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DEPARTMENT OF MECHANICAL ENGINEERING

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Thesis Project Report

"Construction and performance test of refrigerator working on vapor compression refrigeration cycle"

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DECLARATION

This is to certify that the research study entitled, **"Construction and performance test of refrigerator working on vapor compression refrigeration cycle"** is Prepared by Md. Solaiman Hossain, Md. Maksudur Rahman, Md. Arafat, Md. Shahin, Sohel Rana under the supervision **Md. Navid Inan** in the Department of Mechanical Engineering of Sonargaon University. This above thesis work or any part of the work has not been submitted anywhere for ward of my other University.

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ii. Abstract:

Refrigerators are considered to be an important household item that falls under the category of cooling appliances. The basic structure of the refrigerator consists of a thermally insulated compartment which through a proper mechanism lowers down the temperature inside it and transfers the heat from inside to the external environment. As it keeps the temperature lower so it is used to keep and store the food items which can be spoiled at ambient temperature.

Refrigerators in almost all the sizes are available at the market but they are restricted and limited for indoor usage only as they require electricity and are large. But presently, people are more inclined towards outdoor activities and they need to have a refrigerator to keep the essential items saved from spoilage and wastage. So, this project has designed a mini refrigerator that is powered through the batteries and is portable which can be easily used outdoors as well.

iii. Acknowledgments:

We are thankful to our supervisor, teachers, parents, and all the friends who supported us in completing this project. Without their support, it would not have been possible for us to complete this. We would like to extend our thanks and appreciation to **Md. Mostofa Hossain** sir, head of the Mechanical Engineering Department at SU, for his continued encouragement. Lastly,

we thank our project supervisor Mr.Navid Inan sir for the unceasing encouragement, support, and attention.

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CHAPTER-1

1.1. Introduction:

A Domestic refrigerator works on upon Vapors compression Refrigeration cycle. The essential component of the cycles is the evaporator, the compressor, the condenser and the expansion device. The function of compressor is to increase the pressure of the working fluid (called refrigerant) from the evaporator pressure to condenser pressure. A mechanical vapors compression (mvc) technology is use basis of many important industrial, agricultural and refrigerator and air conditioning applications. The refrigerants chlorofluorocarbon (CFCs) and hydro chlorofluorocarbon (HCFCs) both have high ozone depleting potential (ODP) and global warming potential (GWP) and contributes to ozone layer depletion and global warming. Therefore these two refrigerants are required to be replaced with environmentally friendly refrigerants to protect the environment. The hydro fluorocarbon (HFC) refrigerants with zero ozone depletion potential have been recommended as alternatives.

Domestic Refrigerator A domestic refrigerator work upon vapor compression refrigeration cycles.
In vapor compression cycles are basically four basic process:

1) Isentropic compression process
2) Isobaric heat rejection process
3) Isenthalpic expansion and
4) Isobaric and isothermal heat extraction

1.2. Applications Of Refrigeration:

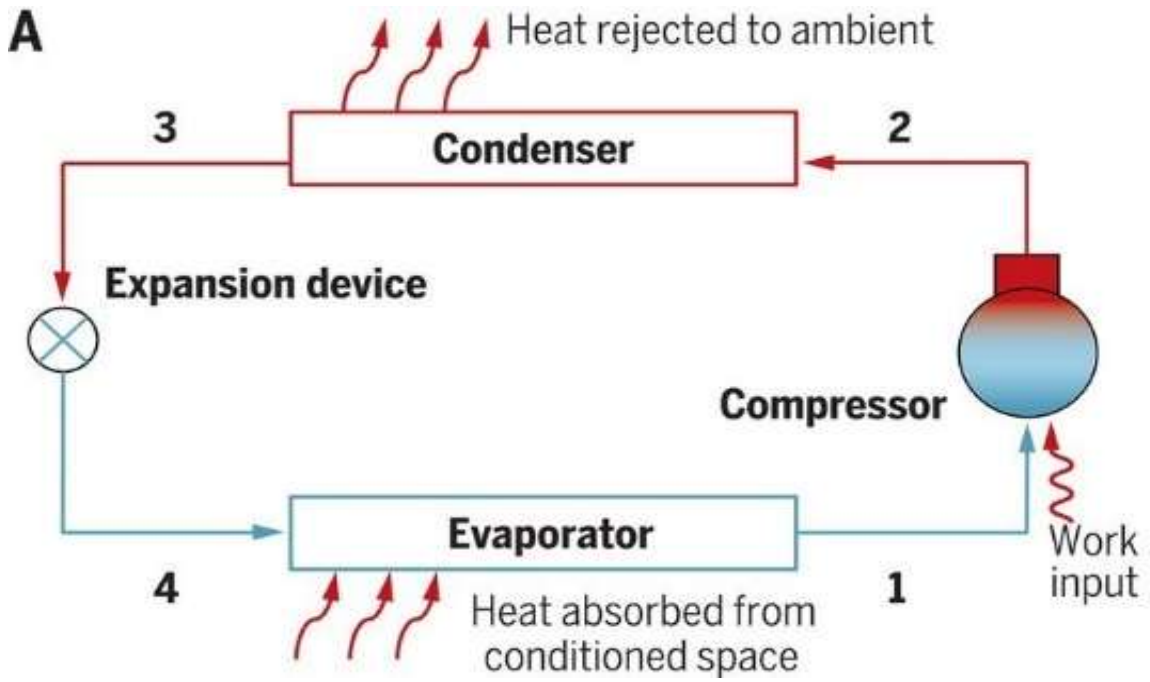
- Cold Storage
- Food Storage
- Refrigerator
- Making of ice
- Ice-Cream plants
- Industrial applications
- Pharmaceuticals
- Data Centre

1.3. Importance of COP:

The coefficient of performance or COP (sometimes CP or CoP) of a heat pump, refrigerator or air conditioning system is a ratio of useful heating or cooling provided to work (energy) required. Higher COPs equate to higher efficiency, lower energy (power) consumption

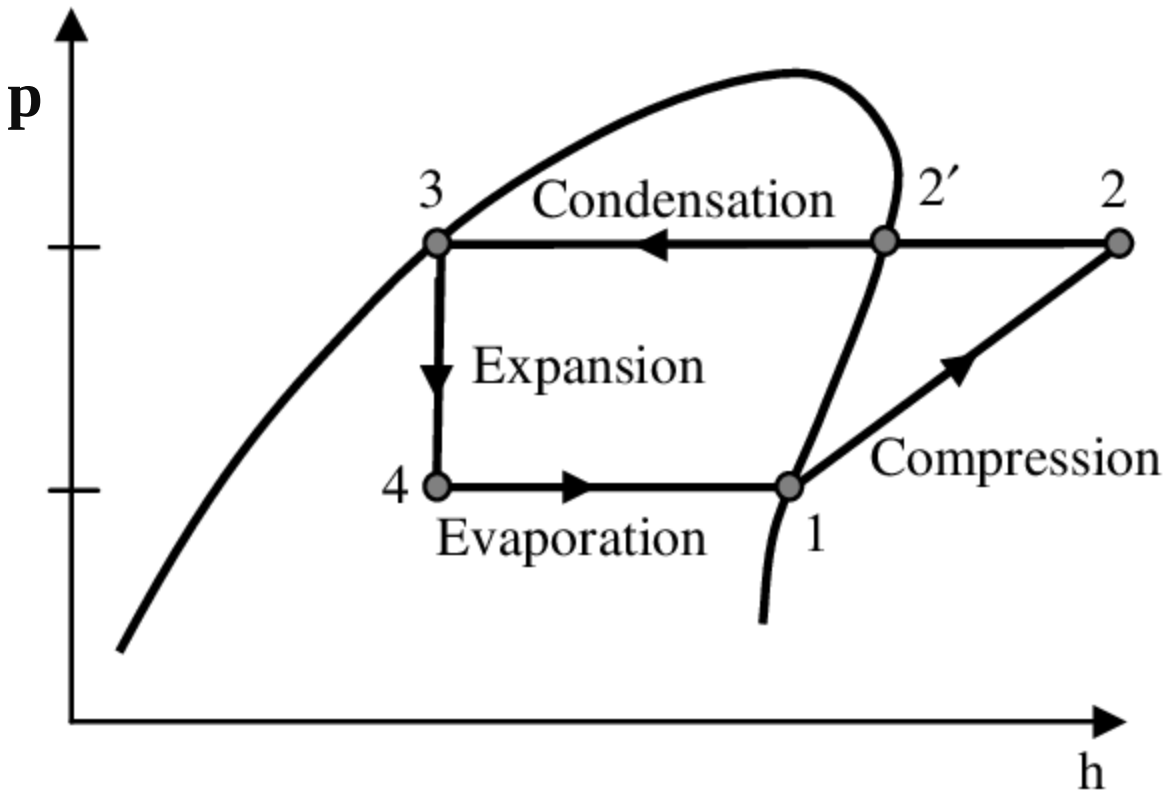
CHAPTER-2

2.1. Refrigeration Cycle:



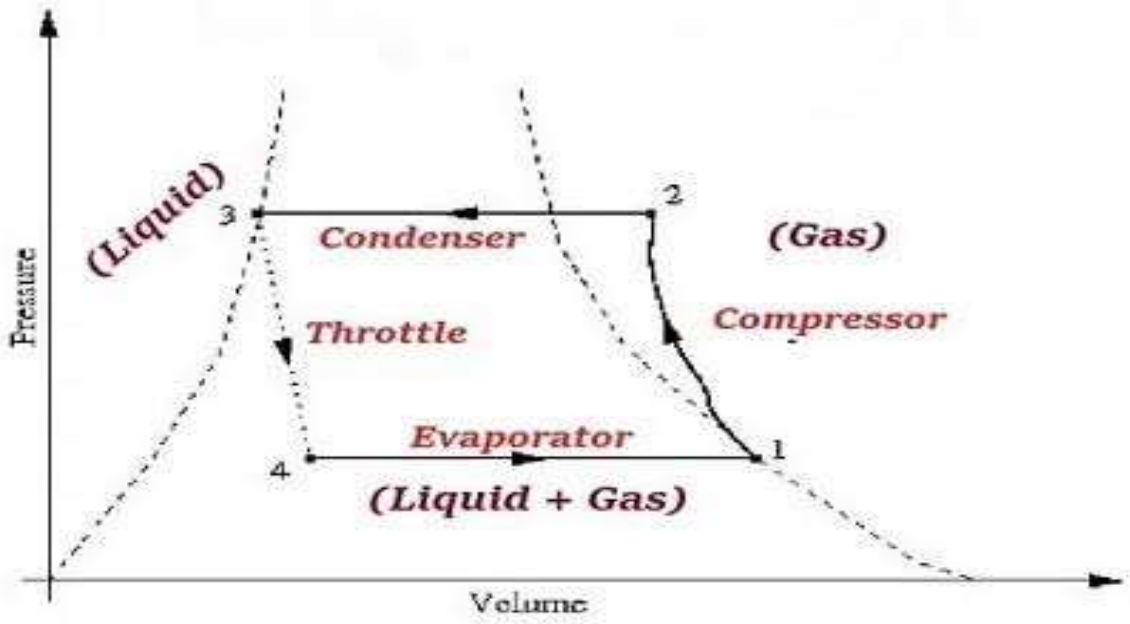
1. Compressor
2. Condenser
3. Evaporator
4. Expansion device

2.2. Refrigeration P-H Diagram:

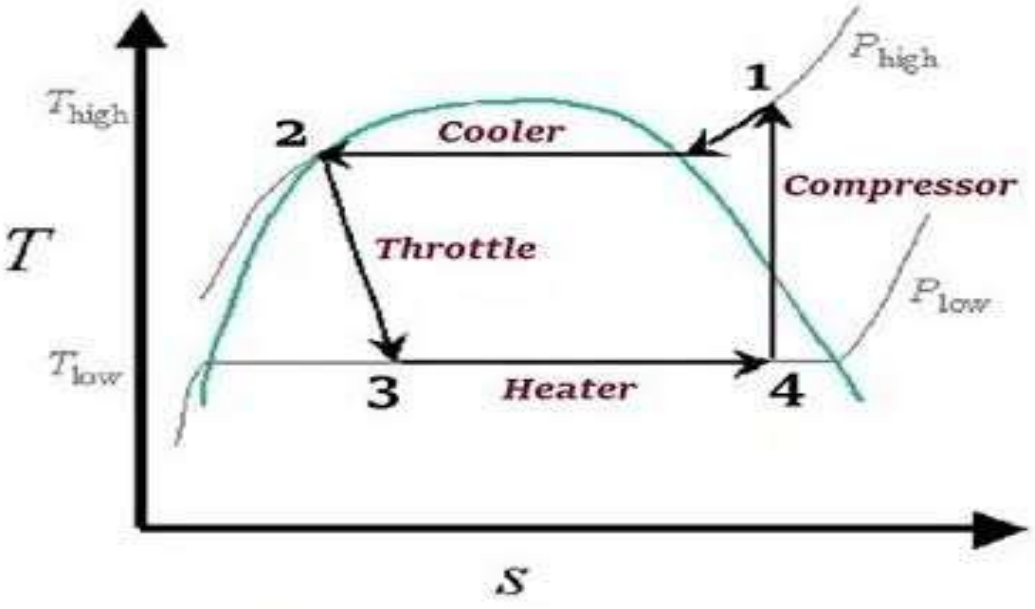


- 1-2 → Isentropic Compression in Compressor
- 2-3 → Constant Pressure Heat Rejection
- 3-4 → Isentropic Expansion in Evaporator
- 4-1 → Constant Pressure Heat Addition

2.3. Refrigeration T-S Diagram:



PV diagram of Refrigeration Cycle



TS diagram of Refrigeration Cycle

Refrigeration Equipment

2.4. Main Equipment's of Refrigeration System:

1. Compressor
2. Condenser
3. Evaporator
4. Expansion device

2.5. Compressor:

A refrigerant compressor is a machine used to compress the refrigerant from the evaporator and to raise its pressure so that the corresponding temperature is higher than that of the cooling medium.

2.6. Types of compressors:

- Reciprocating compressor.
- Scroll compressor.
- Screw compressor.
- Centrifugal compressor.

Reciprocating compressor: Reciprocating compressors are positive-displacement machines that compress and move gases by using a combination of rotational and linear (reciprocating) motion. Their basic function is to raise the pressure level of the gas being compressed.

Scroll compressor: A scroll compressor is a specially designed compressor that works in a circular motion, as opposed to up-and-down piston action.

Centrifugal compressor: Centrifugal compressors, also known as turbo or radial compressors, pressurize a refrigerant by forcing the refrigerant through a rotating impeller.

Screw compressor: The screw compressor is a positive displacement machine that comes with two helical lobed rotors that mesh.

2.7. Condenser :

The condenser is a device used in the high-pressure side of a refrigeration system. Its function is to remove heat of the hot vapor refrigerant discharged from the compressor.

2.8. Types of Condensers:

- Air-cooled
- Water-cooled and
- Evaporative.

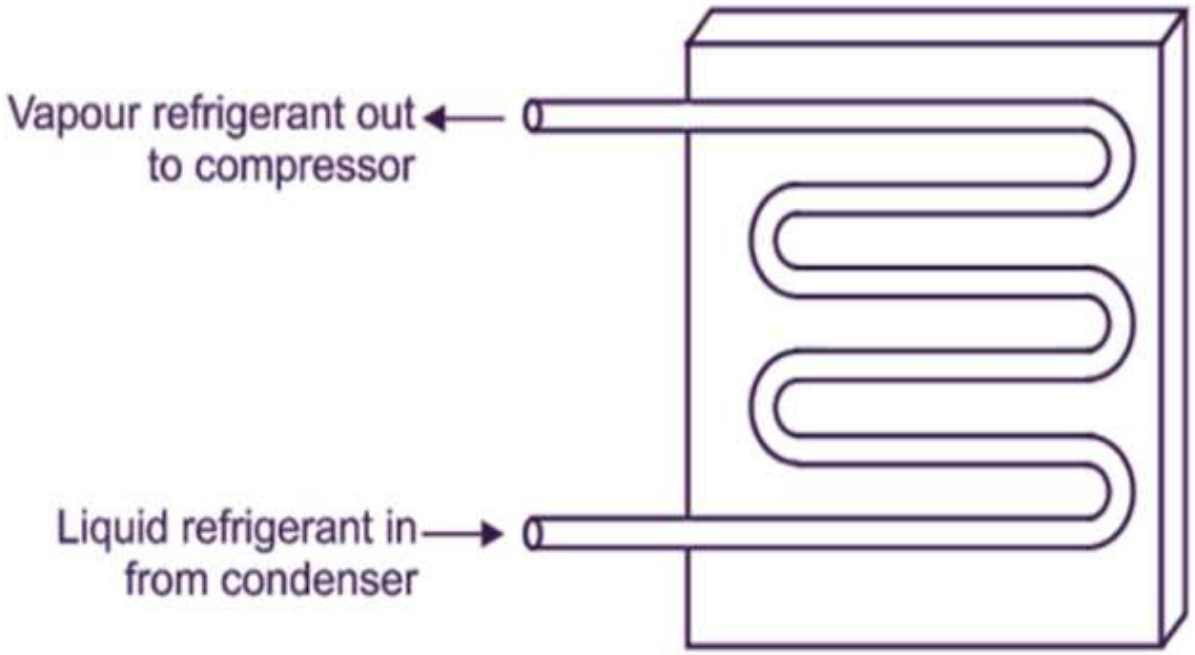
Air-cooled: As their names imply, air-cooled condensers use air as the cooling medium,

water-cooled: water-cooled condensers use water as the medium.

Evaporative condenser: Evaporative condenser is a combination of the above, i.e., uses both water and air.

2.9. Evaporator:

The process of heat removal from the substance to be cooled or refrigerated is done in the evaporator. The liquid refrigerant is vaporized inside the evaporator (coil or shell) in order to remove heat from a fluid such as air, water etc.



2.10. Types of Evaporators:

- Bare Tube Evaporator.
- Plate Surface Evaporator.
- Finned Tube Evaporator.
- Shell and Tube Evaporator.

Bare Tube Evaporator: Bare tube evaporators are the simplest type of evaporator. These evaporators are generally just refrigerant tubes that are made of either copper or aluminium.

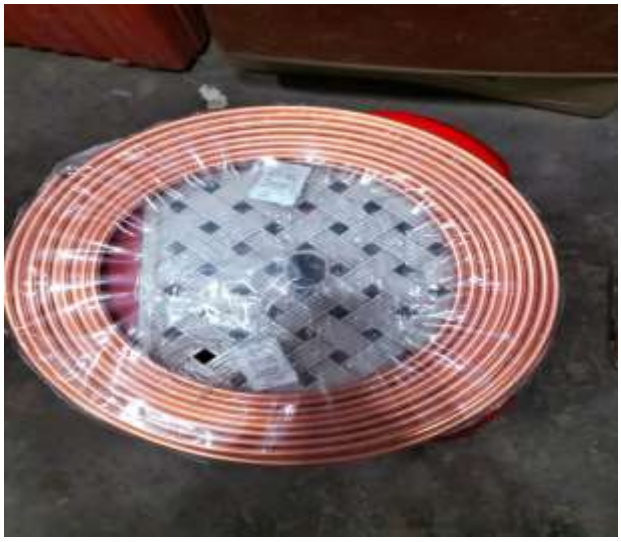
Plate Surface Evaporator: A plate evaporator is an evaporator heat exchanger used to evaporate liquids

Finned Tube Evaporator: Finned evaporators are bare tube evaporators that have been coated with fins.

Shell and Tube Evaporator: A shell-and-tube evaporator is a heat exchanger that is used to cool water, aqueous solutions of propylene and ethylene glycol or other coolants in chillers, in industrial refrigeration systems and provides cooling of gaseous or liquid media.

2.11. Expansion Devices:

The expansion device which is also known as throttling device, divides the high-pressure side and the low-pressure side of a refrigeration system. It is connected between the receiver and the evaporator



2.12. Types of Expansion Devices:

- Thermal expansion valves (TEVs).
- Manual expansion valves.
- Capillary tubes.
- Automatic expansion valves.
- Electronic expansion valves.
- Low-pressure float valves.
- High-pressure float valves.

Thermal expansion valves (TEVs):
Thermal expansion valves, or thermostatic expansion valves, are the expansion devices used most commonly with BPHE evaporators. TEVs are popular expansion devices due to their simplicity and availability, and their relatively good sensitivity and accuracy in regulation.

Manual expansion valves :
This type of expansion valve is simply a hand-operated needle valve. The valves are normally dedicated to large capacity systems with a fixed or very stable thermal load since any change required in refrigerant flow must be achieved by manually adjusting the valve setting.

Capillary tubes: Capillary tube a tube of small internal diameter; holds liquid by capillary action.

Others Accessories Of Refrigeration System:

- Thermostat
- Over load Relay
- Strainer
- Capacitor
- Copper pipe
- Door Switch
- Gas
- Sheet metal
- Gp sheet
- Brazing rod

2.13. Thermostat: The thermostat controls the cooling process by monitoring the temperature and then switching the compressor on and off. When the sensor senses that it's cold enough inside a refrigerator, it turns off the compressor. If it senses too much heat, it switches the compressor on and begins the cooling process again.

2.14. Over load Relay:

PTC relay is a specific starting device, which works for the compressor of the refrigerators. The principle function of the PTC relay is to provide power to the start winding for a brief period to help to trigger the motor of the cooling compressor.

2.15. Strainer: Refrigerator filters, mostly containing activated carbon, work on three simple principles: Adsorption, minute-level filtration due to 0.5-micron pore size, and chemical reactions with contaminants present in water

2.16. Capacitor: It is the run capacitor, which supplies the power to the compressor when the Post Temperature Coefficient (PTC) gets hot. This heat then turns on the capacitor, switching it on. Thus, the compressor gets into the action, cooling down the fridge.

2.17. Copper pipe: Copper tubing is most often used for heating systems and as a refrigerant line in HVAC systems. Copper tubing is slowly being replaced by PEX tubing in hot and cold water applications. There are two basic types of copper tubing, soft copper and rigid copper.

2.18. Door Switch: A refrigerator door switch system for sensing opening of a freezer compartment door and a fresh food compartment door comprises a push button switch installed at the freezer compartment door or the fresh food compartment door, being positioned at a first position for stopping a fan motor for a cool air supply

2.19. Gas: R600a (isobutene) is a hydrocarbon that is becoming increasingly popular due to its low Global Warming Potential (GWP). It is the refrigerant of choice for domestic and light commercial refrigeration units, including fridges and freezers, drink dispensers and standalone display units.

CHAPTER-03

3.1. Methodology

The refrigeration method is linked to the throttling effect. It's just the process of lowering the liquid refrigerant's pressure as it goes through the expansion device. By lowering the pressure, the liquid refrigerant flashes into a vapor, which cools the system

3.2. Types of refrigeration:

The followings are the common types of refrigeration:

- Mechanical compression refrigeration
- Evaporative cooling
- Absorption refrigeration
- Thermoelectric refrigeration
- Vapor compression refrigeration
- Vapor absorption refrigeration

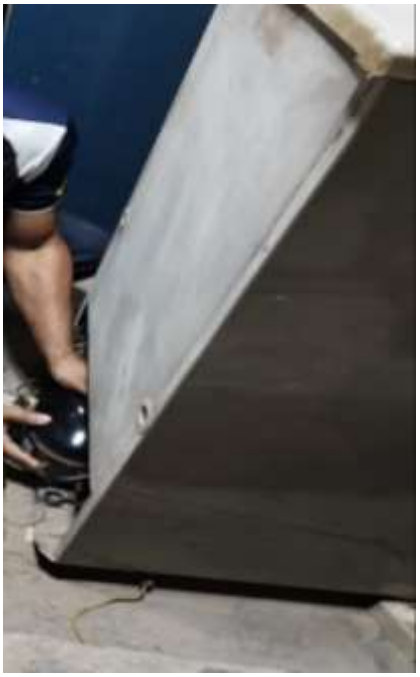
3.3. Working principle:

The working principle of refrigeration is less complex and can be easily understood. A refrigerator is a machine that extracts heat from a body that is at a low temperature and then rejects it to a body that is at a high temperature. A refrigerator is a machine whose primary function is to cool a particular thing.

Heat does not transfer from a low-temperature body to a high-temperature body without the assistance of external labor, according to the second rule of thermodynamics (Clausius statement). As a result, external labor is required to operate a refrigerator.

With the help of an external source, a heat engine can run in a reversible cycle. Heat is absorbed from a cold body and rejected by a hot body in this cycle. As a result, the engine is known as a heat pump. Heat is extracted from the cold body and refused to the hot body in the refrigerator as well. As a result, the refrigerator uses a reversed heat engine cycle.

3.4. Assembly (Team work):



3.5. Power Requirement:

In compressor systems, there is a huge requirement of power by the compressor while minimum power is required for the pump on absorption system to run the system.

3.6. Type of Energy Required:

The vapor absorption system runs particularly on the waste or the extra heat in the plant. The waste heat from the diesel engine, hot water from the solar water heater, etc. can also be used. For the vapor compression refrigeration system. the compressor can be run by electric power supply only. Which is obtained from heavy combustion of fossil fuels.

3.7. Capacity Control of the System:

In the vapor compression cycle, the capacity control of the system is done from the compressor and in all cases stepwise capacity control is achieved. In case of the absorption refrigeration system, it is possible to obtain zero capacity control are available, but they will surely consume lots of power even if there is zero load on the refrigeration system. In the absorption system, when there is zero load of the power consumption is almost zero.

3.8. Physical Properties &Technical Index

R600a	
Chemical Name	n-butane
Molecular formula	(CH3) 2CHCH3
Molecular Weight	58.12
CAS NO.	75-28-5
Boiling point °C	-11.7
Liquid density,25°C,g/cm3	0.551
Critical temperature,°C	134.71
Critical pressure,Mpa	3.64
Critical density/cm3	0.221
Special heat liquid,25°C(KJ/kg°C)	2.38
Vaporation heat (boiling point) KJ/KG	366.5
ODP	0
GWP	0.0011
Other Name	Isobutane R600A
Application	Refrigerant, can replace R12

Item	**Inspect result**
Appearance	Colorless ,no turbide ,no strong stench
Purity ,%,≥	99.9
Moisture,%,≤	0.002
Acidity (HCL),%,≤	0.0001
Vapor reside,%,≤	0.01

Automatic expansion valves:

Automatic expansion valves Automatic expansion valves were the first valves developed to eliminate the need of having a refrigeration engineer manually adjust a hand operated expansion valve. The valve is designed to maintain a constant pressure at the outlet of the valve.

Electronic expansion valves: Electronic Expansion Valves (EEV) are used in a range of refrigeration systems such as commercial cool rooms and walk-in freezers to precisely control the flow of refrigerant into the evaporator.

Low-pressure float valves:

The low-pressure float valve controls the liquid level, and is normally mounted in a chamber parallel to the liquid/vapor separator. For thermosiphon systems, this modifies the effect of the force of gravity, which drives the refrigerant into the evaporator.

High-pressure float valves:

Also used as an expansion device for flooded systems, the high-pressure float valve is located on the high-pressure side of the system and is in open connection to the condenser. It controls the evaporator level indirectly by maintaining a constant level of refrigerant inside the float chamber.

3.9. Refrigeration Systems Troubleshooting Checklist

Symptom	Check Click on underlined items for further information
Refrigerator does not run and the light does not work	• Make sure the refrigerator is plugged in securely • Check for a blown fuse or tripped circuit breaker • Test the power outlet for current • Inspect the electrical cord for damage • Eliminate use of an extension cord, if any is being used • Check the outlet voltage
Refrigerator does not run but the light works	• Check the temperature setting • Make certain there is a three-inch space outside of the refrigerator between the walls and the back and sides and at least a one-inch gap above, to allow for air flow • Clean the condensor coils • Unplug the refrigerator, wait two hours and plug it in. If you hear it running, a problem is causing the compressor to overheat • Test the temperature control • Test the evaporator fan • Test the defrost timer • Test the compressor relay • Test the overload protector • Test the compressor motor
Refrigerator light does not work	• Replace the bulb • Test the door switch

Refrigerator or freezer is not cold enough	• Check the temperature setting • Assure that there is enough room for air flow in the refrigerator or freezer • Check for air flow restrictions in vents • Test the temperature control • Clean the condensor coils • Check the door seals • Test the door switch • Test the defrost heater • Test the defrost timer • Test the evaporator fan • Check for a clogged drain tube • Check for refrigerant leak
Refrigerator or freezer is too cold	• Check the temperature setting • Test the temperature control
Refrigerator is noisy or makes strange sounds	• Hissing and popping is normal on frost free refrigerators, it is the defrost heater • Check that the refrigerator is level • Check the drain pan • Check the condensor fan • Check the evaporator fan • Inspect the compressor mounts
Refrigerator runs continuously	• Defrost the freezer • Clean the condensor coils • Check the door seals • Test the door switch • If you recently adjusted the temperature control, loaded the refrigerator or are in a humid location, it is not uncommon for a refrigerator to run for 24 hours or more before getting cool.

Refrigerator starts and stops frequently	• Clean the condensor coils • Check the outlet voltage • Test the condensor fan • Test the compressor relay • Test the overload protector • Test the compressor motor
Freezer does not defrost automatically	• Test the defrost timer • Test the defrost heater • Test the defrost thermostat
Refrigerator has an unpleasant odor	• Remove spoiled food • Clean refrigerator interior with a solution of hot water and baking soda • Clean the door seals • Remove breaker strips and check for wet insulation
Water on floor outside of refrigerator	• Check the drain pan • If you have an ice-maker, check the water supply hose going into and coming out of the water inlet valve
Water inside the refrigerator	• Clean the drain tube • If you have an ice-maker, check refrigerator and ice-maker for level

3.10. Methods Of Refrigeration

Refrigeration can be classified into two types:

- Natural method.
- Artificial or Mechanical Refrigeration.

Natural method:

The natural method includes the utilization of ice or snow obtained naturally in cold climate. Ice melts at zero degree centigrade. So, when it is placed in a system or space warmer than that temperature, heat is absorbed by the ice and the space is cooled.

Artificial or mechanical refrigeration:

This consists of a refrigeration cycle, where heat is removed from a low temperature space or source and rejected to a high temperature sink with the help of external work.

3.11. Use of Tools:

- Tube Cutter
- Tube Bender
- Hammer
- Welding Can
- Screw driver
- Neon tester
- Cutting Players
- Adjustable wrenches
- Gas manifold
- Hose Pipe
- Vacuum pump
- Lick detector
- Flaring set etc.

3.12. Advantage:

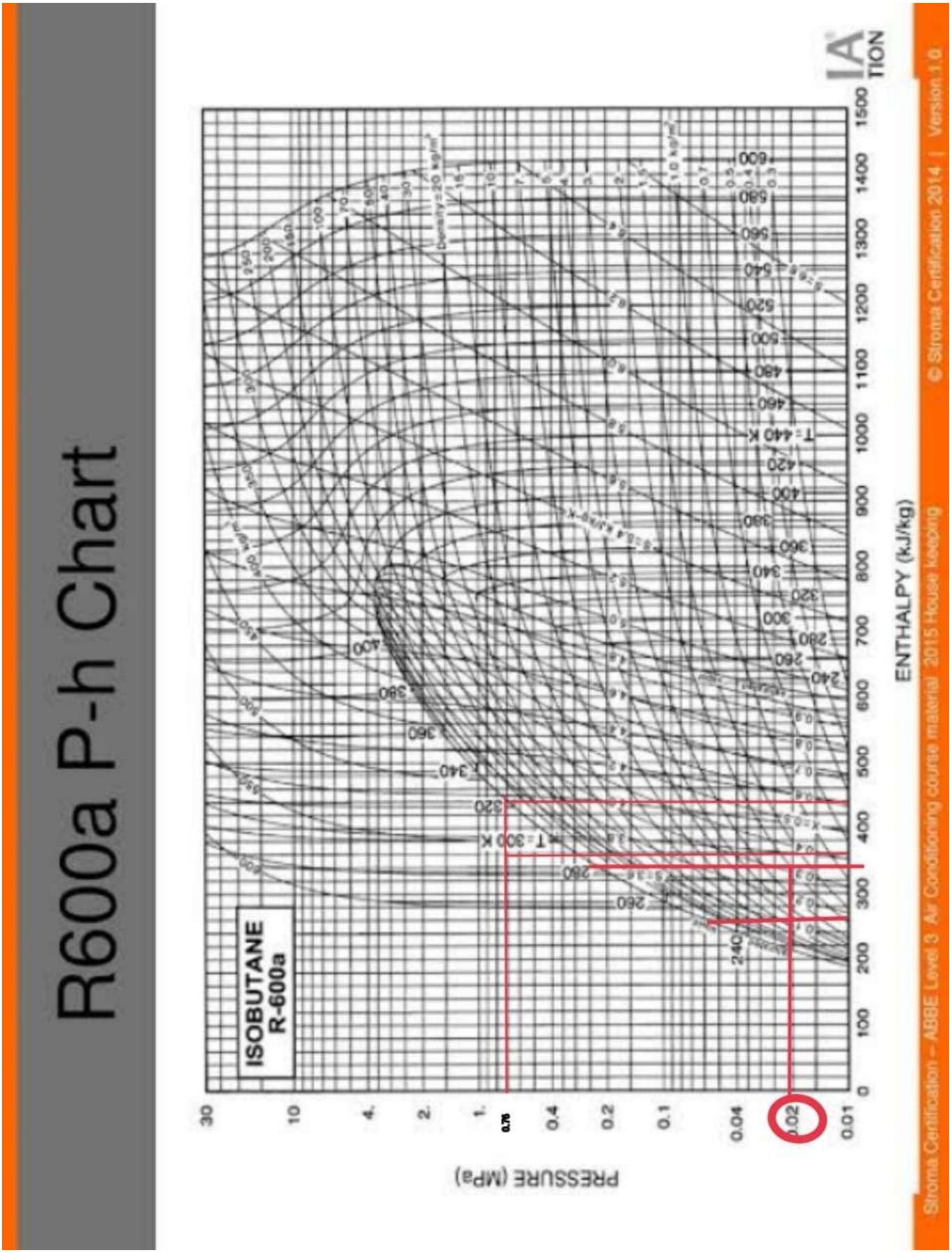
- These are eco-friendly refrigerators. No Chloro Fluoro Carbons.
- It is environmentally friendly and effective.
- Low power consumption and load power
- These are light in weight.
- Give fast temperature response.
- It is portable, small in size.
- Have no vibrations.
- Creates no noise.
- R600a is commonly used due to its low environmental impact and good thermodynamic.

3.13. Disadvantage:

- Safety and explosion-proof measures need to be put into the production process of r600a refrigerant.
- R600a refrigerant is not suitable for air-cooled refrigerators and large-dose filling refrigerators.
- R600a is chemically unstable, so it is extremely dangerous when servicing and installing.

CHAPTER-04

4.1. P-H Chart:



4.2. Actual COP:

Temperature, T1=7°

=(7+273)=280 k ; h1=340 kj/kg

Pressure, p1=3 psi =0.02 Mpa

Discharge temperature, T2=47°

=(47+273)=320k; h2=450 kj/kg

Discharge pressure, p2=110 psi =0.76 Mpa

Condenser outlet temperature, T3=15°

=(15+273)=280 k; h3=380 kj/kg

Condenser outlet pressure, p3=110 psi =0.76 Mpa

Evaporator inlet temperature, T4=-8°

=(-18+273)=255 k; h4=240 kj/kg

Evaporator inlet pressure, p4=3 psi =0.02 Mpa

Compressor Work= (h2-h1)*m

R.E=(h1-h4)*m

Actual COP=R.E/ Compressor Work

Name	Temperature	Pressure	Enthalpy	Mass Fluid	Compressor Work	R.E	Result
Suction	7°	0.02 Mpa	340 kj/kg	0.11	12.1	11	0.91
Discharge	47°	0.76 Mpa	450 kj/kg				
Condenser Outlet	15°	0.76 Mpa	380 kj/kg				
Evaporator inlet	-18°	0.02 Mpa	240 kj/kg				

CHAPTER-05

5.1. Project Execution Monitoring & Project Execution performs following activities:

- We met advisor for the selection of semester project
- Then we have Literature review
- Then, we select the Mini Refrigerator Project.
- Study literature review for the selection of methodology
- Then, we plan to do the project into 3 parts (Analytical Calculations, 3D modeling and Practical Model)
- Then, we apply the suitable Methodology for making practical model
- Then, we get Approval of the method from advisor
- Then, we make a detailed research for appropriate selection of Material
- Then, we had Meeting with the advisor for the approval of Material
- Then, we make a market visit for purchase of Material
- Then, we had a Meeting for practical model making
- Then, we make the Practical Model
- Meeting of all members with advisor for testing criteria
- Then, we perform the testing
- Conclude the project
- Report writing

5.2. Challenges and Decision Making:

Challenges Faced:

- Problems with team members not cooperating/meeting.

– All the group members do their best for this project and cooperate with each other's for their assigned tasks.

– Each member did his assign task and also help in others task too.

- Problems or delays in procuring required parts/components/tools.
  - The major reason for delay in this project was the procurement of the materials. It was task assigned to the member 3 but knowing the difficulty level member 3 and 4 also help him for the purchasing of required parts, components and tools which were being used during the making of the practical model of the project.
- Problems with equipment or components not working or malfunctioning.
  - Major problem we face was the selection of the right material because we waste much of our money buying useless components and waste of the material whole making a practical model makes budget of our project high.

Decision Making:

I learn a lot regarding decision making from this project. We were having much options and methodologies to put for the project, and choosing best one gave me confidence. Staring from choice of project ad project members, going to choose the project, then methodology, purchase of material and their identification, whole project was having much options and ways for solution but finding a perfect solution was problem gave me a lot regarding decision making.

- Decision while choosing my part for the project which a I could do the best Decision while choosing the team members.
- Assigning of the right task to the right person
- Choose of appropriate for methodology for the project Choosing right material for the project
- Choosing best test criteria.

This project was full of challenges, starting form searching for best methodology to the testing criteria. So, choice of the best available option gave you confidence. We get help from some seniors, research papers, journals, web sites and so to find out best possible opportunity and to conclude our project in the best way.

CONCLUSION

5.3. Conclusions:

- **Refrigerant R 600a is HFC Free to on Environment friendly refrigerant gas the remove the global warming to mains component of carbon dioxide (CO_2) remove to save the greenhouse and great high security global warming potential the power less compressor used to save energy to the energy to regulated the future generation to stock fossil fuel.**

- **Food storage the importance of refrigeration storing food at cold temperature relative humidity slows are the growth of microorganisms there by limited food poisoning while preserving foods nutritional qualities and good test.**

- **One of most the importance regions for grounding electrical current is that protects our applications, our home and everyone in, it from surges in electricity of lighting was so to strike or the power was to surge at our place for whatever reasons, this produces dangerously high voltage of electricity.**

- **Microcontrollers as used in automatically controlled products and devices, such as automobile engine control system, implantable medical devices, remote controls, office machines, applications, Power tools, toys and other embedded system. By reducing the size and cost compared to a design the uses a separate. Microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even mor devices and processes. Mixed signal microcontrollers are common integrating analog components needed to control non digital electronic system. In the context of the internet of things microcontrollers are an economical and popular means of data collection. Sensing and actuating the Physical word as edge devices.**

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