical Power Consumption $= (718.07 + 29.96 + 84.99)$

$$= 832.95\ W$$

ii. Idle loss = No load current Consumption (Compressor) + Evaporator Blower Power Consumption+ Condenser Fan Power Consumption (P_2)

$$= (283.15 + 29.96 + 84.99)$$

$$= 398.1\ W$$

System Thermal Efficiency:

$$System\ Thermal\ Efficiency, \qquad \eta = \frac{Total\ Electrical\ Power\ (P_1 - P_2)}{P_1} \times 100$$

$$= \frac{Output}{Input\ without\ loss} \times 100$$

$$= \frac{123}{832.95 - 398.1} \times 100$$

$$= \frac{123}{436.95} \times 100$$

$$= 28.14$$

$$= \mathbf{28}\%$$

Overall System efficiency, η $= \frac{Qout}{Qin}$

$$= \frac{123}{832.95} \times 100$$

$$= 15\%$$

4.3 Basic Design Data from the vehicle (Mercedes-Benz, E250):

Real time "Car Volume" Reading:

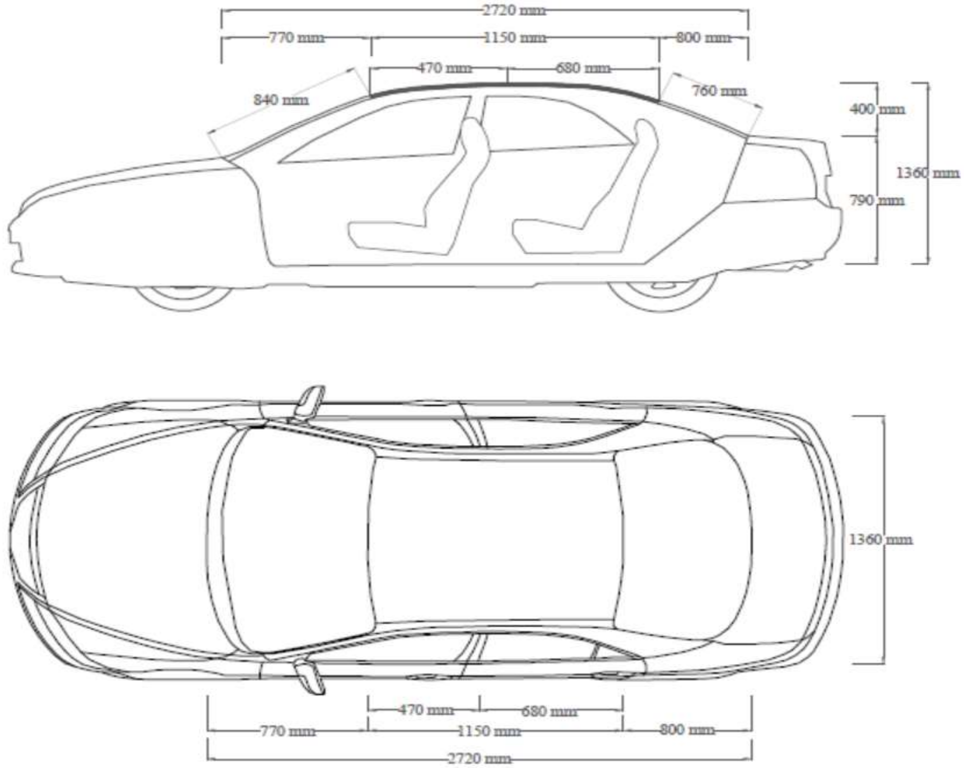

Figure 15: Vehicle interior dimension with all glass

Section-1: Front windshield Length=770mm & Height=840mm

Section-2: Front window glass Length=470mm & Height=400mm

Section-3: Rear window glass Length=680mm & Height=400mm

Section-4: Rear windshield Length=800mm & Height=760mm

Section-5: Vehicle interior Length=2720mm & Height=790mm

Vehicle Width=1360mm

$= V_1 + V_2 + V_3 + V_4 + V_5$

$= \left(\frac{h_b \times b}{2}\right) W + (L \times H)W + (L \times H)W \left(\frac{h_b \times b}{2}\right) W + (L \times H)W$ [Triangle Area, A=$\left(\frac{h_b \times b}{2}\right)$]

$$= \left(\frac{0.4 \times 0.77}{2}\right)1.360 + (0.47 \times 0.40)1.36 + (0.68 \times 0.40)1.36 + \left(\frac{0.4 \times 0.77}{2}\right)1.360$$

$$+ (2.720 \times 0.79)1.360$$

$$= 0.209 + 0.255 + 0.369 + 0.217 + 2.922$$

$$= 3.972m^3$$

Real Time "Car Cooling Time" calculation:

Owing to variations in humidity and likely clothing, recommendations for summer and winter may vary; a suggested typical range for summer is 23 to 25.5 °C (73 to 78 °F), with that for winter being 20 to 23.5 °C (68 to 74 °F). [11]

Comfort Temperature as per Air-conditioning chart, (T_1): 26℃

Initial Temperature in Refrigerant system of car (T_2): 70℃

Mass of air available in real car interior area, $m_1 = \mathrm{V}\rho$ $\quad Where, \rho = 1.184\ kg/m^3$[10]

$$= 3.972 \times 1.184 kg/m^3$$

$$= 4.702\ kg$$

Backup Air-conditioning system heat removed from interior of the car:

$$Q_1 = m_1 \mathrm{Cp}(\mathrm{T2} - \mathrm{T1})$$

$$Q_1 = 4.702\ kg \times 1.006 kg/kg°k \times (70 - 26)°C$$

$$= 208.129\ KJ$$

$$= 208.129 \times 1000$$

$$= 208129\ J$$

Cooling rate of the system 123 J/s

Required Time for cooling complete car from 70°C to 26°C when we did not use car Air-conditioning system as before $= \frac{208129\,J}{123 \times 60}$ sec

$= 28\ min$

Again, as per Air-conditioning chart we know Comfort Temperature is (in car cabin) (T_3): 24°C

Initial Temperature in Air-conditioning system interior of the car (T_4): 26°C

Mass of air available in real car interior area, $m_2 = \text{V}\rho$ $\quad Where, \rho = 1.184\ kg/m^3$

$= 3.972 \times 1.184 kg/m^3$

$= 4.702\ kg$

Backup Air-conditioning system heat removed from interior of the car:

$Q_2 = \ m_2 \text{Cp}(T_4 - T_3)$

$Q_2 = 4.702\ kg \times 1.006 kg/kg°k \times (26 - 24)°C$

$= 9.46\ KJ$

$= 9.46 \times 1000$

$= 9460\,J$

Cooling rate of the system 123 J/s

Required Time for cooling complete car from 26°C to 24°C when car A/C is shut down

$= \frac{9460\,J}{123 \times 60}$ Sec

$= 1.28\ min$

Again, Temperature in car cabin as per Air-conditioning chart (T_5): 18℃

Initial Temperature in Air-conditioning system interior of the car (T_6): 24℃

Mass of air available in real car interior area, $m_3 = \mathrm{V}\rho$ $\quad Where, \rho = 1.20\ kg/m^3$[13]

$$= 3.972 \times 1.20 kg/m^3$$

$$= 4.766\ kg$$

Backup Air-conditioning system heat removed from interior of the car:

$$Q_3 = m_3 \mathrm{Cp}(T_6 - T_5)$$

$$Q_3 = 4.766\ kg \times 1.006 kg/kg°k \times (24 - 18)°C$$

$$= 28.76\ KJ$$

$$= 28.76 \times 1000$$

$$= 28767.57\ J$$

Cooling rate of the system 123 J/s

Required Time for cooling complete car from 24℃ to 18℃ when car A/C is shut down

$$= \frac{28767.57\ J}{123 \times 60} \text{ Sec}$$

$$= 3.89\ min$$

Metabolic Load: [14]

$D_u Bois\ area\ A_{Du}\ is$: $\quad \because A_{Du} = DuBois\ Body\ surface\ area\ (m^2)$

$$A_{Du} = 0.202\ W^{0.425} H^{0.725}$$

For Driver:

Weight: 65 kg

Height: 1.5 m

$$A_{Du} = 0.202\ W^{0.425} H^{0.725}$$

$$A_{Du} = 0.202 \times\ 65^{0.425} 1.5^{0.725}$$

$$= 0.202 \times 5.8950 \times 1.3417$$

$$= 1.5976\ m^2$$

$$Q_{M1} = M \times\ A_{Du}$$

$$= 85 \times 1.5976$$ (For Driver, M=85 W/m^2) [14]

$$= 135.80\ W$$

For Passenger-01

Weight: 70 kg

Height: 1.5 m

$$A_{Du} = 0.202\ W^{0.425} H^{0.725}$$

$$A_{Du} = 0.202 \times\ 70^{0.425} 1.5^{0.725}$$

$$= 0.202 \times 6.0836 \times 1.3417$$

$$= 1.6487\ m^2$$

$Q_{M2} = M \times A_{Du}$

$= 55 \times 1.6487$ (For Passenger, M=55 W/m^2) [14]

$= 90.67\, W$

For Passenger-02

Weight: 68 kg

Height: 1.3 m

$A_{Du} = 0.202\, W^{0.425} H^{0.725}$

$A_{Du} = 0.202 \times 68^{0.425} 1.3^{0.725}$

$= 0.202 \times 6.009 \times 1.2095$

$= 1.4681\, m^2$

$Q_{M3} = M \times A_{Du}$

$= 55 \times 1.4681$ (For Passenger, M=55 W/m^2)

$= 80.74\, W$

For Passenger-03

Weight: 60 kg

Height: 1.3 m

$A_{Du} = 0.202\, W^{0.425} H^{0.725}$

$A_{Du} = 0.202 \times 72^{0.425} 1.3^{0.725}$

$= 0.202 \times 6.1569 \times 1.2095$

$= 1.5042\ m^2$

$Q_{M4} = M \times\ A_{Du}$

$= 55 \times 1.5042$ (For Passenger, M=55 W/m^2)

$= 82.73\ W$

For Passenger-04

Weight: 75 kg

Height: 1.6 m

$A_{Du} = 0.202\ W^{0.425} H^{0.725}$

$A_{Du} = 0.202 \times\ 75^{0.425} 1.6^{0.725}$

$= 0.202 \times 6.2647 \times 1.4060$

$= 2.5016\ m^2$

$Q_{M5} = M \times\ A_{Du}$

$= 55 \times 2.5016$ (For Passenger, M=55 W/m^2)

$= 137.58\ W$

Backup Air-conditioning system heat dispersed from 5 persons when we use car Air-conditioning system as before:

$Q_M = Q_{M1} + Q_{M2} + Q_{M3} + Q_{M4} + Q_{M5}$

$= 135.80 + 90.67 + 80.74 + 82.73 + 137.58$

$= 527.52\ W$

Again, Temperature in car cabin as per Air-conditioning chart (T_5): 18°C
Initial Temperature with 5 persons in Air-conditioning system interior of the car (T_6): 24°C
Mass of air available in real car interior area, $m_4 = \text{V}\rho$ $\quad Where, \rho = 1.20\ kg/m^3$ [13]

$$= 3.972 \times 1.20 kg/m^3$$

$$= 4.766\ kg$$

Backup Air-conditioning system heat removed from interior of the car:

$Q_4 = m_4 \text{Cp}(T_6 - T_5)$

$Q_4 = 4.766\ kg \times 1.006 kg/kg°k \times (24 - 18)°C$

$= 28.76\ KJ$

$= 28.76 \times 1000$

$= 28767.57\ J$

Backup Air-conditioning system heat dispersed from 5 persons when we use car Air-conditioning system as before:

$Q_d = Q_4 + Q_{MAN}$ $\quad \because Q_d = Heat\ disparsed$

$Q_d = 28767.57 + 527.52$

$= 29295.09\ J$

Cooling rate of the system 123 J/s

Required Time for cooling complete car from 24℃ to 18℃ when car A/C is shut down

$$= \frac{29295.09\,J}{123 \times 60}\text{ Sec}$$

$$= 3.96\ min$$

Backup Air-conditioning system heat dispersed from 5 persons when we did not use car Air-conditioning system as before:

$$Q_M = Q_{M1} + Q_{M2} + Q_{M3} + Q_{M4} + Q_{M5}$$

$$= 135.80 + 90.67 + 80.74 + 82.73 + 137.58$$

$$= 527.52\ W$$

Backup Air-conditioning system heat dispersed from interior of the car and all persons with different temperature when we did not use car Air-conditioning system as before:

$$Q_T = Q_1 + Q_2 + Q_3 + Q_4 + Q_{Man}$$

$$= 208129 + 9460 + 28767.57 + 28767.57 + 527.52$$

$$= 275651.66\ J$$

Cooling rate of the system 123 J/s or 123 W Cooling Time required complete car for 5 passengers from 70˚C to 18˚C when we did not use car Air-conditioning system as before

$$= \frac{275651.66\,J}{123 \times 60} sec$$

$$= 37\ Min$$

4.4 System Capacity:

By investigating various sites, suggested typical formula for Battery AH ratting:

2 Current × Time = Battery AH rating = *120 AH*

$$Time\ T = \frac{AH}{2 \times Current}$$

$$T = \frac{120}{2 \times Current}$$

Total system Power Consumption $= 832.95\ W$

System Current @ 12 V Battery $I = \frac{\mathrm{P}}{\mathrm{V}}$

$$I = \frac{832.95\ \mathrm{W}}{12\ \mathrm{V}}$$

$$= 69.41\ A$$

$$T = \frac{120}{2 \times Curre}$$

$$T = \frac{120}{2X\ 69.41}$$

$$= 0.8644\ Hour$$

$$= 51.84\ Min$$

Figure 16: Temperature reading record from backup Air conditioning system

CHAPTER 5

BACKUP AIR-CONDITIONING SYSTEM IN AIR-CONDITIONED VEHICLE

5.1 Retrofitting of backup Air-conditioning system in Air-conditioned vehicle:

Retrofitting of backup Air-conditioning system in Air-conditioned vehicle in automobiles, a Stop-start backup Air-Conditioning system manually shut down the internal combustion Engine to reduce the amount of time the engine spends idling, thereby reducing fuel consumption and emissions.

5.1.1 Types of backup Air-conditioning system in Air-conditioned vehicle:

i. Manual Control.

ii. Automatic Control.

5.2 Importance of backup Air-conditioning system in Air-conditioned vehicle:

i. Backup Air-conditioning system saves fuel and reduces the vehicle's emissions by shutting off the engine in situations where the vehicle is not in motion. When stopped for any reason, the backup system will manually shut off the engine, with seamless functioning.

ii. Start-stop technology is one of the fuel economy car technologies to help reduce CO_2 Emissions. It plays a key role in the way to achieve emission regulation whilst reducing fuel consumption.

5.3 Project View of Backup Air-Conditioning System in Air-Conditioned Vehicle:

Figure 17: Assembling of all the components of backup Air-conditioning system in Air-conditioned vehicle.

5.4 Components:

i. A/C Compressor (As per Manufacturing rating)
ii. Condenser. (As per Manufacturing design)
iii. Expansion Valve. (As per Manufacturing design)
iv. Evaporator(As per Manufacturing design)
v. Condenser Fan(As per Manufacturing rating)
vi. A/C Blower Motor(As per Manufacturing rating)
vii. Suction Pipe
viii. Discharge Pipe
ix. V Belt
x. Belt Tensioner Pulley
xi. Battery 12 V, 120AH
xii. Charge Controller
xiii. Voltage Converter
xiv. Joining Board
xv. On/Off Switch
xvi. Refrigerant R134a (Tetrafluoroethane)

i. **A/C Compressor (10 PA):** A 10 cylinder, double side operating Swash Plate type compressor with fixed displacement, well known for its durability and lack of noise and pulsation. Design pressure of the compressor high pressure side 3.53 MPa and low pressure side 1.67 MPa. (15)

5.4 Discussions:

To survey the vehicle interior, To prepare a drawing, To calculate the cooling load (Without Load), To calculate the cooling load (With Load), Comparison Electrical consumption Without Load and With Load. To calculate the System Thermal Efficiency, Overall efficiency, To calculate of project volume & real car volume, To calculate the cooling time of project & cooling time of real car without passenger, To calculate the cooling time of real car with passenger. To calculate the cooling rate of the system, to calculate the system capacity.

I. First of all we can keep continuing backup A/C system for required time without running engine. That's why we can reduce the fuel consumption & also there are friendly environment created.

II. Backup Air-conditioning system saves fuel and reduces the vehicle's emissions by shutting off the engine in situations where the vehicle is not in motion. When stopped for any reason, the backup system will manually shut off the engine, with seamless functioning.

III. Start-stop backup Air-Conditioning system technology is one of the fuel economy car technologies to help reduce CO_2 emissions. It plays a key role in the way to achieve emission regulation whilst reducing fuel consumption.

IV. Normally there are some limitations comes up front in vehicle air-conditioned system. When we want to use air-conditioned system, then we must keep running the engine of vehicle.

V. When no need of running the engine, after all for keep continuing air-conditioned system the engine has to run which are prodigal.

VI. For making system improvement we can add a backup air-conditioned system which can give us much more advantages.

CHAPTER 6

SUMMARY AND RESULT

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6.1 Summary and Result

- Cooling rate of the system: 123 J/s
- System Thermal Efficiency: 28%
- Overall System efficiency : 15%
- Volume Calculation of Model: $0.1409m^3$
- Mass of air available in our designed area: $0.1668\ kg$
- Heat removed from our designed backup Air-Conditioning system: = 7383.23 J
- Real time "Car Volume" Reading: $3.972m^3$
- Real Time "Car Cooling Time" calculation:
  a) Required Time for cooling complete car from 26℃ to 24℃ when car A/C is shut down = 1.28 Minutes
  b) Required Time for cooling complete car from 24℃ to 18℃ when car A/C is shut down = 3.89 Minutes
  c) Backup Air-conditioning system heat dispersed from 5 persons when we use car Air-conditioning system as before: 3.96 Minutes
- Backup Air-Conditioning System Capacity: 52 Minutes

CHAPTER 7

CONCLUSION

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CONCLUSION

7.1 Conclusion:

This is only backup Air-conditioning system. Its main purpose of save the fuel consumption with less emission and to make comfortable environment in terms of desired temperature to the interior of the car for the passenger's.

The main conclusions emerged from this thesis are summarized as follows:

I. The length of vehicle interior is 2720mm and width 1360mm. So the area of this vehicle interior $3.972m^3$.

II. In this thesis $3.972m^3$ area has been considered for cooling load calculation.

III. It has been calculate the Wastage of Electrical Energy is 398.1W

IV. To calculate the System Thermal Efficiency 28%

V. It has been calculate the Overall efficiency 15%

VI. To calculate the total cooling rate of this system 123W.

VII. It has been calculated that cooling time for interior of the car with passengers.

VIII. The results showed that the total cooling time 3.96 Min found of this backup system for interior of the car with passengers.

IX. It has been calculate that Backup Air-conditioning system heat removed from car and all persons with different temperature.

X. The result showed that the backup Air-condition system capacity is 51.84 Min.

XI. After carrying out through research and analysis in the field of backup air-conditioning systems, we can conclude that implementation of a backup air-conditioning system is one of the best ways of achieving fuel efficient result in Air- conditioned vehicle and it ensures that environment friendly condition is upheld.

XII. When use backup Air-conditioning system on the car, the fuel consumption is zero of the Engine with no emission because whereas Engine start is switched off. That is to say no need to start an Engine for using backup Air-conditioning system. During this period all passenger is feel comfort temperature in the interior of the car.

XIII. Stop-start backup Air-Conditioning system technology is one of the fuel economy car technologies to help reducing CO_2 emissions and save fuel consumption. It plays a key role in the way to achieve emission regulation whilst reducing fuel consumption, and a low temperature heat source can be used to drive the air-conditioning system.

7.2 Recommendation:

Automatic Retrofitting of backup air-conditioning system can be implemented here which cost more & it will would have earned desired output. No additional condenser, expansion valve, dryer receiver, voltage controller and charge controller would have needed in that Automatic backup Air-conditioning System which would increase the output by decreasing input.

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