UTILIZATION OF EXHAUST HEAT FROM IC ENGINE FOR AIR CONDITIONING IN VEHICLES.

[1]DHANANJAY A S, [2]MANIGANDAN M, [3]NAMITH R, [4]MOHAMED MOIN KHAN, [5]VARUN N

[1234]Student, [5]Assistant professor

[1]Department of Automobile Engineering

[1]Srinivas Institute of Technology, Mangaluru, India

Abstract: With the rapid changing environment and atmospheric effect, the air conditioning of the moving vehicle has become a necessity. In the same time consumers are incapable to bear the increasing operating cost of the vehicles due to continuous raise in fuel prices, component costs and maintenance costs associated with vehicles. Approximately 30 to 40% of total energy supplied in internal combustion engine (ICE) is converted to useful mechanical work. The remaining energy is expelled directly to the environment through engine cooling systems and exhaust gases resulting into entropy rise and serious environmental problems. Exhaust gas stream from ICE carries away about 30% of the heat of the combustion. An exploration has been done to research the possibility of waste heat recovery and its subsequent utilization in air conditioning system of a vehicle without increasing the component cost, weight, number of component and bring improvement in vehicle by making it luxurious.

Keywords: vapor absorption refrigeration, ammonium hydroxide, generator, exhaust, IC engine

I.INTRODUCTION

The air conditioning consists of eliminating the heat and humidity inside an occupied space to improve the comfort of the occupants. This process is most often used to create a more comfortable indoor environment, usually reserved for humans and other animals. However, air conditioning is also used to cool parts filled with electronic devices that produce heat, such as power amplifiers for computer servers, and even to display and store certain delicate products, such as works of art. Air conditioners often use a fan to distribute the air conditioner in an occupied space, such as a building or car, to improve thermal comfort and indoor air quality. More generally, air conditioning can designate any technology that modifies air conditions (heating, dehumidification, and cooling, cleaning, ventilation or air circulation). However, in common usage, the term "air conditioning" refers to systems that cool the air. Under construction, a complete system of heating, ventilation and air conditioning is called air conditioning HAVC

This energy consumption increases considerably in the areas of heating, ventilation and air conditioning (HVAC). Due to the serious problems of energy shortages and global environmental problems, the use of waste heat and renewable energy is becoming one of the most interesting research areas. HVAC refrigerants in traditional refrigeration systems contain chlorofluorocarbon (CFC) and hydro chlorofluoro carbon (HCFC). Such components with high ozone depletion potential (ODP) and global warming potential (GWP) accelerate the depletion of the Earth's ozone layer. Therefore, alternative solutions to current refrigeration systems are needed. A known cooling technology, an absorption cooling system fed by waste and / or renewable energy sources is an attractive solution. The absorption cooling systems with solar energy have attracted a lot of attention in recent decades due to the coincidence between solar radiation and the required cooling effect. The absorption cooling system has many advantages, such as the use of a lower quality heat source temperature, the use of natural refrigerants such as water, less moving mechanical parts, no noise, no maintenance and respect for the environment. The energy available in the output stream of many energy conversion devices is considered a waste if it is not recovered or used correctly. About 30 to 40% of the total energy supplied by the internal combustion engine (ICE) becomes a useful mechanical work. The remaining energy is released directly into the environment by the engine cooling systems and exhaust gases, resulting in increased entropy and serious environmental problems. The IC engine exhaust flow takes about 30% of the heat of combustion.

The two basic types of refrigeration are

1. Natural refrigeration.
2. Artificial refrigeration.

1.1 NATURAL REFRIGERATION

In olden days, natural means achieved refrigeration with the use of ice and evaporative **Cooling**.

In earlier times, the ice was

- Transported from colder regions
- Harvested in winter and stored for use
- Made during the night by Radioactive cooling

1.1.1 NOCTURNAL ICE MAKING

In India, prior to the invention of artificial refrigeration technology, the manufacture of ice by night cooling was common. The apparatus consisted of a shallow ceramic tray with a thin layer of water, placed on the outside with a clear exposure to the night sky. The bottom and sides were insulated with a thick layer of hay. On a clear day, the water will lose heat from the radiation upwards. As long as the air is calm and not too high above the freezing point, the heat gain of the convective ambient air will be low enough to allow the water to freeze at dawn

1.1.2 EVAPORATIVE COOLING

Reduction of the temperature resulting from the evaporation of a liquid, which eliminates the latent heat of the surface from which evaporation occurs. This process is used in industrial and domestic refrigeration systems and is also the physical basis of perspiration. In India, in ancient times, water was cooled in this way by keeping it in clay pots, in which it evaporated through small pores and cooled it.

1.1.3 COOLING USING SALTS

The addition of salt to water reduces the freezing point of water and allows water to exist in liquid form at a temperature below 0 ° C. This type of cooling has limited use, since salts can only be removed by heating.

1.2 ARTIFICIAL REFRIGERATION

Refrigeration today is mostly produced by artificial means. Some of the artificial means are

- Cyclic refrigeration.
- Non-Cyclic Refrigeration.
- Thermoelectric Refrigeration.
- Magnetic Refrigeration.

We will focus on the two important types of Cyclic Refrigeration,

1. Vapour Compression Refrigeration.
2. Vapour Absorption Refrigeration.

1.2.1 VAPOR COMPRESSION CYCLE

The components of a vapor-compression refrigeration cycle are a compressor, condenser, expansion valve, and evaporator as shown in the fig 1.2.1.1. A low pressure, low temperature liquid is converted to vapor in the evaporator, thus absorbing heat from the refrigerated space and keeping that space cool. The fluid is driven around the cycle by the compressor, which compresses the low temperature, low pressure vapor leaving the evaporator to high pressure, high temperature vapor. That vapor is condensed to liquid in the condenser, thus giving off heat at a high temperature to the surrounding environment. Finally, the high pressure, high temperature liquid leaving the condenser is cooled and reduced in pressure by passing it through an expansion valve. The rate of work input to the compressor is most of the power requirement to run the refrigeration system. Power will be needed to drive one or more fans, but their power requirement will be small in comparison with that needed to drive the compressor.

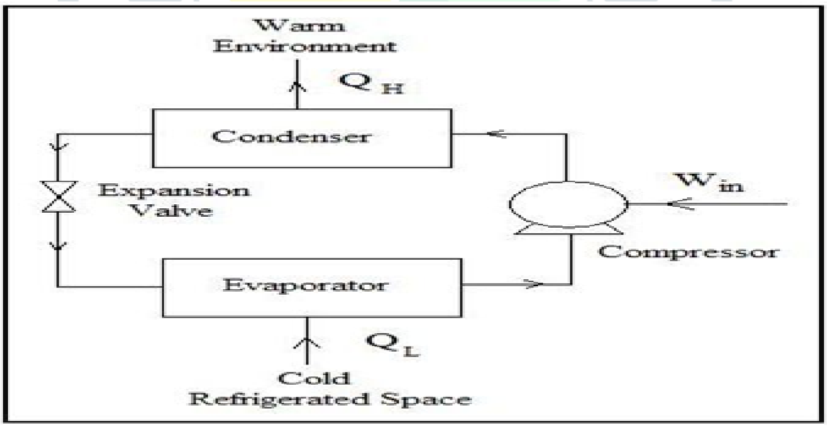

Figure 1.2.1.1: Vapour Compression Cycle

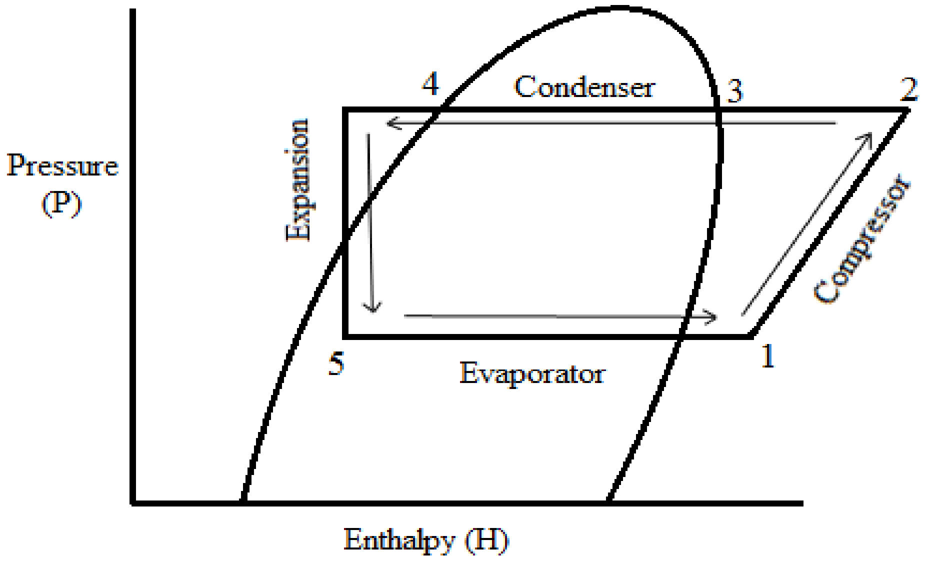

Figure 1.2.1.2: Pressure-enthalpy diagram for Vapour Compression Cycle

The following processes are shown in the p-h diagram:

COMPRESSION

In this stage, the refrigerant enters the compressor as a gas under low pressure and having a low temperature. Then, the refrigerant is compressed adiabatically, so the fluid leaves the compressor under high pressure and with a high temperature. In the figure 1.2, 1-2 shows Compression

CONDENSATION

In the fig 1.2, 2-4 shows Condensation process. The high pressure, high temperature gas releases heat energy and condenses. The condenser is in contact with the hot reservoir of the refrigeration system. (The gas releases heat into the hot reservoir because of the external work added to the gas.) The refrigerant leaves as a high pressure liquid.

THROTTLING

The liquid refrigerant is pushed through a throttling valve, which causes it to expand. As a result, the refrigerant now has low pressure and lower temperature, while still in the liquid phase. (The throttling valve can be either a thin slit or a plug with holes in it. When the refrigerant is forced through the throttle, its pressure is reduced, causing the liquid to expand.). Process 4-5 in fig 1.2 shows the process of expansion.

EVAPORATION

The low pressure, low temperature refrigerant enters the evaporator, which is in contact with the cold reservoir. Because a low pressure is maintained, the refrigerant is able to boil at a low temperature. So, the liquid absorbs heat from the cold reservoir and evaporates. The refrigerant leaves the evaporator as a low temperature, low pressure gas and is taken into the compressor again, back at the beginning of the cycle. From the fig 1.2 the process 5-1 shows Evaporation.

1.2.2 VAPOR ABSORPTION CYCLE

Figure 1.2.2.1 shows a vapor absorption cooling system, which includes a generator, an absorber, an evaporator and a condenser. In the vapor absorption system, the refrigerant used is ammonia, water or lithium bromide. The refrigerant produces a cooling effect in the evaporator and releases the heat to the atmosphere through the condenser. The absorber and the generator perform a function similar to that of the compressor in the steam compression cycle. The absorbent allows the flow of refrigerant from the absorbent to the generator. Another important difference is the method by which the energy is assigned to the system. In the vapor compression system, the energy input occurs in the form of mechanical work performed by the electric motor. In the vapor absorption system, the energy input is in the form of heat

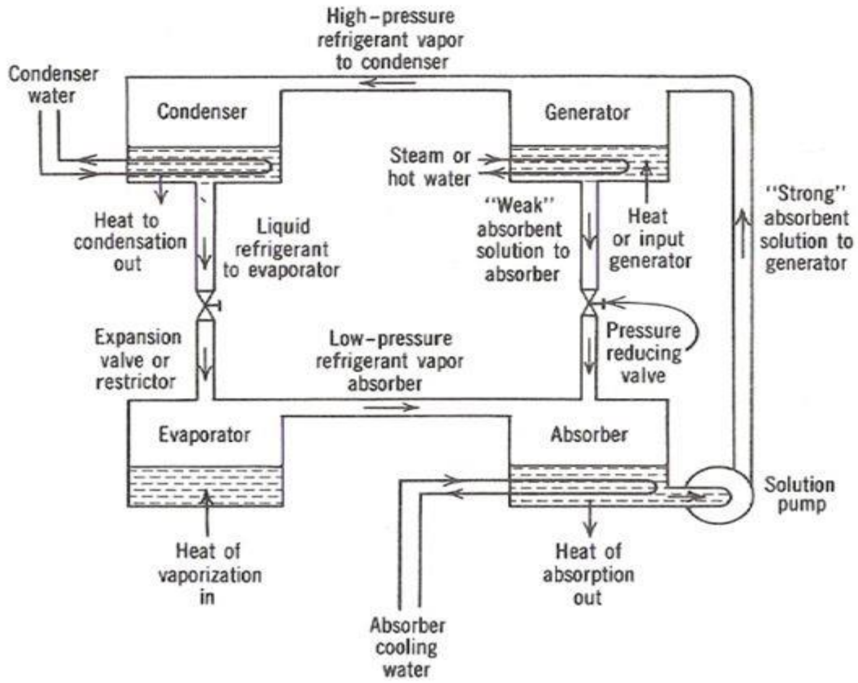

Figure 1.2.2.1: Vapour Absorption Refrigeration Cycle

The absorption cooling cycle takes place in three phases:

EVAPORATION
A liquid refrigerant evaporates in a low partial pressure environment, thus extracting heat from its surroundings (e.g. the refrigerator's compartment). Because of the low partial pressure, the temperature needed for evaporation is also low.

ABSORPTION
The new gaseous refrigerant is absorbed by another liquid (e.g. a salt solution).

REGENERATION
The refrigerant-saturated liquid is heated, causing the refrigerant to evaporate out. The hot gaseous refrigerant passes through a heat exchanger, transferring its heat outside the system (such as to surrounding ambient-temperature air), and condenses. The condensed (liquid) refrigerant supplies the evaporation phase.

II. LITERATURE SURVEY

G Vicatos et.al [1] in their work Energy from the exhaust gas of an internal combustion engine is used to power an absorption refrigeration system to air-condition an ordinary passenger car. The theoretical design is verified by a unit that is tested under both laboratory and road-test conditions. For the latter, the unit is installed in a Nissan 1400 truck and the results indicate a successful prototype and encouraging prospects for future development. The theoretical analysis, is verified by both laboratory and road tests through the results obtained. This work results from a prototype which will have to be improved for further development. The claim that is made from this work is that it has shown the feasibility of such a system in a positive frame.

Abhilash Pathania et.al [2] on a study reveals that it comprises four heat exchanges, namely, an air finned forced convection condenser, an air finned forced convection evaporator, and a pair of shell and tube type absorbers, plus four one-way refrigerant valves, an expansion valve, and an exchange valve. For a refrigerant system the following things are needed. Specific Cooling Power (SCP), Coefficient of Waste Heat Recovery (CWHR), Coefficient of Waste Heat Cooling (CWHC). At present, for an automobile waste heat absorption cooling system, the demand for CWHC can be easily met, but for SCP, further research is needed, which will be studied in part II of this project.

Isaac Mathew Pavoodath et.al [3] suggested absorption refrigeration systems have many fundamental advantages besides environmentally friendly refrigerants and electricity saving. Briefly, there are: simplicity, low maintenance, and high temperature heat input capability, low pump power, inherent flexibility in operation, with a system performance insensitive to ambient temperature. The absorption system has no rotating component or machined surface. Compared with vapour compression refrigeration systems, no solution pump is needed in absorption refrigeration systems in which there is no crystallization or rectification problem. So absorption refrigeration systems are suitable for vibration, incline, and rotation occasion. Such a system would vastly help take of the compressor load of the vehicle engine and would prove a great percentile of power saving for small capacity engines. It will thus take away the need for the extra fuel burnt for the same purpose, as well. The satisfaction of using vast amounts of energy earlier let out into the environment untapped is thus gained.

Khaled S. AlQdah et.al [4] in his work presents an experimental study of an aqua-ammonia absorption system used for automobile air conditioning system, this system using the exhaust waste heat of an internal combustion diesel engine as energy source. The energy availability that can be used in the generator and the effect of the system on engine performance, exhaust emissions, auto air conditioning performance and fuel economy are evaluated. The main objective of this work is to investigate the feasibility to utilize the waste heat from the diesel engine from the exhaust for automobile air conditioning system and to explore the advantages of this system over conventional air-conditioning system. Feasibility study should make to decide the unit's chances to be produced on commercial scales in Jordan, because it has many advantages such as low emissions and environmental impact in addition to less engines fuel consumption and more economic.

Sachin Kaushik et.al [5] in a paper provides an analytical study of absorption refrigeration technology. Through the application of the first and second laws of thermodynamics upper and lower limits for the coefficient of performance (COP) of absorption cooling cycles are derived. These upper and lower limits, besides being dependent on the environmental temperatures of components of the cycle, are also dependent on the thermodynamic properties of refrigerants, absorbents, and their mixtures. The objective of this work is to design a lithium bromide–water (LiBr-H2O) absorption refrigerator with a nominal capacity of 5.25 kW. The various stages of refrigeration system are presented including the design of the evaporator, absorber, solution heat exchanger, generator and condenser and finally COP is calculated.

S.P Barbule et.al [6] as per their experimental analysis and references, it has found that, it is possible to design an automobile air conditioning system using engine exhaust based on Vapour Absorption Refrigeration System. Also this system can be employed to commercial heavy vehicles including those which are concerned in the transportation of refrigerated products, as this system can easily provide the cabin refrigeration/air-conditioning as per the requirements by using the exhaust heat of the vehicle's engine (which is in abundance in such vehicles) thus will not add any extra engine to run the air- conditioning/refrigerating unit in vehicle and hence reduce the operational cost.

N. Chandana reddy et.al [7] in a paper the waste heat from C. I engine is suggested as one of the alternative energy source for refrigeration system From the experimental study, the vapour absorption refrigeration system can be obtained using heat that is expelled in to the atmosphere from C. I. engine. Through the study and by analysing the obtained results it is evident that the waste heat based refrigeration system is economic, eco-friendly with zero CO_2 emissions. Hence the system selected is technically proven, echo friendly and economically better.

Anand Sankar M et.al [8] identified that there are large potentials of energy savings through the use of waste heat recovery technologies. Waste heat recovery defines capturing and reusing the waste heat from internal combustion engine for heating, generating mechanical or electrical work and refrigeration system. It would also help to recognize the improvement in performance and emissions of the engine. COP of the such system is less as compare to the traditional VCRS system but COP can be increase by doing some improvement in the cycle and increasing the source temperature of desorption process in thermodynamic cycle.

J. S. Jadhao et.al [9] reviewed on Exhaust Gas Heat Recovery for I.C. Engine. Concluded that there are large potentials of energy savings through the use of waste heat recovery technologies. Waste heat recovery defines capturing and reusing the waste heat from internal combustion engine for heating, generating mechanical or electrical work and refrigeration system. It would also help to recognize the improvement in performance and emissions of the engine. If these technologies were adopted by the automotive manufacturers then it will be result in efficient engine performance and Low emission. The waste heat recovery from exhaust gas and conversion in to mechanical power is possible with the help of Rankine, Stirling and Brayton thermodynamic cycles, vapour absorption. For waste heat recovery thermoelectric generator is use low heat, which has low efficiency. It is helpful for the same amount of increases in thermal efficiency and reduction in emission.

Arun Bangotra et.al [10] in his work, the generator is designed which is the main unit of vapour absorption refrigeration system. This will be located nearest to the exhaust manifold at tail-end where the heat is available from exhaust gases. The air conditioning for small car can run at 0.8 TR and need about 5 KW for evaporating refrigerant in vapour absorption system. This heat is available in the exhaust gases and has been estimated based on actual I.C-Engine driving cycles. As calculated the air conditioning system for small car can run at 0.8 TR and needs 5 kW heat for evaporating refrigerant from mathematical modelling calculation. Therefore the generator is designed to have capacity of 5 kW with temperature around 95°C and pressure of 20 bar of area 0.22 m2 with no. of tubes 32 having approx. weight 2 kg. The coefficient of performance can be found to be between 0.85 and 1.045. Reducing the fresh air intake and sealing the automobile body can result in a saving in cooling requirements such as door sealing and tinting the glass.

I. HORUZ et.al [11] experimentally investigated utilising the exhaust gases from the refrigerated road transport vehicles for the purpose of refrigeration. It was experimentally proven that it was possible to use the VAR system driven by the waste heat in the exhaust gases. He suggested that such a system could be used in road transport vehicles. He believes that this area of study is worth pursuing in terms of energy and cost savings, and suggests that a prototype design study be undertaken.

Shah Alam et.al [12] in his work three fluid vapor absorption systems is used for air conditioning of four strokes, four cylinders passenger car. The capacity of air conditioner is one ton. The exhaust of car is used to heat the ammonia solution in the generator. The temperature of exhaust heat is measured at different engine speed under 1/4th and half opening of throttle valve. The analysis shows that the maximum amount of useful heat available in the exhaust gas is about 6 KJ/sec. In this study it is found that the amount of heat required for generator is 3.02 KJ/sec. However the heat present in the exhaust is more than this amount. Therefore, the required heat to run the one-ton air conditioner that is needed to convert ammonia solution into ammonia vapor is sufficient.. The useful heat available in the exhaust gas is more than the heat required in the generator and able to run air conditioning unit.

2.1 PROBLEM FORMULATION

In the view of literature survey, it was found that there is scope for future development of the vapor absorption air conditioning system in automobiles by utilizing the waste exhaust heat from the I.C engine for the better fuel efficiency and to reduce emission of CFCs and HCFCs to atmosphere.

This project aims the fabrication of prototype of vapor absorption air conditioning system by utilizing the waste exhaust heat form internal combustion engine.

III. OBJECTIVES AND METHODOLOGY

3.1 OBJECTIVES

- To recover the engine exhaust heat for reutilization in air conditioning system in an automobile.
- To differentiate between existing refrigeration cost and proposed target cost.
- To reduce the work load on the engine and to run the compressor of conventional air conditioning system.
- To improve fuel efficiency of the vehicle.
- To reduce the emission of CFCs and HCFCs into atmosphere.

3.2 METHODOLOGY

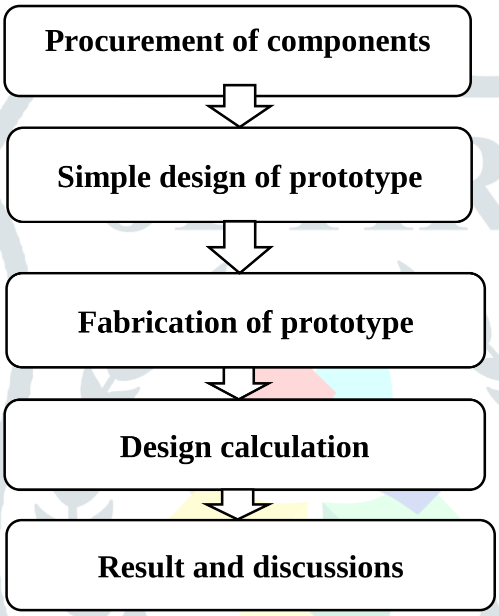

Fig 3.2.1: Flowchart for methodology

Procurement of IC Engine: A basic internal combustion engine of about 99.27 cc is taken for this prototype i.e., of two wheeler vehicle. Where the engine is removed from the vehicle or separated.

Simple Design of Prototype: A simple design sketch made to place the components in correct position.

Fabrication of Prototype: Firstly a basement for engine is made. From the casing of the engine the silencer is being connected to the generator tank where in the exhaust heat is being circulated inside the tank. The coil being coiled inside the generator tank is being connected to the various parts as detailed in chapter 6.

Design Calculation: Volume of the absorber tank, separator tank and generator tank are being calculated based on the ammonium hydroxide being used.

Results and Discussions: Writing the results based on the amount of cooling being done

3.3 WORKING PRINCIPLE

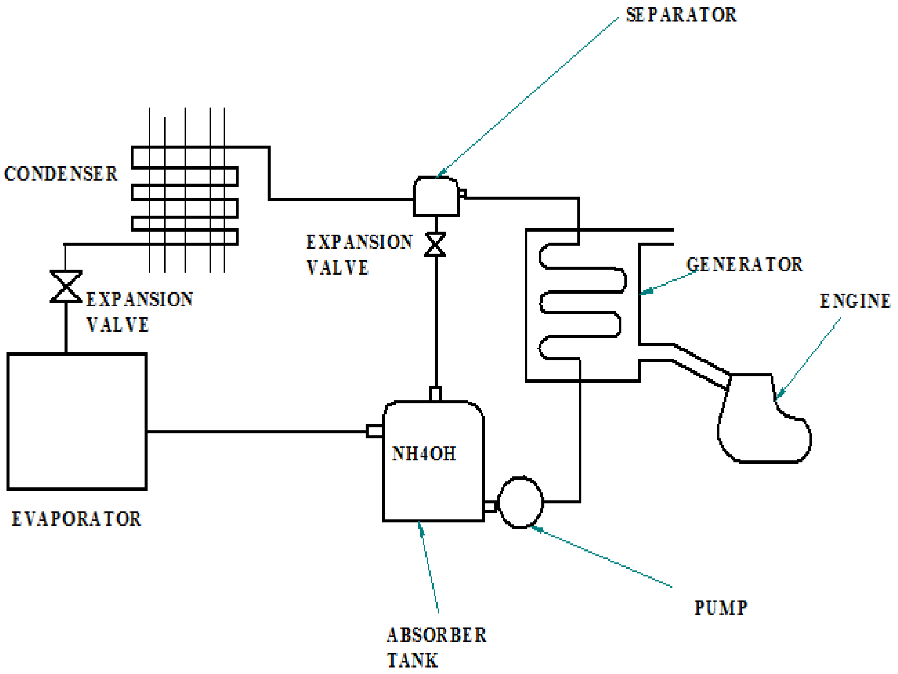

Fig 3.3.1: Working Principle

Vapour absorption cycle is a refrigeration cycle (VAR) which produces refrigerating effect by using heat as input and a very little mechanical work is required to operate VAR cycle. The working fluid is usually an Ammonia water. The low pressure ammonia vapour leaving the evaporator enters the absorber where it is absorbed by the cold water. Aqua-ammonia solution formed by the water has the ability to absorb very large quantity of ammonia vapour. To increase the pressure of the solution up to 10 bar the strong solution thus formed in the absorber is pumped to the generator by the liquid pump. By the exhaust heat of automobile the strong solution of ammonia is heated by some external source, in our system. During the heating process the ammonia vapour is driven off the solution at high pressure leaving behind the hot weak ammonia solution in the generator. After passing through the pressure reducing valve, the weak ammonia solution flows back to the absorber at low pressure. The high pressure vapour from the generator is condensed in the condenser to high pressure liquid ammonia the condensed liquid ammonia from the condenser is stored in a receiver valve; it is supplied to the evaporator through the expansion valve. The liquid ammonia is passed to the expansion valve in which its high pressure and temperature is reduced at a controlled rate after passing through it. The liquid vapour ammonia at low pressure and temperature is evaporated and changed into vapour refrigerant. In evaporator, the liquid vapour ammonia absorbs its latent heat of vaporization from the medium to be cooled.

IV.COMPONENTS USED

4.1 GENERATOR

Fig 4.1.1: Generator

Generator tank is being used to heat the strong aqua ammonia solution up to the boiling temperature of about 37 C to produce the vapor of ammonia where the heat source is being obtained by the engine exhaust heat. The ammonia solution is being circulated through the coil being coiled inside the tank so that it gets the large heating area to pass through and to get evaporated. The solution absorbs heat from the exhaust heat, causing the refrigerant to boil (vaporize) and separate from the absorbent solution.

4.2 RECTIFIER TANK

Fig 4.2.1: Rectifier

The rectifier tank is a system used to separate the vapor and the solution being used inside the system for the operation. In our project the rectifier tank is used to separate the ammonia vapor from the ammonium solution and the separated ammonia vapor is being send into the condenser whereas the liquid solution is being sent back to the absorber tank for the repeating of the process back.

4.3 CONDENSER

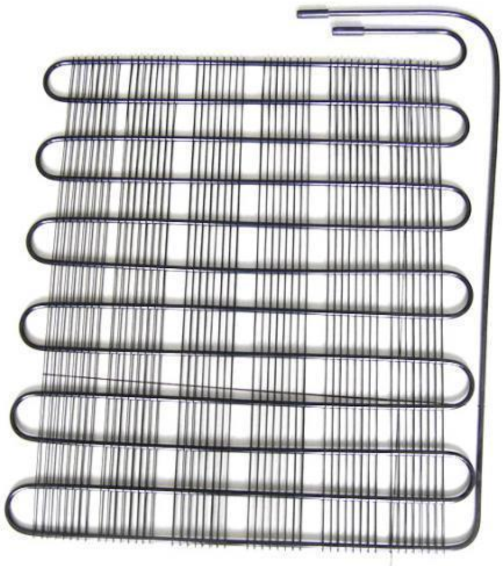

Fig 4.3.1: Condenser

In systems involving heat transfer, a condenser is a device or unit used to condense a substance from its gaseous to its liquid state, by cooling it. In so doing, the latent heat is given up by the substance and transferred to the surrounding environment. The purpose of condenser is to condense the refrigerant vapors. Inside the condenser, cooling water flows through tubes and the hot refrigerant vapor fills the surrounding space. As heat transfers from the refrigerant vapor to the water, refrigerant condenses on the tube surfaces. The condensed liquid refrigerant collects in the bottom of the condenser before traveling to the expansion device.

4.3.1 SPECIFICATIONS OF CONDENSER

- Type: Wire and tube coil
- Material: Mild steel
- No. of turns = 26
- Outer diameter of condenser pipe= 6mm
- Thickness = 1mm
- Area of the condenser = 0.95m × 0.4 m = $0.38m^2$

4.4 CAPILLARY TUBE

Fig 4.4.1: Capillary tube

From the condenser, the liquid refrigerant flows through an expansion device into the evaporator. The expansion device is used to maintain the pressure difference between the high-pressure (condenser) and low-pressure (evaporator) sides of the refrigeration system by creating a liquid seal that separates the high-pressure and low pressure sides of the cycle. As the high-pressure liquid refrigerant flows through the expansion device, it causes a pressure drop that reduces the refrigerant pressure to that of the evaporator. This pressure reduction causes a small portion of the liquid refrigerant to boil off, cooling the remaining refrigerant to the desired evaporator temperature. The cooled mixture of liquid and vapor refrigerant then flows into the evaporator.

4.4.1 CAPILLARY TUBE SPECIFICATIONS

Material: Copper
Inner diameter = 0.3mm
Thickness = 0.1mm
Capillary tube length = 3m

4.5 EVAPORATOR

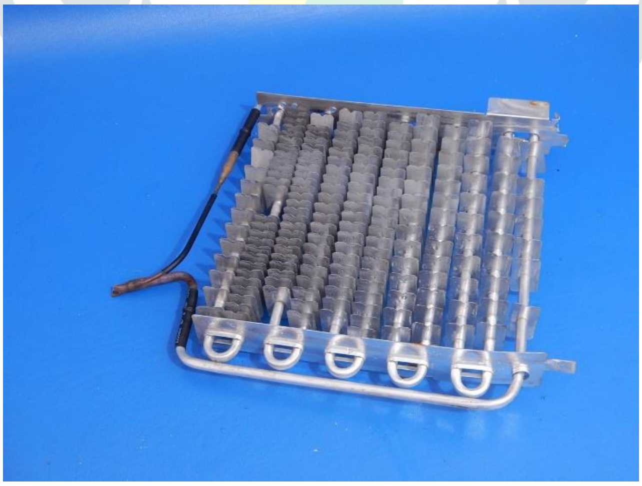

Fig 4.5.1 Evaporator

The purpose of evaporator is to cool the circulating ammonium hydroxide. The evaporator contains a bundle of tubes that carry the system space to be cooled/chilled. High pressure liquid condensate (refrigerant) is throttled down to the evaporator pressure.

At this low pressure, the refrigerant absorbs heat from the circulating water and evaporates. The refrigerant vapors thus formed tend to increase the pressure in the vessel. This will in turn increase the boiling temperature and the desired cooling effect will not be obtained. So, it is necessary to remove the refrigerant vapors from the vessel into the lower pressure absorber. Physically, the evaporator and absorber are contained inside the same shell, allowing refrigerant vapors generated in the evaporator to migrate continuously to the absorber.

4.6 ABSORBER TANK

Fig 4.6.1: Absorber tank

Inside the absorber, the refrigerant vapor is absorbed by the ammonium solution. As the refrigerant vapor is absorbed, it condenses from a vapor to a liquid, releasing the heat it acquired in the evaporator.

The absorption process creates a lower pressure within the absorber. This lower pressure, along with the absorbent's affinity for water, induces a continuous flow of refrigerant vapor from the evaporator. In addition, the absorption process condenses the refrigerant vapor and releases the heat removed from the evaporator by the refrigerant. As the concentrated solution absorbs more and more refrigerant; its absorption ability decreases. The weak absorbent solution is then pumped to the generator where heat is used to drive off the refrigerant. The hot refrigerant vapors created in the generator migrate to the condenser. The condenser turns the refrigerant vapors to a liquid state and picks up the heat of condensation, which it rejects to air. The liquid refrigerants return to the evaporator and completes the cycle.

4.7 ENGINE

Fig 4.7.1: Engine

4.7.1 ENGINE SPECIFICATION

Engine Displacement: 99.27 CC
Engine Type: 4 stoke, Air cooled
Max. Power: 8.2 PS @ 7500 rpm
Max Torque: 8.05 Nm @4500 rpm
Number of cylinders: 1
Valves per cylinder: 2
Fuel type: Petrol
Starter: Kick

4.8 DC DIAPHRAGM PUMP

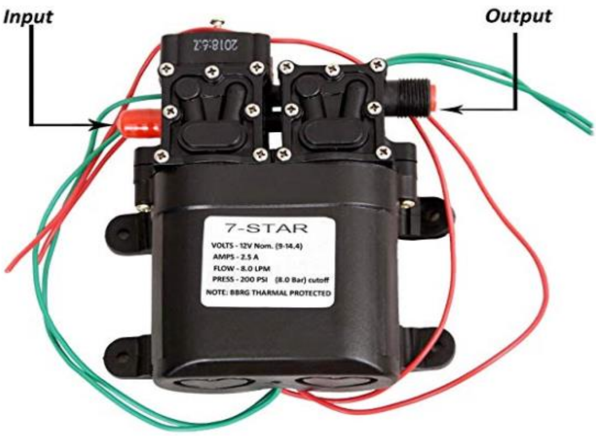

Fig 4.8.1: DC Diaphragm pump

The DC Diaphragm pump is used to pump the ammonium hydroxide from the absorber tank to the generator tank with the exact amount of pressure required for the solution to pass through the generator tank.

4.8.1 SPECIFICATION

Type: Auto Diaphragm DC pump
0.08 HP = 60 W
Pump flow rate = 5 LPM
Rated pressure = max 8bar
Dimensions: 165×95×60mmsss

4.9 SEALED LEAD ACID BATTERY

Fig 4.9.1: Sealed lead acid battery

A sealed lead acid battery or gel cell is a lead acid battery that has the sulphuric acid electrolyte coagulated so it cannot spill out. They are partially sealed, but have vents in case gases are accidently released for example by overcharging. They can be used for smaller applications where they are turned upside down. They are more expensive than normal lead acid batteries. But they are also safer.

The lead-acid battery was invented in 1859 by French physicist Gaston Plante and is the oldest type of rechargeable battery. Despite having a very low energy-to-weight ratio and a low energy-to-volume ratio, its ability to supply high surge currents means that the cells have a relatively large power-to-weight ratio. These features along with their low cost, makes it attractive for use in motor vehicles to provide the high current required by automobile starter motors. As they are inexpensive compared to newer technologies, lead-acid batteries are widely used even when surge current is not important and other designs could provide higher energy densities. Large-format lead-acid designs are widely used for storage in backup power supplies in cell phone towers, high availability settings like hospitals, and stand-alone power systems. For these roles, modified versions of the standard cell may be used to improve storage times and reduce maintenance requirement

V.DESIGN CALCULATION

5.1 ABSORBER CALCULATION

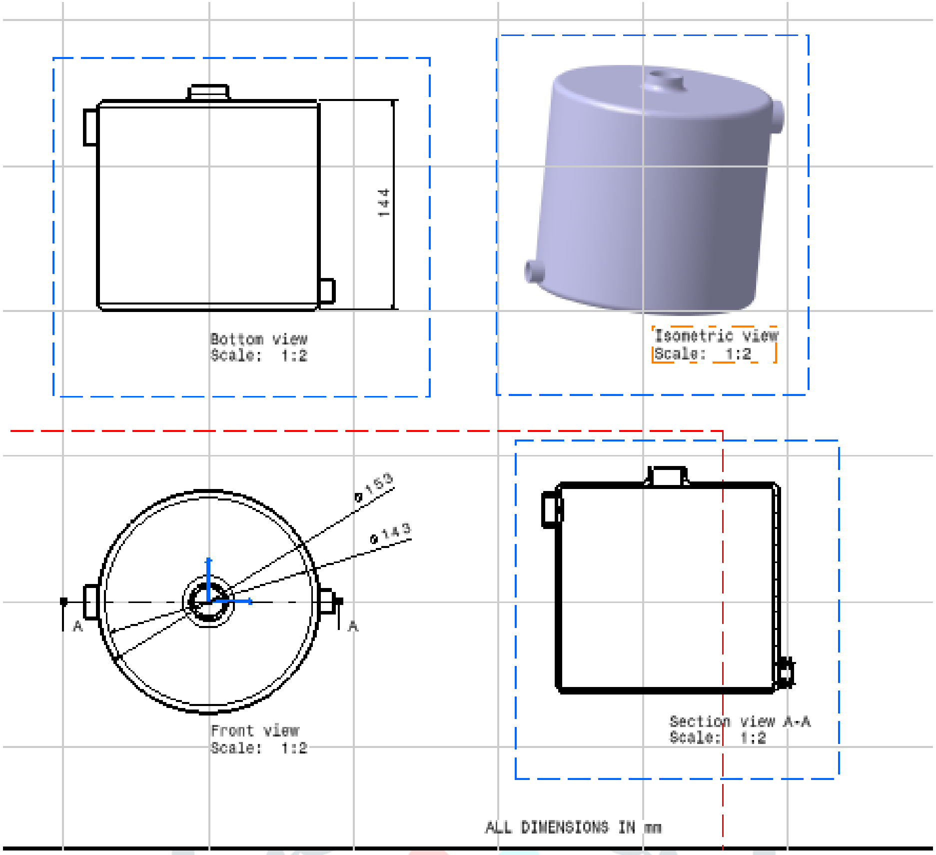

Fig 5.1.1: Drafting Of Absorber Tank

- Type: cylindrical tank
- Material used: Stainless Steel
- Refrigerant= Ammonia
- Absorber = Water
- Inner diameter of the tank = 150mm
- Outer diameter of the tank = 153mm
- Length of the tank = 141.4mm
- Total volume of the tank = V = $\frac{\pi}{4} \times d^2 \times h$

$=\frac{\pi}{4} \times 150^2 \times 141.4$=2.5ltrs

5.2. RECTIFIER CALCULATION

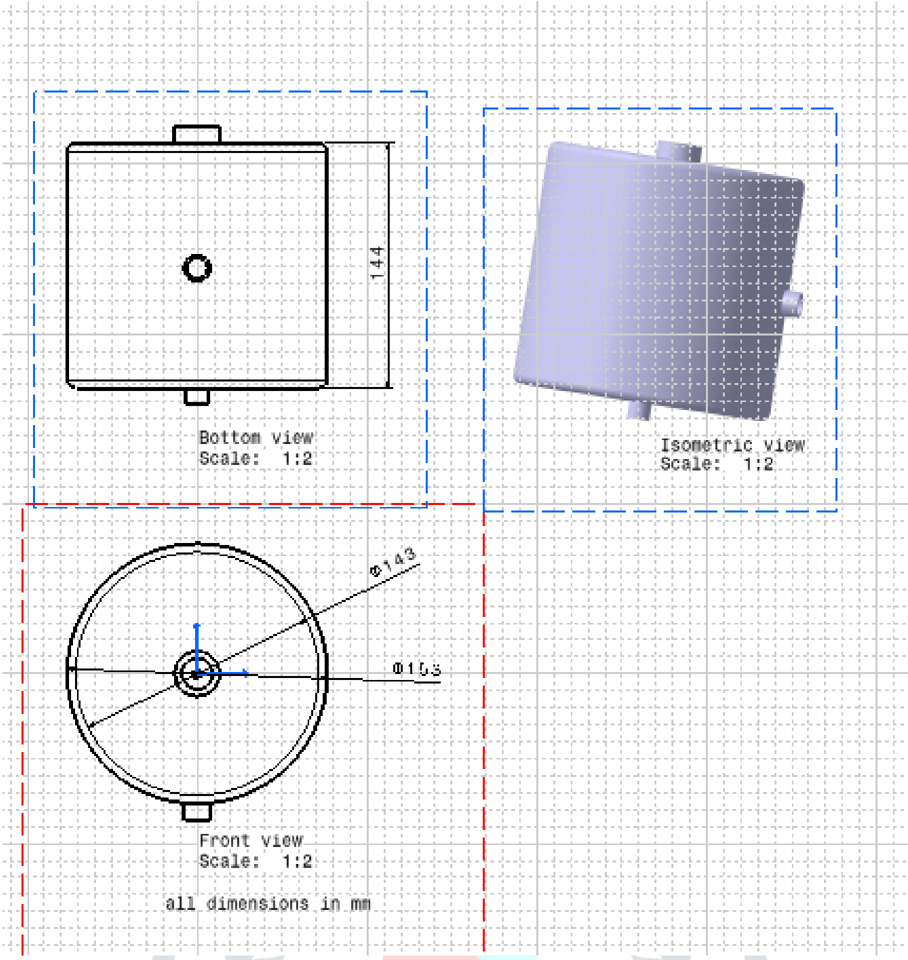

Fig 5.2.1: Drafting Of Rectifier Tank

- Type: cylindrical tank
- Material used: Stainless Steel
- Refrigerant= Ammonia
- Absorber = Water
- Inner diameter of the tank = 150mm
- Outer diameter of the tank = 153mm
- Length of the tank = 141.4mm
- Total volume of the tank = V = $\frac{\pi}{4} \times d^2 \times h$

$=\frac{\pi}{4} \times 150^2 \times 141.4 = 2.5$ltrs

5.3 GENERATOR CALCULATION

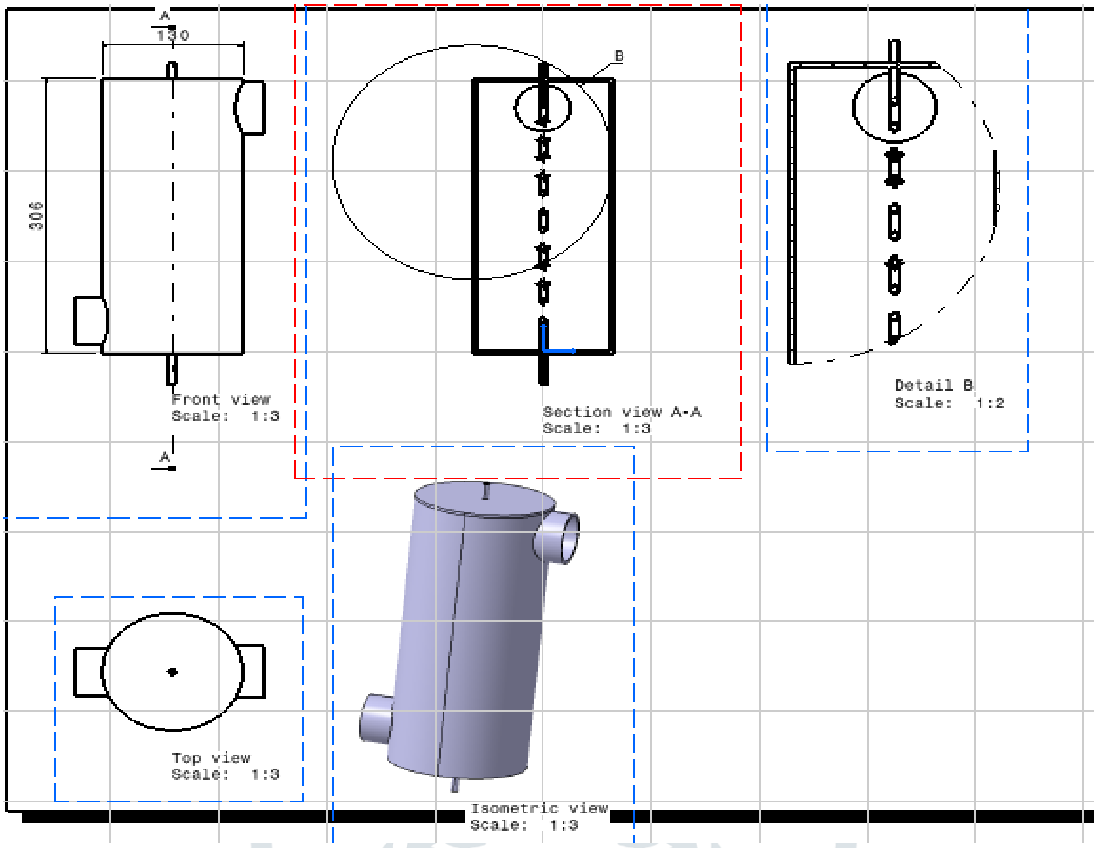

Fig 5.3.1: Drafting Of Generator

- Material used: Stainless steel
- Diameter =130mm
- Length = 300mm
- Area of generator = V = $\frac{\pi}{4} \times d^2 \times h$

  $= \frac{\pi}{4} \times 130^2 \times 300$

  $= 398.1 \times 10^3$ mm^2
- Length of copper pipe used =1000mm
- Number of coils =7
- Diameter of copper pipe =8mm
- Surface area available for heating = $\pi \times d \times l$

  $= \pi \times 8 \times 1000$

  $= 25.13 \times 10^3$ mm^2

VI. FABRICATION PROCESS

Fig 6.1: Fabrication Process of the Project

A frame is constructed using an L shaped bar and are welded using arc welding for the mounting of the parts required for the process. The engine is mounted inside the frame with the help of the underneath supports so the required height is maintained for the efficient working. From the exhaust port of the engine outlet the silencer is connected to the generator, the silencer of the vehicle is used for sufficient length and the rest of the part is being eliminated from the system. The generator is a cylindrical structure in which the copper material is coiled inside for the circulation of the refrigerant being used for the process of cooling. The cylindrical structure is being holed according to the calculated diameter in which two holes are used for the exhaust inlet and exhaust outlet, while the rest of the two holes are used for the inlet and outlet of the system from the generator. The absorber tank and the rectifier tank is constructed using stainless steel material according to the above mentioned calculations. The absorber tank is used to store the liquid refrigerant ammonium hydroxide which is used in the system for cooling, while the rectifier tank is used for the separation of ammonia vapor from the solution for the transfer of cooling to the system. The absorber tank and the rectifier tank are drilled for the holes of the suitable diameter for the inlet and outlet of the solution and the top and bottom ends of both the tanks are welded using tungsten gas welding (TIG). A filler cap is mounted on the top of the absorber tank for the filling of the ammonium hydroxide solution or for the top-up of the solution, even the filler cap is welded using the TIG. The drain valve is brazed on to the absorber tank for draining of the solution. Copper pipes are used for the connection between the tanks and are brazed.

A DC Diaphragm pump is being used in the operation which is connected between the absorber tank and the generator for pumping up the solution from absorber tank to the generator. Capillary tube is used between the absorber and rectifier for the expansion of the area, while the other one is used between condenser and evaporator. In both the cases the capillary tube is brazed for the connection. A battery is used as a power source to the pump with specifications mentioned in the previous chapter.

VII. RESULTS AND DISCUSSION

7.1 RESULT

The following results were obtained according to the calculations made for the volume of the tank i.e. absorber tank, rectifier tank and generator.

With all the components it is possible to install a vapour absorption refrigeration system utilizing the waste heat energy of the vehicle's engine exhaust gases to produce refrigerating effect inside the automobile's cabin. Using a vapour absorption refrigeration system within an automobile as an air conditioner will not only reduce the fuel consumption of the vehicle but will also provide many other advantages like the efficiency of the engine is not decreased considerably. The installation cost required for the system is less when compared with vapor compression system being used in the vehicles in recent times.

- The power being obtained after combustion is not left out to the atmosphere instead is being used to vapor the liquid which is being pumped into the generator.
- It was found that the cooling space of volume 26250cm^2 can be cooled up to 25-26 ^{0}C in 7 to 8 minutes continuous engine running.s

- The pump is being used to transfer the refrigerant from the absorber to the generator which is being bought under the calculated specifications for the pumping of it at certain pressure so the cooling process is effective. And the input power supplied to pump is neglected
- The calculated area of cooling is being constructed according to the engine output efficiency and cooling of the area is being observed.
- The equipment being mounted on the system are of standard dimensions and are checked for the efficiency of their work.

7.2 DISCUSSIONS

This type of modification can bring change in modern vehicles and also day to day life. Since it does not use the power from IC engine to run compressor unlike in VCR system it saves the fuel. This type system can be used in different types of engine of varying capacity. Due to the undetermined value of fuel this type of system can bring a great advantage to automakers as well as the customers.

In the present world, fuel crisis is high, so the mileage of vehicles has an important role to be considered. Sure, this project is a tool to improve our creativity in the field of refrigeration systems. And in the social point of view, it is a new idea to implement in the present vehicles & results in better fuel efficiency. Hope, the physical effort behind this will extend our knowledge in practicability.

This type of system can be used in trucks carrying goods which is to be maintained under certain pressure like food items and medicines.

More improvements can be made for customer’s satisfaction and comfort, and also reliable of efficiency and other factors

Since its working is fully manual, customers may feel some discomfort but long use can make them perfect and also feel no discomfort.

VIII. CONCLUSION AND SCOPE FOR FUTURE WORK

8.1 CONCLUSION

The conclusion of the project is that many new technologies and innovations are being introduced, but we have also made different arrangements for the cooling in the vehicles. The ability to design a refrigeration unit in a car using the residual heat of the vehicle engine based on the vapor absorption refrigeration system is realistic. Also taking into account environmental safety, this system is environmentally friendly because it involves the use of ammonia (a natural gas) as a refrigerant and is not responsible for the greenhouse effect and the environment. Depletion of the OZONE layer. In this way, we can conclude that, from the total heat supplied to the engine in the form of fuel combustion, about 35% to 40% becomes useful mechanical work; the remaining heat is classified in the residual heat and is expelled from the system, resulting in an increase in entropy; it is therefore necessary to use this residual heat in a useful work. The lost heat recovery system is the best way to recover lost heat and save fuel.

8.2 SCOPE FOR FUTURE WORK

- The experimental procedure can be implemented in large scale.
- Fuel efficiency of the vehicle is improved as compressor is being abolished from the mechanism.
- Greenhouse gas effects are reduced by using this working principle so that it is less hazardous to environment.
- R&D on this field would be a good field of research.
- In future this type of system maybe incorporated inside the vehicle for better efficiency.
- Different liquids such as lithium bromide can be used as refrigerant in this process of work.
- The experimental procedure is even implemented using solar power and Electrolux refrigeration system.

COST ESTIMATION

SL.NO.	COMPONENTS USED	COST(Rs.)
1.	ENGINE	4500
2.	DC DIAPHRAGM PUMP	1026
3.	BATTERY	600
4.	CONDENSER	150
5.	EVAPORATOR	450
6.	TANK WORKS	1700

7.	FRAME WORK	7250
8.	COPPER PIPE	500
9.	CAPILLARY TUBE	320
10.	TRANSPORATION	500
	TOTAL	**17000**

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