

VAPOR ABSORPTION REFRIGERATION SYSTEM USING WASTE HEAT FROM ENGINE

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering Degree in
Mechanical Engineering

By

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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with grade “A” by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of SHERLIN VIJESH J (Reg.No.37150177) and STEFFIN S (Reg.No.37150184) who carried out the project entitled **"VAPOR ABSORPTION REFRIGERATION SYSTEM USING WASTE HEAT FROM ENGINE"** under our supervision from September 2020 to April 2021.

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DECLARATION

We **SHERLIN VIJESH J (Reg.No.37150177)** and **STEFFIN S (Reg.No.37150184)** hereby declare that the Project Report entitled “**VAPOR ABSORPTION REFRIGERATIO SYSTEM USING WASTE HEAT FROM ENGINE**” done by me under the guidance of **Dr. A. KARTHIKEYAN, ME., Ph.D.**, is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

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PLACE : CHENNAI**

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ABSTRACT

The development of the world has led to increase the demand for energy utilization. All industrial process uses a lot of thermal energy by burning fossil fuel to produce steam or heat for the purpose. After the processes, heat is rejected to the surrounding as a waste. This waste heat can be converted to useful refrigeration by using heat operated refrigeration system, such as vapor absorption refrigeration system. Vapor Absorption Refrigeration (VAR) system usually runs with heat energy. Absorption system which runs with waste heat will be more effective. The performance of the VAR system under various conditions is calculated. The results show that an increase in the input temperature increases the performance of the system. This enables us to use energy from engine exhaust for vapor absorption refrigeration system.

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LIST OF SYMBOLS AND ABBEREVIATIONS

VARs	Vapor absorption refrigeration system
NH ₃	Ammonia
T ₁	Initial temperature
T ₂	Final temperature
ΔT	Change in temperature
W ₁	Initial watt meter
W ₂	Final watt meter
M	Mass flow rate
C _p	specific heat capacity
Dt	Change in temperature
T	Time in second
Ref. effect	Refrigerator effect
Act. COP	Actual coefficient of performance
COMP. Capacity	Compressor capacit

CHAPTER-1

INTRODUCTION

Energy conservation has become a hot subject of debates on conserving renewable resources and lowering prices. Based on forecasts of energy resource declines in the medium and long term, it is important to establish more energy and exergy efficient processes. Energy optimization experiments must also take environmental preservation into account. According to the Montreal Protocol, which was signed in 1987 by 46 countries and amended in 1990 to safeguard the ozone layer, the ongoing replacement of chlorinated fluorocarbons (CFCs) by alternative refrigerants is a significant point to mention absorption refrigeration systems.

Other driving factors include the continued improvement in internal combustion engine efficiency and the growing use of air conditioning in cars, which has reached the status of an important necessity in daily life. Internal combustion engines are possible energy sources for absorption refrigeration systems, since nearly one-third of the energy available in the combustion phase is lost as exhaust smoke. As a result, using exhaust gas in an absorption refrigeration system will improve the overall performance of the system.

The aim of this project is to investigate the feasibility and potential of using exhaust gas from internal combustion engines as a source of energy for an absorption refrigeration device. An experimental research on a commercial 215-1 refrigerator was conducted for this purpose. The effect of the absorption refrigeration system on engine power output and exhaust emissions is studied in order to better understand how this system affects the operation of an internal combustion engine.

1.1. NEEDS FOR ENERGY CONSERVATION

India is one of the world's most populated country, the demand for power leads to burning of considerable fossil fuels which has an adverse effect in environment. In this context, efficient use of energy and its conservation are paramount important. It has been estimated that nearly 25,000 MW can be saved by implementing end-use of energy efficiency and demand of management measures throughout India. One unit of energy saved at the consumption level reduces the need for fresh capacity creation by 2.5 times to 3 times, proficient energy utilization and reusing become considerably more fundamental. Moreover, efficient use of energy can be achieved at least less than one-fifth of the cost of fresh capacity creation. Aside from diminishing petroleum derivative utilization, energy protection would enormously supplement our endeavors to fulfill our power needs. 1.2 Heat recuperation from squander a waste warmth recuperation unit (WHRU) is a warmth exchanger that concentrates heat from hot surges of high energy content, for example, hot vent gases from a diesel engine, steam from cooling towers, or even waste water from different cooling measures, for example, steel cooling.

1.2 WASTE HEAT RECOVERY EQUIPMENT'S METHODS

To preheat the incoming steam, waste heat from various processes exhaust gases, as well as the exhaust stream of a cooling tower, may be used. This is one of the most straight forward waste heat recovery methods.

1.2.1 Refrigeration By Waste Heat Recovery

Due to the rising demand for electricity, we were forced to take the requisite measures to recycle waste heat from a variety of sources. The use of excess heat should be the main priority in order to solve the energy shortage and protect the global environment. The key goal of this paper is to discover the most efficient way to extract excess heat from a domestic refrigerator's condenser. We all know the refrigerator condensers reject a lot of heat into the room, which makes us uncomfortable in the summer when the temperature rises. This waste heat can be used for a variety of household tasks, including keeping food warm, heating water, drying clothes, and drying grains. This tends to be a very useful option for improving overall refrigerator performance and utilizing waste heat. This study demonstrates that such a scheme is practical as well as cost-effective. When designing a refrigeration machine, bear in mind that the heat recovery system does not decrease the refrigeration unit's energy quality, and the key purpose of the modernized device must also be to have a cooling effect with the same parameters. Furthermore, it is important to remember that the majority of excess heat is collected while the refrigeration systems are operating at their most effective in the summer, while it will be highly needed in the winter. The year-round requirement for domestic hot water for sanitary and industrial uses could be an exception.

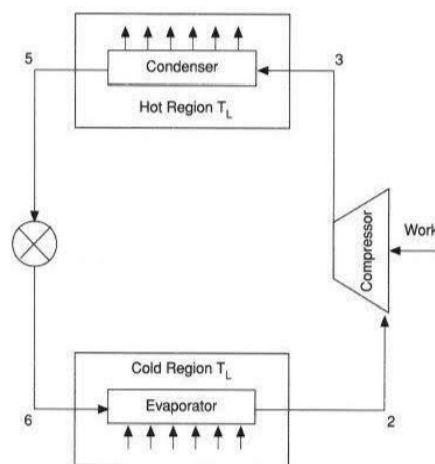
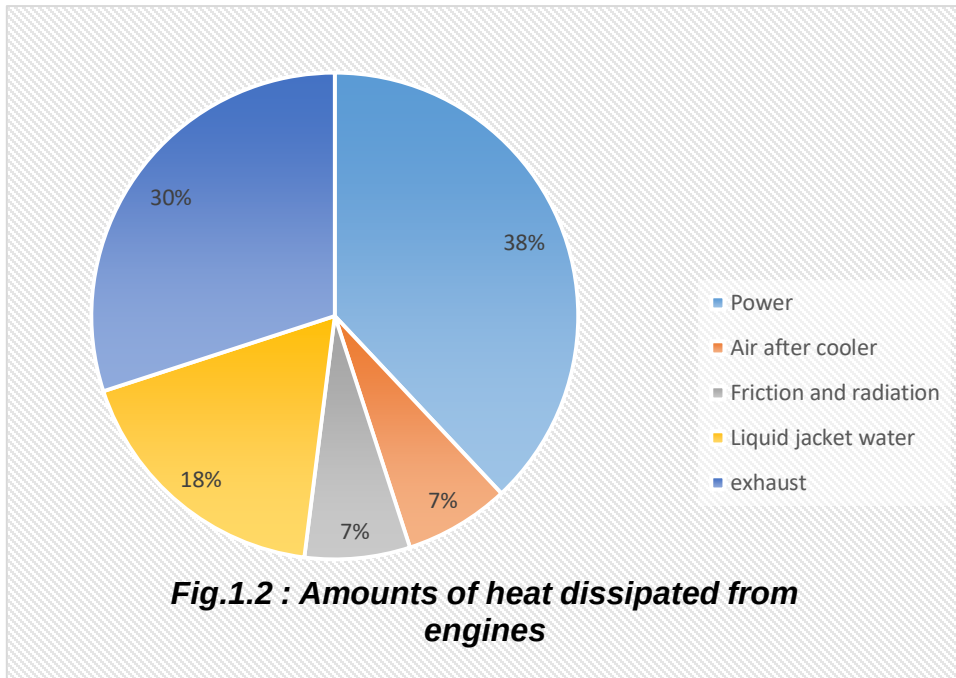


Fig1.1: Typical waste heat energy recovery system

1.2.2 Waste heat potential from engines

Squander heat will be heat, which is created in an interaction via fuel ignition or substance response, and afterward "unloaded" into the climate despite the fact that it could be reused for some helpful and monetary reason. During engine run time, there are four wellsprings of usable waste warmth from a responding engine: fumes gas, engine coat cooling water, lube oil cooling water, and turbocharger cooling are scattered to the environment. The single biggest measure of unused warmth from the engine is the fumes heat, which contains about 30% of the fuel energy. It is apparent that fumes gases come out from the fumes port at a high temperature, it has been seen that in diesel engines fumes outflow are at the high temperature of 250°C to 600°C (approx.) with top caliber and amount.

Fig 1.2 shows the measure of warmth dispersed from engines at same time period. Fig. 1.2 Amounts of warmth dispersed from engines if the waste warmth were put to proper use, there would be incredible energy or fuel reserve funds.



The fumes gas from the engine can be utilized straightforwardly for measure drying. By and large, the boiling water and low-pressure steam gave by responding engine frameworks are appropriate for low-temperature measure prerequisites, space warming, consumable water warming, cooling or refrigeration, and driving retention chillers to give cold water. Squander recuperation hardware is important for the WHR framework to recuperate heat from the streams and transform it into a usable structure.

1.3 VAPOR ABSORPTION

The basic vapor absorption refrigeration method underpins the operation of the ammonia-water absorption refrigeration device. Ammonia is used as the refrigerant, and water is used as the absorbent in this device. The ammonia-water absorption device is used in both domestic and commercial applications where a temperature of above 32 degrees F is needed.

The ammonia-water solution has the advantage of having a good affinity for ammonia and being soluble under a wide range of operating conditions used in various refrigeration applications. Furthermore, the ammonia-water solution is very stable and compatible with a wide range of components, with the exception of copper and its alloys, which corrode when exposed to ammonia. We've already known that ammonia is the most suitable refrigerant; however, due to its toxicity, its applications are limited, and it isn't used in air conditioning.

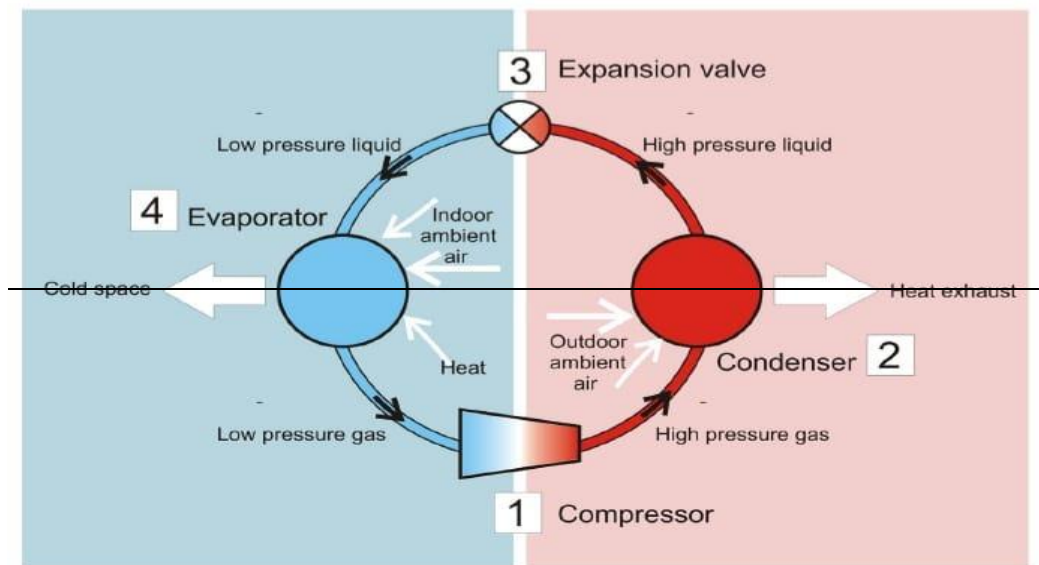


Fig.1.3: Vapor absorption refrigeration system (VARS)

1.3.1. Role of water in vapor absorption system

In water, ammonia is easily miscible. Ammonium Hydroxide readily liberates ammonia gas when heated slightly. The exothermic reaction of ammonia with water is used to circulate hydrogen in the system, and the fuel energy from this exothermic reaction is used to fuel the system.

1.3.2. Role of ammonia in vapor absorption system

As ammonia from the evaporator reaches the absorber, it is quickly absorbed by water, forming a solid ammonia-water solution. Heat is released during the absorption process, which reduces water's ammonia absorption capacity; as a result, the absorber is cooled by the cooling water.

1.4 SYSTEM ANALYSIS

Fig 1.4 illustrates a schematic block diagram of a basic absorption refrigeration device, which requires an absorber, strainer, and generator to replace the compressor in a vapor compression refrigeration system. The system's other part is identical (condenser, evaporator and expansion valve). NH_3 is used as a refrigerant, and water is used as an absorbent in this device. The low-pressure ammonia vapor refrigerant from the evaporator reaches the absorber, where it is captured by the absorber's cool water.

The mixture of ammonia vapor passed from the evaporator to the absorber. Inflowing the upper portion of the absorber is a continuous trickle of weak ammonia solution fed by gravity from the tube.

This weak solution, flowing down through the absorber comes into contact with the mixed ammonia gas which readily absorbs the ammonia from the blend, and it passes through the absorber coil and to return to the evaporator.

Thus flows continuously between the absorber and the evaporator. The strong ammonia solution formed in the absorber flows down to the absorber vessel and hence

to the boiler system, thus finishing the full cycle of operation. The liquid flow of the unit is purely gravitational.

Heat is produced in the absorber by the process of absorption. This heat must be degenerate into the surrounding air. Heat must also be degenerate from the condenser. The evaporator converts high-pressure liquid ammonia into liquid ammonia, which is then transferred to the cooper tube. This is how a straight forward vapor absorption refrigeration cycle works in its entirety.

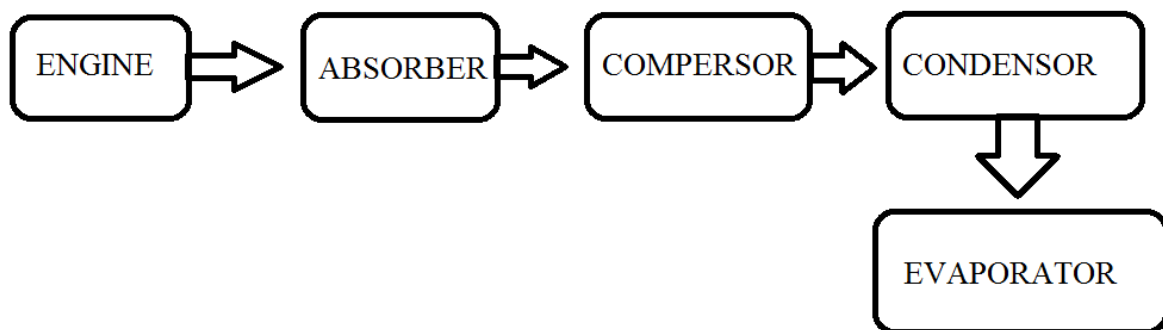


Fig 1.4: Vapor absorption refrigerator system cycle

CHAPTER-2

LITERATURE REVIEW

2.1. VAPOR COMPRESSION REFRIGERATION CYCLE

This refrigeration cycle is similar to a reversed Rankine cycle. A working fluid (often referred to as the refrigerant) is moved into the machine and changes condition (from liquid to gas and back). Significant volumes of heat energy are transferred using the refrigerant's latent heat of vaporization, and pressure variations are used to monitor when the refrigerant expels or absorbs heat energy. However, for a refrigeration period with a hot reservoir at about room temperature (or slightly higher) and a cool reservoir at about 34°F, the refrigerant's boiling point must be very mild. As a result, a variety of fluids have been established as viable refrigerants. Ammonia, Freon (and other chlorofluorocarbon refrigerants, aka CFCs), and HFC-134a are the most common (a non-toxic hydrofluorocarbon).

2.2. DEVELOPMENTS IN VCRS

Rossi and Braun developed a mechanistic model of a roof-top air conditioning unit (1999). The relevance of real-time simulation is illustrated in this model, which includes a demonstration of a smart automated integration phase sizing algorithm that correctly simulates start-up and on-off cycling. For the configuration of the system-model, a completely finite-volume formulation of the mass and energy balances in heat exchangers is assumed and used. The validation is presented using the start-up measurements of a 3-ton roof top device.

Jing Xia and his colleagues developed a different flow-model for an evaporator (1997). They looked at how the evaporator behaved as the condensing temperature, compressing speed, expansion valve release, and secondary fluid conditions changed. The relative accuracies of assumption of homogeneous flow and step flow patterns in the heat exchanger were observed by Jackobsen and his company. They came to the conclusion that the homogeneous flow model was an acceptable representation and it over-predicted the evaporator's sensitivity. They choose to use the slip-flow approach when it comes to refrigerant dynamics. Sevnsson concentrated his efforts solely on liquid chillers. This model was built using a phase-by-phase lumped parameter formulation in the heat exchangers. The heat-exchanger phase-wise lumped parameter formulation is sufficient and suitable for studying the dynamics of the device in response to load disturbances. These disruptions are caused by step shifts in the condenser side water flow speeds.

Wang and Wang (1999) introduced single-stage and two-stage centrifugal chiller models that were mechanistic. The construction of a comprehensive model of a centrifugal compressor is based on the first principles, which include the momentum equation, energy equation, and velocity triangles. The capacity management method of the inlet guide vane or pre-rotation vanes has also been integrated and inculcated in the model. Heat exchangers are developed and engineered in a rather simple way.

CHAPTER-3

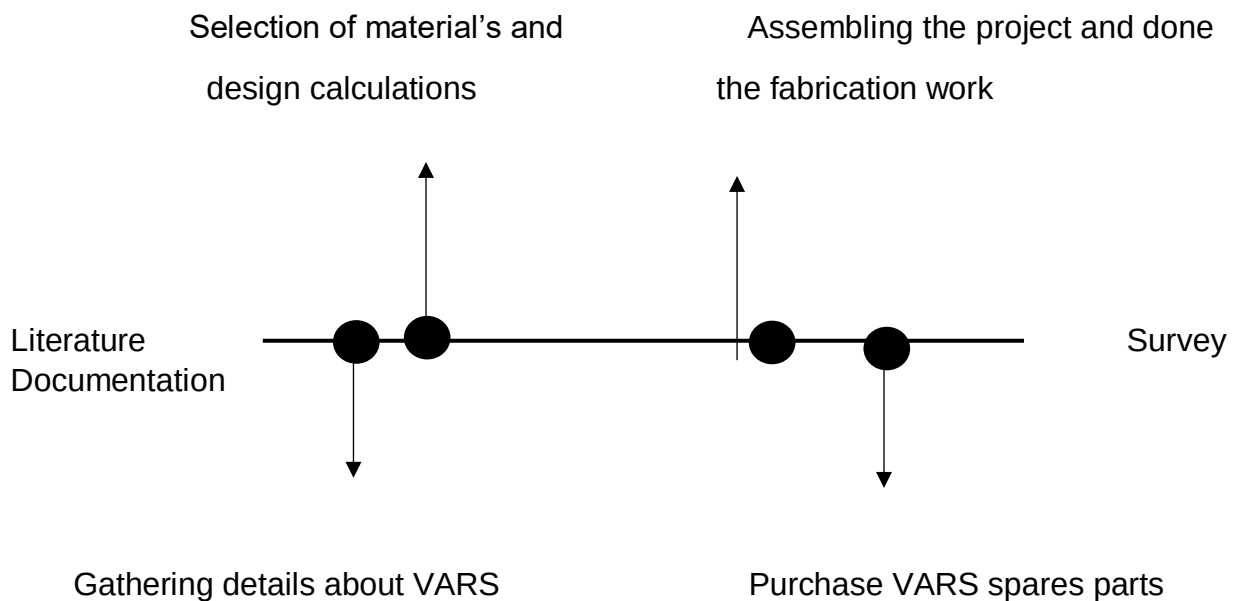
AIM AND SCOPE

The project entails the use of heat engine resources to power an absorption refrigeration device. Absorption refrigeration works on the concept of using three gases to achieve the cooling effect: ammonia (refrigerant), water (absorbent), and hydrogen. Ammonia is used as a refrigerant because it is readily available, environmentally efficient, and has a superior cooling effect. Hydrogen is used to lower the partial pressure of ammonia vapor in the evaporator chamber, allowing more ammonia to evaporate and thereby provide more cooling. The generator, which heats aqua ammonia to produce ammonia vapors, requires heat input. An experimental setup for absorption refrigeration is created in this project, which uses heat engine energy to provide input heat.

CHAPTER-4

MATERIALS AND METHODOLOGY

4.1 METHODOLOGY



To design a vapor absorption refrigeration system based on $\text{H}_2\text{O}-\text{NH}_4$ has a refrigeration capacity of 175 (0.05) watts. The system operates at an evaporator temperature of 5degree centigrade ($P_{\text{sat}}=8.72\text{mbar}$) and a condensing temperature of 30degree centigrade ($P_{\text{sat}}=32.3\text{ mbar}$). The concentration of solution at the exit of absorber and generator are 0.35 and 0.45, respectively. Assume 100 percent effectiveness for the solution pump, exit condition of refrigerant at evaporator and condenser to be saturated and the condition of the solution at the exit of absorber and generator to be at equilibrium.

The vapor absorption device uses thermal energy instead of mechanical energy. In the vapor absorption device, the compressor is supplemented by an absorber, a generator, a strainer, a condenser, and an evaporator. The vapor refrigerant from the evaporator is drawn into an absorption unit, where it is absorbed by the refrigerant's weak solution, resulting in a solid solution that is pumped to the generator and heated by an external source. During the heating process, the vapor refrigerant flows into the evaporator, and the cycle is full. At least two fluids are needed by the VAR method. The first substance acts as a coolant, and the second acts as an absorber.

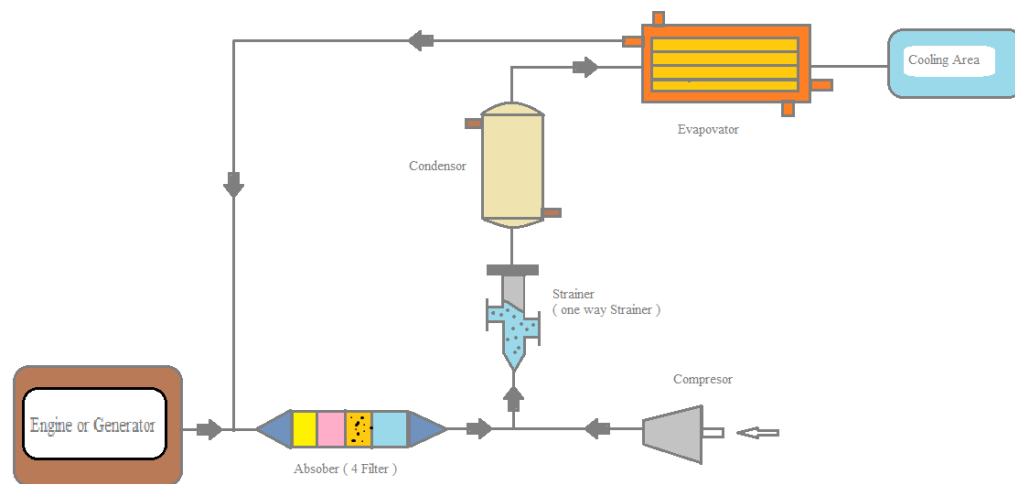


Fig.4.1: Block Diagram of vapor absorption refrigeration system

4.2 THE PRIMARY COMPONENTS OF THE REFRIGERATION SYSTEM

- Generator (engine)
- Absorber
- Condenser
- Evaporator
- Compressor
- Ammonia gas

- Copper tube
- Frame
- Valves, Gauges and Connecting adapters

4.2.1 Engine (Generator)

In this project we are using four-stroke bike engine. A four-stroke IC engine is a mechanism that transforms heat or thermal energy into mechanical operation. Steam engines, diesel engines, and gasoline (petrol) engines in automobiles are examples of popular IC engines. IC engines are only designed to do useful work. In a typical bike spark ignition engine, the performance of a modern internal combustion engine is about 37%. Exhaust, flowing cooling water, lubrication fluid, and radiation are all used to deny energy in the form of heat. The air conditioning of moving cars has become a must these days due to the greenhouse effect, evolving climate, and atmospheric effect. Vapor Compression Refrigeration System (VCRS) and Vapor Absorption Refrigeration System (VARS) provide the cooling effect (VARS). Although the COP of the VCRS system is higher than that of the VARS system, the VCRS is more suited in terms of operational conditions. The electric load of a car is rising day by day as comfort and driving efficiency increase.

An engine, also known as a generator, is a system that converts mechanical energy from one source. Heat engines convert heat into energy through a number of thermodynamic processes. The heat produced by the combustion of a fuel allows the gaseous combustion materials in the combustion chamber to expand and propel a piston, which drives the crankshaft. Electric engines use power, pneumatic engines compressed air, and wind-up toy clockwork engines use elastic energy.

The term "engine" was first used to differentiate the internal combustion engine from the steam engine, which was widely used at the time, powering locomotives and other machines such as steam rollers. The word "engine" comes from the Latin verb "moto," which means "to put in motion" or "to keep moving." As a result, an engine is a mechanism that transmits motion.

In modern English, the words engine and engine are synonymous. In certain engineering jargons, an engine is a device that burns or otherwise absorbs gasoline, altering its chemical composition, while an engine is a device that is powered by electricity, air, or hydraulic friction that does not alter the chemical composition of its energy supply. Despite the fact that rockets consume fuel, the word "rocket engine" is used in rocketry.

A heat engine may also be used as a prime mover, which is a component that converts fluid flow or pressure changes into mechanical energy. An vehicle with an internal combustion engine may have a number of engines and pumps, but the engine is the source of power for all of them. Another way to think of it is that an engine gets its power from somewhere else and transforms it into mechanical energy, while an engine gets its power from pressure (derived directly from the explosive force of combustion or other chemical reaction, or secondarily from the action of some such force on other substances such as air, water, or steam).



Fig.4.2: Four stroke IC Engine

Type: Single Cylinder 4-Stroke engine

Power: 3.75Kilowatts

Speed: 1500rpm

Bore: 80mm

Stroke: 110mm

The exhaust temperatures were noted for different loading conditions from 0 percent of loading to 75 percent of loading. The exhaust temperature was observed to be vary from 138°C -223°C. These temperatures were taken into account, and the study was carried out based on them. And there will be some heat loss after the exhaust, the measurement temperatures ranged from 100°C to 180°C.

4.2.2 Absorber



Fig.4.3: Absorber

The absorber is used to absorb and filter the inlet exhaust gas from engine. It has 4 filters which will do the process accordingly. The absorber is a kind of vessel made up of water as the absorbent and the previously absorbed refrigerant. As a consequence, the absorber is made up of a mild solution of the refrigerant (in this case, ammonia) and absorbent (water in this case). As evaporator ammonia reaches the absorber, it is absorbed by the absorbent, lowering the pressure within the absorber and allowing more refrigerant to flow from the evaporator to the absorber. Water absorbs less ammonia at high temperatures, so it is cooled by an additional coolant to increase its ammonia absorption ability.

4.2.3 CONDENSER

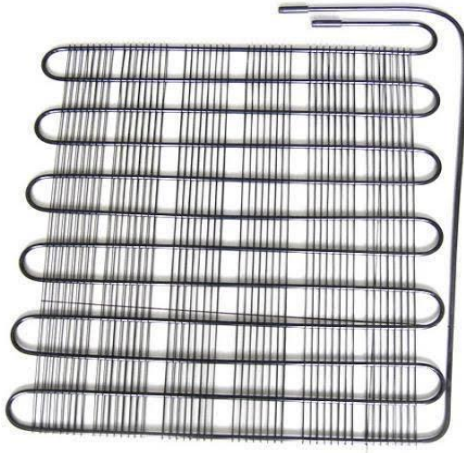


Fig.4.4: Condenser

A condenser is a device or unit that uses cooling to condense a gaseous material into a liquid state in heat transfer systems. As a result, the substance's latent heat is released and transmitted to the ambient world. In many industrial systems, condensers are used for effective heat rejection. Condensers are available in a range of shapes and sizes, varying from very small (hand-held) to very large (industrial-scale units used in plant processes). A refrigerator, for example, uses a condenser to transfer heat from the inside of the appliance to the outside air.

Air conditioners, industrial chemical applications such as distillation, steam power stations, and other heat-exchange devices all use condensers. In certain condensers, cooling water or ambient air is used as the coolant.

A condenser is a heat transfer device that transfers heat from a working fluid (for example, water in a steam power plant) to a secondary fluid or the ambient air. The effective heat transfer that happens during phase changes, in this case during the condensation of a vapor into a liquid, is used by the condenser. The temperature of the

vapor entering the condenser is normally greater than that of the secondary solvent. When the vapor cools, it approaches boiling, condenses into a liquid, and emits a significant volume of latent heat. The amount of vapor reduces as the phase continues, while the quantity of liquid increases; at the condenser's outlet, only liquid remains. Any condenser structures include an extra duration to subcool this condensed liquid below the saturation temperature.

The operating fluid, the secondary fluid, the geometry, and the material are only a few of the configuration variables in condenser design. Hot, air, refrigerants, and phase-change compounds are examples of secondary fluids.

Condensers have two significant design advantages over other cooling technologies:

- The temperature of the working fluid remains comparatively stable during condensation, maximizing the temperature difference between the working and secondary fluids.
- Heat transfer by latent heat is much more effective than heat transfer by sensible heat alone.
- A surface condenser is a device that mechanically separates the condensing medium and vapors and is used where direct contact is not needed. It's a shell and tube heat exchanger that's mounted at the steam turbine's outlet in thermal power plants. The cooling water usually runs through the tube side, while the steam reaches the shell side, where it condenses on the heat transfer tubes' outsides. The condensate drips to the bottom and pools in a built-in pan known as a hot well. The disparity in relative volume between the steam and condensate creates a vacuum or partial vacuum on the shell side. On the other hand, the vapor will be fed into the tubing as the coolant water or air circulates across the outside.
- A condenser is a chemistry device that cools hot vapors and causes them to condense into a liquid. For laboratory-scale condensers, rather than industrial-

scale condensers, see "Condenser (laboratory)." The Liebig condenser, Graham condenser, and Allihn condenser are all examples. This is not to be confused with a condensation reaction, which involves the incorporation and removal of two fragments to form a single molecule.

Ground glass joints are common on commercially produced condensers, which come in lengths of 100, 200, and 400 mm. Air-cooled condensers do not have a water jacket, whereas water-cooled condensers do.

- In industrial-scale distillation systems, larger condensers are used to cool condensed vapor into liquid distillate. The coolant usually flows through the tube side, while the distilled vapor passes through the shell side, with the distillate settling at or flowing out the bottom.
- A standard house's condenser unit for central air conditioning
- In central air conditioning systems, a condenser unit usually includes a heat exchanger section to cool and condense incoming refrigerant vapor into liquid, a compressor to increase the refrigerant's pressure and pass it along, and a fan to blast outside air into the heat exchanger section to cool the refrigerant within. The following is an example of a standard condenser device configuration: For the compressor inside, the heat exchanger portion wraps around the sides of the device. The refrigerant passes through several tube passes in this heat exchanger portion, which are enclosed by heat transfer fins that enable cooling air to flow from outside to inside the device. A engineized fan is mounted at the top of the condenser device and is protected by grating to prevent any items from falling inside and destroying the fan. Outside cooling air is drawn in through the heat exchanger parts on the sides and blown out the top through the grating by the fan. These condenser devices are mounted on the exterior of the building they're attempting to cool, with tubing running between the appliance and the structure, one for vapor refrigerant and the other for liquid refrigerant. Of course, the compressor and fan within the unit need an electric power supply.

- In a direct-contact condenser, hot vapor and cold liquid are inserted into a vessel and allowed to blend freely instead of being isolated by a membrane like a heat exchanger tube wall. The vapor gives up its residual heat and condenses to a solvent, while the liquid absorbs the heat and warms up. A single condensable material, such as a water spray used to cool and change the humidity of the air, is normally found in the entering vapor and liquid.

4.2.3.1 Other Types of Condensers

There are three other condensers used in VARS systems:

- Water-cooled condenser
- Air-cooled condenser
- Evaporative condenser
- Water cooled condenser – These condensers are the more powerful kind, but they are a little more expensive to build. These condensers, which are widely used in swimming pools and condensers piped for city water flow, need routine operation and maintenance. To save water, they will need a cooling tower. Water-cooled condensers require a continuous supply of makeup water as well as water treatment to avoid corrosion and algae formation. Tube in tube, shell and coil, and shell and tube condensers are all options depending on the design. They're all designed to get the same result, but in different ways.
- Air cooled condenser–If the condenser is on the outside of the device, the air cooled condenser is the most convenient choice. These condensers are easy to mount and eject heat to the outside. Domestic refrigerators, upright freezers, and residential packaged air conditioning units are the most common applications for this condenser. The air cooled condenser has the advantage of being very easy to vacuum. Since dirt may cause severe problems with the condensers results, it is strongly advised that they be kept clean.

- Evaporative condenser – Although they are the least common option, they are used where either the water supply is insufficient to run a water-cooled condenser or the condensation temperature is lower than an air-cooled condenser would attain. Evaporative condensers can be used inside or outside of a building and work at a low condensing temperature under normal conditions.
 - These are usually used in large commercial air-conditioning systems. They are reliable, but they aren't always the most powerful.

4.2.4 EVAPORATOR



Fig.4.5: Evaporator

An evaporator is a system used in the process of transforming a chemical substance's liquid form to its gaseous form/vapor. In that step, the liquid is evaporated, or vaporized, into a gas phase of the targeted material. In that phase, the targeted material is vaporized into a gas form.

An evaporator is a type of radiator coil that is used in a closed compressor-driven liquid coolant circulation system. This is referred to as an air-conditioning system (A/C) or a refrigeration system because it helps a compressed cooling chemical, Ammonia, to evaporate/vaporize from liquid to gas inside the system while absorbing heat from the enclosed cooled environment, such as a refrigerator or indoor rooms. This functions for a condenser radiator coil in a closed A/C or refrigeration device that exchanges heat from the coolant, such as into the atmospheric setting.

A heat exchanger in which a liquid refrigerant is evaporated at low pressure and temperature is known as an evaporator. In an evaporator, heat is extracted from the environment that has to be cooled. The liquid refrigerant evaporates at low pressure and temperature in an evaporator, which is made up of copper or steel tubes.

To extract heat from air, water, and brine, the liquid refrigerant is evaporated within the evaporator coil. The liquid refrigerant derives its latent heat of vaporization from the cooling fluid (air, water, or brine) in the evaporator.

- i. Direct Expansion system: A direct expansion mechanism is one in which a liquid refrigerant is evaporated within the evaporator cooling coil and the fluid to be cooled is transferred along the cooling coil's surface.
- ii. Indirect System: Water or brine is chilled in an evaporator in a massive air conditioning device, and the chilled fluid is filtered into a copper or steel hose. The cooled copper and steel tubing is pushed via a fan. This kind of system is known as an indirect system.

4.2.4.1 Other types of evaporator

- Air-cooled evaporator/dry expansion evaporator (DX-coil)
- Liquid cooling evaporator:

a) Shell and coil

b) Wire and tube

- Plate-type evaporator

a) Shell and Coil Evaporator: A dry expansion evaporator, the shell and coil evaporator (DX coil). The evaporator coil receives liquid refrigerant and produces vapor; the coil is still dry. A long metallic tube with strong thermal conductivity is mounted in a perfectly sealed shell as the cooling coil.

To avoid leaks, all ends of the coil move through the shell's corner and are fixed to it. The liquid refrigerant leaving the condenser through the expansion valve passes through a coiled tube and evaporates, with the vapor produced in the evaporator being sucked by the compressor.

Water is constantly supplied into the casing, and chilled water emerges at the other end. The cooling coil absorbs the heat of the bath. As a result, the evaporator produces a cooling effect. This form of evaporator is commonly found in limited volume units up to a capacity of 10 TR and is ideal for water coolers.

b) Wire and tube evaporator: The wire and tube evaporator is made up of a coiled tube with metallic wires arranged parallel to each other and welded or brazed to the wall. The refrigerant inside is in contact with the coil's whole surface. The wires serve as fins to increase the rate of heat transfer.

The liquid refrigerant is pumped through the coil before being evaporated. This is suitable for small-scale plants.

- Plate-type evaporator: The tubes manufactured in coil form are either welded or brazed on one side of the plate in this type of plate evaporator, which is the most common type of plate evaporator. The evaporator is made up of a coiled tube and a plate. Plate evaporators are used in domestic refrigerators and freezers, among other areas.

The coiled tubes are often sandwiched between two parallel plates and inserted in grooves cut into both plates. The thermal interaction between the tubes holding

refrigerant and the plate is excellent. Plate evaporators like these are used in plate freezers.

4.2.5 Compressor

The compressor is a mechanical system that keeps the refrigerant flowing in order to complete the refrigeration period. Vapor produced in the evaporator at low temperatures and pressures is sucked by the compressor, which compresses it at higher temperatures and pressures before delivering it to the condenser, where heat is rejected to the atmosphere by water or air, depending on the type of condenser (either water-cooled or air-cooled). A compressor is usually powered by an electric engine. The power supply to the refrigeration device is the electrical energy supplied.

The main function of compressors are as follows:

- (a) It extracts the refrigerant vapor from the evaporator in order to preserve the ideal pressure and temperature.
- (b) The compression process raises the pressure and temperature of refrigerant vapor.

4.2.5.1 Compressors are classified into three major types:

- (a) Reciprocating compressor
 - (i) Open-type compressor
 - (ii) Hermetic sealed compressor
- (b) Rotary-type compressor
- (c) Centrifugal compressor

(a) Reciprocating compressor

The reciprocating compressor compresses vapor refrigerant by the reciprocating (back and forth) motion of the piston in a cylinder. It is appropriate for refrigerants that need a relatively limited displacement at a relatively high pressure (such as R-12, R-22, NH₃, etc.). Reciprocating compressors come in sizes ranging from 0.5 to 150 kW.

Tiny compressors are used for small refrigerating units like domestic refrigerators and window air conditioners, and large-capacity facilities like cold storage, NH₃ plants, and central air conditioning systems use compressors up to 150 kW.

i. Open-type compressor

The open-type compressor is modular in the sense that different capacities can be sustained by changing the compressor's rpm. It can be powered by any kind of prime mover or machine, including electric engines, gasoline/diesel engines, and so on. Both the engine and the compressor are individual systems that are connected by a standard shaft for power transmission. In the event of an engine failure, the engine can be quickly substituted.

(ii) Hermetic sealed compressor

Both the compressor and the electric engine are housed in a metallic dome. There is no need for a shaft seal in this sort of compressor. The compressor and engine share a shaft and are housed in the same body. There are no refrigerant leaks and all joints are fully welded. Noise and movements are absolutely removed in this situation. This is for low-capacity units like domestic refrigerators, window air conditioners, and so on.

(b) Rotary Compressor:

The rotary compressors are designed to pump refrigerant vapors with a low or moderate condensing pressure (such as NH₃, R-21 and R-114).

(c) Centrifugal Compressor:

The centrifugal force of a centrifugal compressor raises the pressure of the refrigerant vapor. This compressor is commonly used to treat refrigerant vapor that requires a large displacement and works at a low condensing pressure (such as NH₃, R-11, R-113, etc.).

The centrifugal compressor's impeller has specially shaped blades that extend radially from the core to the outer periphery. The compressor's impeller is connected to the engine shaft. By centrifugal force, the refrigerant vapor is forced away from the impeller's base to the outer perimeter as it rotates.

4.2.6 Ammonia gas

A nitrogen-and-hydrogen-based gas It is the most stable compound of these elements and is used as a starting material for many commercially important nitrogen compounds. Ammonia is mostly used as a fertilizer. It is normally added directly to the soil in the United States from tanks containing liquefied coal. Ammonia salts, such as ammonium nitrate, NH₄NO₃, ammonium sulphate, (NH₄)₂SO₄, and other ammonium phosphates, can also be found. Urea, (H₂N)₂C=O, is the most widely used nitrogen fertilizer in the world. Industrial explosives (e.g., trinitrotoluene [TNT], nitroglycerin, and nitrocellulose) are also made of ammonia.

Ammonia is used in the garment industry to create synthetic fibers such as nylon and rayon. It's also used to stain cotton, fur, and silk, as well as scouring them. In the processing of certain synthetic resins, ammonia is used as a catalyst. More importantly, it neutralizes acidic by-products of petroleum extraction, and it stops raw latex from coagulating during transportation from plantation to factory in the rubber industry. Ammonia is also used in the ammonia-soda process (also known as the Solvay

process), and is a commonly used method for processing soda ash, as well as the Ostwald process, which transforms ammonia to nitric acid.

4.2.6.1 Preparation of Ammonia

In 1774, English physical scientist Joseph Priestley prepared pure ammonia for the first time, and French chemist Claude-Louis Berthollet determined its precise composition in 1785. Ammonia is one of the top five chemicals manufactured in the United States on a regular basis. The Haber-Bosch process, which entails the direct reaction of elemental hydrogen and elemental nitrogen, is the most common commercial method of processing ammonia.



4.2.7. Copper Tube

Internally grooved copper tubes, also known as "micro fin tubes," are a modern air conditioning and refrigeration coil technology with a small diameter. Smooth coils are less effective at transferring heat than grooved coils. Smaller diameter coils transmit heat more efficiently than larger condenser and evaporator coils with circular copper tubes and aluminum or copper fins, which have been the industry standard for many years. The new generation of environmentally friendly refrigerants needs higher pressure, which small diameter coils can tolerate. Since they use fewer refrigerant, fin, and coil components, they have lower material prices.

Since the evaporators and condensers coils are smaller and lighter, they allow the design of smaller and lighter high-efficiency air conditioners and refrigerators.

Copper's high heat exchange properties, long-term longevity, corrosion resistance, low maintenance expense, and antimicrobial properties make it an excellent heat transfer

content. Heat transfer is improved by grooving the inside surface of the tube with Micro Groove technology. This raises the surface-to-volume ratio, blends the refrigerant, and uniformly distributes refrigerant temperatures in the channel.

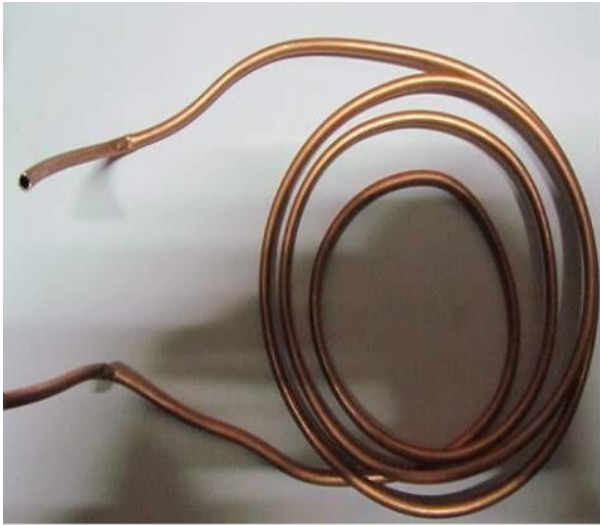


Fig.4.6: copper tube

4.2.8. Frame

All of the parts are mounted to a steel frame that is 18mm thick, as seen below. Two 6inch mild steel strips are tightly clamped around the generator with 1 inch screws. A single 6inch mild steel strip that is bolted to the frame and a brace at the bottom also clamps the absorber. The condenser is similarly connected to the plate, with the frame being removed behind the condenser to maximize convection heat transfer. The evaporator is protected by a wooden frame at its base. Two small screws are used to secure the pump to the frame. The heating coil is connected to the generator's frame.

4.2.9. Valves, Gauges and Connecting adapters

To control the mass flow rate of steam coming out of the generator, one stainless steel steam valve is used at the generator's outlet. Three ball valves are used, one for each of the three generator outlets. One is used to control the flow of weak solution (weak in water) from the generator to the absorber, the other is used to control the flow of solution from the strainer and the third is used to fill the generator with water -Ammonia solution. On the generator, two gauges, one pressure gauge (range 760mm of Hg vacuum to 0mm of Hg) and one temperature gauge (thermocouple range 0-200 degrees centigrade), are mounted to check the state of steam before allowing it to flow through the system. All of the connections are made with $\frac{1}{4}$ th inch diameter bronze connecting adapters that have brass washers on both sides. Teflon is used to seal all of these connections, ensuring that they are leak-proof.

CHAPTER-5

RESULTS AND DISCUSSION

Experiments are performed for different exhaust gas temperature and brake power (load) which provides the required heat to the generator to produce the better cooling in refrigeration system.

5.1 CALCULATION

STEP-1:

Initial temperature T1 = 31 °C

Final temperature T2 = 28 °C

Change in temperature $\Delta T = dt = T2 - T1$

= 31-28

= 3 °C

Initial watt meter W1= 74.4

Final watt meter W2= 74

Watt meter reading = 74.4-74

= 0.4

Ref. effect = $m \cdot c_p \cdot dt/t$

M = 23

Cp = 4.1896

dt = 3

$$\begin{aligned}
 t &= 600\text{sec} \\
 \text{Ref. effect} &= 23 \times 4.1896 \times 3 / 600 \\
 &= 0.48 \text{ kw} \\
 \\
 \text{Act cop} &= \text{Ref. effect} / \text{work input} \\
 &= 0.48 / 0.4 \\
 &= 1.2 \\
 \text{Compressor capacity} &= \text{Ref. effect} / 3.5 \quad \text{ton} \\
 &= 1.2 / 3.5 \\
 &= 0.34 \text{ ton}
 \end{aligned}$$

STEP-2:

$$\begin{aligned}
 \text{Initial temperature } T_1 &= 31 \text{ }^\circ\text{C} \\
 \text{Final temperature } T_2 &= 26 \text{ }^\circ\text{C} \\
 \text{Change in temperature } \Delta T = dt &= T_2 - T_1 \\
 &= 31 - 26 \\
 &= 5 \text{ }^\circ\text{C} \\
 \text{Initial watt meter } w_1 &= 74.4 \\
 \text{Final watt meter } w_2 &= 74 \\
 \text{Watt meter reading} &= 74.4 - 74 \\
 &= 0.4 \\
 \text{Ref. effect} &= m \text{ cp } dt/t \\
 M &= 23
 \end{aligned}$$

$$\begin{aligned}
 C_p &= 4.1896 \\
 dt &= 5 \\
 t &= 700 \text{ sec} \\
 \text{Ref. effect} &= 23 \times 4.1896 \times 3 / 700 \\
 &= 0.68 \text{ kw} \\
 \\
 \text{Act cop} &= \text{Ref. effect/work input} \\
 &= 0.68 / 0.4 \\
 &= 1.7 \\
 \text{Compressor capacity} &= \text{Ref. effect} / 3.5 \quad \text{ton} \\
 &= 1.7 / 3.5 \\
 &= 0.48 \text{ ton}
 \end{aligned}$$

STEP-3:

$$\begin{aligned}
 \text{Initial temperature } T_1 &= 31 \text{ }^\circ\text{C} \\
 \text{Final temperature } T_2 &= 24 \text{ }^\circ\text{C} \\
 \text{Change in temperature } \Delta T = dt &= T_2 - T_1 \\
 &= 31 - 24 \\
 &= 7^\circ\text{C} \\
 \text{Initial watt meter } w_1 &= 74.4 \\
 \text{Final watt meter } w_2 &= 74 \\
 \text{Watt meter reading} &= 74.4 - 74 \\
 &= 0.4
 \end{aligned}$$

$$\text{Ref. effect} = m \text{ cp dt/t}$$

$$M = 23$$

$$C_p = 4.1896$$

$$dt = 7$$

$$t = 600\text{sec}$$

$$\text{Ref. effect} = 23 \times 4.1896 \times 7 / 800$$

$$= 0.84 \text{ kw}$$

$$\text{Act cop} = \text{Ref. effect/work input}$$

$$= 0.84 / 0.4$$

$$= 2.107$$

$$\text{Compressor capacity} = \text{Ref. effect} / 3.5 \quad \text{ton}$$

$$= 2.107 / 3.5$$

$$= 0.602 \text{ ton}$$

STEP-4:

$$\text{Initial temperature } T_1 = 31 \text{ }^\circ\text{C}$$

$$\text{Final temperature } T_2 = 22 \text{ }^\circ\text{C}$$

$$\text{Change in temperature } \Delta T = dt = T_2 - T_1$$

$$= 31 - 22$$

$$= 9 \text{ }^\circ\text{C}$$

$$\text{Initial watt meter } w_1 = 74.4$$

$$\text{Final watt meter } w_2 = 74$$

$$\text{Watt meter reading} = 74.4-74$$

$$= 0.4$$

$$\text{Ref. effect} = m \text{ cp dt/t}$$

$$M = 23$$

$$C_p = 4.1896$$

$$dt = 9$$

$$t = 900\text{sec}$$

$$\text{Ref. effect} = 23 \times 4.1896 \times 9 / 700$$

$$= 0.96 \text{ kw}$$

$$\text{Act cop} = \text{Ref. effect/work input}$$

$$= 0.96/0.4$$

$$= 2.4$$

$$\text{Compressor capacity} = \text{Ref. effect}/3.5 \quad \text{ton}$$

$$= 2.4/3.5$$

$$= 0.68 \text{ ton}$$

STEP-5:

$$\text{Initial temperature } T_1 = 31 \text{ }^\circ\text{C}$$

$$\text{Final temperature } T_2 = 20 \text{ }^\circ\text{C}$$

$$\text{Change in temperature } \Delta T = dt = T_2 - T_1$$

$$= 31-20$$

$$= 11 \text{ }^\circ\text{C}$$

Initial watt meter w1 = 74.4

Final watt meter w2 = 74

Watt meter reading = 74.4-74

= 0.4

Ref. effect = $m \text{ cp dt/t}$

M = 23

Cp = 4.1896

dt = 11

t = 1000sec

Ref. effect = $23 \times 4.1896 \times 11 / 1000$

= 1.05kw

Act cop = Ref. effect/work input

= 1.05/0.4

= 2.64

Compressor capacity = Ref. effect/3.5 ton

= 2.64/3.5

= 0.757 ton

5.2 TABULATION

T1 °C	T2 °C	ΔT (T2-T1) °C	W1	W2	W2- W1	REF.EFFECT (kw)	ACT COP	COMP CAPACITY (ton)
31	28	3	74.4	74	0.4	0.48	1.2	0.34
31	26	5	74.4	74	0.4	0.68	1.7	0.48
31	24	7	74.4	74	0.4	0.84	2.107	0.602
31	22	9	74.4	74	0.4	0.96	2.4	0.68
31	20	11	74.4	74	0.4	1.05	2.64	0.757

Table 5.1: Calculated values the system using refrigerator Ref. effect, Act COP, COMP. Capacity

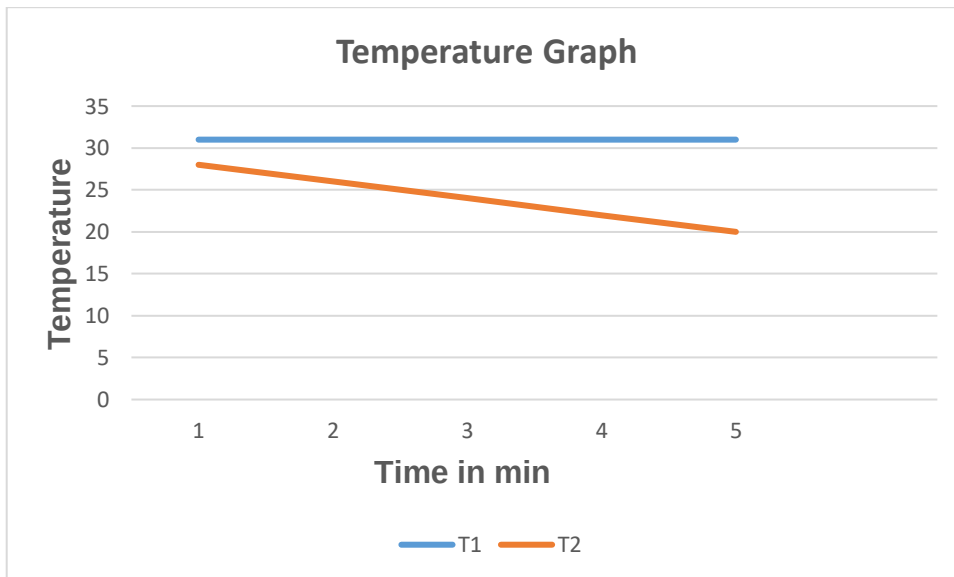


Fig.5.1: Temperature graph

In this graph we take Time as X and Temperature as Y, also The T1 as Temperature 1, T2 as Temperature 2, According from that graph result, if we increase the Acceleration of Engine or Generator that output Temperature will be get down.

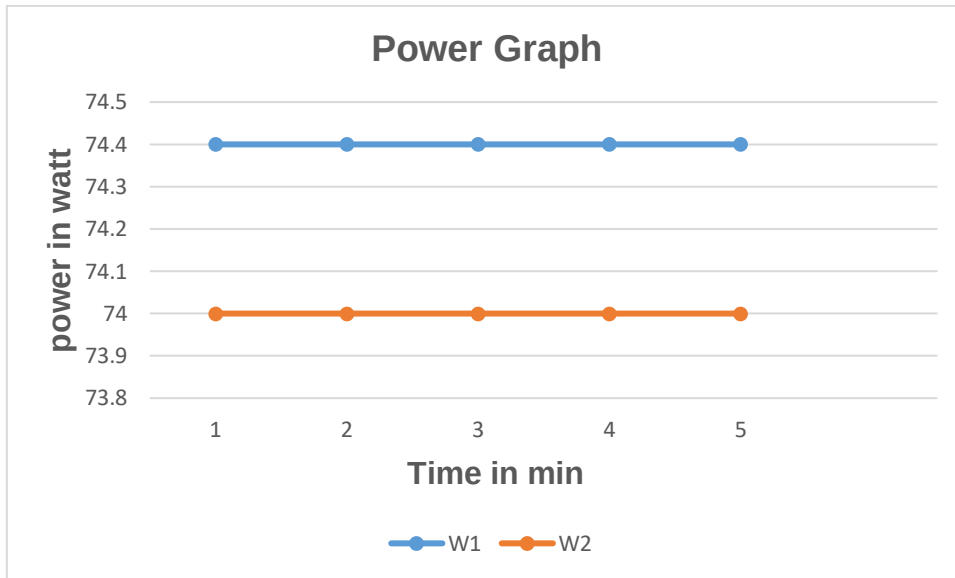


Fig.5.2: Power graph

In this graph we take Time as X and Watt as Y, also The T1 as Temperature 1, T2 as Temperature 2, According from that graph result, if we increase the Acceleration of Engine or Generator that output is input and output watt (W1 & W2) will be Maintained Same Value.

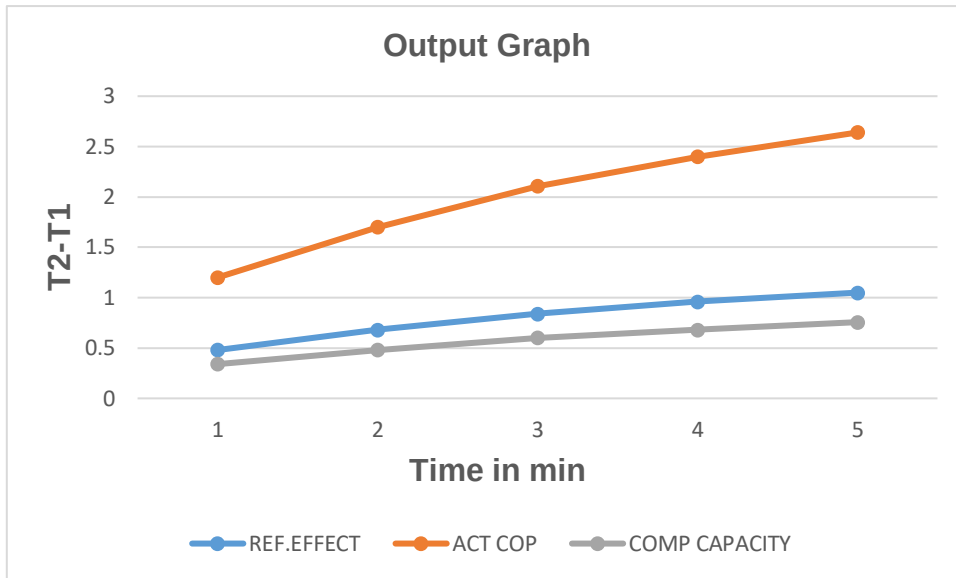


Fig.5.3: Output Graph

In this graph we take Time as X and $T_1 - T_2$ as Y, also The T_1 as Temperature 1, T_2 as Temperature 2, According from that graph result, if we increase the Acceleration of Engine or Generator that output is show That Different Values of Ref. effect, ACT Cop, Comp Capacity.

5.3 3D MODAL DIAGRAM

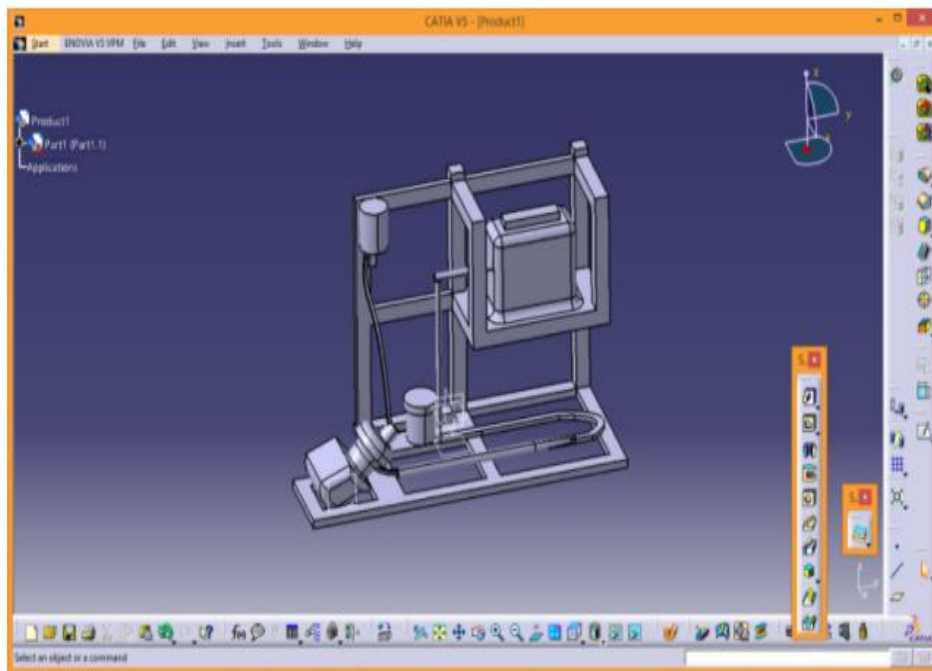


Fig 5.4: front view.

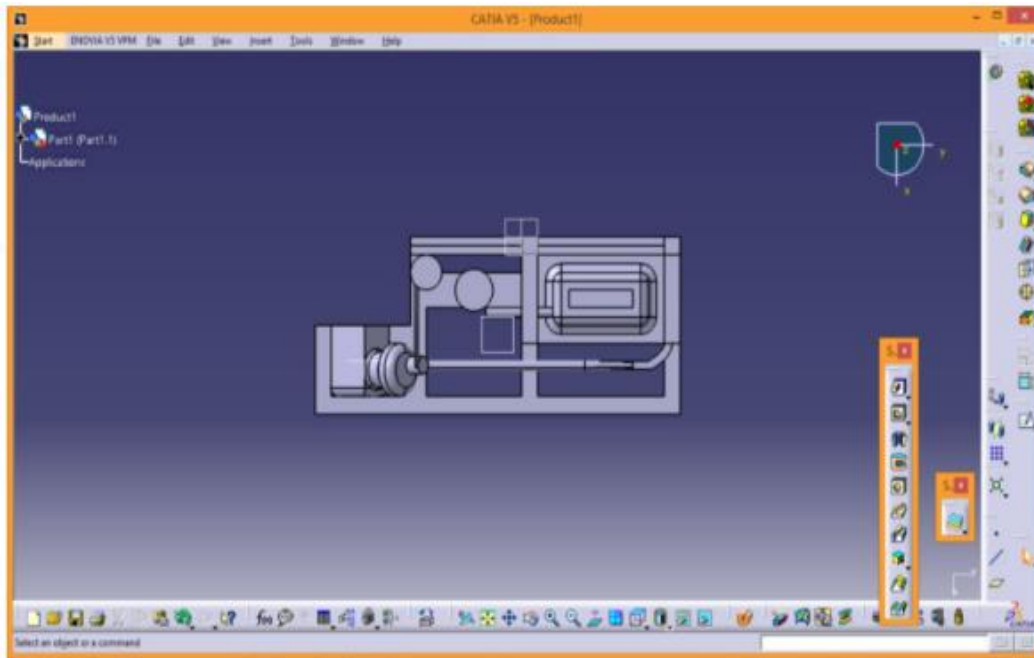


Fig 5.5: Top view

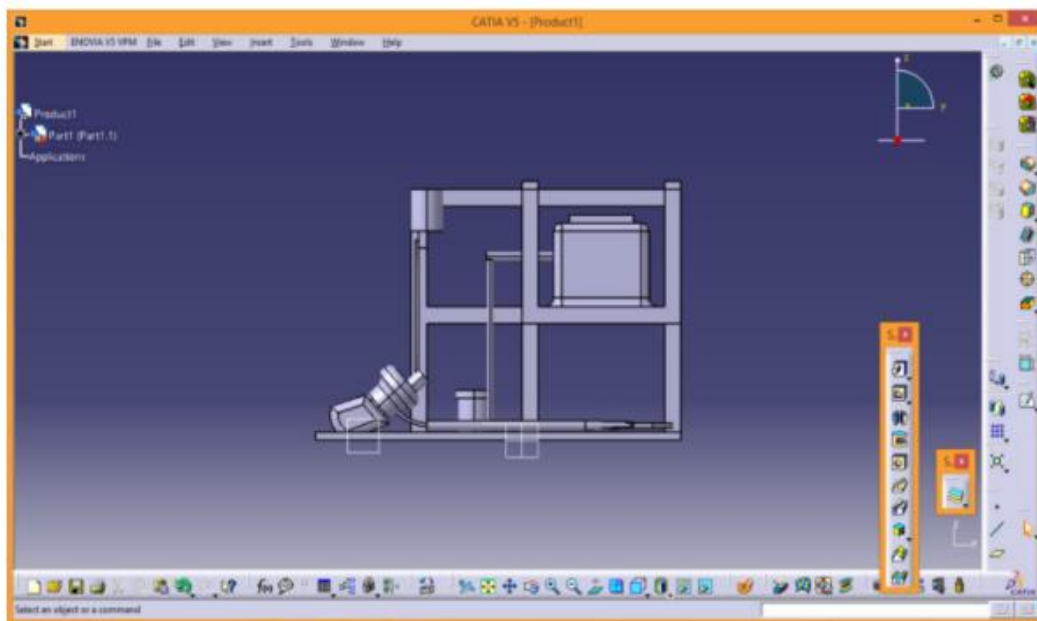


Fig 5.6: Back view

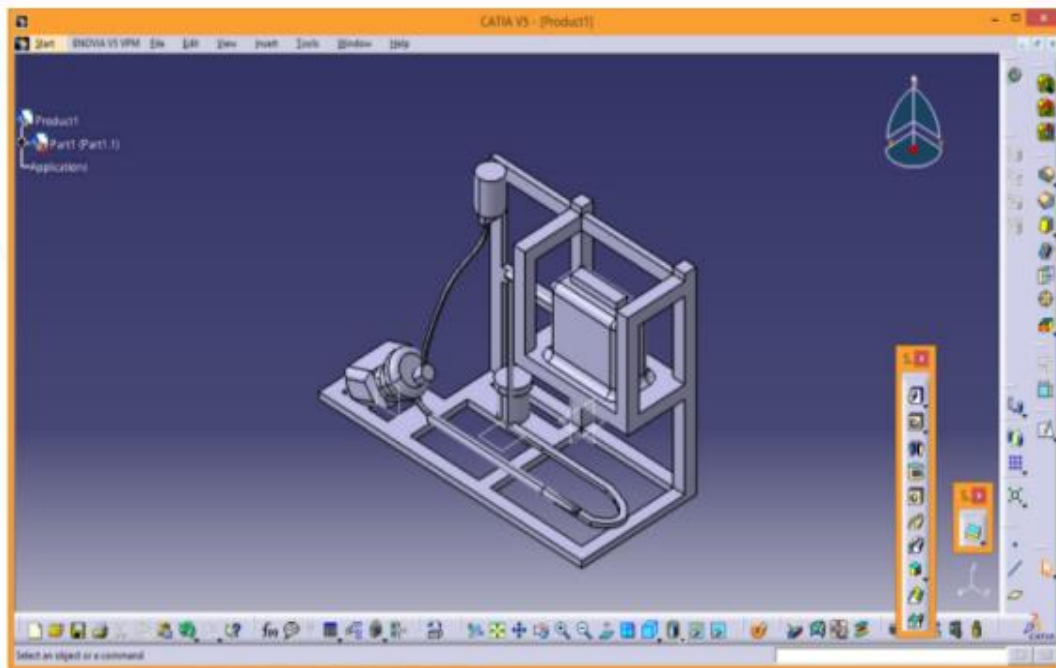


Fig 5.7: Side view

CHAPTER-6

SUMMARY AND CONCLUSION

6.1 SUMMARY

As in India, substantial vehicle doesn't give any significance of Air molding framework because of its expense. Additionally this energy is completely squandered. So we can move toward utilizing this waste warmth energy. Furthermore, we have reached at the level to use squander heat into making the refrigeration impact. For this reason the fume assimilation framework is more appropriate without influencing the vehicle's effectiveness.

6.2 CONCLUSION

The possibility to design a refrigeration unit inside an automobile using the waste heat from the engine of the vehicle based on Vapor Absorption Refrigeration System is realistic. Also keeping in mind the Environmental safety view, In this way we can conclude, that out of the total heat supplied to the engine in the form of fuel combustion, approximately, 35% to 40% is converted into useful mechanical work; the remaining heat is categorized under the waste heat and expelled out of the system, resulting in the rise of entropy, so it is required to utilize this waste heat into useful work. Possible methods to recover the waste heat from internal combustion engine through the study on the performance and emissions of the internal combustion engine are discussed upon and can be designed. Waste heat recovery system is the best way to recover waste heat and saving the fuel.

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VAPOR ABSORPTION REFRIGERATION SYSTEM USING WASTE HEAT FROM ENGINE

Submitted in partial fulfillment of the requirements for the award of Bachelor of

Engineering Degree in Mechanical Engineering By SHERLIN VIJESH J (Reg.No.37150177)

STEFFIN S (Reg.No.37150184) / DEPARTMENT OF MECHANICAL ENGINEERING SCHOOL

OF MECHANICAL ENGINEERING SATHYABAMA INSTITUTE OF SCIENCE AND

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STEFFIN S (Reg.No.37150184) who carried out the project entitled "VAPOR ABSORPTION REFRIGERATION SYSTEM USING WASTE HEAT FROM ENGINE" under our supervision from September 2020 to April 2021. Internal Guide Dr. A. KARTHIKEYAN, ME., (PhD)., Head of the Department Dr. G.

ARUNKUMAR, ME., PhD., / Submitted for Viva voce Examination held on _____

Internal Examiner External Examiner DECLARATION We SHERLIN VIJESH J

(Reg.No.37150177) and STEFFIN S (Reg.No.37150184) hereby declare that the Project

Report entitled "VAPOR ABSORPTION REFRIGERATIO SYSTEM USING WASTE HEAT FROM ENGINE" done by me under the guidance of Dr. A. KARTHIKEYAN, ME., (PhD)., is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering. DATE : SIGNATURE OF THE CANDIDATE PLACE : CHENNAI 1. 2.