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Sonargaon University (SU)
সোনারগাঁও ইউনিভার্সিটি (এসইউ)

Development of Portable Air Cooler Operating Two Types of Refrigerant (R-410a & R-22a)

A Thesis
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September, 2022

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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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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.

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ABSTARCT

In day to day life because of the rising temperatures there is a high demand for cooling systems. The project is based on an abstract of creating a cooling system which is an air conditioner embedded with a cooling chamber. The current project is portable model which has the main functioning component as the air conditioner and the secondary component as the cooling chamber which acts as a refrigerator. The current project looks into creating a product which gives the user the comfort of two devices in one system. The basic advantage of the system is that two components run on a single compressor. The system is so formed that most of the refrigerant is moved to the air conditioning system and rest of the refrigerant is moved to cooling chamber thus producing maximum cooling through air conditioner and required cooling to the products through cooling chamber.

TABLE OF CONTENTS

Letter of Transmittal		ii
Declaration		iii
Acknowledgement		iv
Abstract		v
Table of Contents		vi
Table of Figure		viii
CHAPTER-1	**INTRODUCTION**	
1.1 Introduction		01
1.2 Air Conditioner		02
1.3 Objective		03
1.4 Structure of the Projects		03
CHAPTER 2	**LITERATURE REVIEW**	
2.1 Introduction		04
2.2 Literature Review		04
2.3 Summary		06
CHAPTER-3	**HARDWARE AND SOFTWARE ANALYSIS**	
3.1 Introduction		07
3.2 Components Rating		08
3.3 Compressor		08
3.4 R410 Refrigerant		10
3.5 Evaporator		11
3.6 Condenser		14
3.7 Digital Thermometer		16
CHAPTER-4	**METHODOLOGY**	
4.1 Methodology		19
4.2 Working Step Chart		19

4.3 Block Diagram 20
4.4 Basic Drawing 21
4.5 Working Principle 21
4.6 Our Final Project View 22

CHAPTER-5 RESULT AND DISCUSSION
5.1 Discussion **23**
5.2 Result 23
5.3 Advantage 23
5.4 Application 24

CHAPTER-6 CONCLUSION
6.1 Conclusion 25
6.2 Future Scope 25

Reference 26

LIST OF FIGURES

FIGURE NO	FIGURE NAME	PAGE NO
3.1	COMPRESSOR	9
3.2	Bar Tube Evaporator	12
3.3	Plate Evaporator	13
3.4	Finned Tube Evaporator	14
3.5	Condenser	16
3.6	Digital Temperature Sensor	16
3.7	Digital Temperature Sensor Display	17
4.1	Working Flow Chart	19
4.2	Block Diagram	20
4.3	Basic Structure Diagram	21
4.4	Our Project Prototype (Top View)	22
4.5	Our Project Prototype (Front View)	22

CHAPTER 1

INTRODUCTION

1.1 Introduction

Air conditioning systems are one of the most important products in contemporary world. They are vital in creating comfort living conditions. With the effect of global warming temperatures are rising, as a result air conditioner sales are increasing drastically every year. Various types of air conditioning systems are available in the market to cater the needs of different levels of air conditioning for homes, offices, industries, shopping malls etc.

Portable air conditioner is an innovative product originally derived from standard window air conditioner running on vapor compression refrigeration cycle. Standard window air conditioner or Split Air conditioner is limited to be used in room or inside a closed environment, once fixed it cannot be mobilized. Portable air conditioner runs on vapor compression refrigeration cycle with rotary compressor. Unlike conventional air conditioners which run in a closed environment, portable air conditioners can be used in both closed environment and open environments like a retail outlet or a showroom or in any open hall with air conditioner focused on specific location. In addition to that portable air conditioner gives localized air conditioning effect which cannot be achieved with conventional type air conditioners.

In this paper the performance of a portable air conditioner based on vapor compression refrigeration cycle and running on R23 refrigerant has been evaluated. Various types of heat exchangers used in refrigeration and air-conditioning systems have been studied in detail. In the present analysis R-22 refrigerant is used as the working fluid. As, it is an ozone harming substance. An optional refrigerant which is ozone harm free refrigerant should be considered. Their comparison is given below.

Air conditioners, refrigerators and freezers rely on the circulation of a refrigerant--a chemical that can efficiently remove heat from the surroundings R22 is an HCFC, While R134a Is an HFC like R12, which is the original ozone-depleting refrigerant, R22 is

marketed under the brand name Freon, and it's one of the earliest CFC alternatives. Its chemical name is chloro-difluoro methane, and it belongs to a closely related class known as hydro-chlorofluorocarbons (HCFCs). These refrigerants also contain chlorine that can potentially find its way into the upper atmosphere. R134a belongs to another class of CFC alternatives, called hydro fluorocarbons (HFCs), that don't contain chlorine. Its chemical name is tetra fluoro ethene. It isn't the only CFC alternative on the market, and it isn't the best.

1.2 Air Conditioner

An air conditioner is a system or a machine that treats air in a defined, usually enclosed area via a refrigeration cycle in which warm air is removed and replaced with cooler and more humid air. Air conditioning (often referred to as AC, A.C., or A/C) is the process of removing heat from a confined space, thus cooling the air, and removing humidity. Air conditioning can be used in both domestic and commercial environments. This process is used to achieve a more comfortable interior environment, typically for humans or animals; however, air conditioning is also used to cool/dehumidify rooms filled with heat-producing electronic devices, such as computer servers, power amplifiers, and even to display and store artwork.

Air conditioners often use a fan to distribute the conditioned air to an occupied space such as a building or a car to improve thermal comfort and indoor air quality. Electric refrigerant-based AC units range from small units that can cool a small bedroom, which can be carried by a single adult, to massive units installed on the roof of office towers that can cool an entire building. The cooling is typically achieved through a refrigeration cycle, but sometimes evaporation or free cooling is used. Air conditioning systems can also be made based on desiccants (chemicals which remove moisture from the air) and subterranean pipes that can distribute the heated refrigerant to the ground for cooling

1.3 Objectives

The objectives of this project are:

- To study about a **Development of Portable Air Cooler Operating Two Types of Refrigerant (R-410a & R-22a)**
- To implement a **Development of Portable Air Cooler Operating Two Types of Refrigerant (R-410a & R-22a)**
- To test the performance of the cooling system.

1.4 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

2.1 Introduction

In this section topics related to **Development of Portable Air Cooler Operating Two Types of Refrigerant (R-410a & R-22a)** are included. These provide a sampling of problems appropriate for application of **Development of Portable Air Cooler Operating Two Types of Refrigerant (R-410a & R-22a)**. The references are summarized below.

2.2 Literature Review

Franck Lucasa, Pascal Ortegaa, Mathieu Davidb, Frantz Sinamab, Boris Brangeonb Fabien Picgirardc, ICAE2015[4]:A method to evaluate energy performance of buildings cooled by room air conditioners. Because of their low cost, small air conditioning systems (AC) like split air conditioning systems are often installed without a proper study of building envelope performance. Furthermore, these systems are sometimes installed by tradesmen who neglect to comply with the appropriate rules and regulations. Finally, when routine maintenance is not rigorously carried out, the energetic performance of the system is compromised over time.

This article presents a practical, global approach to diagnose the performance of existing small air-conditioning installations in buildings applied in Reunion Island. This tropical Island aspires to become electricity self-sufficient.. This approach relies on a numerical tool and dynamic simulations of buildings equipped with AC. The simulations, which take account of the building envelope, a description of the system as well as the practices of the users, are based on the kernel calculation Energy. They also take into account the climatic conditions and provide an estimate of the annual electricity consumption related to the cooling of the zone. This global analysis helps to qualify the entire system by assigning an energy label.

- *Buildings account* for over 42% of consumption of final energy [1] in France and between 20 and 40% in other developed countries. Perez Lombard [2] reports that the share of HVAC system for heating ventilation and air conditioning has now become the largest energy end use in the residential and non-residential sector. Wong [4] estimates that its represents one third of the total energy consumption for residential housings in Hong Kong.

- *Improving the design of buildings* and of the AC systems in order to reduce cooling loads is the subject of a great deal of research in southern hemisphere tropical climates. A large body of expertise has evolved, especially in respect to French overseas departments, like Reunion Island. As a result of this work, specific recommendations to design buildings adapted to the tropical climate have been established.

Jadhav T. S., Lele M.M., Engineering Science and Technology, an International Journal 18, 2015[5]: Theoretical energy saving analysis of air conditioning system using heat pipe heat exchanger for Indian climatic zones. Heat pipe heat exchanger (HPHX) is an excellent device used for heat recovery in air conditioning systems. The Energy Conservation Building Code (ECBC) e Bureau of Energy Efficiency (BEE) India classifies Indian climatic zones into five categories viz., Hot and Dry , Warm and Humid ,Composite, Cold and Temperate. From the paper we can say that indicated that very limited information is available on annual energy saving analysis of air conditioning system with HPHX for Indian climatic zones.

The paper investigates the possible energy savings using HPHX for heat recovery in air conditioning system for Indian climatic zones. This paper discusses the use of HPHX only for the heat recovery application i.e., exchange of sensible heat between fresh outdoor air and conditioned return air. The maximum energy saving potential is revealed for hot and dry, warm and humid and composite Indian climatic zones.

- *In the last six decades*, India's energy use has increased 16 times and the installed electricity capacity by 84 times. In 2008, India's energy use was the fifth highest in the world. The air conditioning contributes towards significant energy usage of a building. The building sector represents about 33% of electricity consumption in India, with

commercial sector and residential sector accounting for 8% and 25% respectively. - *The Energy Conservation* Building Code (ECBC) e Bureau of Energy Efficiency (BEE)
India[2] classifies Indian climatic zones into five categories viz., Hot and Dry (e.g. Ahmadabad, Jodhpur etc), Warm and Humid (e.g. Mumbai, Chennai etc), Composite (e.g. Nagpur, Jaipur etc), Cold (e.g. Guwahati etc) and Temperate (e.g. Bangalore etc).

2.3 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 AND SOFTWARE ANALYSIS

3.1 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

1) Compressor 2pcs
2) Coolant/Refrigerant
3) Evaporator 2pcs
4) Condenser 2pcs
5) Expansion valve 2pcs
6) Temperature Sensor
7) Fan
8) Wire
9) Clip
10) Cable Tie
11) Switch
12) Chamber Materials

3.2 Components Rating and Quantity

Table 3.1: Component's Name and Price

Sl. No.	Components Name	Specification	Quantity	Unit Price	Total Price
01	Compressor	220V AC	2	2850	5700
02	Refrigerant	R410a, R22a	60-70 gm		1000
03	Evaporator	Copper tube	50 Feet	45	2250
04	Condenser	Irone (8 Layers)	2	950	1900
05	Capillary Tube	34 Size	18 Feet	10	180
06	hamber Materials	PVC	1 piece	2250	2250
07	Fan		2	1150	2300
08	Others				5250
Total					20,830/=

3.3 Compressor

A **compressor** is a mechanical device that increases the pressure of a Refrigerant by reducing its volume. An air compressor is a specific type of Refrigerant compressor. Compressors are similar to pumps: both increase the pressure on a fluid and both can transport the fluid through a pipe. As Refrigerants are compressible, the compressor also reduces the volume of a Refrigerant. 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 Refrigerant without reducing its pressure. Each stage further compresses the Refrigerant 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

Use of Compressor

Air compressors have many uses, including: supplying **high-pressure clean air to fill Refrigerant 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 Refrigerant) by reducing the volume of the substance. Compressors are used in many applications, most of which involve increasing the pressure inside a Refrigerant storage container, such as:

- Compression of Refrigerants in petroleum refineries and chemical plants

- Storage of Refrigerant 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
- Refrigerant turbines
- Powering pneumatic tools
- Pipeline transport of natural Refrigerant

3.4 R410 Refrigerant

R410 (**Iso-Butane**) is refrigerant grade Iso-Butane used as a replacement for R12 and R134a in a variety of high temperature refrigeration applications. ... It is the refrigerant of choice for domestic and light commercial refrigeration units, including fridges and freezers, drink dispensers and stand alone display units.

For the longest time, chlorofluorocarbons, hydrochlorofluorocarbons and hydrofluorocarbons have been used as refrigerants. Research, however, has shown that CFC, HCFCs, and HFCs are harmful to the environment. One of the biggest concerns has been the depletion of the ozone layer. Strides have been made (and are still continuing) to ensure that all refrigerants are safe, efficient, and above all, green. Most harmful refrigerants are being phased out and being replaced with eco-friendly refrigerants like R410.

Properties of R410

Here are some of the top properties of R410 refrigerant.

- R410 is friendly to the environment – doesn't cause the greenhouse effect
- It has a low power consumption

- The refrigerant is compatible with different lubricants
- Its load temperature speed is low
- The cooling performance of R410 is very strong

Uses of R410A

As highlighted earlier, R410 has become the refrigerant of choice because of its eco-friendly properties. Let's look at some of the applications of this refrigerant.

- The refrigerant is used in geothermal power generation
- R410 is ideal for industrial refrigeration
- It's applicable in beverage dispensers
- It's used in dehumidifiers
- R410 can be used in plug-ins and vending machines
- They can also be used as feedstock in the petrochemical industry
- It's used in aerosol sprays

3.5 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.

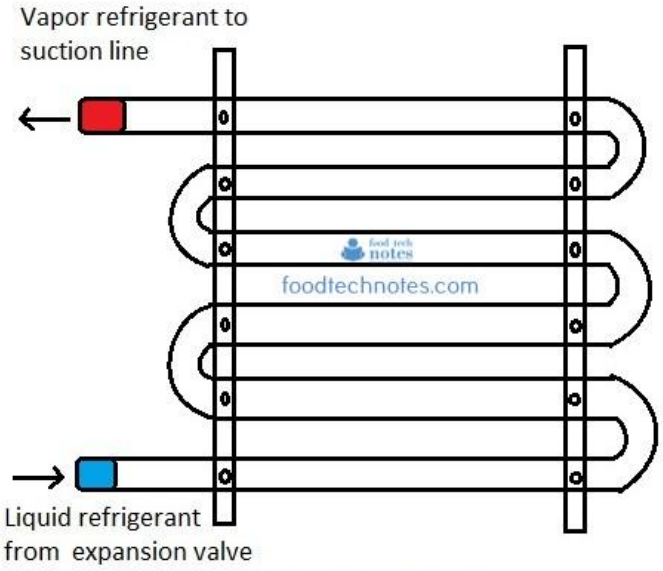


Figure 3.2: Bare Tube Evaporator

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.

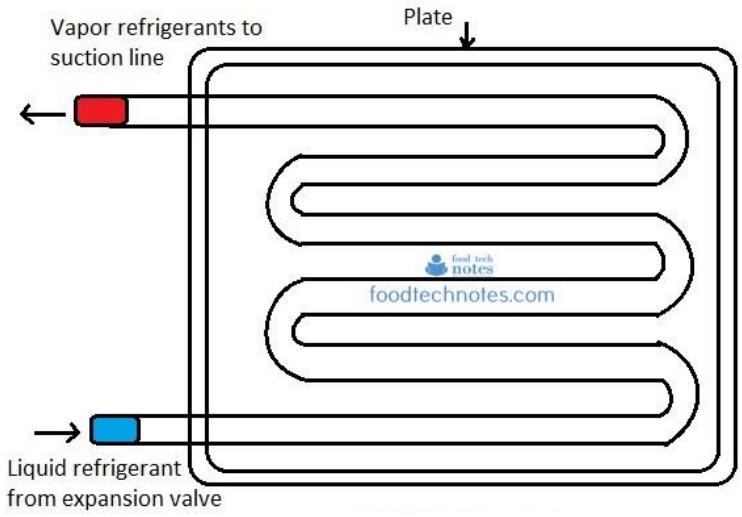


Figure 3.3: Plate Evaporator

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.

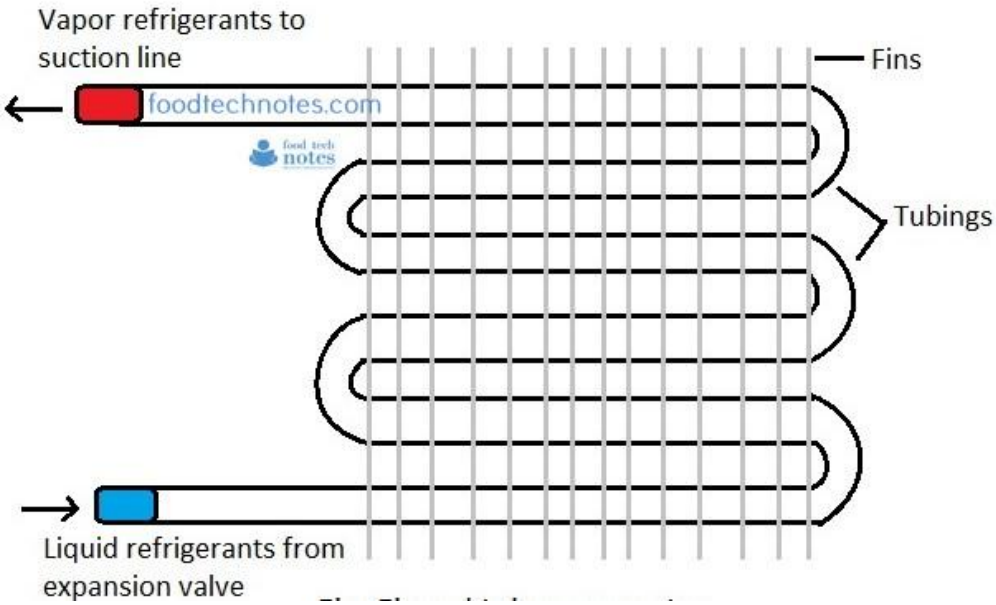


Figure 3.4: Finned Tube Evaporator

3.6 Condenser

In systems involving heat transfer, a **condenser** is a heat exchanger used to condense a Refrigeranteous 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.

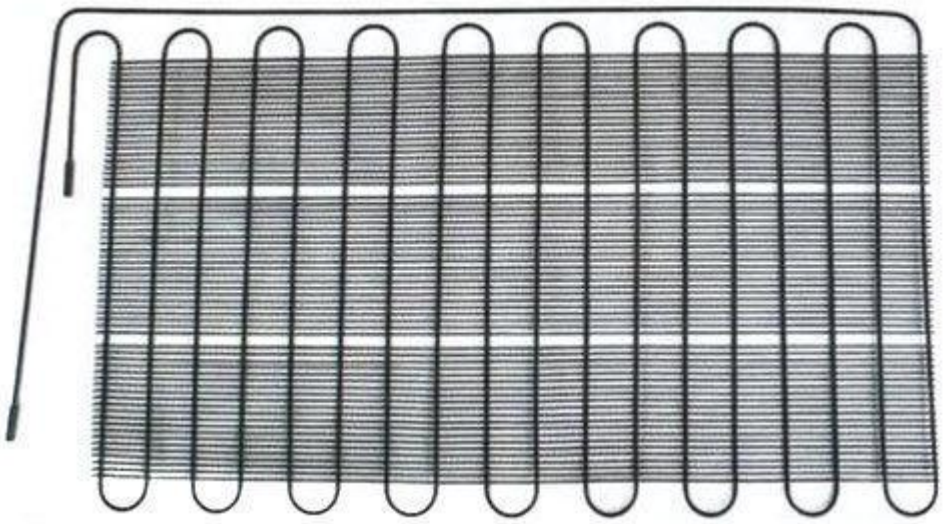


Figure 3.5: Condenser

3.7 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

4.1 Our methodologies for the project

Our methodology for the project:

- Creating an idea for **Portable Air Cooler cycle System using two Type of Refrigerant,** 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.

4.2 Working Step Chart

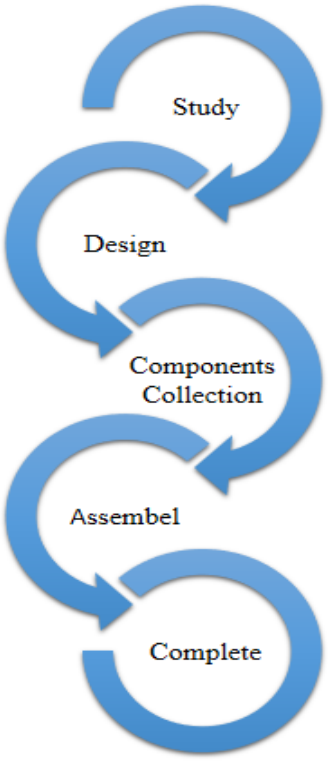


Figure 4.1: Working Step Chart

4.3 Block Diagram

In our project we have set up a **Portable Air Cooler cycle System using two Type of REFRIGERANT**. Here, in this system, we are use AC source for operate. Here we also use a Compressor, Coolant, Evaporator, Temperature Sensor, Fan, DC Motor, chamber materials etc.

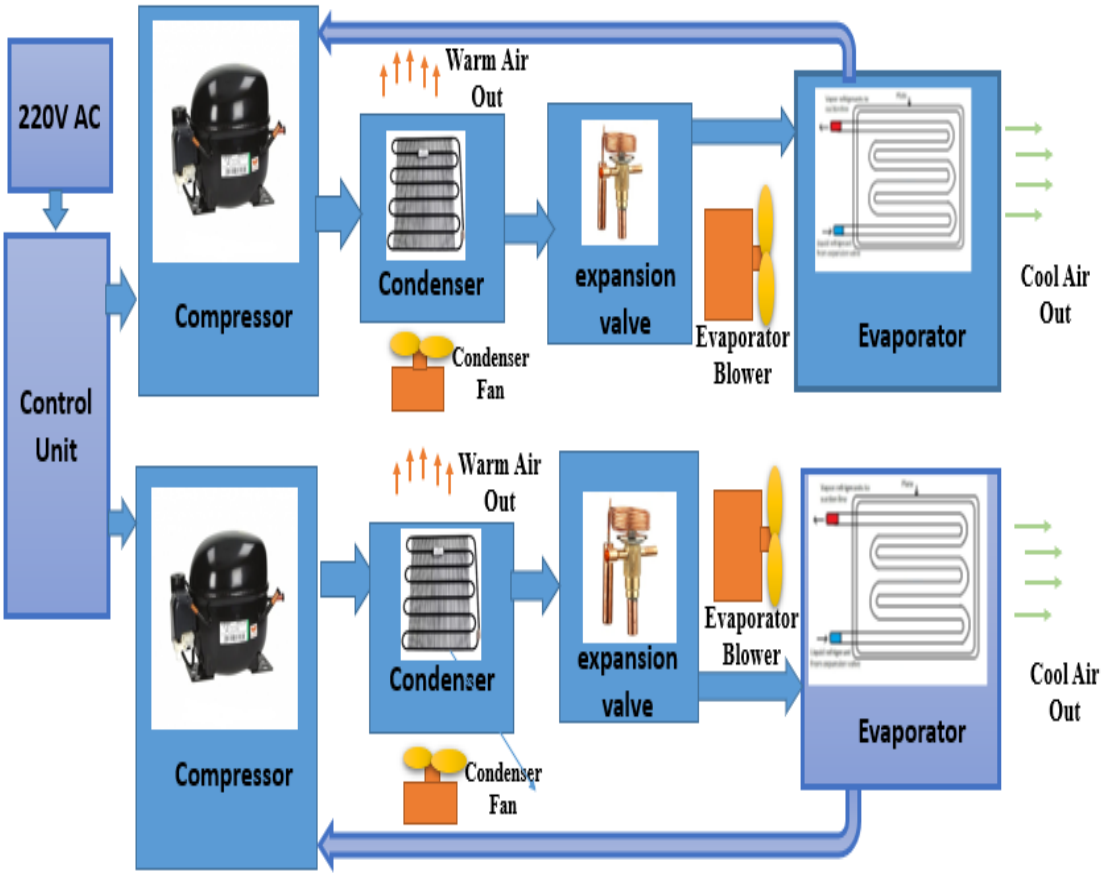


Figure 4.2: Block Diagram of Portable Air Cooler cycle System using two Type of REFRIGERANT.

4.4 Basic Drawing of System

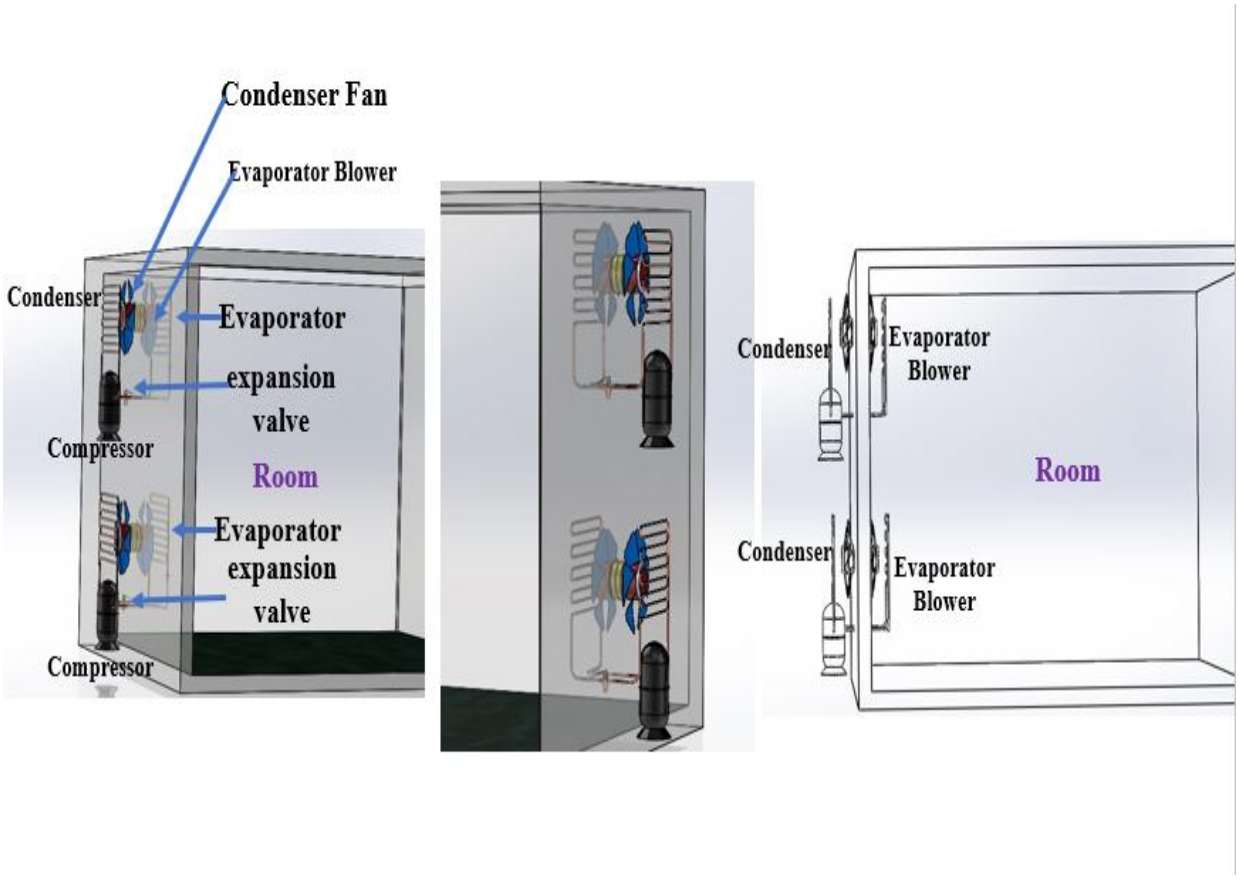


Figure 4.3: Basic Drawing of Development of Portable Air Cooler Operating Two Types of Refrigerant (R-410a & R-22a)

4.5 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 Refrigerant condenser to the capillary tube the evaporator side will rotate in a circular motion. There will be Refrigerant in the compressor which will compress the compressor to the system. When the Refrigerant enters the condenser, it will remain heated. When the Refrigerant goes to the capillary tube , the Refrigerant cools and spreads its cold inner reside of room by a fan. We have used two types of Refrigerant in our system. Another compressor will work the same procedure with the different Refrigerant. Air will supply in the room and reduce the inside temperature through this air condition. Here our aim is to find out which Refrigerant is more efficient after the operation.

4.6 Our Final System View



Figure 4.4: Our Project Prototype (Top View)

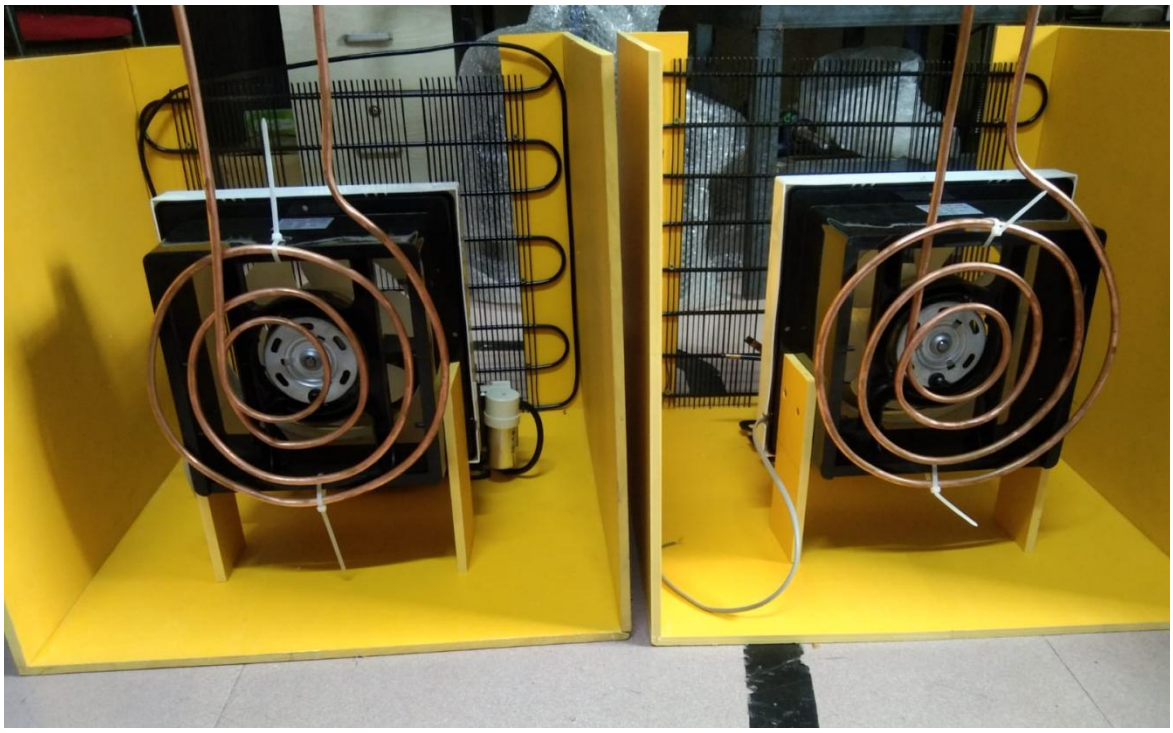


Figure 4.5: Our Project Prototype (Front View)

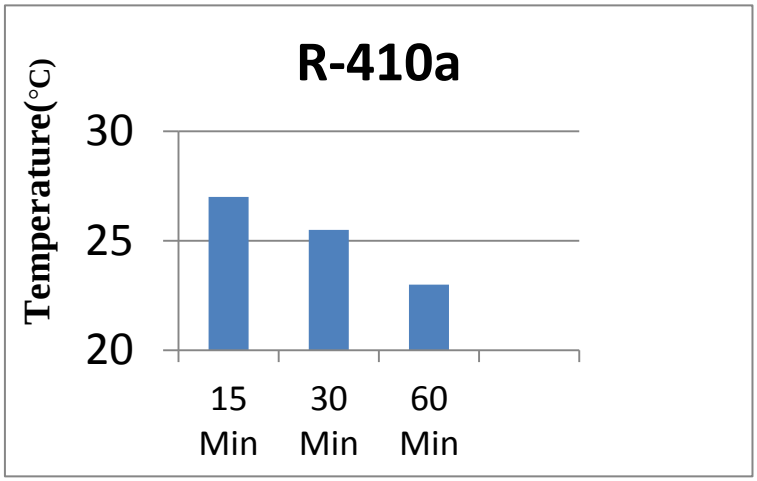
CHAPTER 5
RESULT AND DISCUSSION

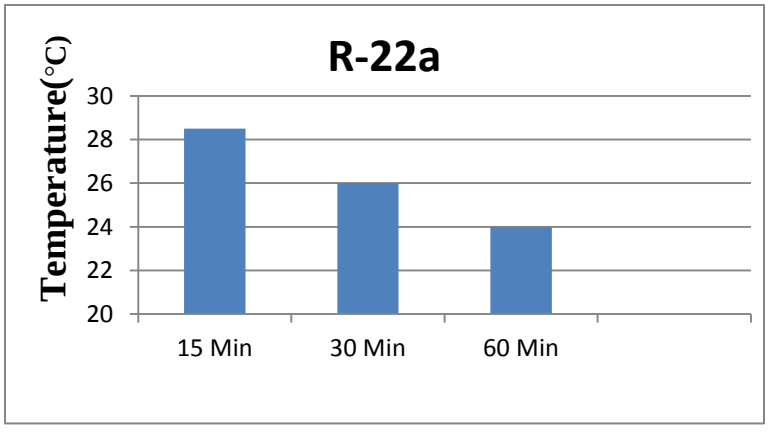
5.1 Discussion

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.

5.2 Result

Result Data and Graph





5.3 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 outside 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
- Ease of operation.
- Easy of operation.

5.4 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

CHAPTER 6
CONCLUSION

6.1 Conclusion

The portable Air conditioner system satisfies the need of user at the most economical cost. It provides transportability, can be move anywhere easily. It is completely non-polluting. Detailed portable air cooler cycle system cycle has been presented along with classification of types of capillary tube full of coolant used in this cooling systems. It can be very useful in tropical countries which have high temperatures and humidity during the summer. **After getting result we can say R410a better performance than R22a.**

6.2 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 and a display to measure and monitoring the cooling situation.

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