CHAPTER 1

INTRODUCTION

With the ever so increasing demand for greener technology, and awareness and publication of the depleting natural resources of our earth, the time has come to put forward commercial products into the market such that we, as humans, on a global scale, will contribute to reducing the usage of household equipment's run by using natural gas, oil, petroleum, etc. which are all found in the bounty of earth but also are the leading cause for bringing harm to it. The air conditioning system that we have built truly relies on that very role of being a clean and green technology by incorporating a solar thermal collector which aims at reducing the work of the compressor thereby reducing the power drawn from electricity mains with the help of nanofluid. The block diagram depicting the entire system is given in figure 1.1.

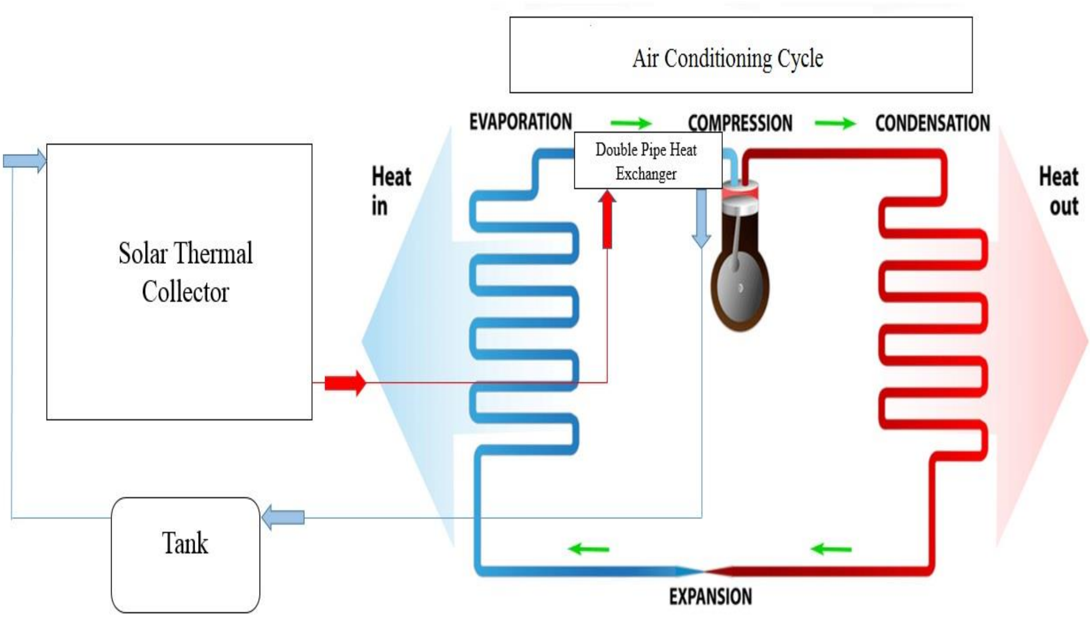


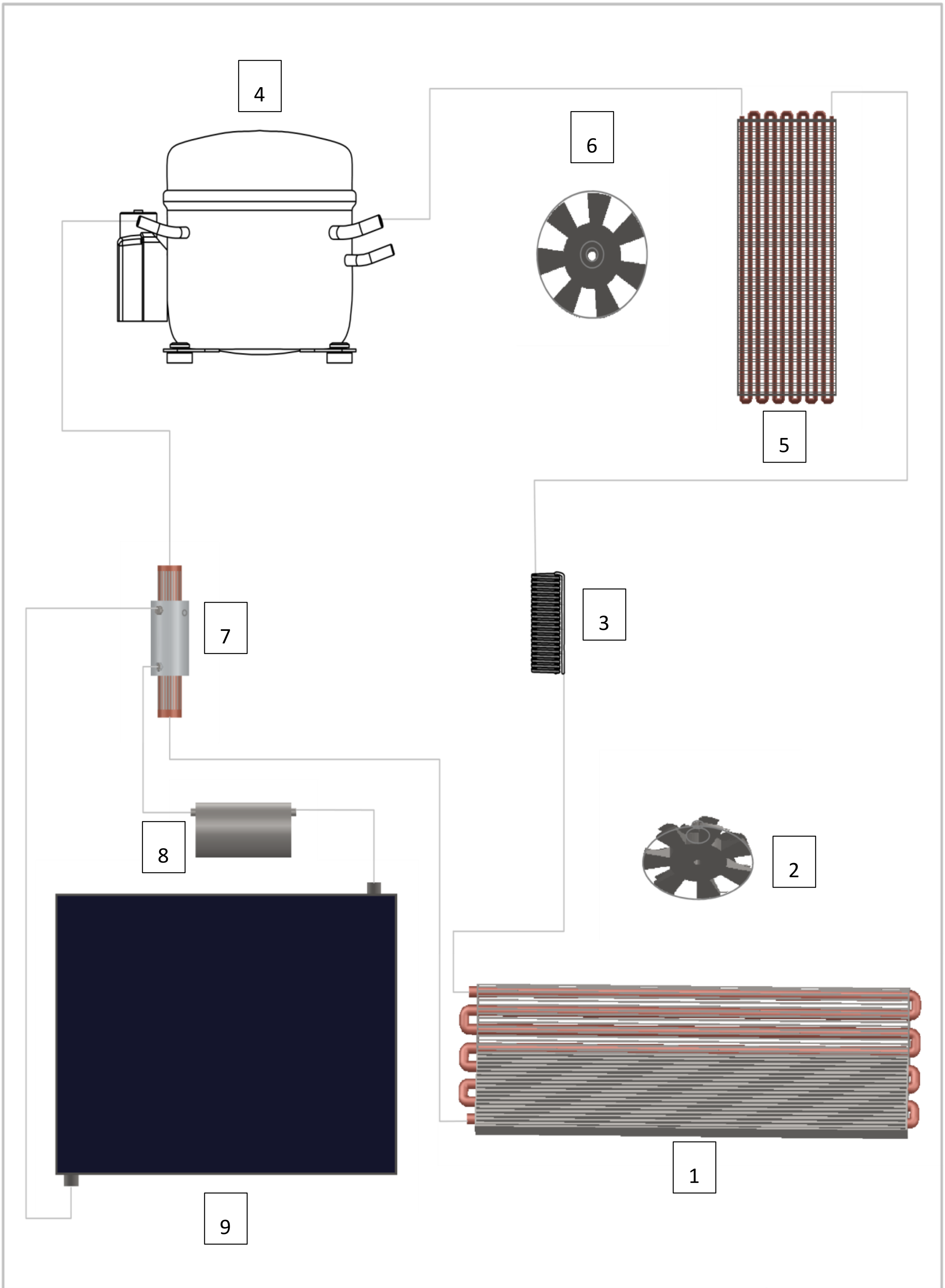
Figure 1.1. Block Diagram of System

1.1 Solar assisted air conditioning:

The aim of the project is to investigate the performance by solar assisted air conditioning system. The air conditioning system relies on one of the basic laws of physics: If a gas is heated, it will expand. All air conditioning systems use a closed loop cycle for the refrigerant (R-134a). The compressor, is typically used to pressurise the refrigerant to allow the process to take place. Alternatively, an external heat source (such as a solar thermal collector) may be used to capture the direct solar energy and impart the heat to the heat transferring fluid (water or nanofluid), and the fluid then imparts its thermal energy to the refrigerant through a double pipe heat exchange thus creating pressure within a closed loop of refrigerant. The more heat the refrigerant is exposed to, the more time the compressor remains shut off due to the continued pressurization of the refrigerant, therefore reducing the run time of the compressor and eventually reducing power consumed.

The air conditioning system has a solar thermal collector installed adjacent to the condenser, which is used to capture heat and impart it in to the refrigerant prior to it passing in to the compressor. To optimise efficiency, the collector has heat conducting inner coils inside it and a header tank (containing the heat transferring fluid). Once the refrigerant passes through the collector, it enters the compressor and the final pressurisation of the cycle occurs.

Once the refrigerator achieves the desired temperature, the condenser will turn off. The refrigerant will continue to cycle until the refrigerator temperature deviates too much from the desired temperature. During this process, gradually, pressure within the circulating refrigerant will decrease and therefore reduce the ability for the system to maintain the desired temperature. When the pressure drops too low, the compressor will turn back on and appropriately re-pressurise the refrigerant. Contrary to this, due to the solar thermal collector system, the refrigerant continues to be pressurised from the heat being imparted in to it and therefore the compressor will remain off considerably longer. The systematic diagram has been shown in figure 1.2.



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBUR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	Part		Part
1	Evaporator	6	Condenser Fan
2	Evaporator Fan	7	Double Pipe
3	Capillary Tube	8	Tank
4	Compessor	9	Solar Thermal Collector
5	Condenser	10	

TITLE:

Systematic Diagram

MATERIAL:
Copper,Iron and Aluminium

DWG NO.

A4

WEIGHT: 18Kg

SCALE:1:5

SHEET 1 OF 1

Figure 1.2 Systematic Diagram

As such, the system consumes collectively much less electricity and, in tandem with the solar thermal collector cycle, optimise energy savings and reduce running costs. This is potentially a substantial savings for the average home, given typically a third of the household power bill is associated with heating and cooling.

The project is mainly divided according to its components into 3 sections:

1.1.1. Air Conditioning System
1.1.2. Solar Thermal Collector
1.1.3. Double Pipe Heat Exchanger

1.1.1. Air Conditioning System

Air conditioning is the process of altering the properties of air (primarily temperature and humidity) to more comfortable conditions, typically with the aim of distributing the conditioned air to an occupied space such as a building or a vehicle to improve thermal comfort and indoor air quality. In common use, an air conditioner is a device that lowers the air temperature. The cooling is typically achieved through a refrigeration cycle, but sometimes evaporation or free cooling is used. In the most general sense, air conditioning can refer to any form of technology that modifies the condition of air (heating, cooling, (de-)humidification, cleaning, ventilation, or air movement). However, in construction, such a complete system of heating, ventilation, and air conditioning is referred to as heating, ventilation, and air conditioning (HVAC-as opposed to AC)

Refrigeration Cycle: In the refrigeration cycle, heat is transported from a colder location to a hotter area. As heat would naturally flow in the opposite direction, work is required to achieve this. A refrigerator is an example of such a system, as it transports the heat out of the interior and into its environment. The refrigerant is used as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere. The cycle is explained in the systematic diagram given on figure 1.3.

1. Circulating refrigerant vapour enters the compressor and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed refrigerant vapour is now at a temperature and pressure at which it can be condensed and is routed through a condenser.

2. Here it is cooled by air flowing across the condenser coils and condensed into a liquid. Thus, the circulating refrigerant removes heat from the system and the heat is carried away by the air.

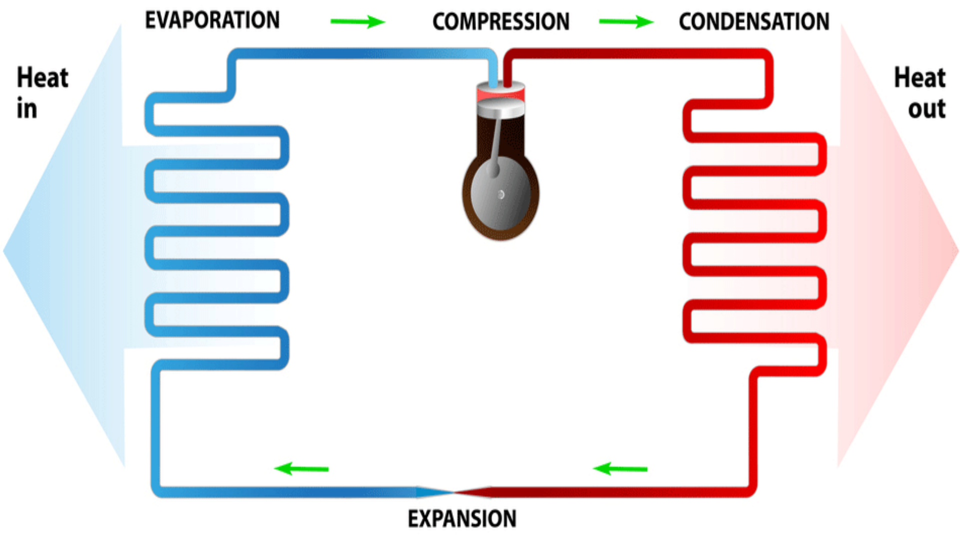


Figure 1.3. Refrigeration Cycle

4. The cold refrigerant is then routed through the evaporator. A fan blows the warm air (which is to be cooled) across the evaporator, causing the liquid part of the cold refrigerant mixture to evaporate as well, further lowering the temperature. The warm air is therefore cooled. To complete the refrigeration cycle, the refrigerant vapour is routed back into the compressor.

3. The condensed and pressurized liquid refrigerant is next routed through an expansion valve where it undergoes an abrupt reduction in pressure. That pressure reduction results in flash evaporation of a part of the liquid refrigerant, lowering its temperature.

1.1.2. Solar Thermal Collector

A solar thermal collector collects heat by absorbing sunlight. A collector is a device for capturing solar radiation. Solar radiation is energy in the form of electromagnetic radiation from the infrared (long) to the ultraviolet (short) wavelengths. The quantity of solar energy striking the Earth's surface (solar constant) averages about 1,000 watts per square meter under clear skies, depending upon weather conditions, location and orientation.

Solar collectors are either non-concentrating or concentrating. In the non-concentrating type, the collector area (i.e., the area that intercepts the solar radiation) is the same as the absorber area (i.e., the area absorbing the radiation). In these types the whole solar panel absorbs light. Concentrating collectors have a bigger interceptor than absorber as seen in figure 1.4. they cover larger area than non-concentrating type as seen in figure 1.5. Flat-plate and evacuated-tube solar collectors are used to collect heat for space heating, domestic hot water or cooling with an absorption chiller.

Fig 1.4. Evacuated Tube Collector

Fig 1.5. Flat-plate Collector

Based on research and literature survey carried out, the solar thermal collector will be designed as a Flat-Plate Collector. They consist of

(1) A dark flat-plate absorber
(2) A transparent cover that reduces heat losses
(3) Heat-transport fluid (water and nanofluid)
(4) Heat insulating backing

Applications of a solar thermal collector:

The main use of this technology is in residential buildings where the demand for hot water has a large impact on energy bills. Commercial applications include laundromats, car washes, and eating establishments. The technology can also be used for space heating/cooling if the building is located off-grid or if utility power is subject to frequent outages.

1.1.3. Double Pipe Heat Exchanger

Heat exchangers are devices that transfer heat in order to achieve desired heating or cooling. An important design aspect of heat exchanger technology is the selection of appropriate materials to conduct and transfer heat fast and efficiently.

Copper has many desirable properties for thermally efficient and durable heat exchangers. First and foremost, copper is an excellent conductor of heat. This means that copper's high thermal conductivity allows heat to pass through it quickly. Other desirable properties of copper in heat exchangers include its corrosion resistance, biofouling resistance, maximum allowable stress and internal pressure, creep rupture strength, fatigue strength, hardness, thermal expansion, specific heat, antimicrobial properties, tensile strength, yield strength, high melting point, alloyability, ease of fabrication, and ease of joining.

The combination of these properties enable copper to be specified for heat exchangers in industrial facilities, HVAC systems, vehicular coolers and radiators, and as heat sinks to cool computers, disk drives, televisions, computer monitors, and other electronic equipment. Copper is also incorporated into the bottoms of high-quality cookware because the metal conducts heat quickly and distributes it evenly.

A CAD model has been made for the double pipe heat exchanger which is given in figure 1.6. It explains the flow of the refrigerant as well as indicates the inlet and outlet openings in the pipe.

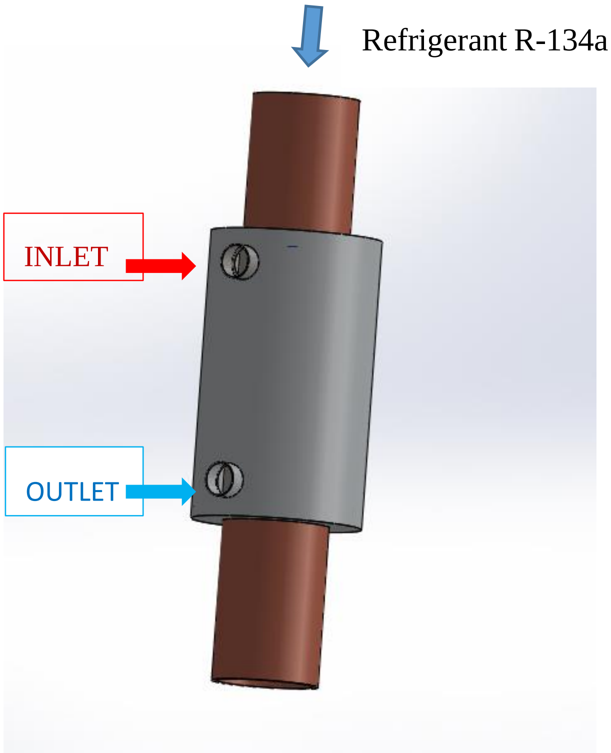


Figure 1.6. Double Pipe Heat Exchanger

CHAPTER 2

LITERATURE SURVEY

Rakib I.Zaman et al in his paper titled, ***"Optimization of Small Window Type Air Conditioner".*** Some research has been focused on optimizing medium to large capacity refrigeration systems, considering both materials cost and operating costs, no such study has yet been done for a small system like the window air conditioner.

Later on some systematic and scientific procedure had been made for optimum deign of liquid chilling plant to predict the performance of its components. [1]

Juan Carlos et al in his paper titled, ***"A Numerical Study on the Application of Nano fluids in Refrigeration Systems".*** The use of Nano fluids as secondary coolants in vapour compression refrigeration systems was numerically studied.

A simulation model for a liquid-to-water heat pump, with reciprocating compressor and double-tube condenser and evaporator was studied. The multi-zone method was employed in the modelling of the heat exchangers. [2]

Frederick F. Simon et al in his paper titled, ***"Flat-plate solar-collector performance evaluation with a solar simulator as a basis for collector selection and performance prediction".*** The use of a solar simulator for performance determination permits collector testing under standard conditions of wind, ambient temperature, flow rate and "Sun".

The performance results determined with the simulator have been found to be in good agreement with outdoor performance results. [3]

John E. Minardi et al in his paper titled, ***"Performance of a "black" liquid flat-plate solar collector".*** A cost-effect, "black" liquid, flat-plate solar collector has been designed, and prototypes have been built and tested. In these collectors a highly absorbent "black" liquid flows in transparent channels and directly absorbs solar energy. [4]

A. Qiu Haitao et al in his paper titled, ***"Green Air-conditioner Design"*** Research has been focused on high-efficiency, energy-saving, and environmental friendly air-conditioning worldwide. This article discusses the design process of a whole-new green air-conditioner with emphasis on the above issues. [5]

A.Braunstein et al in his paper titled ***"On the development of the solar photovoltaic and Thermal (PVT) Collector"*** has thoroughly studied the design and performance of a solar photovoltaic and thermal (PVT) collector.

In this paper a theoretical analysis of the PVT collector using a simulation model is presented. Moreover, the model defines the cases and conditions for which the use of the PVT collector is preferable. [6]

Ihaddadene R et al in his paper titled, ***"The effects of light intensity and collector surface on the performance of a solar thermal collector".*** This system comports a collector, a storage tank, a high power lamp simulating solar energy and a control and command cabinet. The increase of the light intensity from 1043, 12 to 2649, 10 W 1m2 increased the effectiveness of the collector. [7]

J. Jerold John Britto et al in his paper titled, ***"Performance Evaluation of Window Air Conditioner by Incorporating Evaporative Cooling System on the Condenser".*** The experimental results reveals that thermodynamic characteristics of new system i.e. Evaporative Cooling System are considerably improved and power consumption decreases by about 8% and the coefficient of performance increases by about 14.25%. [8]

A. Adhikari et al in his paper titled, ***"Thermal Efficiency Test of Locally Manufactured Solar Flat Plate Collector of Nepal".*** The study was thus carried out to know the present status of flat plate collectors manufactured in Nepal in terms of their thermal performance and also to investigate some guidelines for efficiency enhancement[9]

CHAPTER 3

HARDWARE

In this chapter, the design and hardware installation of various components of the system are discussed. Broadly classifying the system into two parts, first the design of solar thermal collector and second, the air conditioning system.

3.1 Solar Thermal Collector

The different layers that make up the Solar Thermal Collector are researched and the best material has been chosen for the fabrication. The materials used for each layer has been given in the below sections. A Flat-plate collector design has been implemented. The different layers of the Solar Thermal Collector as depicted in Figure 3.1. are given below:

3.1.1. Sheet Metal Frame

3.1.2. Thermal Insulator

3.1.3. Absorber

3.1.4. Copper Pipe

3.1.5. Glazing material

Sun rays strike the surface of the Tempered Glass

Heat absorbed by the black-painted aluminium sheet, also known as absorber, transfers the heat to copper tubing

Layer of insulation provided by the polyurethane foam prevents the heat from escaping out

All of the above contained in the sheet metal box, which is painted in black-matte paint

Figure 3.1. Layers of Solar Thermal Collector

3.1.1. Sheet Metal Frame

The box which will house the different components of the solar thermal collector is made out of sheet metal. Sheet metal is metal formed by an industrial process into thin, flat pieces. It is one of the fundamental forms used in metalworking and it can be cut and bent into a variety of shapes. For this project, the sheet metal is made up of aluminium due to its flexibility, wide range of options, cost effectiveness, and thermal conductivity.

The thickness of the sheet metal is 0.25mm. The outer and inner surfaces of the sheet metal box have been painted in black matte paint as shown in Figure 3.8. to absorb as much radiation as is possible from direct sunlight and also to help retain this energy within the collector. The dimensions for cutting out the material needed to make the box are given below in Figure 3.2.

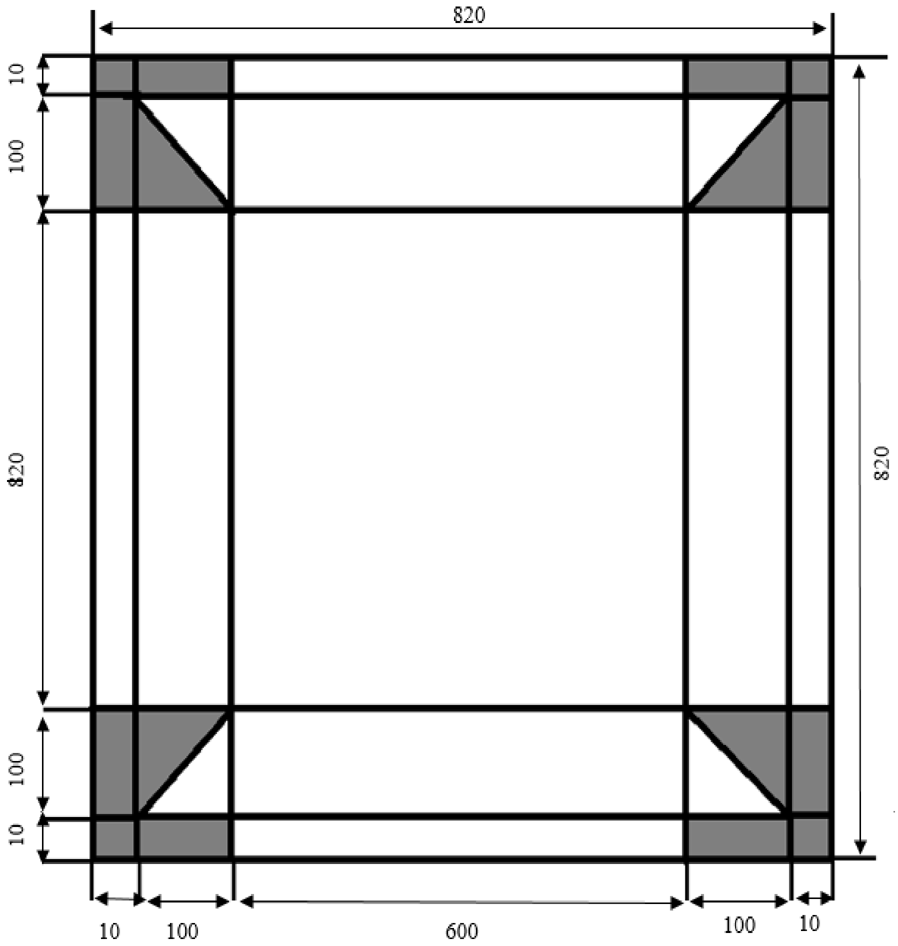


Fig 3.2. Sheet Metal Cut out Dimensions

After the sheet metal was cut out according to the given dimensions in figure 3.3. by using a cutting tool, the sheet metal was bent and hammered along the marked straight lines to form a square box of dimension 60cm x 60cm x 10cm as depicted in figure 3.3

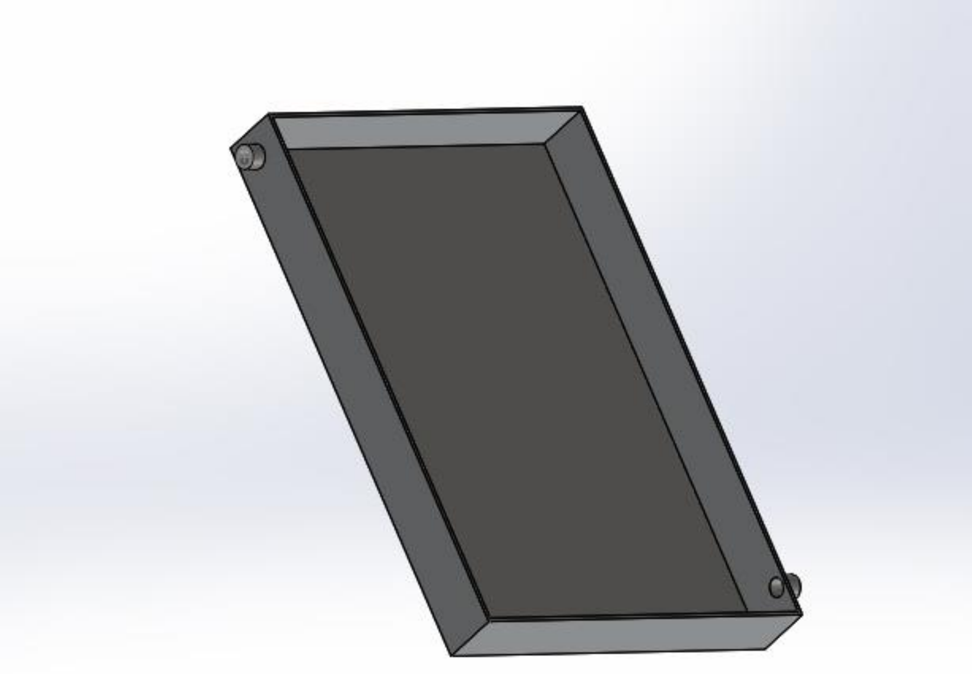


Figure 3.3 Sheet Metal Box

3.1.2. Thermal Insulator

Polyurethane also known as PU Foam is primarily used for thermal insulation required beneath the aluminium sheet to prevent the heat from escaping into the outer layer of the box as well as keeping the heat trapped in the above layers of the collector. Secondarily, this rigid foam gives the much needed stability and carries the weight of the two layers above it which is the aluminium sheet and the copper pipe. The dimensions of the foam layer are 600mm x 600mm x 60mm and its sides were glued with synthetic resin glue to the inner surfaces of the box. This layer is depicted after gluing to the inside of the box in the Figure 3.4

Applications of Polyurethanes:

- Used in the manufacture of high-resilience foam seating
- Rigid foam insulation panels
- Microcellular foam seals and gaskets
- Durable elastomeric wheels and tires (such as roller coaster, escalator, shopping cart, elevator, and skateboard wheels)

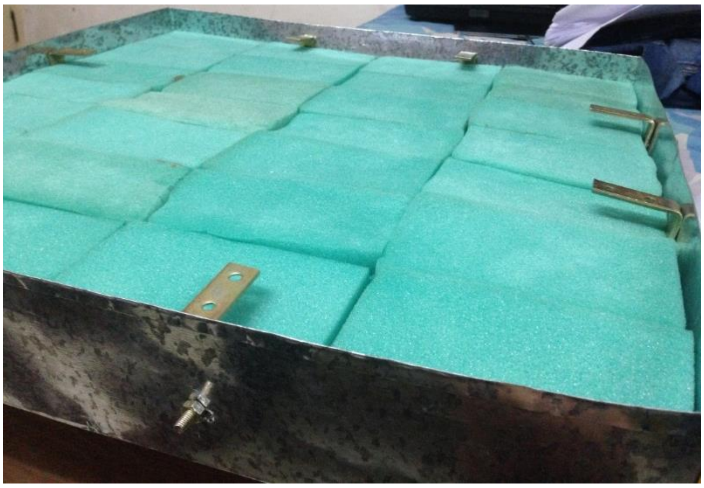


Figure 3.4. Layer of PU Foam

3.1.3. Absorber

The layer which is used to clamp the copper pipe onto is made up of Aluminium. It is so chosen due to its excellent properties which include:

- Good thermal conductivity
- Low density and therefore low weight
- High strength
- Superior malleability
- Excellent corrosion resistance

The thickness of this layer is 0.25mm. The dimensions with which it has been cut out is 60cmx60cm. It has been painted in black matte paint to increase the amount of radiation that it can absorb and retain within the dimensions of the collector. It also transfers the thermal energy from its plate to the copper pipe in addition to the radiation energy from the sun which is directed onto the layer of tempered glass. The figure 3.5. depicts the layer of absorber.

Figure 3.5. Aluminium Sheet

3.1.4. Copper Pipe

Copper tubing is most often used for supply of hot and cold tap water, and as refrigerant line in HVAC systems. HVAC (heating, ventilating, and air conditioning) is the technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality. HVAC system design is a sub discipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer.

Copper is a soft, malleable and ductile metal with very high thermal and electrical conductivity. It is used as a conductor of heat and electricity, as a building material, and as a constituent of various metal alloys. A picture depicting copper pipe is shown in figure 3.6.

Figure 3.6. Copper Pipe

There are two basic types of copper tubing, soft copper and rigid copper. Copper tubing is joined using flare connection, compression connection, or solder. Soft copper is the most popular choice for refrigerant lines in split-system air conditioners and heat pumps as soft (or ductile) copper tubing can be bent easily to travel around obstacles in the path of the tubing.

For the tubing inside the solar thermal collector, copper tubing of size 3/8 has been chosen of length 12m for the coiling in spiral arrangement as shown in figure 3.7. The entire length of the tube was spirally wound, keeping one end of the tube as inlet and the other end as outlet. The tube was appropriately positioned on the aluminium sheet and markings were made, where holes were drilled to screw in U-shaped clamps to hold the pipe onto the sheet and prevent it from displacing from its required position and shape.

Figure 3.7. Arrangement of Spiral Flow Copper Tube

3.1.5. Glazing material

Solar collectors are a fairly tough test of glazing materials. Collectors glazing is exposed to high temperatures, long time outdoor exposure, impacts from hail and/or vandals, while also requiring high light transmission and reasonable cost.

The ideal glazing material for solar collectors would have these properties:

- High temperature capability
- Transmit light very well
- Long life when exposed to UV and high temperatures
- Good impact resistant
- Light weight and easy to work
- Opaque to long IR to reduce heat loss
- Low cost

It is hard to find a glazing material that satisfies each and every specification provided above, but glass is a good glazing material for solar collectors. High transmission (low iron) tempered glass is used on the majority of commercial solar collectors. Toughened or tempered glass is a type of safety glass processed by controlled thermal or chemical treatments to increase its strength compared with normal glass. As a result of its safety and strength, toughened glass is used in a variety of demanding applications including:

- Passenger vehicle windows
- Architectural glass doors and tables
- Refrigerator trays
- Mobile screen protectors
- As a component of bulletproof glass, for diving masks, and various types of plates and cookware.

Tempered Glass is used when strength, thermal resistance, and safety are important considerations. Dimensions of the tempered glass is 60cm x 60cm x 8mm. The figure 3.8 depicts a picture of tempered glass.

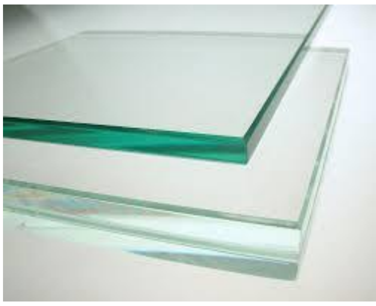


Figure 3.8. Tempered Glass

The assembled Solar Thermal Collector with all the different layers has been put together and the model has been shown in figure 3.9.

Figure 3.9. Solar Thermal Collector

3.1.6. Electronic Components

The main purpose of the program written for the collector was to read and display the temperatures at the inlet and outlet of the collector along with the flow rate of the fluid within the collector. Components needed for this program are:

3.1.6.1. Arduino Uno Board

3.1.6.2. Temperature Sensors (2)

3.1.6.3. Flow rate sensor

3.1.6.4. LCD

- 4.7K pull up resistor
- Connecting wires
- 9V battery for portable display

3.1.6.1. Arduino Uno

The Arduino Uno is a microcontroller as shown in Figure 3.10. The main purpose of using the Arduino Uno is because it acts as an intermediate between the sensors and the LCD by reading the data from the sensors (temperature and flow rate sensors) which is in digital form, then giving the output onto the display (LCD). The figure 3.10 shows a picture of the Arduino Uno board.

Figure 3.10. Arduino Uno

3.1.6.2. Temperature Sensor

The temperature sensors used for this program are 1m long Waterproof digital temperature sensor probes based on DS18B20 sensor. Used when needed to measure something far away, or in wet conditions. As it is digital, any signal degradation even over long distance does not take place.

These 1-wire digital temperature sensors are fairly precise (±0.5°C over much of the range) and can give up to 12 bits of precision from the onboard digital-to-analog converter. The only downside is they use the Dallas 1-Wire protocol, which is somewhat complex, and requires a bunch of code to parse out the communication. When using with microcontroller put a 4.7k resistor to sensing pin, which is required as a pullup from the DATA to VCC line. The figure 3.11. shows the temperature sensor used in the program. One was placed at the inlet of the collector and another at the outlet. The cable and sensor specifications are given in Appendix-1.

Figure 3.11. Temperature Sensor

3.1.6.3. Flow rate sensor

YF-S201 Water Flow Sensor can be used to measure the flow of liquids in both industrial and domestic applications. This sensor basically consists of a plastic valve body, a rotor and a hall effect sensor. The pinwheel rotor rotates when water / liquid flows through the valve and its speed will be directly proportional to the flow rate. The hall effect sensor will provide an electrical pulse with every revolution of the pinwheel rotor. This water flow sensor module can be easily interfaced with Microcontrollers, Arduino Boards and Raspberry Pi. The PWM output of this module is connected to interrupt pin of microcontroller unit and the number of pulses / interrupt per unit time is counted. The rate of water flow will be directly proportional to the number of pulses counted. The range of flow rate it is able to detect is 1-30L/min. It can operate within a temperature range of -25°C ~ 80°C. The figure 3.12 shows the flow rate sensor used in the program. The specifications are given in Appendix-1.

Figure 3.12. Flow rate sensor

3.1.6.4. LCD

Figure 3.13. LCD

The Serial LCD as shown in Figure 3.13. is extremely easily to interface with PCs, microcontrollers or any other device which can send the serial commands. The interface contains only 3 pins, +5V, GND and RX. It uses only 1 microcontroller pin, and so it saves lots of hardware complexities and time. The LCD displays the temperature at inlet and outlet of the collector as well as flow rate given by the flow rate sensor.

3.1.6.5. Assembly of flow and temperature sensor

Using the data pin of flow sensor and temperature sensor, digital input is given to the Arduino Uno and a 9V power supply is given to the microcontroller. A 16x2 LCD is attached to the power supply and the data pin is given to the Arduino for serial communication between LCD and microcontroller.

The circuit connections of the collector with the number of pins are given in brackets in figure 3.14.

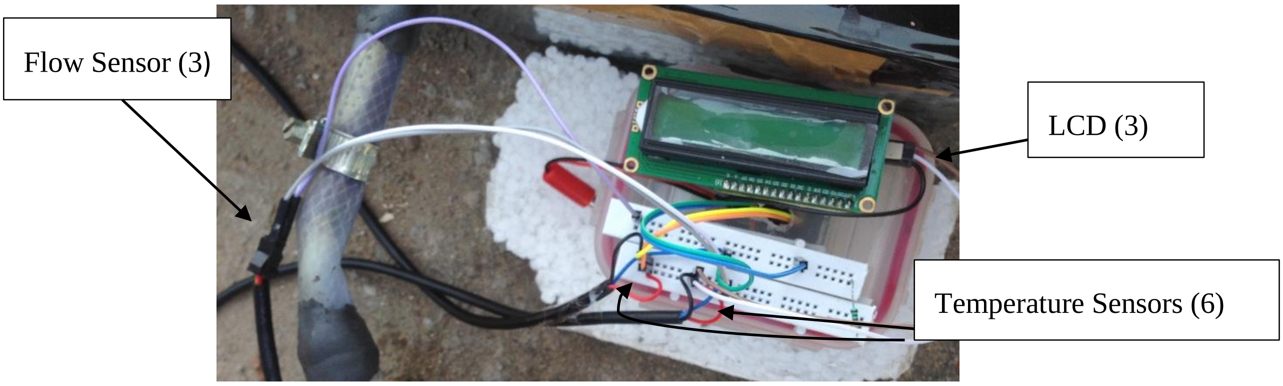


Figure 3.14. Circuit connections in collector

3.2. Air Conditioning System

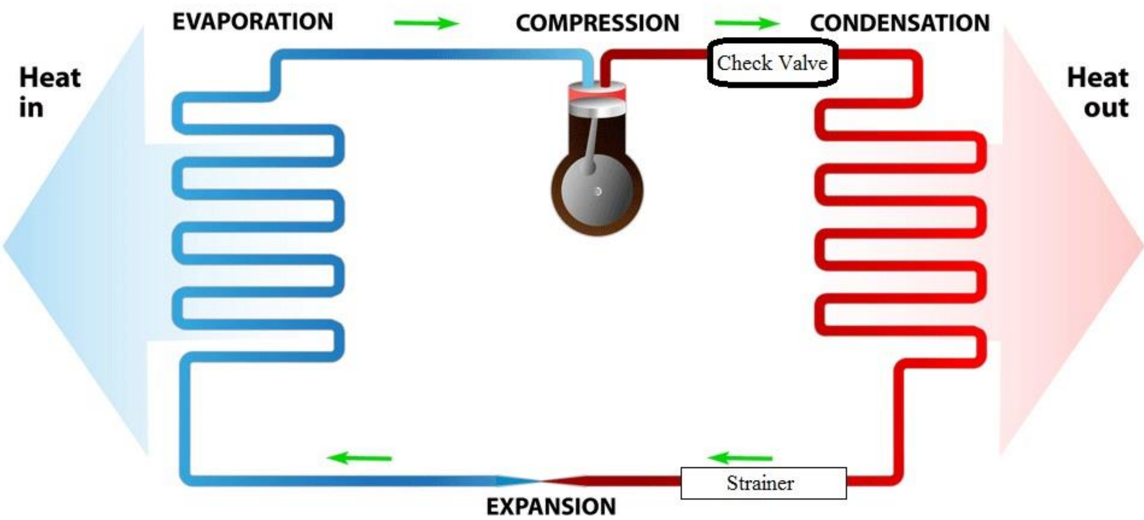


Figure 3.15. Components of A/C system

The air conditioning system has been welded together as per the figure 3.15. which depicts the components involved within the system which are the same basic components required in any air conditioning system. The basic components involved are:

- Compressor
- Condenser Coil
- Capillary Tube
- Evaporator Coil

3.2.1. Compressor

Refrigeration compressors and air conditioning compressors provide air conditioning, heat pumping and refrigeration for large-scale facilities and equipment. They use compression to raise the temperature of a low-pressure gas, and also remove vapour from the evaporator. The figure in 3.16 shows the compressor used in the system.

Refrigerant compressors work by taking in low pressure gas on the inlet and compressing it mechanically. This compression creates a high temperature, high pressure gas - an essential step in the overarching refrigeration cycle. The compressor used in the system is from the LG company having model number: LGMA42LM. The technical specifications of the compressor are given in the Appendix as Table 3.1

Figure 3.16. Compressor

3.2.2. Condenser Coil

A condenser is a device or unit used to condense a substance from its gaseous to its liquid state, by cooling it. In doing so, the latent heat is given up by the substance, and will transfer to the condenser coolant. Condensers are typically heat exchangers which have various designs and come in many sizes ranging from rather small (hand-held) to very large industrial-scale units used in plant processes. The condenser in the system is of dimension 9x9x2Rows as shown in figure 3.17.

Figure 3.17. Condenser Coil

3.2.3. Capillary Tube

Capillary tube is one of the most commonly used throttling devices in the refrigeration and the air conditioning systems. The capillary tube is a copper tube of very small internal diameter. It is of very long length and it is coiled to several turns so that it would occupy less space. The internal diameter of the capillary tube used for the refrigeration and air conditioning applications varies from 0.5 to 2.28 mm (0.020 to 0.09 inches) as shown in figure 3.18.

Figure 3.18. Capillary Tube

When the refrigerant leaves the condenser and enters the capillary tube its pressure drops down suddenly due to very small diameter of the capillary. In capillary, the fall in pressure of the refrigerant takes place not due to the orifice but due to the small opening of the capillary. The decrease in pressure of the refrigerant through the capillary depends on the diameter and the length of the capillary. Smaller is the diameter and more is the length, more is the drop in pressure of the refrigerant as it passes through it. In the normal working conditions of the refrigeration plant there is drop in pressure of the refrigerant across the capillary but when the plant stops the refrigerant pressure across the two sides of the capillary equalize. Due to this reason when the compressor restarts there won’t be much load on it. Also, due to this reason one cannot over-charge the refrigeration system with the refrigerant.

The capillary tube is non-adjustable device that means one cannot control the flow of the refrigerant through it as one can do in the automatic throttling valve. Due to this the flow of the refrigerant through the capillary changes as the surrounding conditions changes. For instance, as the condenser pressure increases due to high atmospheric pressure and the evaporator pressure reduces due to lesser refrigeration load the flow of the refrigerant through the capillary changes. Thus the capillary tube is designed for certain ambient conditions. However, if it is selected properly, it can work reasonably well over a wide range of conditions.

3.2.4. Evaporator Coil

An evaporator is a device used to turn the liquid form of a chemical into its gaseous form. The liquid is evaporated, or vaporized, into a gas. The number of turns in the evaporator coil is 6 as shown in figure 3.19.

Figure 3.19. Evaporator Coil

3.2.5. Housing

In the commercial industry, air conditioning appliances are divided on the basis of an outdoor unit and indoor unit. Outdoor unit consists of compressor and condenser coil. Evaporator coil and blower fan are attached in the indoor unit. In the project, one particular housing has been designed with two opposite directions of air flow. The compartment at the bottom houses most of the weight of the system, which comprises of the compressor, the condenser coil and the fan for the cooling of condenser. Upper compartment comprises of the continuation of the capillary tube and evaporator coil and blower fan. The upper compartment has been given an insulation layer of thermocole to enhance the cooling effect. The figure 3.20 given explains the exact dimensions of the outer housing and the final fabrication of the outer housing is seen on figure 3.21 including the thermocole used to cover the evaporator coil area.

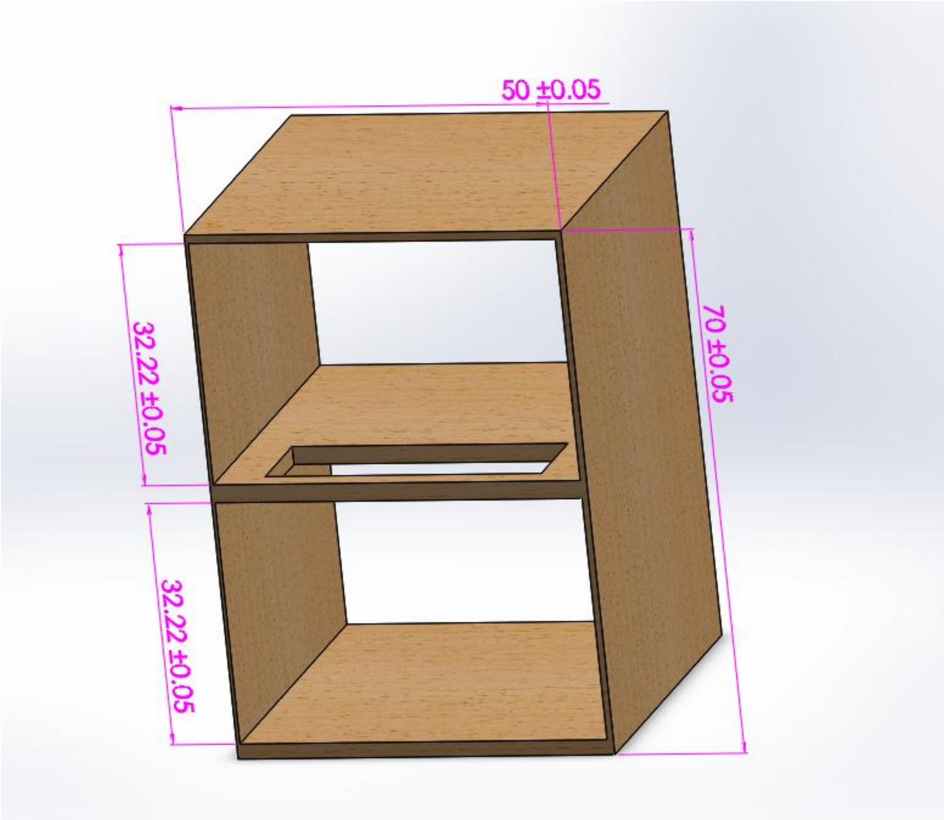


Figure 3.20. Housing Dimensions

Figure 3.21. Air Conditioning system setup

3.2.6. Control System

In this section, the electronic components used in the program that controls the switch ON/OFF of the compressor, which is the main component in the air conditioning system has been explained. Components needed for this program are:

3.2.6.1. Arduino Uno Board

3.2.6.2.Relay

3.2.6.3.Temperature Sensor DS18B20

- 9V Battery for power supply to Arduino Board

3.2.6.1. Arduino Uno

Figure 3.22. Arduino Board

The purpose of using Arduino Uno as shown in figure 3.22 is so that the compressor's relay is switched ON/OFF by the signal given by the Arduino. If temperature sensor detects a temperature >36 degrees then the Arduino gives the signal to the relay to switch ON the compressor else if temperature<25, then the Arduino gives the signal to the relay to switch OFF the compressor.

3.2.6.2. Relay

Figure 3.23. Relay

The figure 3.23. shows a 2-channel relay module board with LED indicators which is the main component for switching ON/OFF of the compressor. It can be controlled by microcontrollers such as Arduino, AVR, PIC, ARM any other microcontroller operating at 5V.

3.2.6.2. Temperature Sensor

The same temperature sensor, which is the DS18B20 was used as in the collector. Specifications are the same as mentioned in the Appendix. With the use of the temperature sensor which is placed at the evaporator coil, the set temperature, once detected by the Arduino will send a signal to the relay to switch ON/OFF the compressor.

The circuit connections have been shown in the figure 3.24. which shows the components used for the program.

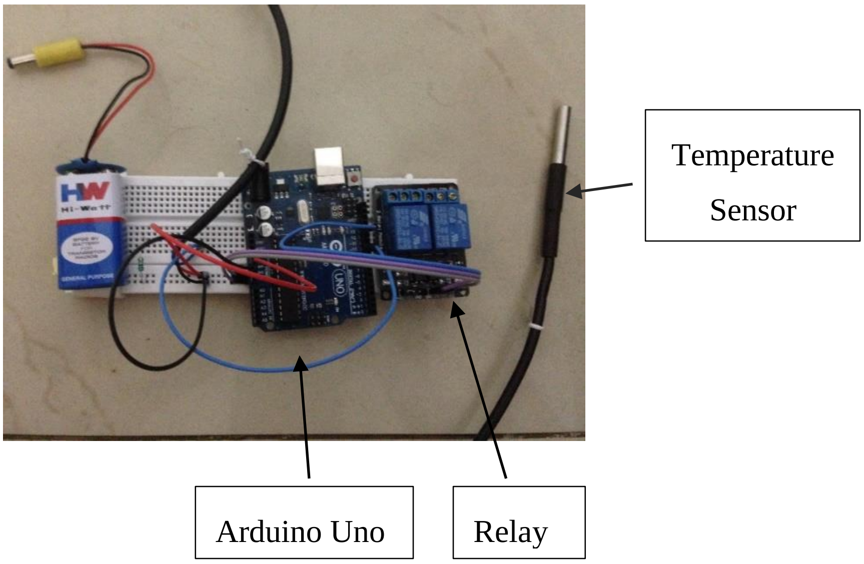


Figure 3.24. Circuit for control system

3.3 Nanofluid

A nanofluid is a fluid containing nanometer-sized particles, called nanoparticles. These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The nanoparticles used in nanofluids are typically made of metals, oxides, carbides, or carbon nanotubes. Common base fluids include water, ethylene glycol and oil.

Nanofluids have novel properties that make them potentially useful in many applications in heat transfer, including microelectronics, fuel cells, and hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger, in grinding, machining and in boiler flue gas temperature reduction. As they exhibit enhanced thermal conductivity and the convective heat transfer coefficient compared to the base fluid, their purpose in the project has been to increase the heat transfer capacity with the refrigerant in the double pipe heat exchanger. The nanofluid was separately prepared in a laboratory using an apparatus known as the ultrasonic sonicator as shown in figure 3.25.

Figure 3.25. Ultrasonic Sonicator

3.3.1 Preparation

The preparation of the nanofluid was carried out in a laboratory taking the necessary precautions and steps followed accordingly as given below.

Aim:

To prepare 3.5 litres of nanofluid using Al_2O_3 nanoparticles

Apparatus Required:

Ultrasonic Sonicator

Beaker 350 ml (1)

Beaker 500ml (1)

Mixer rod

Spatula

Weighing Scale

Chemical Required:

Base fluid – water (3.5L)

Al_2O_3 nanoparticles (1.4g)

Procedure:

1. Take 350 ml glass beaker and place it inside a 500 ml glass beaker with ice. The smaller glass beaker will have the solution and the bigger beaker is meant to surround the solution with ice.
2. For a single batch of nanofluid, measure 0.14g of AL_2O_3 nanoparticle with a spatula and place it on a butter paper and keep it on the weighing scale to accurately measure its weight.
3. Mix the particles with a glass mixer rod in 350 ml of distilled water.
4. Before switching on the ultrasonic sonicator, clean the probe of the sonicator to avoid any involvement of foreign particles.
5. Set the sonicator for 5 cycles * 10% for a time limit of 20 minutes.
6. Close the sonicator door and move away from the sonicator as vibrations and noise are made during the process.
7. Press the start button. After 20 minutes the nanofluid solution will be thoroughly mixed.
8. For 3.5 Litres of nanofluid solution, the above steps were repeated 10 times.

The prepared solution is shown in the figure 3.26 below giving a comparison of water and nanofluid solution.

Figure 3.26. Comparison between water and nanofluid solution

CHAPTER 4

SOFTWARE

This chapter mainly focuses on the algorithm for the program codes used for the operation of the system. The coding was done in Arduino Software. There were two programs written for:

4.1. Flow and Temperature Sensing

4.2. Control System