Design and Fabrication of Compression Refrigeration System

A Thesis
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A report submitted to the Department of Mechanical Engineering, Sonargaon University of Bangladesh in partial fulfillment of the requirements for the Award of Degree of Bachelor of Science in Mechanical Engineering.

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LETTER OF TRANSMITTAL

September, 2022

To

Nuruzzaman Rakib
Lecturer
Department of Mechanical Engineering.
Sonargaon University of Bangladesh

Subject: Submission of Project Report.

Dear Sir,
We are pleased to submit the project report on "**Design and Fabrication of Compression Refrigeration System".** It was a great pleasure to work on such an important topic. This project has been done as per instruction of your supervision and according to the requirements of the Sonargaon University.

We expect that the project will be accepted by the concerned authority we will remain happy to further explanation that you may feel necessary in this regard.

Thank You
Sincerely yours,

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DECLARATION

We do hereby solemnly declare that, the work presented here in this project report has been carried out by us and has not been previously submitted to any University/ Organization for award of any degree or certificate

We hereby ensure that the works that has been prevented here does not breach any existing copyright.

We further undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

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First, we started in the name of almighty Allah. This thesis is accomplished under the supervision of **Nuruzzaman Rakib,** Lecturer, Department of Mechanical, Sonargaon University. It is a great pleasure to acknowledge our profound gratitude and respect to our supervisor for this consistent guidance, encouragement, helpful suggestion, constructive criticism and endless patience through the progress of this work. The successful completion of this thesis would not have been possible without his persistent motivation and continuous guidance.

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ABSTARCT

The global warming and energy crisis have become most important environmental problems of this twenty-first century. To overcome these problems, scientists have worked on inventing different devices to lessen this impact. Refrigerators used in daily life are one of the indispensable tools. Uninterrupted power should be supplied to the refrigerators in order to maintain cooling service. Domestic refrigerator may be operating continuously to maintain proper food storage condition. The continuous operation of this equipment accounts more electrical consumption. A significant amount of waste heat is rejected by the condensers of refrigerator. This project work is based on the simulation, optimum designing as well as finding out the economic feasibility.

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CHAPTER 1

INTRODUCTION

Introduction

A refrigerator is a common household appliance that consists of a thermally Insulated compartment and which when works, transfer heat from the inside of the compartment to its external environment. Generally, it works on the vapor compression cycle that uses a circulating liquid refrigerant which absorbs heat from the space to be cooled and subsequently rejects that heat elsewhere.

All such systems have four components: - A compressor, a condenser, evaporator and expansion valve. Circulating refrigerant enters the compressor in the thermodynamic state known as a saturated vapor and is compressed to a higher pressure, resulting in a higher temperature. The hot, compressed vapor is then in the thermodynamic state known as a superheated vapor and it is at a temperature and pressure at which it can be condensed with typically available cooling water or cooling air. That hot vapors is routed through a condenser where it is cooled and condensed into liquid by flowing through a coil or tubes with cool water or cool air flowing across the coil or tubes. This is where the circulating refrigerant rejects heat from the system and the rejected heat is carried away by the air. The condensed liquid refrigerant, in the thermodynamic state known as a saturated liquid, is next routed through an expansion valve where it undergoes an abrupt reduction in pressure. That pressure reduction results in the adiabatic flash evaporation of a part of the liquid refrigerant.

The cost of energy use for refrigeration in beverages industries and other profit-making sectors such as big and mini supermarkets and domestic users has been quite confronting. The designed parameters of the major components in a vapors compression refrigeration system are also responsible for their energy consumption, exegetics efficiency and energy destruction (irreversibility) in the system. Energy of a vapors compression system can be defined as the useful work obtained from the system when it is brought to the standard environmental conditions. Energy analysis deals more with energy loss in vapors compression system. Therefore, the application of TiO2 Nanoparticles as additives in vapors compression system using R600a as working fluid can reduce the energy loss in the system components. Various researchers have worked on replacement of R600a as a substitute for R134a in refrigeration system [1–8] The solutions provide adjustment of the system components such as capillary tube length and condenser. Some researchers have worked on experimental and theoretical energy performance analysis of vapors compression refrigeration system. [9–12] Their works looked at the components responsible greatly for energy loss and provided means of minimizing the energy loss and improving the energy efficiency of the refrigeration system.

Refrigeration System

Refrigeration may be defined as the process of reducing and maintaining a temperature of a space or material below that of the surroundings. This is accomplished by removing heat from body being refrigerated and transferred it to another body whose temperature is higher than that of the refrigerated body or space. It is evident that refrigerating and heating are actually opposite ends of the same process. Often, it is the desired result that distinguishes one from the other. Refrigeration is basic to the heating, ventilation and air conditioning industry. One of the most important applications of refrigeration has been the preservation of perishable food products, food processing, packaging, storing and transportation by storing them at low temperatures.

Refrigeration systems are also used extensively for providing thermal comfort to human beings by means of air conditioning. Air Conditioning refers to the treatment of air so as to simultaneously control its temperature, moisture content, cleanliness, odour and circulation, as required by occupants, a process, or products in the space. The subject of refrigeration and air conditioning has evolved out of human need for food and comfort. The purpose of refrigerator is to transfer heat from a cold chamber which is at a lower temperature than that of its surrounding. Elementary refrigerators have been used which utilizes the melting of ice or the sublimation of carbon-dioxide at atmospheric pressure to provide cooling effect.

Objectives

The objectives of this project are:

- To study about **Compression Refrigeration System.**
- To implement **a Compression Refrigeration System.**
- To test the performance of the cooling system.

Structure of the Project

This Project is organized as follows:

Chapter 1 Introduction: The first chapter contains the statement of the introduction, air conditioner, objectives of the study, methodology used in the project and the project outline.

Chapter 2 Literature Review: The chapter two contains our literature review part.

Chapter 3 Hardware and Software: Chapter three describes the theoretical model. Here we mainly discuss about Hardware development of our project etc.

Chapter 4 Methodology: Chapter four describes the theoretical model. Here we mainly discuss about proposed system architecture in details with having block diagram, circuit diagram, project working principle, complete project image, project instrument cost analysis etc.

Chapter 5 Result and Discussion: Chapter five deals with the result and discussion and discuss about our project advantages and application.

Chapter 6 Conclusion: Chapter six all about our project conclusion and future scope.

CHAPTER 2

LITERATURE REVIEW

Introduction

In this section topics related to **Compression Refrigeration System** are included. These provide a sampling of problems appropriate for application of **Compression Refrigeration System**. The references are summarized below.

Literature Review

In international engineering research journal paper by Ashish Matkar,et.al [1] the design and analysis of direct cool refrigerator with vertical evaporator is studied. In this paper effect of vertical evaporator on performance in household refrigerator instead of conventional O or C type evaporator is studied but the experimentation and analysis is done with R134a refrigerant whereas impact with R600a refrigerant is not discussed.

The first reasonably successful air- cooled unit was Isko. Fred W. Wolf designed and marketed a household system called DOMELRE, a contraction of Domestic _Electric Refrigerator. The Wolf system was marketed by Mechanical Refrigerator Company and later by Isko until absorbed by Frigidaire in 1922. The paper regarding 'Domestic refrigerators – recent developments' which was published by R. Rademacher, et.al [2] throws light on the study and research done on domestic refrigerators and its recent developments. This paper doesn't give any idea regarding design and analysis of a vertical roll bond evaporator.

The determination of the theoretical and experimental performance analysis, cooling capacity and overall heat transfer coefficient of evaporators was discussed in paper by Horuz, et.al [3]. The experimental evaporator was analyzed with correlations together with the parameters of air velocity, fin spacing, tube diameter, evaporator temperature, refrigerant type and frost height. It is concluded that when the experimental and theoretical overall heat transfer coefficients were compared with those from the manufacturing catalogues (for the same working conditions), the latter was to be15- 30% higher than the former one. The theoretical and experimental performance analysis, cooling capacity and overall heat transfer coefficient of evaporators studied and predicted in this paper. This paper doesn't give any idea regarding design and analysis of a vertical roll bond evaporator.

A distributed parameter model for prediction of the transient performance of an evaporator is presented in the paper by S.Porkhial, et.al [4]. The model is capable of predicting the refrigerant temperature distribution, tube wall temperature, quality of refrigerant, inventory mass of refrigerant as a function of position and time. An efficient two-level iteration method is proposed to obtain the numerical solution of the model without solving a large set of non-linear equations simultaneously. A round bound evaporator of 12 cubic feet refrigerator with R12 as working fluid were chosen as a sample and some tests were carried out to determine its transient response. The results indicate that the theoretical model provides a reasonable prediction of dynamic response compared with the experimental data. Transient behavior of temperature, pressure, mass flow rate, mass of liquid and vapour of refrigerant, quality, heat transfer in household refrigerators have been presented. Also time dependent displacement of interface between saturated and superheated regions has been shown. Extensive investigation of theoretical and experimental results shows that with a controllable compressor, power consumption can be reduced. This model predicts transient behavior of temperature, pressure, mass flow rate, mass of liquid and vapor of refrigerant, quality, heat transfer in household refrigerators.

This paper doesn't give any idea regarding design and analysis of a vertical roll bond evaporator. A set of equations, which can be used to predict the performance parameters of an evaporator, when there is an oblique angle between the inlet air velocity and frontal face of the evaporator was studied by by Nan Chen, et.al [5]. In order to calculating the performance, a simulation model for predicting the performance of a plate-fin tube evaporator, on which frost formation occurs, has been presented. This model adopts different numerical algorithms according to different flow conditions including laminar, transitional and turbulent flow patterns. An experimental setup is built to verify the validity of this model. Then a comparison between the model's predictions and laboratory test data is provided. After correction, the numerical program based on this model is used to predict relationship between the oblique angel of the inlet air velocity and performance parameters (including frost weight, pressure drop and refrigerating capacity of the evaporator).

Summary

We try to do this project by reading the above literature, and we have been able to make our project successful by reducing the mistakes of last year's project.

CHAPTER 3

HARDWARE ANALYSIS

Introduction

Hardware is the most visible part of any information system. Here our hardware is Compressor, Coolant, Evaporator, Condenser, Expansion valve, Temperature Sensor, DC Motor, chamber materials etc.

Hardware

- Compressor
- Refrigerant
- Condenser
- Capillary Tube
- Wire
- Clip
- Cale Tiew
- Evaporator
- Switch
- Chamber Material

Compressor

A **compressor** is a mechanical device that increases the pressure of a gas by reducing its volume. An air compressor is a specific type of gas compressor. Compressors are similar to pumps: both increase the pressure on a fluid and both can transport the fluid through a pipe. As gases are compressible, the compressor also reduces the volume of a gas. Liquids are relatively incompressible; while some can be compressed, the main action of a pump is to pressurize and transport liquids.

Many compressors can be staged, that is, the fluid is compressed several times in steps or stages, to increase discharge pressure. Often, the second stage is physically smaller than the primary stage, to accommodate the already compressed gas without reducing its pressure. Each stage further compresses the gas and increases its pressure and also temperature (if inter cooling between stages is not used).

Mathematically the work done by the reciprocating compressor is equal to the work done by compressor **during compression** and discharge minus the work done during the suction of fluid. p_2, v_2, T_2 are the corresponding pressure, volume, and temperature after compression.

Figure 3.1: Compressor

Compressor Specification

1. Model No: HVY57AA
2. Efficiency: Optimized
3. Refrigerant Type: R600a
4. Cooling Capacity: 88.3W

Use of Compressor

Air compressors have many uses, including: supplying **high-pressure clean air to fill gas cylinders**, supplying moderate-pressure clean air to a submerged surface supplied diver, supplying moderate-pressure clean air for driving some office and school building pneumatic HVAC control system valves, supplying a large

Use and Application

A compressor is a device that increases the pressure of a substance (usually a gas) by reducing the volume of the substance. Compressors are used in many applications, most of which involve increasing the pressure inside a gas storage container, such as:

- Compression of gases in petroleum refineries and chemical plants
- Storage of gas in high pressure cylinders
- Cabin pressurization in airplanes
- Air storage for underwater activities
- Filling tires

Other applications include, but are not limited to:

- Refrigeration and air conditioners
- Rail vehicle operation
- Gas turbines
- Powering pneumatic tools
- Pipeline transport of natural gas

R600a Refrigerant

A refrigerant is a working fluid used in the refrigeration cycle of air conditioning systems and heat pumps where in most cases they undergo a repeated phase transition from a liquid to a gas and back again. Refrigerants are heavily regulated due to their toxicity, flammability and the contribution of CFC and HCFC refrigerants to ozone depletion and that of HFC refrigerants to climate change.

Isobutane is used as a refrigerant. Use in refrigerators started in 1993 when Greenpeace presented the Greenfreeze project with the former East German company Foron. In this regard, blends of pure, dry "isobutane" (R-600a) (that is, isobutane mixtures) have negligible ozone depletion potential and very low global warming potential (having a value of 3.3 times the GWP of carbon dioxide).

As a refrigerant, isobutane poses a fire and explosion risk in addition to the hazards associated with non-flammable CFC refrigerants. Substitution of this refrigerant for motor vehicle air conditioning systems not originally designed for isobutane is widely prohibited or discouraged. Vendors and advocates of hydrocarbon refrigerants argue against such bans on the grounds that there have been very few such incidents relative to the number of vehicle air conditioning systems filled with hydrocarbons.

Characteristics And Application

Isobutane, or R-600a, is a hydrocarbon that is used in some refrigeration equipment, such as domestic fridges or small commercial refrigerated appliances. The volumetric capacity of R-600a is approximately 50% less than that of R-12 and R-134a, so it cannot be used a replacement for them. When working with hydrocarbon refrigerants, it is very important that they are very pure, as if there are any impurities present (sulphur, water, etc.) it could cause the oil lubricants in the system to degrade and damage the compressors, among other things. Furthermore, if the hydrocarbon is not very pure it can sometimes be mixed with other hydrocarbons, which can drastically alter the physical and thermodynamic properties of the original hydrocarbon. The isobutane that is used in refrigeration applications is not odourised, as it is when used for domestic purposes (domestic hydrocarbons are odourised so they a leak can be detected quickly). It is therefore not easily detectable when there is a leak.

Evaporators

Introduction Evaporation and evaporation are two processes in which simultaneous heat and mass transfer process occurs resulting into separation of vapor from a solution. Evaporation and vaporization occur where molecules obtain enough energy to escape as vapor from a solution. The rate of escape of the surface molecules depends primarily upon the temperature of the liquid, the temperature of the surroundings, the pressure above the liquid, surface area and rate of heat propagation to product.

Working Principle of Evaporator and its Types

The function of evaporator is to absorb heat from surrounding location or medium which is to be cooled by means of refrigerant. The refrigerant either boils as it flows through a pipe, tube or other type of space so that liquid is continuously wetting all the inside surface or it boils in a shell around submerged tubes through which the fluid to be cooling is flowing. Various methods are used for evaporators, depending upon the refrigerant to be used and evaporator application, but iron, steel and copper predominate. Refrigerant evaporators should be of extended surface or finned tube type whatever practical. In order to keep the average surface temperature down, a good bond between the fin and tube is essential. Integral fins formed out of the tube itself are best in this respect and give the best heat transfer rate.

Type of evaporators based on operating condition:

1. Flooded type evaporator
2. Dry or direct expansion type evaporator

Type of evaporator based on construction:

1. Bare tube evaporator
2. Plate evaporator
3. Finned tube evaporator
4. Shell tube evaporator
5. Tube in tube evaporator

Bare tube evaporator:

The bare tube evaporators are made up of copper tubing or steel pipes. The copper tubing is used for small evaporators where the refrigerant other than ammonia is used while the steel pipes are used with the large evaporators that uses ammonia as refrigerants.

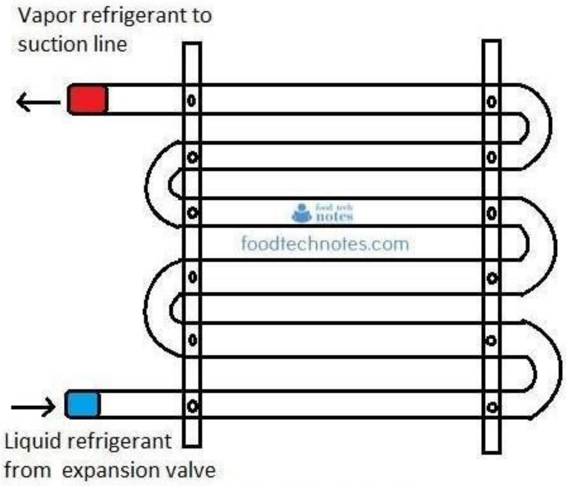

Figure 3.2: Bare Tube Evaporator

The evaporator comprises of several turns of tubing and are usually used for liquid chilling. In blast cooling and freezing operations, atmospheric air flows over bare tube evaporator and the chilled air leaving it used for cooling purposes. **Plate evaporators:** In plate type evaporators, the coil usually made of copper of aluminum is embedded in the plate so as to form a flat looking surface. Externally the plate type evaporator looks like single plate but inside it, there are several turns of the metal tubing through which the refrigerant flows.The advantage of plate type evaporator is that they are more rigid as the external plate provides lots of safety. The external plate also helps increasing heat transfer from metal tubing to the substance to be chilled. These types of evaporators are easy to clean and can be manufactured cheaply. They can be converted into box shape, partitions or shelves as required for different purposes. Due to various advantage and flexibility offered by plate type evaporator, they are used extensively.

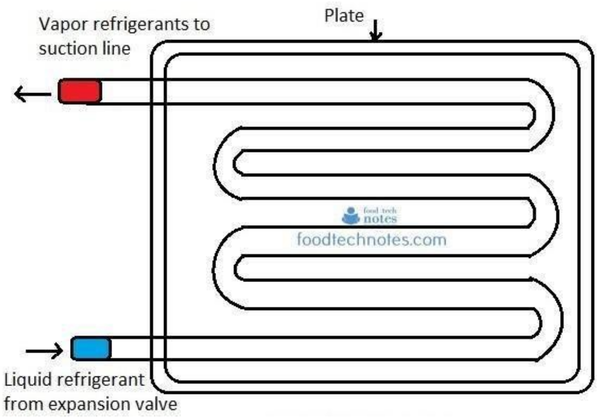

Figure 3.3: Plate Evaporator

Finned tube evaporator:

The finned evaporators are tube type evaporators covered with the fins. When the fluid (air or water) to be chilled flows over the bare tube evaporator, lots of cooling effect from the refrigerant goes wasted since there is less surface for transfer of heat from fluid to refrigerant. The fins on the finned tube evaporator increases contact surface area and increases heat transfer rate. Thus finned evaporators are more effective than bare tube evaporators.

For fins to be effective, it is very important that there is good contact between coil and the fins. In some cases fins are soldered directly to surface of the coil and in other cases, the fins are just slipped over the surface of tubes or coils. The finned evaporators are most commonly used in the air conditioners of almost all type like window, split, packaged and central air conditioning. In this system, finned evaporator is known as cooling coil.

The hot air flows over finned evaporator for cooling. To increase effectiveness of heat transfer from evaporator, the tubing are also given internal fins. These fins are made by forming different internal cross section shapes at the time of manufacturing of tubing.

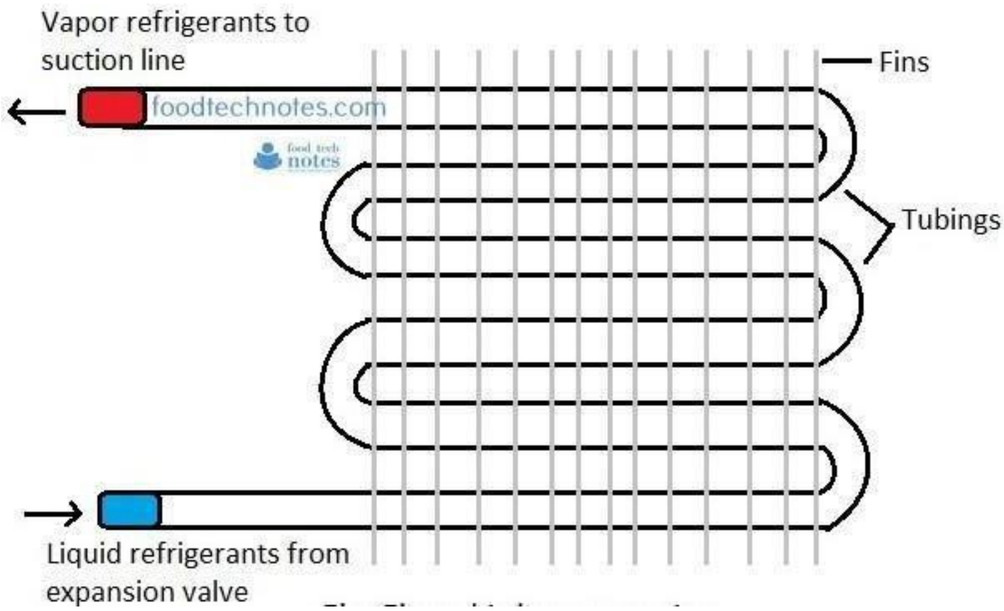

Figure 3.4: Finned Tube Evaporator

Condenser

In systems involving heat transfer, a **condenser** is a heat exchanger used to condense a gaseous substance into a liquid state through cooling. In so doing, the latent heat is released by the substance and transferred to the surrounding environment. Condensers are used for efficient heat rejection in many industrial systems. Condensers can be made according to numerous designs, and come in many sizes ranging from rather small (hand-held) to very large (industrial-scale units used in plant processes).

A refrigerator uses a condenser to get rid of heat extracted from the interior of the unit to the outside air. Condensers are used in air conditioning, industrial chemical processes such as distillation, steam power plants and other heat-exchange systems. Use of cooling water or surrounding air as the coolant is common in many condensers.[1]

Principle of Operation

A condenser is designed to transfer heat from a working fluid (e.g. water in a steam power plant) to a secondary fluid or the surrounding air. The condenser relies on the efficient heat transfer that occurs during phase changes, in this case during the condensation of a vapor into a liquid. The vapor typically enters the condenser at a temperature above that of the secondary fluid. As the vapor cools, it reaches the saturation temperature, condenses into liquid and releases large quantities of latent heat.

As this process occurs along the condenser, the quantity of vapor decreases and the quantity of liquid increases; at the outlet of the condenser, only liquid remains. Some condenser designs contain an additional length to subcool this condensed liquid below the saturation temperature. Countless variations exist in condenser design, with design variables including the working fluid, the secondary fluid, the geometry and the material. Common secondary fluids include water, air, refrigerants, or phase-change materials.

Condensers have two significant design advantages over other cooling technologies:

- Heat transfer by latent heat is much more efficient than heat transfer by sensible heat only

- The temperature of the working fluid stays relatively constant during condensation, which maximizes the temperature difference between the working and secondary fluid.

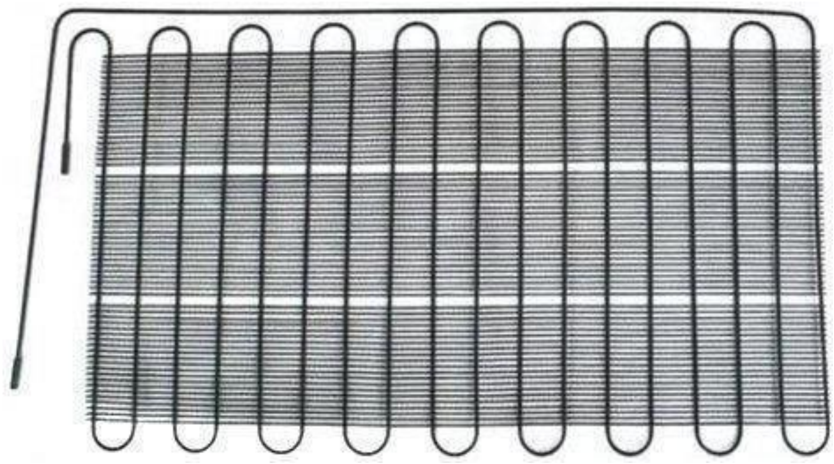

Figure 3.5: Condenser

Digital Thermometer

A thermometer is a device that measures temperature or a temperature gradient (the degree of hotness or coldness of an object). A thermometer has two important elements: a temperature sensor (e.g. the bulb of a mercury-in-glass thermometer or the pyrometric sensor in an infrared thermometer) in which some change occurs with a change in temperature.

Figure 3.6: Digital Temperature Sensor

some means of converting this change into a numerical value (e.g. the visible scale that is marked on a mercury-in-glass thermometer or the digital readout on an infrared model). Thermometers are widely used in technology and industry to monitor processes, in meteorology, in medicine, and in scientific research. Some of the principles of the thermometer were known to Greek philosophers of two thousand years ago. As Henry Carrington Bolton (1900) noted, the thermometer's "development from a crude toy to an instrument of precision occupied more than a century, and its early history is encumbered with erroneous statements that have been reiterated with such dogmatism that they have received the false stamp of authority."

The Italian physician Santorio Santorio (Sanctorius, 1561-1636) is commonly credited with the invention of the first thermometer, but its standardization was completed through the 17th and 18th centuries. In the first decades of the 18th century in the Dutch Republic, Daniel Gabriel Fahrenheit made two revolutionary breakthroughs in the history of thermometry. He invented the mercury-in-glass thermometer (first widely used, accurate, practical thermometer) and Fahrenheit scale (first standardized temperature scale to be widely used).

Figure 3.7: Digital Temperature Sensor Display

Specification

- Temperature range: -50~ +110°C
- Using environment: Temperature: -5~ +50°C Humidity: 5%~80%
- Accuracy: ±1°C
- Size: 47*28*14mm
- Weight: 22g
- Color: Black and white

CHAPTER 4

METHODOLOGY

Our methodologies for the project

Our methodology for the project:

- Creating an idea for **Compression Refrigeration System,** And drawing and listed of components/materials to know which components/materials need to construct it.
- Collecting the all components/materials construct the system.
- Finally, we constructed this system & checked it finally that working very well.

Working Step Chart

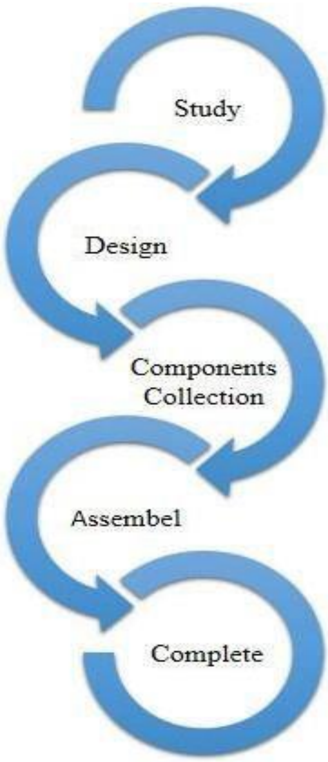

Figure 4.1: Working Step Chart

Block Diagram

In our project we have set up a **Compression Refrigeration System**. Here, in this system, we are use AC source for operate. Here we also use a Compressor, Coolant, capillary tube, Temperature Sensor, Condenser, chamber materials etc.

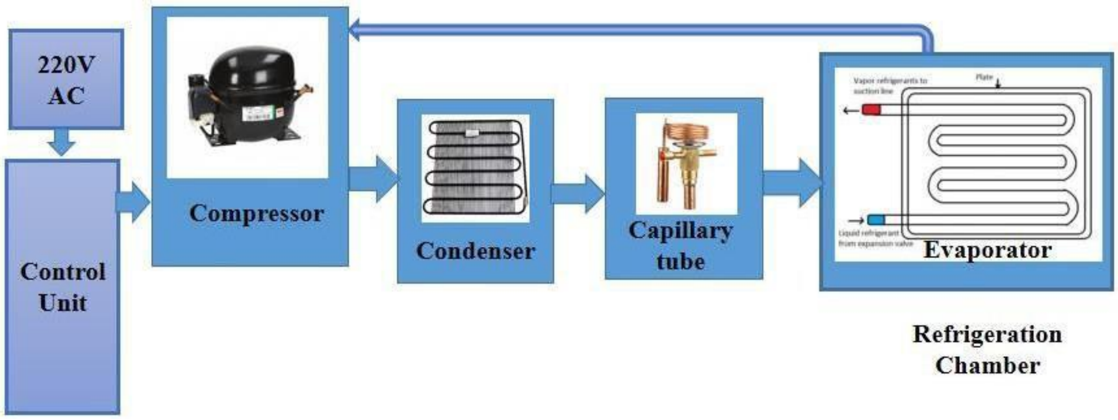

Figure 4.2: Block Diagram of **Compression Refrigeration System**

Basic Structural Design

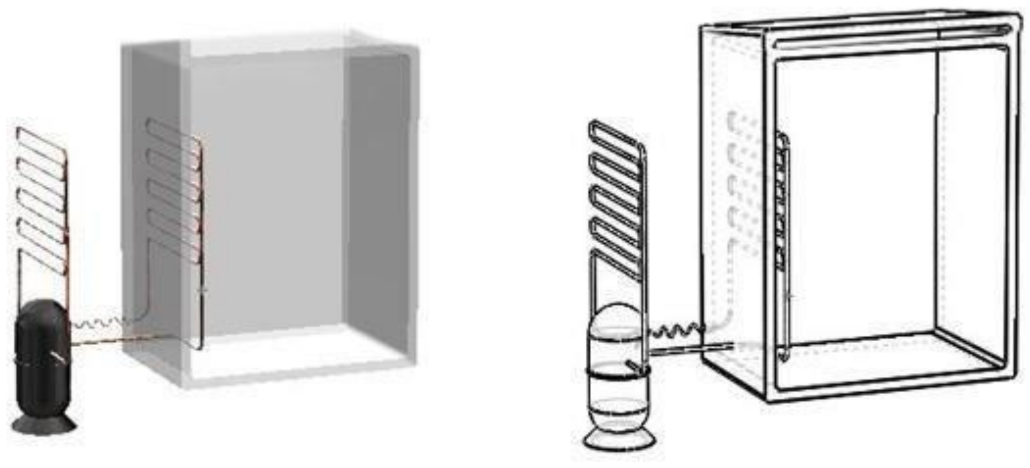

Figure 4.3: Basic Drawing of **Compression Refrigeration System**

Working Principle

Connecting with the power source here is AC 220 volts coming to the circuit. The compressor will come with a 220-volt controller unit. From the compressor through the gas condenser to the capillary tube the evaporator side will rotate in a circular motion. There will be gas in the compressor which will compress the compressor to the system. When the gas enters the condenser, it will remain heated. When the gas goes to the capillary tube, the gas cools and spreads its cold inner reside of refrigeration. Here our aim is to find out which gas is more efficient after the operation.

Our Final System View

Figure 4.4: Our Project Prototype (Front View)

Figure 4.5: Our Project Prototype (Back View)

Figureb4.6: Compressor Space

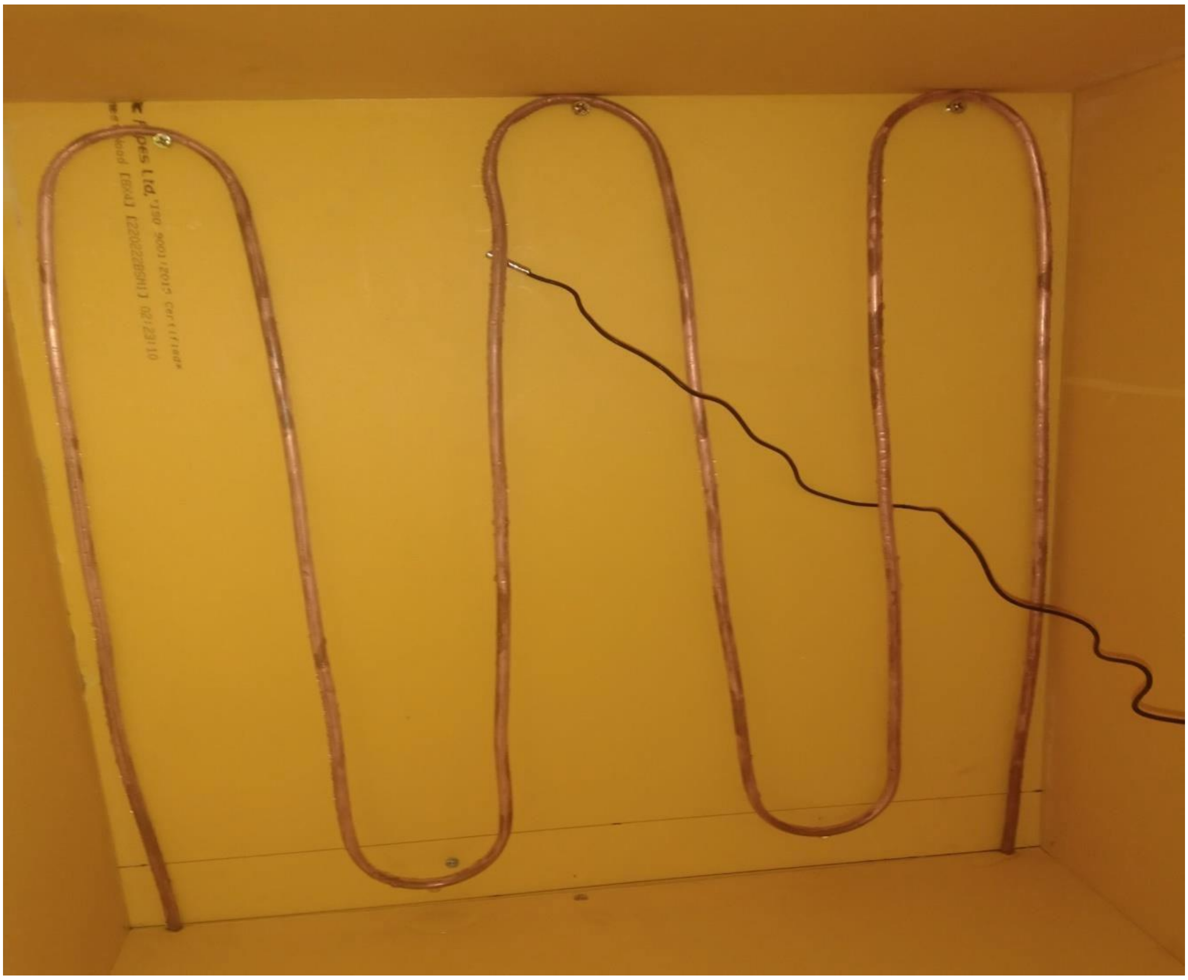

Figure 4.7: Evaporator

CHAPTER 5
RESULT AND DISCUSSION

Discussion

While working on our project, we did face some difficulties as it is a very complex system but the end results, we came up with were quite satisfactory. We have put the whole system through several tasks to validate our work and also have taken necessary notes for future improvements. Some future recommendations that we have involves improvement in system design and wiring, adding features for more efficient.

Result

After making our project we observe it very careful. It works as we desire. Our project give output perfectly and all equipment are work perfectly. We check how much it works and we get perfect output from this project.

- ❑ Finally, we have completed our project successfully & check our project its run accurately according to our objective.
- ❑ At first, we start our system and operate different condition.
- ❑ This system measures the temperature with the help of temperature sensor. And make temperature as need in this refrigeration system.
- ❑ All the temperature data output will show in temperature display.

Figure 5.1: Starting Temperature

Figure 5.2: After Cooling Temperature

Advantage

There are many advantages of our project because of its accuracy. Some of the advantages are pointed out below:

- Creates a comfortable and productive work environment.
- Improve inside refrigeration Air Quality.
- Energy-efficient cooling solution.
- Environmentally friendly.
- No Oil consumption.
- Less skill technicians is sufficient to operate.
- Installation is simplified very much.
- Simple construction
- Easy of operation.

Application

The application areas for this project in this modern and practical world are huge and some of these are given below:

- It can be used for Industrial work.
- It can be used in factories.
- It can be use for indoor purpose

Real Time Cooling Data Table

Time	Temperature
0 min	32°C
5 min	-7.5°C
15 min	-8.4°C
30 min	-8.9°C
30-60 min	-8.9°C

CHAPTER 6
CONCLUSION

Conclusion

The main objective of this project was to develop a **Compression Refrigeration System** based on certain specifications. This was successfully implemented. We consider this project as a journey where we acquired knowledge and also gained some insights into the subject which we have shared in this report. In a refrigeration system capillary tube is more adjustable and better device. The initial and running cost of this system is really less. No outside energy source is required to run the system. This refrigeration system has wide scale application in hotel industries, chemical industries.

Future Scope

The model can be improved by making some changes in the hardware and components. Some suggestions are given below-

- We will increase its working accuracy level.
- We will increase its cooling system.
- We will add a sensor for automatic compressor on/off .

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