Fabrication and Performance Evaluation of Rectangular and Oval Cross Section Solar Water Heater

A report submitted to the Department of Mechanical, 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

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ABSTRACT

Solar energy is getting popular nowadays. Technologies have been developed which made solar energy a cheaper and reliable source of energy. Due to pollution and other factors, solar has become the most popular source of energy. Along with power generation, now water heaters are also developed which are working on the solar technology. It is a reliable method and can be used in areas which do not have access to wood, coal and gas. This project is based on design and fabrication of solar water heater. In this project, active water heaters are employed which way. Copper Pipe of both is oval and rectangular used to compare the heat transfer. A motor will be suck water from reserves tank to hot water tank and galvanized copper pipe will be heated from the sun light. Between rectangular & oval pipe we found oval pipe heat transfer rate is more than rectangular pipe. Local materials and manufacturing methods were used to fabricate the solar water heater to limit the cost of project. At the end impact of the project was discussed on social, economic and environmental grounds.

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CHAPTER 1
INTRODUCTION

1.1 Introduction

This project is intended to design a water heating system by using solar technology. There are various design and manufacturing constraints but here the most general and efficient way would be used. It includes thorough study of the mechanism of the solar water heater. After designing such mechanism, the heater would be manufactured, and the results would be presented. Solar energy technology is used in various places in different ways. It is used to produce electricity and it provides energy which is used to cook food. [1] Solar systems are designed in such a way that water can be heated to any temperature. But at domestic levels water can be heated up to 60 ºC. Evaculed types of solar heaters and glazed plate heaters are the most common types of solar powered water heaters used in the world. Some of the systems are active and others are passive. Active systems are divided into direct and indirect solar systems. In this project indirect solar system will be designed.

The world relies heavily on fossil fuels for most of its energy demands, and this has caused a lot of harm to the Earth. [2] The increase of green-house gas levels in the atmosphere is largely due to the combustion of fossil fuels as a source of energy. This has caused global warming which has led to climate change, floods, forest fires, rising sea levels and the melting of glaciers. These are just some consequences of the over-reliance on fossil fuels for our energy demands. Solar energy provides an alternative and environmentally friendly energy source to the fossil fuels used for our energy needs. Over the last few decades, solar energy systems have gained more recognition because they can provide energy at a low long-term cost and minimal environmental damage.

[3] Researchers have developed several techniques for harnessing solar energy, these techniques include applications for space heating, water heating, electricity generation and many others. Solar energy is generated by the fusion reaction of hydrogen atoms in the sun. This fusion reaction results in the release of high-energy particles called gamma

rays. Gamma rays are transmitted as electromagnetic radiation to the Earth, which is at about 150 million kilometers from the sun. Electromagnetic radiation comes in three forms: infrared rays, visible light, and ultraviolet rays. [4] Solar energy reaching the Earth's surface can be harnessed directly by using photovoltaic (solar cells) and solar concentrators. Photovoltaic are used for electricity generation, while solar concentrators are used as a source of thermal energy. The utilization of solar energy collectors (concentrators) to transform radiation into heat energy is the basis of the solar water heating technology. A simple solar water heater consists of a collector, a tank, and the flow channel through which the working fluid is transported.

1.2 Problem Statement

Considering the epileptic nature of electric power supply in our country, the reliance on solar applications for water heating will lead to better reliability of service for hot water needs and will have minimal negative impact on the environment. This would reduce the reliance on electric heaters, which have higher operational costs and depend on fossil fuels as a primary energy source.

1.3 Motivation for the Study

A lot of research has gone into the solar energy field over the past few decades. This is mostly because of the increased world-wide acknowledgement of the environmental effects that the use of fossil fuel as an energy source comes with. This current study would result in the design and construction of a portable solar water heating system which would provide hot water. The use of locally sourced materials would reduce the financial resources required compared to the importation of these materials. With this system our country going through a recession and a pandemic which has further impacted the nation's economy, the availability of locally made solar water heating systems would help boost the local economy and curb the rate of importation.

1.4 Objective

The aim of this project is to design and construct a portable solar water heater. The objectives are:

- To design and Construct Solar Water Heater Rectangular and Oval Cross Section.
- To carry out the performance evaluation of the constructed solar water heater.
- To compare the performance of the above two types to set the best performance.

1.5 Structure of the Project

This Project is organized as follows:

Chapter 1 Introduction: The first chapter contains the statement of the introduction, problem statement, motivation of our study, objectives and the project outline.

Chapter 2 Literature Review: The chapter two contains introduction, about solar water heater theory, types of solar water heater, literature review part and summary.

Chapter 3 Hardware and Software Analysis: Chapter three describes the theoretical model. Here we mainly discuss about proposed system about Hardware.

Chapter 4 Methodology: Chapter four deals with our project methodology, working steps, block diagram, structural design, working principle.

Chapter 5 Result and Discussion: Chapter five deals with our project discussion, result part of our project advantages and our project application study.

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

CHAPTER 2
LITERATURE REVIEW

2.1 What is Solar Water Heater

Solar water heater the conversion of sunlight into renewable energy for water heating using a solar thermal collector. Solar water heating system comprises various technologies that are used worldwide increasing. In a "close-coupled SWH system the Storage Tank is horizontally mounted immediately above the solar collectors on the roof. No pumping is required as the hot water naturally rises into the tank thought thermo siphon flow. [5] In a "pump-circulated" system the storage tank is ground – or floor – mounted and is below the level of the collectors; a circulating pump moves water or heat transfer fluid between the tank and the collector.

A Solar Water Heater is a device which provides hot water for bathing, washing, cleaning, etc. using solar energy. It is generally installed at the terrace or where sunlight is available and heats water during day time which is stored in an insulated storage tank for use when required including morning. We are blessed with Solar Energy in abundance at no cost. The solar radiation incident on the surface of the earth can be conveniently utilized for the benefit of human society.

One of the popular devices that harness the solar energy is solar hot water system (SHWS). [6] A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water. The solar energy incident on the absorber panel coated with selected coating transfers the hat to the riser pipes underneath the absorber panel. The water passing through the risers get heated up and is delivered the storage tank. The re-circulation of the same water through absorber panel in the collector raises the temperature to 80 C (Maximum) in a good sunny day [7].

The total system with solar collector, storage tank and pipelines is called solar hot water system. Broadly, the solar water heating systems are of two categories. They are: closed loop system and open loop system. In the first one, heat exchangers are installed to protect the system from hard water obtained from bore wells or from freezing temperatures in the cold regions.

2.2 Types of Solar Water Heaters

Solar water heaters can be either active or passive. An active system uses an electric pump to circulate the heat transfer fluid; a passive system has no pump. The amount of hot water a solar water heater produces depends on the type and size of the system, the amount of sun available at the site, proper installation, and the tilt angle and orientation of the collectors. Solar water heaters are also characterized as open loop (also called "direct") or closed loop (also called "indirect"). An open-loop system circulates household (portable) water through the collector. A closed-loop system uses a heat-transfer fluid (water or diluted antifreeze, for example) to collect heat and a heat exchanger to transfer the heat to household water.

2.3.1 Active Systems

Active systems use electric pumps, valves, and controllers to circulate water or other heat-transfer fluids through the collectors. They are usually more expensive than passive systems but are also more efficient. Active systems are usually easier to retrofit than passive systems because their storage tanks do not need to be installed above or close to the collectors. But because they use electricity, they will not function in a power outage. Active systems range in price from about $2,000 to $4,000 installed.

2.3.2 Open-Loop Active Systems

Open-loop active systems use pumps to circulate household water through the collectors. This design is efficient and lowers operating costs but is not appropriate if your water is hard or acidic because scale and corrosion quickly disable the system. These open-loop systems are popular in nonfreezing climates such as Hawaii. They should never be installed in climates that experience freezing temperatures for sustained periods. You can install them in mild but occasionally freezing climates, but you must consider freeze protection. Re circulation systems are a specific type of open-loop system that provide freeze protection. They use the system pump to circulate warm water from storage tanks through collectors and exposed piping when temperatures approach freezing. Consider re circulation systems only where mild freezes occur once or twice a year at most. Activating the freeze protection more frequently wastes electricity and stored heat. Of course, when the power is out, the pump will not work and the system will freeze. To guard against this, a freeze valve can be installed to provide additional protection in the event the pump doesn't operate. In freezing weather, the valve dribbles warmer water through the collector to prevent freezing.

2.3.3 Closed-Loop Active Systems

These systems pump heat-transfer fluids (usually a glycol-water antifreeze mixture) through collectors. Heat exchangers transfer the heat from the fluid to the household water stored in the tanks. Double-walled heat exchangers prevent contamination of household water. Some codes require double walls when the heat transfer fluid is anything other than household water.

2.3.4 Passive Systems

Passive systems move household water or a heat-transfer fluid through the system without pumps. Passive systems have no electric components to break. This makes them generally more reliable, easier to maintain, and possibly longer lasting than active systems. Passive systems can be less expensive than active systems, but they can also be less efficient. Installed costs for passive systems range from about $1,000 to $3,000, depending on whether it is a simple batch heater or a sophisticated thermo siphon system.

2.3 Literature Review

The solar energy that the Earth receives in a day is far greater than the total amount of energy that humans use up in the same time period. Eighteen days of the incident solar radiation on Earth would give an equivalent amount of energy when compared to all the planet's reserves of natural gas, coal and oil (Union of concerned scientists, 2015). Outside the earth's atmosphere, solar radiation contains about 1,300 watts per square meter. [4] A third of this gets reflected into space once it reaches the earth's atmosphere, the rest travels toward the surface of the earth. On average, over the earth's surface, every square meter receives about 4.2 kilowatt-hours of solar energy in a day (Union of concerned scientists, 2015).

Although the solar energy received by the Earth daily is greater than amount used by humans, the intensity of this solar energy or radiation incident on the Earth's surface depends on some factors. These factors include the geographic location and its inherent climate, the weather patterns or season and the time of day. [5] At certain periods within the year, the Earth is near the sun, this is because the Earth revolves elliptically around the sun. When the Earth is nearer the sun, its surface receives a higher amount of solar radiation. Earth's rotation around the sun is on a tilted axis of 23.5° and this plays a role in determining the incident radiation at a given location. For the six months within the two equinoxes, the Earth's tilted rotation brings about longer daytime in the northern hemisphere. [6] The southern hemisphere on the other hand, has longer days for the six months after the fall equinox. The southern parts of the United Kingdom and other middle latitudes get higher amounts of radiation during summer due to the longer days.

However, during winter, regions around the middle latitude receive lower amounts of solar energy because the solar rays are incident at a tilted angle during winter in middle latitude regions (Office of energy efficiency and renewable energy, 2013). The intensity of the solar radiation received on the earth's surface depends on the angle the sun's rays make with the earth's surface. This angle ranges from 0°: when the sun is just above the skyline, to 90°: when the sun is directly overhead. [7] The greatest intensity of solar radiation striking the Earth's surface can be observed at solar noon. This is when the sun is at its highest position (90°) in the sky, on a clear, cloudless day (Energy information administration, 2020). At angles less than 90°,the solar rays travel longer distances through the atmosphere, making them less intense by the time they reach the Earth's surface.

As solar rays travel through the Earth's atmosphere, some rays get absorbed or reflected and others get scattered. Various elements such as the air molecules, water vapour, the clouds, dust particles and volcanoes influence whether the solar rays get absorbed, reflected, or scattered. Based on this, solar radiation is classified into two components, diffuse and direct beam solar radiation. [8] Direct beam rays reach the earth's surface without being diffused. Diffuse rays get scattered, absorbed or reflected by the dust particles, air molecules or water vapor in the Earth's atmosphere (Adefarati & Bansal, 2019).

When the solar collector of a SWH is inclined, the diffuse rays striking it comprises the sky diffuse radiation, and a third component of solar radiation: Ground reflected radiation (Ineichen et al., 1990). The ground reflected radiation reflects off the earth surface and strikes the collector. [9] The direct radiation gets affected by atmospheric conditions, on a clear, dry day it can reduce by up to 10% and during thick, cloudy days, by up to 100% (Office of energy efficiency and renewable energy, 2013). Global solar radiation is the total amount of solar energy the earth's surface receives, it is equivalent to the sum of the diffuse, direct beam and ground reflected radiation.

While concentrating solar systems require direct beam solar radiation to function properly, the flat-plate collector system functions properly with both the diffuse and direct beam solar radiation (Energy information administration, 2020). Scientific researchers record the amount of solar radiation incident on specific locations at various periods during the year. [10] These values are used to estimate the amount of solar radiation incident in other locations with similar latitudes and local weather. Solar energy measurements are usually expressed as the total amount of solar radiation on a horizontal surface, or as the total solar radiation on a surface tracking the sun. Solar radiation data is usually represented as kilowatt-hours per square meter (Office of energy efficiency and renewable energy, 2013).

2.4 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 Plastic Pipe

Plastic pipe is a tubular section, or hollow cylinder, made of plastic. It is usually, but not necessarily, of circular cross-section, used mainly to convey substances which can flow liquids and gases (fluids), slurries, powders and masses of small solids. It can also be used for structural applications; hollow pipes are far stiffer per unit weight than solid members.

Product Description:

Product Name:	clear pvc tubing
Material:	pvc
Size:	from 1/8inch (ID 3mm) to 2inch (ID 50mm)
Wall Thickness:	from 1mm to 4mm
Color:	clear / blue / red / yellow / black / green / orange etc.
Working Pressure:	from 2bar (30psi) to 4bar (60psi)
Temperature Range:	from -5 to 65 degree C.
Length/roll	10m, 20m, 30m, 50m/roll or other.

Application:

Suitable for low pressure transfer of various Fluids and air, such as fuel, water, light chemicals, oxygen, gas for watering systems, peristaltic pumps, electrical and thermal insulation, analytical systems in plant equipment, laboratories, watering system and many other low pressure industry applications.

Figure 3.1 : Plastic Pipe

3.2 Temperature Meter

A temperature meter is an instrument used to measure the temperature of beings or things. The most widely recognized temperature meter is a mercury thermometer used to measure the temperature of people.

Figure 3.2: Temperature Meter

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

3.3 Pump Motor

Figure 3.3: Pump Motor

- Power:16.8W
- Max Flow Rate: 700 L/H
- Max Water Head: 5M Max
- Circulating Water Temperature: 60°C

Specification:

- Material: ABS (Acrylonitrile Butadiene Styrene) + Stainless Steel

- Overall Size: Approx. 80 x 48 x 63mm/3.15 x 1.89 x 2.48"

- Pump Inlet Diameter: 16mm(Outer), 12mm(Inner)

- Pump Outlet Diameter: 12mm(Outer), 6.9mm(Inner)

- Inlet/Outlet: 1/2" male thread

- Voltage: 6-12V DC

- Maximum Rated Current: 1.2A

- Power:16.8W

- Max Flow Rate: 700 L/H

- Max Water Head: 5M

- Max Circulating Water Temperature: 60°C

3.4 Oval Pipe

A **structure** is an arrangement and organization of interrelated elements in a material object or system, or the object or system so organized.[1] Material structures include man-made objects such as buildings and machines and natural objects such as biological organisms, minerals and chemicals. Abstract structures include data structures in computer science and musical form. Types of structure include a hierarchy (a cascade of one-to-many relationships), a network featuring many-to-many links, or a lattice featuring connections between components that are neighbors in space Buildings, aircraft, skeletons, anthills, beaver dams, bridges and salt domes are all examples of load-bearing structures. The results of construction are divided.

Figure 3.4: Oval Pipe

into buildings and non-building structures, and make up the infrastructure of a human society. Built structures are broadly divided by their varying design approaches and standards, into categories including building structures, architectural structures, civil engineering structures and mechanical structures. The effects of loads on physical structures are determined through structural analysis, which is one of the tasks of structural engineering. The structural elements can be classified as one-dimensional (ropes, struts, beams, arches), two-dimensional (membranes, plates, slab, shells, vaults), or three-dimensional (solid masses).[2]: 2 Three-dimensional elements were the main option available to early structures such as Chichen Itza. A one-dimensional element has one dimension much larger than the other two, so the other dimensions can be neglected in calculations; however, the ratio of the smaller dimensions and the composition can determine the flexural and compressive stiffness of the element. Two-dimensional elements with a thin third dimension have little of either but can resist biaxial traction.[2]: 2–3

3.5 Rectangular Pipe

A structure is an arrangement and organization of interrelated elements in a material object or system, or the object or system so organized.[1] Material structures include man-made objects such as buildings and machines and natural objects such as biological organisms, minerals and chemicals. Abstract structures include data structures in computer science and musical form. Types of structure include a hierarchy (a cascade of one-to-many relationships), a network featuring many-to-many links, or a lattice featuring connections between components that are neighbors in space Buildings, aircraft, skeletons, anthills, beaver dams, bridges and salt domes are all examples of load-bearing structures. The results of construction are divided

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3.6 Fogging Misting Nozzle T Connector

A **fog nozzle** is a firefighting hose spray nozzle that breaks its stream into small droplets. By doing so, its stream achieves a greater surface area, and thus a greater rate of heat absorption, which, when compared to that of a smoothbore nozzle, speeds its transformation into the steam that smothers the fire by displacing its oxygen. Specially designed fog nozzles (with no stream adjustment) have been certified by Underwriters Laboratories (UL) for use on Class B & C hazards.

Figure 3.6: Fogging Misting Nozzle

Fog nozzles play an important part in firefighting tactics due to their versatility. The wide variety of fog nozzle manufacturers allows them to accommodate different sizes of fire hose—most often attack hand line—and streams and are capable in both fire protection and attack. With regard to flow rate, it is imperative to be sure that each fog nozzle be able to handle the flow rate of its water supply because the master stream devices to which they are sometimes attached can expel up to 2,000 US gallons (7.6 m^3) per minute. Nevertheless, as with almost all fog nozzles, those on master stream devices come with either automatic or manual spray pattern and stream adjustments. However, one significant disadvantage of fog nozzles is that the ratio of surface area to volume of the compressed air foam (CAF) bubbles (which are formed by mixing air into a solution of water and foaming agents at the pump) exceeds that of fog nozzles' water droplets; therefore, the mechanical deflection in the nozzles themselves causes a loss of bubble structure, thereby reducing the CAF's ability to absorb heat.

Despite this drawback, provided an appropriate nozzle pressure and water supply, fog nozzles are effective for any ground fire situation. Fog nozzles come in many in different styles and sizes, but there are three types which encompass most: automatic, selectable, and manually adjustable. All contain an adjustable baffle that, like a thumb placed on the end of a garden hose, keeps their flow rates and stream reaches steady and finely adjustable despite variations in water pressure at the nozzle. To adjust the flow, the first two types use a control handle, or 'bale' located at the top of nozzle;

however, selectable nozzles have a fixed set of flow rates (e.g., 60, 95, and 125 GPM (gallons per min)[*clarification needed*]) that are chosen with a ring or bezel located at their tips. It is important to note that selectable nozzles will only flow if the pump pressure exceeds the nozzle pressure. Moreover, the selectable nozzle will change its nozzle pressure and reach as the handle is moved, but the automatic nozzle will automatically re-adjust its opening as the firefighter adjusts its flow rate in order to maintain the correct pressure.

3.7 Solar Cell

These panels are designed with solar cells composed of semiconductor materials. The main function of Solar panels is to convert solar energy into DC electrical energy generally of 12V, which is further used for the rest of the circuit.

Figure 3.7:1 Picture of solar sell system.

The number of cells required and their size depends on the rating of the load. The collection of solar cells can produce maximum electricity. But the solar panel must place exactly at right angles to the sun rays.

Certain materials can be made to produce electricity when light falls on them; this is called the photovoltaic effect. Solar panels use this effect to convert energy from sunlight into direct current (DC) electrical energy. An inverter unit then changes this into alternating current (AC) for your home's electrical circuits. Any excess energy can be fed back to the electricity grid, for which you may be paid an agreed **feed-in tariff**, or it could be fed into a battery storage system so you can use the stored power later (at night, for instance).

Solar panels work best when they're north facing, pointed directly at the sun, at an optimal angle and not blocked by trees or shading. The effectiveness of solar panels also depends on where you live and the weather. A solar cell is a solid-state electrical device (p-n junction) that converts the energy of light directly into electricity (DC) using the photovoltaic effect. The process of conversion first requires a material which absorbs the solar energy (photon), and then raises an electron to a higher energy state, and then the flow of this high-energy electron to an external circuit. Silicon is one such material that uses such process. [12]

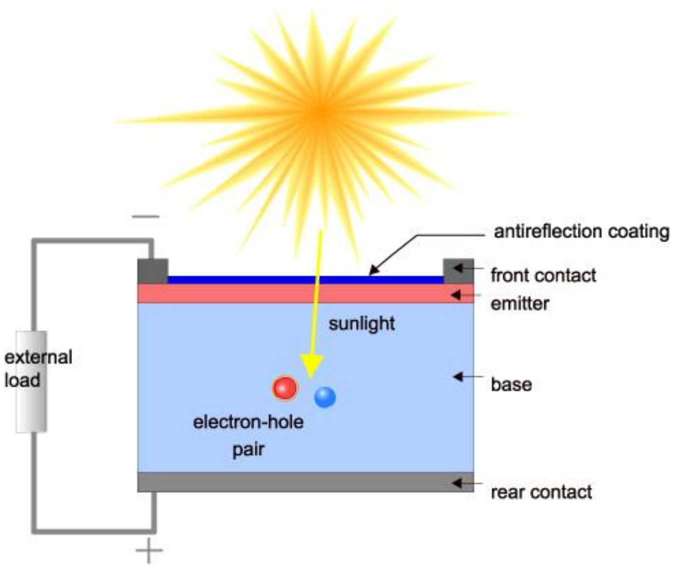


Figure 3:7:2: Solar sell system Curve.

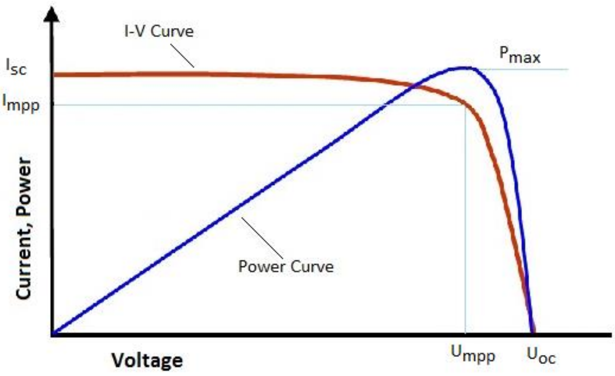


Figure 3:7:3: Solar sell system Curve.

3.8 Arduino Nano

Arduino is open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling Lights, motors, and other actuators.

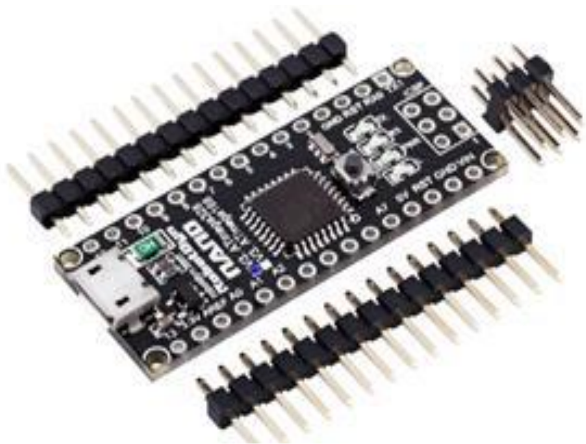


Figure 3.8:1: Arduino Nano

The micro-controller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, Maxims'). Arduino Nano is a surface mount breadboard embedded version with integrated USB. It is a small, complete, and breadboard friendly component. It has everything that Decimal/ Duemilanove has (electrically) with more analog input pins and onboard +5V AREF jumper. Physically, it is missing power jack. The Nano can automatically sense and switch to the higher potential source of power.

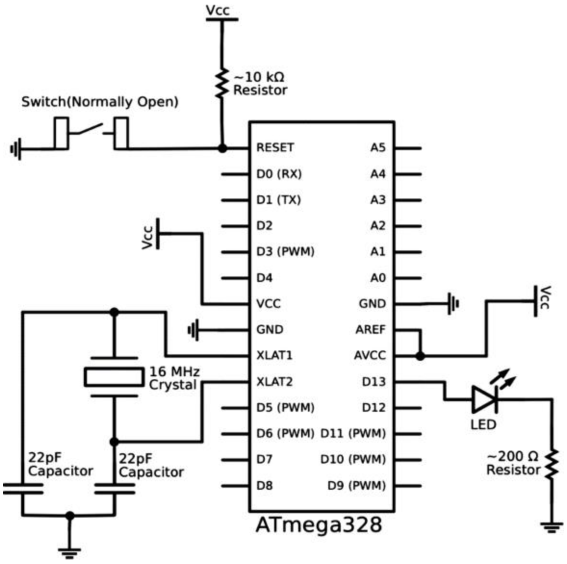


Figure 3.8:2: Arduino Nano Schematic Diagram

Nano's got the breadboard-ability of the Boarding and the Minibus with smaller footprint than either, so users have more breadboard space. It's got a pin layout that works well with the Mini or the Basic Stamp (TX, RX, ATN, and GND on one top, power and ground on the other). This new version 3.0 comes with ATMEGA328 which offer more programming and data memory space. It has two layers. That make it easier to hack and more affordable. One of the best features of Arduino Nano is, it's easy to use, compact and also small.

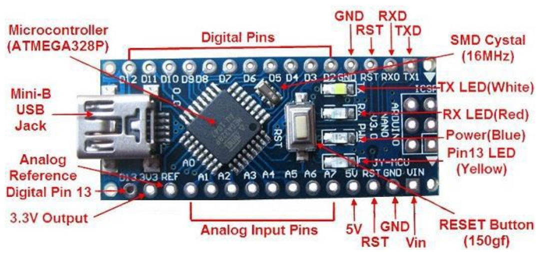


Figure 3.8:3: How Arduino Nano looks like

Specifications:

- Micro-controller: Atmel ATmega328
- Operating Voltage (logic level): 5 V
- Input Voltage (recommended): 7-12 V
- Input Voltage (limits): 6-20 V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 8
- DC Current per I/O Pin: 40 mA
- Flash Memory: 32 KB (of which 2KB used by boot loader)
- SRAM : 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz
- Dimensions: 0.70" x 1.70"

Features:

- Automatic reset during program download
- Power OK blue LED
- Green (TX), red (RX) and orange (L) LED
- Auto sensing/switching power input
- Small mini-B USB for programming and serial monitor
- ICSP header for direct program download
- Manual reset switch

Micro-controller IC ATmega328p

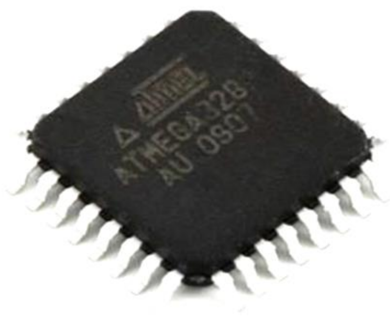


Figure 3.8: Micro-controller IC AT mega 328p

The high-performance Microchip Pico Power 8-bit AVR RISC-based micro-controller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughput's approaching 1 MIPS per MHz, balancing power consumption and processing speed.

3.9 Water Heater

Water heating is a heat transfer process that uses an energy source to heat water above its initial temperature. Typical domestic uses of hot water include cooking, cleaning, bathing, and space heating. In industry, hot water and water heated to steam have many uses. Domestically, water is traditionally heated in vessels known as water heaters, kettles, cauldrons, pots, or coppers. These metal vessels that heat a batch of water do not

Figure 3.9: Micro-controller IC AT mega 328p

produce a continual supply of heated water at a preset temperature. Rarely, hot water occurs naturally, usually from natural hot springs. The temperature varies with the consumption rate, becoming cooler as flow increases. Appliances that provide a continual supply of hot water are called water heaters, hot water heaters, hot water tanks, boilers, heat exchangers, geysers (Southern Africa and the Arab world), or calorifiers. These names depend on region, and whether they heat potable or non-potable water, are in domestic or industrial use, and their energy source. In domestic installations, potable water heated for uses other than space heating is also called domestic hot water (DHW).Fossil fuels (natural gas, liquefied petroleum gas, oil), or solid fuels are commonly used for heating water. These may be consumed directly or may produce electricity that, in turn, heats water. Electricity to heat water may also come from any other electrical source, such as nuclear power or renewable energy. Alternative energy such as solar energy, heat pumps, hot water heat recycling, and geothermal heating can also heat water, often in combination with backup systems powered by fossil fuels or electricity. Densely populated urban areas of some countries provide district heating of hot water. This is especially the case in Scandinavia, Finland and Poland. District heating systems supply energy for water heating and space heating from combined heat and power (CHP) plants such as incinerators, central heat pumps, waste heat from industries, geothermal heating, and central solar heating. Actual heating of tap water is performed in heat exchangers at the consumers' premises. Generally the consumer has no in-building backup system as redundancy is usually significant on the district heating supply side.

CHAPTER 4
METHODOLOGY

4.1 Our methodologies for the project

Our methodologies for the project:

- Creating an idea for design and construction of an Fabrication and Performance Evaluation of Rectangular and Oval Cross Section Solar Water Heater**.** And designing a block diagram & structural diagram to know which components we need to construct it.
- Collecting all the components of our system.
- Setting up all the components in a PCB board & then soldering. Lastly, assembling all the blocks in a board and to run the system & for checking purposes.

4.2 Working Step Chart

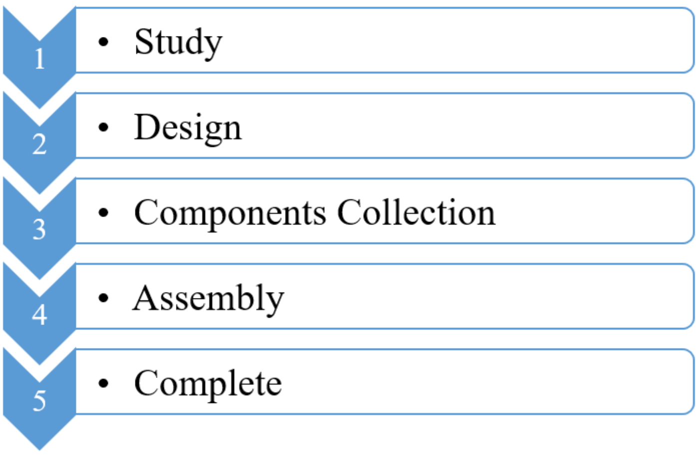


Figure 4.1: Working Step Chart

4.3 Block Diagram

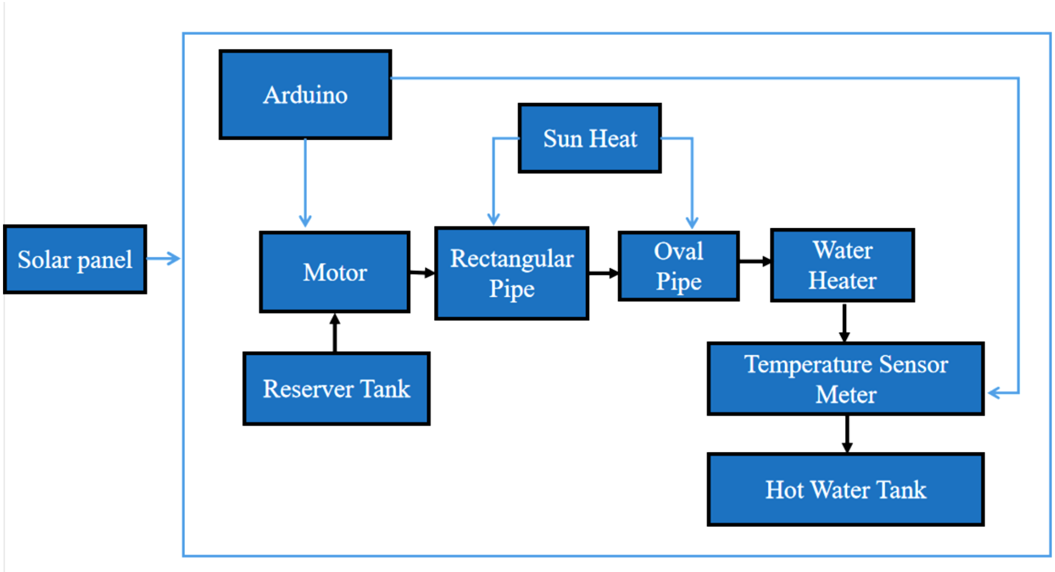


Figure 4.2: Block Diagram of Our System

Solar panel generate the power supply in this system. Here we use Pump motor, Oval Pipe and Rectangular pipe that will continuously from reserve tank to hot water tank. While travelling inside copper pipe sunlight heat will increase the overall water temperature.

In this system we will heat water mainly by using solar energy. Here we use pump motor, Oval Pipe and Rectangular Pipe, arduino show the Temperature Sensor meter in temperature, Reserve tank etc.

4.4 Structural Design

The schematic diagram here is representing the electrical circuit and the components of the project. Here we have used standardized symbols and lines.

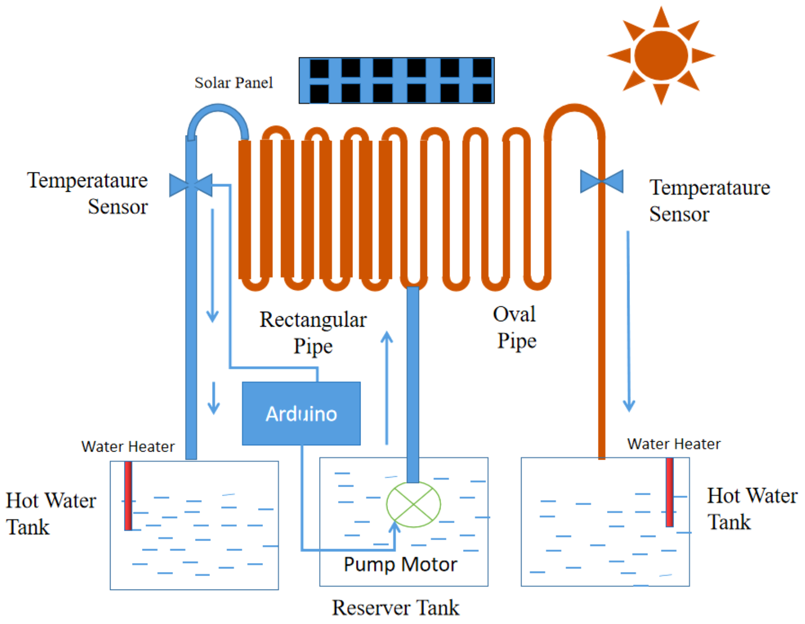


Figure 4.3: Structural Diagram of the Project

4.5 Working Principle

This system uses solar energy to heat water. Solar panels generate electricity to power a pump motor, which moves water continuously through rectangular & oval copper pipes. The pipes are designed to absorb solar heat. Water from a reserve tank flows through this system, getting heated as it passes through the solar-heated pipe. A temperature sensor monitors the water temperature. Once the water reaches the desired temperature, it's stored in a tank for later use. This process maximizes the use of solar energy for water heating, providing an efficient and eco-friendly solution.

4.6 Final System View

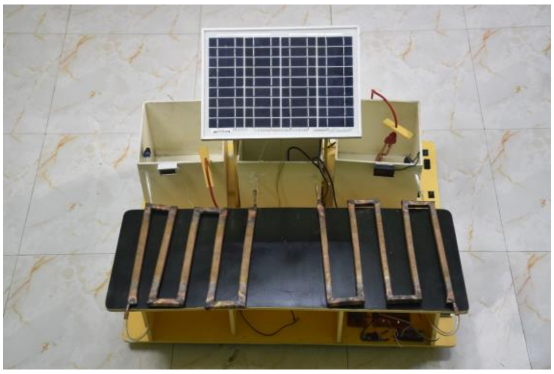


Figure 4.4: Final System Overview (Top View)

CHAPTER 5

RESULT AND DISCUSSION

5.1 Result

Now, it's time to talk about the results. We have written our commands using the Arduino IDE and the following things can happen:

- After power this project then it will be able to operate.
- Here we use a submersible pump to flow our liquid.
- Reserve tank water is normal.
- After starting flow of water trough pump it will get hot from the heat of Copper Pipe and store in hot water tank.
- All the normal and heated water data were collected.

Table: 1

	Rectangular Copper Pipe Output	
Time	**T in (°C)**	**T out (°C)**
10:00 am	18.1	20.3
10:30 am	19.9	21.1
11:00 am	20.8	22.4
11:30 am	21.3	22.9
12:00 am	22	23
02:10 pm	23.2	24.2
02:25 pm	22.6	23.2
02:40 pm	21.1	22
02:55 pm	22	23.2
03:10 pm	20.8	22.5

Rectangular Copper Pipe Output

Graph of Flow Rate:

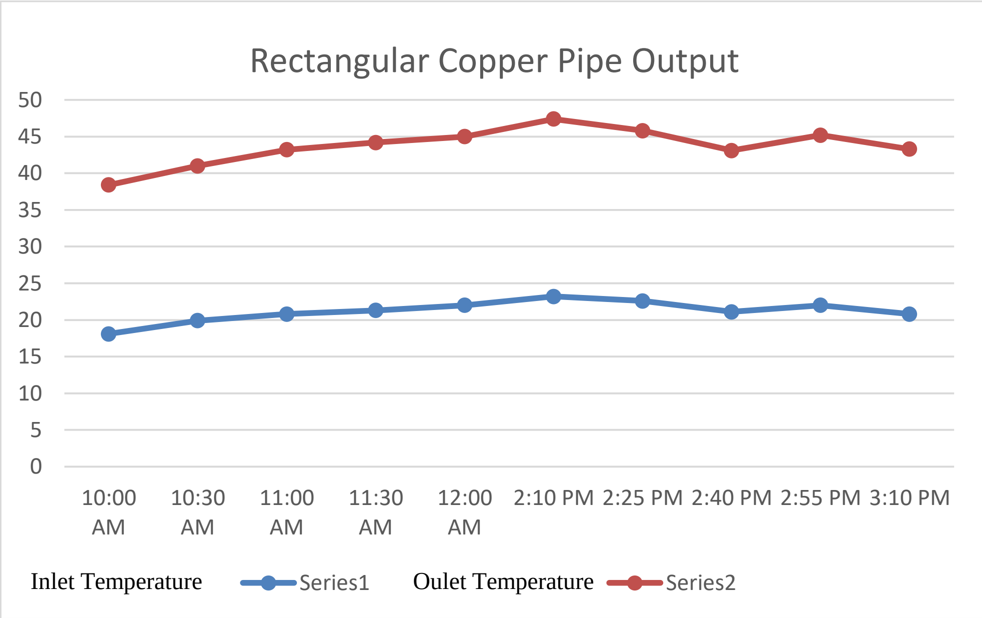
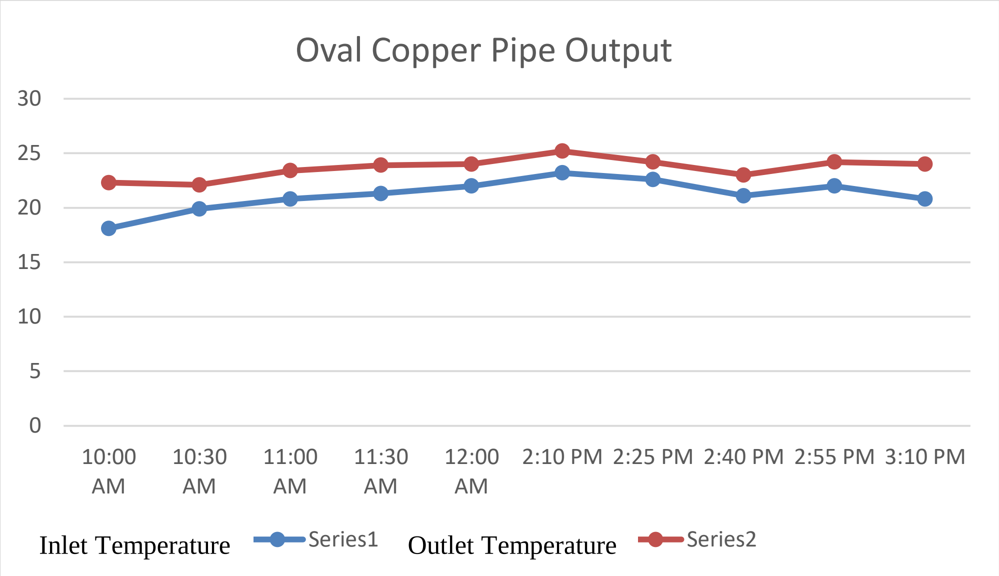


Table: 2

	Oval Copper Pipe Output	
Time	**T in (°C)**	**T out (°C)**
10:00 am	18.1	22.3
10:30 am	19.9	22.1
11:00 am	20.8	23.4
11:30 am	21.3	23.9
12:00 am	22	24
02:10 pm	23.2	25.2
02:25 pm	22.6	24.2
02:40 pm	21.1	23
02:55 pm	22	24.2
03:10 pm	20.8	24

Oval Copper Pipe Output

Graph of Flow Rate:



5.2 Discussion:

Table: 3 Temperature Change difference between Oval & Rectangular Pipe

Temperature Change Over Time			
Time	**T in (°C)**	**T out (°C) (Oval)**	**T out (°C) (Rectangular)**
10:00 am	18.1	22.3	20.3
10:30 am	19.9	22.1	21.1
11:00 am	20.8	23.4	22.4
11:30 am	21.3	23.9	22.9
12:00 am	22	24	23
02:10 pm	23.2	25.2	24.2
02:25 pm	22.6	24.2	23.2
02:40 pm	21.1	23	22
02:55 pm	22	24.2	23.2
03:10 pm	20.8	24	22.5

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.

5.2.1 Rectangular Copper Pipe Output:

The table shows the output temperature of a rectangular copper pipe at different times. The table has two main sections: time and temperature. The time section is labeled "Time" and it shows the time at which the temperature was recorded. The temperature section is divided into eight columns labeled "T in (°C)", "Tout (°C)",

Here are some of the temperatures recorded in the table:

- At 10:00 AM, the temperature was 18.1 degrees Celsius ("T in (°C)") and 20.3 degrees Celsius ("T out (°C)")
- At 11:00 AM, the temperature was 20.8 degrees Celsius ("T in (°C)") and 22.4 degrees Celsius ("T out (°C)")

"Rectangular Copper Pipe Output". The graph shows the output of a rectangular copper pipe at different times of the day. The x-axis is labeled "Time" and shows the time at which the output was measured. The time appears to be in a 24-hour clock format, starting at 10:00 AM and ending at 3:10 PM. The y-axis is labeled but the label is cut off. However, based on the values it likely shows the output temperature in degrees Celsius (°C).Here are the data points shown for the two series:

- Series 1:
    - 10:00 AM: 35.5°C
    - 11:00 AM: 42.0°C
    - 2:10 PM: 40.0°C
    - 3:10 PM: 38.5°C
- Series 2:
    - 10:00 AM: 20.0°C
    - 11:00 AM: 23.0°C
    - 2:10 PM: 22.5°C
    - 3:10 PM: 21.5°C

5.2.2 Oval Copper Pipe :

The table has two main sections: time and temperature. The time section is labeled "Time" and it shows the time at which the temperature was recorded. The temperature section is divided into eight columns. The first two columns are labeled "T in (°C)" and "Tout (°C)" and likely represent the inlet and outlet temperatures of the pipe, respectively. The remaining six columns are unnamed and their purpose is not clear from the table itself. It is possible they represent temperatures at different points along the pipe, but without more information it is difficult to say for sure.

Here are some of the temperatures recorded in the table:

- At 10:00 AM, the temperature was 18.1 degrees Celsius ("T in (°C)") and 22.3 degrees Celsius ("T out (°C)")
- At 11:00 AM, the temperature was 20.8 degrees Celsius ("T in (°C)") and 23.4 degrees Celsius ("T out (°C)")
- At 12:00 PM, the temperature was 22.0 degrees Celsius ("T in (°C)") and 24.0 degrees Celsius ("T out (°C)")

After taking ten hours data changes we found that Oval pipe exchange more heat than Rectangular pipe. Overall heat transfer efficiency of oval pipe is more than rectangular pipe.

5.3 Advantage

Using solar energy, rather than other sources of energies like fossil fuels and gasses helps us to reduce our dependence on the harmful energy resources. Therefore, solar water, heaters are 50% more efficient than other water heating system. They reduce greenhouse gases, improve the quality of the environment, and save our money. Cost of solar water, heating systems are usually expensive compare to other water heaters but it saves the users money in the long run. Its hot water will be essentially free after a few years (4-6 years) usage. There are many advantages with the solar water heaters which are explained in detail as:

Environmental

Solar water, heaters do not pollute, the environment. It help to avoid CO_2, NO, SO_2 and wastes which basically created by the local utilities when generate power or when burning the fuel to heat domestic water. The replacement of solar water heaters with other water heaters can avoid around 50 Tons of CO2 emissions which are generally produced by electric, water heaters within around 20 years.

Economic

With using a solar water, heating system the user can save 50% to 85% annually on his utility bills over the cost of electric, water heater. The cost of hot water is relevant to the intensity of solar radiation falling on the system, and is varying from region to region.

Long-term

After few years in which the system is used by the users, it generates free hot water which saves users money, and there would be no worries from future fuel shortages and price, increases. These systems are good solutions to reduce the foreign oils usages. It helps to be independent. A home which already has a solar water, heater, is good for resale.

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

- Solar water heating is free process.
- Water heating with a solar is healthy
- Solar cookers make no noise.
- Solar water heating system is portable.
- Power cuts is not an issue
- Cost-effectiveness
- Reduce energy waste
- No Oil consumption.
- Simple construction
- Ease of operation.

5.4 Disadvantages

- Water will be heat slowly.
- Foggy Weather it will not able to produce heat.
- It is a demo project so it is use in small scale.

5.5 Application

Some of the application areas of the project have been pointed out below:

- **Residential Buildings:** Solar water heaters are extensively used in homes for domestic hot water needs, including bathing, washing dishes, and laundry. They can significantly reduce electricity or gas bills by utilizing free solar energy.
- **Commercial Buildings:** Hotels, hostels, hospitals, and other commercial establishments often install solar water heating systems to meet their high demand for hot water. These systems can be scaled up to accommodate larger volumes of hot water usage.
- **Swimming Pools**: Solar water heaters can heat swimming pools efficiently, especially in regions with abundant sunlight. They help extend the swimming season by maintaining comfortable water temperatures without relying on conventional heating methods.
- **Industrial Processes:** Many industries require large amounts of hot water for various manufacturing processes, cleaning, and sanitation. Solar water heaters can supplement or replace conventional water heating systems, reducing operational costs and environmental impact.

CHAPTER 6
CONCLUSION

6.1 Conclusion

It was a demo project and intended to design and fabricate a solar water heater. This project was completed by following the research and theoretical knowledge. A reliable and low-cost solar water heater according to the local needs was developed as stated in the objectives. It involved a great research knowledge while designing the components and management skills. All the parts were manufactured and assembled to achieve the desired results by using the local materials and technologies. As stated earlier that project was designed and completed with local needs, it helps a lot to reduce the cost of project. It reduces the time and cost of the materials and manufacturing. It was a good project which involved five people. It was a great privilege for us to work in this project and complete it within time. Cost effectiveness was the main objective which was fulfilled throughout the project. We learn to work more in less time.

6.2 Future Scope

We are thinking about adding many features to our project in the future to get more desirable outcomes. Some of the steps that we are thinking about taking are given below:

- In future, we are looking forward to improving our whole system design to make it more efficient.
- In future, we are thinking about adding more features to the system such as online temperature monitoring system, online motor control system etc.

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