CHAPTER I
INTRODUCTION

1.1 Background

A cylindrical solar water heater is designed and manufactured in the Department of Mechanical Engineering, University of Bahrain. It consists of a cylindrical tube made from high quality glass having a length of 0.8, 0.14m outer diameter and a thickness of 6mm. A copper coil tube in the shape of spiral rings, with the tube inner diameter of 2mm and outer diameter of 3.175mm, painted black, serves as a collector to the incident solar energy on the cylinder wall. The thermal performance was evaluated extensively throughout the months of March and April 2002; a maximum temperature difference of 27.8°C between inlet and outlet of the solar water heater at a mass flow rate of 9kg/h was achieved. The efficiency of the cylindrical solar water heater was calculated. The maximum value during the experimental period was found to be 41.8%. This reveals a good capability of the system to convert solar energy to heat which can be used for heating water. An economic analysis has reveals that the cylindrical solar water heater compared with the flat plate collector is cost effective. [1].Solar water heating (SWH) is the conversion of sunlight into heat for water heating using a solar thermal collector. A variety of configurations is available at varying cost to provide solutions in different climates and latitudes. SWHs are widely used for residential and some industrial applications. A sun-facing collector heats a working fluid that passes into a storage system for later use. SWH are active (pumped) and passive (convection-driven). They use water only, or both water and a working fluid. They are heated directly or via light-concentrating mirrors. They operate independently or as hybrids with electric or gas heaters. In large-scale installations, mirrors may concentrate sunlight into a smaller collector. Solar water heaters are one of the predominant technologies for the extraction of solar thermal energy. Thermosiphon solar water heaters have been the most attractive option for hot water compared to forced circulation systems. Hence, commercialization of thermosiphon solar water heating system must always focus on the improvement in its efficiency. Operating characteristics of thermosiphon solar water heaters contribute to the efficiency of the system to a greater extent, because the performance of the system is based on the mass flow rate of collector, absorber plate temperature and temperature rise of fluid from inlet to outlet. The performance of thermosiphon solar water heaters varies significantly with absorber plate efficiency and loss factors. Unlike other parameters which greatly rely on the operating conditions like input energy and flow properties, plate efficiency factors were found to be dependent on the design of the system. [2] Mathematical derivations which are useful for the prediction of performance and comparison of different collectors were also worked out. In addition to the design, constructional features of the system, flow properties of the working fluid have a major role to play over the thermal performance of the system. Experiments were conducted using different types of refrigerants as working fluid in two phases closed thermosiphon solar water heater system under various environmental condition. The heat transfer phenomena in solar water heaters can be enhanced by the use of twists inserted in the flow path of fluid inside the riser tubes which induces swirl flow. Hence twisted tapes act as turbulent promoters thereby improving the thermal performance of the system. Various forms of turbulent promoters including twisted tapes, wire coils, ribs, axially supported discs were experimented for heat transfer augmentation. [3]

1.2 Basics of Solar Water Heating

The most popular type of solar collector for water heating is the flat panel design (other types include evacuated-tube, concentrating, and integral collector storage). A flat panel collector is an insulated weatherproof enclosure with an absorber plate, flow tubes, and a transparent cover. The transparent cover allows solar energy to pass through and be absorbed by the absorber and flow tubes. The heat generated is then transferred to the fluid circulating through the flow tubes.

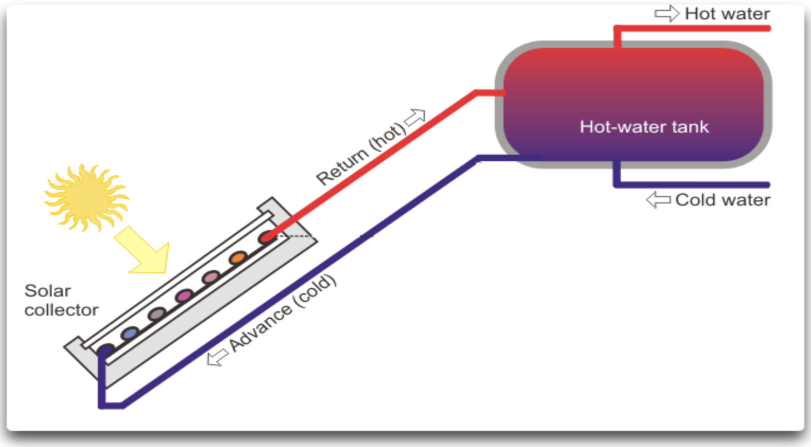


Figure 1.2.1: Solar Water Heating System

Once the solar energy is collected, it is commonly employed with the pumped indirect SWH system. Best suited for colder climates, an indirect system pumps heat-transfer fluid (usually a non-toxic propylene glycol-water antifreeze mixture) through collectors, and then transfers the heated fluid from the collectors to a storage tank. Heat exchangers transfer the heat from the fluid to the household water stored in the tanks. Water stored within the tank is then heated when the fluid passes through a heat exchanger located inside the storage tank. Antifreeze fluid is used to prevent collector piping from freezing and allow for the maximum transfer of heat from the solar collector to the storage tank. Many indirect systems design also incorporate an external heat exchanger.

The drain-back system is another common cold climate system. With this system, the water in the collectors and exposed piping drains into an insulated drain-back reservoir tank each time the pump shuts off. Removing all water from the collectors and piping when the system is not collecting heat provides a fail-safe method of ensuring that collectors and the collector loop piping never freeze.

In warmer climates, direct systems are more commonly used. The direct system circulates potable water directly through the solar collector into the storage tank. In other words, the water that is used in the house is the same water that has circulated through the solar collector. These systems incorporate various strategies to control the operation of the circulating pump, which can include photovoltaic or differential controllers' Passive direct systems are also used in warmer climates. The unique characteristic of these systems is that they do not use pumps or other electrical components, thereby providing a simple and reliable system. The most common passive systems are the thermosiphon (see diagram below) and integral collector storage systems. Indirect thermosiphon systems could also be used in colder climates. Solar water heating systems typically cost between 1,60,000 Tk and 400,000 Tk installed, depending on the type and size of system. Some state governments and local utilities may offer rebates or other financial incentives to help reduce the costs (see below). With regular inspection, the system will operate for 20 to 30 years with minimal maintenance and costs.

1.3 Objective

The main objectives of this thesis work are following.

a. To provide a cost effective solar water heater having copper body integrated with natural circulation and hot water storage system.
b. To provide an extraction system having floating ball and flexible pipe in order to get upper layer warm water from the reservoir tank. .
c. To implementation of Cylindrical Solar Water Heater.
d. To provide a solar water heater using the copper as the conducting material.

1.4 Advantages

The performance of a cylindrical solar water heater**.**

a. Production cost is very low.
b. No need of purchase special machine.
c. It's operated and maintenance is simple.
d. It is compact and portable.
e. It can be efficiently used.
f. No needs extra power totally Renewable Energy system.

1.5Applications

The scopes of this project are:

- This method can be widely used in industries or homes where hot water is neede.

CHAPTER II

LITERATURE REVIEW

2.1 History of Solar Water Heater (SWH)

A solar water heater is a device that captures sunlight to heat water. It can be an economical way to generate hot water for your family (for shower and bath).A solar heater not only enables substantial energy savings as solar power is free in contrast to natural gas or fuel oil. Moreover, it is a way to produce hot water for sanitary use throughout the year without emitting any CO_2. [4]

2.1.1 Solar Water Heater (SWH) Use in Developed Countries

Today, most developed country's homes and businesses use natural gas, electricity or oil to provide them with hot water. The amount of energy required to meet their hot water needs is not insignificant. According to the US Department of Energy (DOE), heating water today accounts for up to 14 percent of the average household's energy use, and nearly four percent of total US energy consumption. With electricity and natural gas prices continuing to rise, the costs of having a constant supply of hot water can really add up. [5]

Solar water heating (SWH) technologies are a simple, reliable, and cost-effective method of harnessing the sun's energy to provide for the energy needs of homes and businesses. Simply stated, SWH systems collect the energy from the sun to heat air or a fluid. The air or fluid then transfers solar heat directly or indirectly to their water supply. [6]

Though these systems have been in use for centuries, with today's technological advances, SWH technologies can be operated efficiently and affordably in any climate. Systems are specifically designed for various climatic and geographical areas of the country. Regions with temperatures that fall below freezing require the use of an indirect or drain-back system, while warmer, sunnier climates can use a direct system, which directly heats the water to be used.

SWH systems also provide an important opportunity to reduce our nation's growing demand for energy from fossil fuels. By installing a SWH system, a typical household can meet 50 to 80 percent of their hot water needs. In warm and sunny climates like Hawaii, a SWH unit can meet 100 percent of a household's hot water needs. Reduced demand for fossil fuels will improve the environment by reducing air and water pollution as well as the heat-trapping gases that cause global warming. And though they cost a little bit more up front to install, a SWH system will save consumers money in the long run as the fuel source (the sun's energy) will always be free. [8]

While the number of installations continues to grow by the thousands every year, there still exists an enormous untapped market with great potential for reducing a significant portion of our nation's energy use.

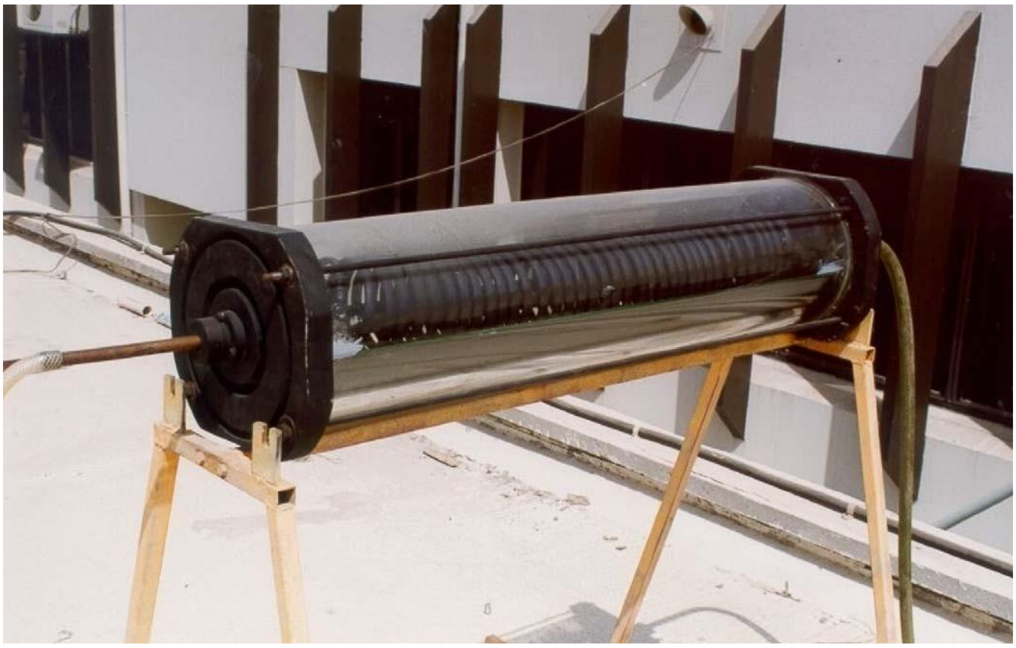


Figure 2.1.1.1: **Cylindrical solar water heater**

2.1.2 Solar Water Heater (SWH) Uses in Bangladesh

Bangladesh have very advanced whether for using water heater as we see in curve, we noticed that Bangladesh have average maximum heat about 29°c and around seventh months in year have over 24°C temp.

The heater can use in different kind of purpose in Bangladesh.

- To fulfil the need of hot and purified water
- To industrial requirement of hot water supply
- Produce steam of any required era
- For supply in big kitchen and hospital required

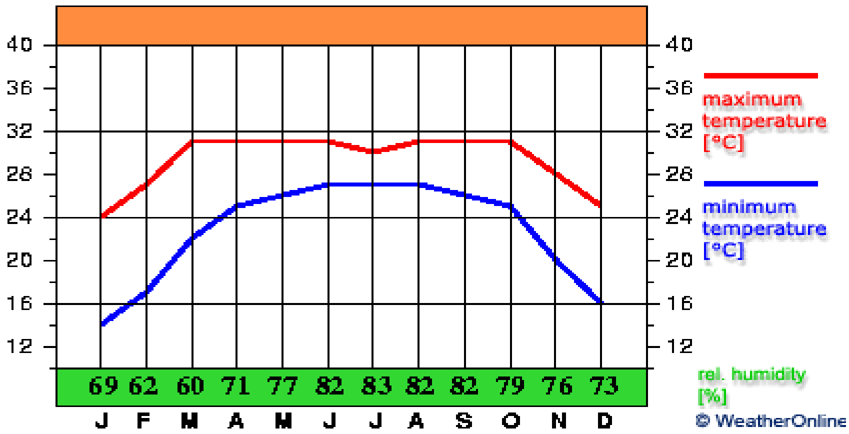


Figure2.1.2.1: Weather Graph of Bangladesh

2.2Solar Water Heating for Swimming Pools

In order to maintain swimming pool temperatures during different seasons, homeowners and businesses may want to invest in solar water heating systems. Conventional natural gas and electric heaters are available for heating swimming pools, but they can be costly and inefficient. By comparison, SWH systems for swimming pools are cost competitive, primarily because the fuel source is free and the operating costs are low. A typical solar pool heating system can range from $2,000 to $4,000, depending on variable factors such as ease of installation, and safety requirements, and access to financing. The investment, however, is well worth the effort as a SWH system for a pool can pay for itself in just 2 to 4 years when account for the energy bill savings. Solar pool heating systems are also highly reliable and generally maintenance free. [6]

Solar heating systems are available for both in-ground and aboveground pools. They are effective because swimming pools require a low temperature heat source, which a relatively small solar collector can easily provide. Most SWH systems for pools include a solar collector, filter, pump, and flow control valve. Pool water is first pumped through the filter. Then it flows through the solar collector where it is heated before returning to the pool. Some systems offer manual automatic sensor valves that can send water through the collector when the collector temperature is greater than the pool temperature, or bypass the collector when its temperature is similar to the pool water. In particularly hot climates, passing pool water through the solar collectors during the evening hours can serve as a cooling mechanism.

- Cylindrical Parabolic Solar Water Heater

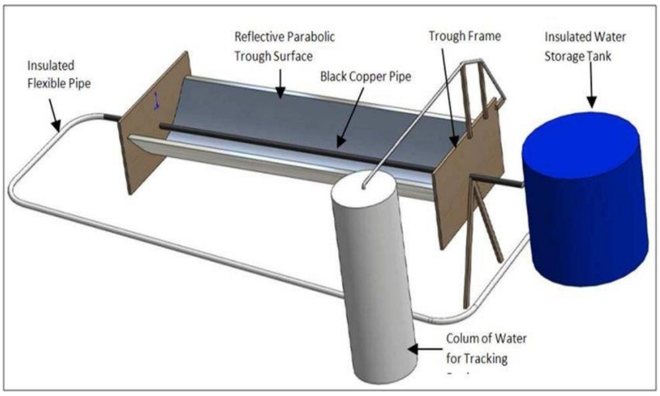
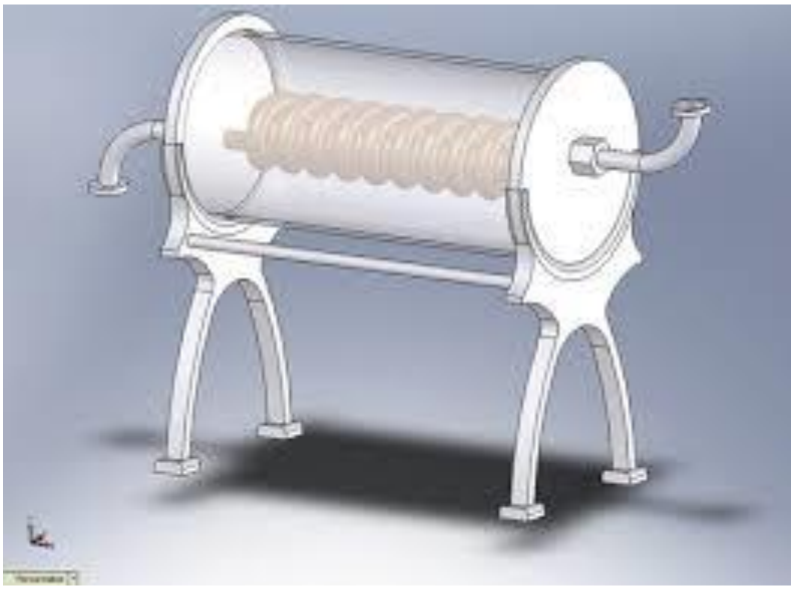


Figure 2.2.1: **Cylindrical Parabolic Solar Water Heater**

Pumps circulate household water through the collectors and into the home. They work well in climates where it rarely freezes.

- Phenomenological Cylindrical Solar Water Heater



- Figure 2.2.2: **Phenomenological Cylindrical Solar Water Heater**

Pumps circulate a non-freezing, heat-transfer fluid through the collectors and a heat exchanger. This heats the water that then flows into the home. They are popular in climates prone to freezing temperatures.

2.4 Selecting a solar water heater

Before purchase and install a solar water heating system, some steps have to be followed:

- Estimate the cost and energy efficiency of a solar water heating system
- Evaluate your site's solar resource
- Determine the correct system size
- Investigate local codes, covenants, and regulations.

Also understand the various components needed for solar water heating systems, including the following:

- Heat exchangers for solar water heating systems
- Heat-transfer fluids for solar water heating systems

2.5 Installing and maintaining the system

The proper installation of solar water heaters depends on many factors. These factors include solar resource, climate, local building code requirements, and safety issues; therefore, it's best to have a qualified solar thermal systems contractor install system.

After installation, properly maintaining system will keep it running smoothly. Passive systems don't require much maintenance. For active systems, discuss the maintenance requirements with system provider, and consult the system's owner's manual. Plumbing and other conventional water heating components require the same maintenance as conventional systems. Glazing may need to be cleaned in dry climates where rainwater doesn't provide a natural rinse.

Regular maintenance on simple systems can be as infrequent as every 3–5 years, preferably by a solar contractor. Systems with electrical components usually require a replacement part or two after 10 years. Learn more about solar water heating system maintenance and repair.

2.6 Improving energy efficiency

After water heater is properly installed and maintained, try some additional energy-saving strategies to help lower water heating bills, especially if require a back-up system. Some energy-saving devices and systems are more cost-effective to install with the water heater.

2.7 Other water heater options

- Conventional storage water heaters
- Demand water heaters
- Heat pump water heaters.

CHAPTER III

THEORETICAL ASPECTS

3.1 Working Principal of SWH

A cylindrical solar water heater is designed and manufactured in the Department of Mechanical Engineering, University of Bahrain. It consists of a cylindrical tube made from high quality glass having a length of 1.524 m, 0.383 m outer diameter and a thickness of 0.00254 m. A copper coil tube in the shape of spiral rings, with the tube inner diameter of 0.05 m and outer diameter of 0.06 m, painted black, serves as a collector to the incident solar energy on the cylinder wall. The thermal performance was evaluated extensively throughout the months of September and October 2020; a maximum temperature difference of 4.3 °C between inlet and outlet of the solar water heater at a mass flow rate of $2.52\times10^{-6}m^3$/secwas achieved. The efficiency of the cylindrical solar water heater was calculated. The maximum value during the experimental period was found to be 31.6%. This reveals a good capability of the system to convert solar energy to heat which can be used for heating water. An economic analysis has revealed that the cylindrical solar water heater compared with the flat plate collector is cost effective.

3.2 HowSolar Water Heater (SWH) Work

Solar water heating systems include storage tanks and solar collectors. There are two types of solar water heating systems: active, which have circulating pumps and controls, and passive, which don't.

3.3 Components of Solar Water Heater

Sl.No.	Components Name	Specification
1.	Glass Tube.	5 Ft
2.	Iron Bar.	5.5 Ft
3.	Copper Pipe.	50 Ft
4.	Foil Paper.	5.5 in
5.	Wood.	34 in
6.	Temperature Meter.	4 Pieces
7.	Water Pot	2 Pieces

3.3.1 Glass Tube

Glass tubes are mainly cylindrical hollow-wares. Their special shape combined with the huge variety of glass types (like borosilicate, flint, alum inosilicate, soda lime, lead or quartz glass), allows the use of glass tubing in many applications. For example, laboratory glassware, lighting applications, solar thermal systems and pharmaceutical packaging to name the largest. In the past, scientists constructed their own laboratory apparatus prior to the ubiquity of interchangeable ground glass joints. Today, commercially available parts connected by ground glass joints are preferred; where specialized glassware are required, they are made to measure using commercially available glass tubes by specialist glassblowers. For example, a Schleck line is made of two large glass tubes, connected by stopcocks and smaller glass tubes, which are further connected to plastic hoses.

Figure 3.3.1 Glass Tube

Compared to other materials like plastics the importance of cylindrical half-finished products in glass is high. Main reasons are the difficulty associated with 3-d forming of glass in general. In order to create hollow objects from glass the cylinder shape is a natural starting material.

Cylindrical glass tubes have:

- the lowest surface area and the most compact design
- highest mechanical strength against pressure and impact
- automated further processing due to symmetry.

Compared to molded glassware the process of tube drawing achieves:

- better optical clarity
- more homogeneous distribution of wall thickness
- higher precision or volume and geometry in general

3.3.2 Iron Bar

An iron bar is a bar of refined iron. It can be created through the Smiting skill at level 15 by using iron ore on a furnace, granting 12.5 Smiting experience. When a player smelts iron ore, there is a 50% chance that the ore will be too impure and lacking in actual iron ore to yield an iron bar. When this happens, the iron ore disappears and the player is granted no Smiting experience. However, if a player wears a ring of forging while smelting iron ore, or casts Superheat Item on it, there is no chance that it will be too impure. An iron bar can be smoothed on an anvil through the Smiting skill to create iron weapons and armor. When smoothed, each bar grants 25 experience, with a maximum of 125 being given for the iron plate body.

16 iron bars are required for quests (18 if you want your own blurted sword). Animal Magnetism requires 5, The Knight's Sword requires 2 (4 if you want your own blurted sword), Death Plateau requires 1, The Giant Dwarf requires 1, Troll Romance requires 1, Swan Song requires 5 and One Small Favor requires 1.

Figure 3.2.2: Iron Bar

An iron bar is a bar of metal, refined through the Smiting skill by smelting an iron ore in a furnace, requiring 15 Smiting and granting 12.5 Smiting experience.

At level 15 Smiting players have a 50% chance of success to smelt an iron bar from an iron ore. The player's chance of success increases by 1% each additional Smiting level the player has advanced past level 15, up to a maximum of 80% at level 45 Smiting. However, using a ring of forging, casting Superheat Item, or using the Blast Furnace to smelt iron ore will always succeed in producing an iron bar.

An iron bar can be forged on an anvil to create iron weapons and armor, granting 25 Smiting experience per bar used.

3.3.3 Copper Pipe

Copper pipes are commonly used in the construction industry for water supply lines and refrigerant lines in HVAC (heating, cooling, and air-conditioning) systems. Copper pipes can be manufactured as soft or rigid copper and offer excellent corrosion-resistance and reliable connections. The three most common types of copper pipe used in residential and commercial construction are Type K, Type L, and Type M. A fourth type, used for drain-waste-vent, or DWV, piping, can be found in some older homes.

Figure 3.3.3: Copper Pipe

1. **Copper Pipe Sizing**

The actual outside diameter (OD) of rigid copper type is always 1/8 inch larger than the nominal size, or what the pipe is called. For example, a "1/2-inch" copper pipe has an outside diameter of 5/8 inch. It is true with all three common types of new pipe, K, L, and M. The inside diameter (ID) of copper pipe is determined by the wall thickness of the pipe, which varies by the pipe type. The internal or external fluid pressure may determine the type of copper piping specified for any application, the installation, the service conditions, and the local building code requirements.

Here Is a List of the Common Types of Copper Piping

2. **Type K Copper Pipe**

Type K copper pipe has the thickest wall of all the common types. It is used for water distribution, fire protection, oil, HVAC, and many other applications in the construction industry. Type K pipe is available in a rigid and flexible form and can be used with flared and compression fittings. It is recommended for main water lines and underground installations because its thickness helps it withstand the pressure from backfilled earth in trenches. Type K pipe is not approved for use in natural gas applications because the gas environment can damage the joints of the pipes.

3. **Type L Copper Pipe**

Type L copper pipe is used for interior plumbing, fire protection, and some HVAC applications. It is available in rigid and flexible forms and can be used with sweat, compression, and flare fittings. Type L is considered the most common type of copper piping, as it can be used in many more applications than Type K. Flexible Type L copper can be used to repair or replace old water lines, although rigid tubing is more durable. Type L also can be used outside the home where it will be directly exposed. Type L copper is thinner than Type K but thicker than type M.

4. **Type M Copper Pipe**

Copper pipe type M wall is thinner than both type K and L copper. Sold in both rigid and flexible forms, Type M is used most commonly for domestic water service and vacuum systems. It can be used with sweat, compression, and flare fittings. Type M tubing is favored for residential work for its relatively low price; a thinner wall means less copper and thus a lower price. Type M copper is not allowed by plumbing codes in all areas and applications. Always check with the local building authority for restrictions on its use.

Copper DWV Piping: Copper pipe for plumbing drains and vents was used in many old homes and has been all but replaced with PVC or ABS plastic pipe in modern construction. It is suitable only for above-ground applications and has a low-pressure rating of 10 to 15 pounds per square inch (psi), much lower than the water pressure of most municipal water supply systems. DWV pipe usually has yellow markings to distinguish it from M type copper.

3.3.4 Foil Paper

Aluminum foil (or aluminum foil in North America), often referred to with the misnomer tin foil, is aluminum prepared in thin metal leaves with a thickness less than 0.2 mm (7.9 mils); thinner gauges down to 6 micrometers (0.24 mils) are also commonly used.[1] In the United States, foils are commonly gauged in thousandths of an inch or mils. Standard household foil is typically 0.016 mm (0.63 mils) thick, and heavy-duty household foil is typically 0.024 mm (0.94 mils). The foil is pliable, and can be readily bent or wrapped around objects. Thin foils are fragile and are sometimes laminated to other materials such as plastics or paper to make them more useful. Aluminum foil supplanted tin foil in the mid-20th century.

Annual production of aluminum foil was approximately 800,000 tones (880,000 tons) in Europe and 600,000 tones (660,000 tons) in the U.S. in 2003.[2] Approximately 75% of aluminum foil is used for packaging of foods, cosmetics, and chemical products, and 25% is used for industrial applications (e.g., thermal insulation, cables, and electronics).It can be recycled.

In North America, aluminum foil is known as "aluminum foil". It was popularized by Reynolds Metals, the leading manufacturer in North America. In the United Kingdom and United States, it is, informally, widely called tin foil, for historical reasons (similar to how aluminum cans are often still called "tin cans"). Metallized films are sometimes mistaken for aluminum foil, but are actually polymer films coated with a thin layer of aluminum. In Australia, aluminum foil is widely called alfoil.

Figure 3.3.4: Foil paper

Aluminium foil is produced by rolling sheet ingots cast from molten billet aluminium, then re-rolling on sheet and foil rolling mills to the desired thickness, or by continuously casting and cold rolling. To maintain a constant thickness in aluminium foil production, beta radiation is passed through the foil to a sensor on the other side. If the intensity becomes too high, then the rollers adjust, increasing the thickness. If the intensities become too low and the foil has become too thick, the rollers apply more pressure, causing the foil to be made thinner.

The continuous casting method is much less energy intensive and has become the preferred process.[8]For thicknesses below 0.025 mm (1 mil), two layers are usually put together for the final pass and afterwards separated which produces foil with one bright side and one matte side.[9]The two sides in contact with each other are matte and the exterior sides become bright; this is done to reduce tearing, increase production rates, control thickness, and get around the need for a smaller diameter roller.

3.3.5 Wood

Wood is a porous and fibrous structural tissue found in the stems and roots of trees and other woody plants. It isan organic material - a natural composite of cellulose fibres that are strong in tension and embedded in a matrix of lignin that resists compression. Wood is sometimes defined as only the secondary xylem in the stems of trees,[1] or it is defined more broadly to include the same type of tissue elsewhere such as in the roots of trees or shrubs. In a living tree it performs a support function, enabling woody plants to grow large or to stand up by themselves. It also conveys water and nutrients between the leaves, other growing tissues, and the roots. Wood may also refer to other plant materials with comparable properties, and to material engineered from wood, or wood chips or fibre.

Figure 3.3.5: Wood

Wood has been used for thousands of years for fuel, as a construction material, for making tools and weapons, furniture and paper. More recently it emerged as a feedstock for the production of purified cellulose and its derivatives, such as cellophane and acetate. As of 2005, the growing stock of forests worldwide was about 434 billion cubic meters, 47% of which was commercial.[2] As an abundant, carbon-neutral renewable resource, woody materials have been of intense interest as a source of renewable energy. In 1991 approximately 3.5 billion cubic meters of wood were harvested. Dominant uses were for furniture and building construction.

3.3.6 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. These thermometers consist of a graduated glass capillary with a pool of mercury in one end.

Figure3.3.6: Temperature Meter

Features

- Noncorrosive body
- High efficiency
- Long operational life

Specification

- Theory: Temperature Sensor
- Usage: Household
- Color: Silvery
- Accuracy: ±1°C
- Temperature range: -9.9°C~+99.9°C (+14°F~ +244°F).

CHAPTER IV
CONSTRUCTION OF SOLAR WATER HEATER

4.1 Methodology

A careful study of already existing solar water systems was done; and a choice was made on the type of system to be designed with a focus on simplicity, installation, and maintenance cost as well as durability. The use of locally available materials was made a matter of priority. A round-plate collector was used as the absorber. It was integrated with underneath grids or coils of fluid carrying tubes and placed in an insulated casing with a glass or transparent cover. A cold water tank placed above and a hot water tank below incorporated with a thermometer and a carriage are integrated into the system. The water gets heated up and flows into a storage tank through the thermosiphon principle. The performance of the thermosiphon system depends upon the size and capacity of the storage tank, the thermal capacity of the collector, and the connecting pipes including fluid flow and on the pattern of hot water use. All components were designed for and constructed in line with the design values obtained. The system was tested on a normal sunny day, rainy day, and cloudy day between the hours of 9:00 a.m. and 1:30 p.m. and results collected were tabulated.

4.2 Project Overview

Solar water heaters are a clean and lucrative source of energy since they collect energy from sunlight and use it to heat water for showers or swimming pools. As compared with Tesla's solar tiles, they use less space and can be more efficient and cheaper. This is especially true if water heating is your main concern (e.g. having a swimming pool at home). The information provided in the infographic and below can help you determine the system most suitable in your home. This project deals with the study, analysis and design of Economical Cylindrical Solar Water Heater. Solar collectors, storage tanks and heat transfer fluids are the three core components in solar water heater applications. Among all flat plate collector type solar water heater is the most efficient. The development of an efficient low-cost flat plate collector is an essential first step toward the effective utilization of solar energy for water heating.

Our aim is to develop a solar water heater at an affordable price and test the prototype for efficiency. Replacement of Copper material with Aluminum will make it affordable. The floating assembly helps the system to extract the hot water from the supply tank. The objective is to design, fabricate and test a prototype of a flat plate collector type solar water heater.

4.3 Construction Processes

Flowing processes, we completed our total project.

- At first, we collected instruments according to our design.
- We cut them according to our project design.
- Two kinds of wood stand on Two sides.
- Then we connected two iron bars.
- Banded Copper pipes entered inside the glass tubes.
- Finally, we connected the temperature meter& we check our system.

4.4 Material Specifications

Sl.No.	Components Name	Specification
1.	Glass Tube.	05 Ft
2.	Iron Bar.	5.5 Ft
3.	Copper Pipe.	50 Ft
4.	Foil Paper.	5.5 in
5.	Wood.	34 in
6.	Temperature Meter.	04 Pieces
7.	Water Pot	02 Pieces

CHAPTER V

EXPRIMENTS RESULT

5.1 Complete Project Picture

Figure5.1.1: Complete Project Picture

5.2 Data

Time	Inlet Temp (Centigrade)	Outlet Temp (Centigrade)	Flow rate (Liter/Min)
9.00am	**23**	**27.2**	**0.6**
9.30 am	**23**	**27.2**	**0.6**
10.00 am	**23**	**27.4**	**0.6**
10.30 am	**23.7**	**27.9**	**0.9**
11.00 am	**23.7**	**28**	**0.9**
11.30 am	**23.8**	**27.9**	**0.9**
12.00 pm	**25**	**28**	**1.2**
12.30 pm	**25**	**28**	**1.2**
1.00 pm	**25**	**28.2**	**1.2**
1.30pm	**25**	**28.1**	**1.2**

5.3 Result Analysis

Given,

[From Table 5.2]

Outlet temp = 27.2 ℃

Inlet temp = 23 ℃

Flow rate, Q = 1×10-5 m3/sec

D = 5 cm

= 0.05 m

H = 50 ft

= 15.24 m

Cp = 376.512 J/kg.k

Irad = 1380 W/m2

Temperaturedeference,

ΔT = (27.2 – 23) ℃

= 4.2 ℃

= (273 + 4.2) K

= 277.2 K

Mass flow rate,

M = ρ × Q   (Q= Volume flow rate)

= 1000 × 1×10^{-5}

= 0.01 kg/sec

Now, Useful gain energy,

$Q_u = M\, C_p\, (\Delta T)$

= 0.01 × 376.512 × 277.2

= 1043.69 J/s

= 1043.69 watt

Area, A = π× D × H

= 3.14 × 0.05 × 15.24

= 2.392 m^2

Efficiency, $\eta = \frac{\text{Qu}}{A \times \text{Irad}} \times 100$

$= \frac{1043.69}{2.392 \times 1380} \times 100$

= 31.6 %

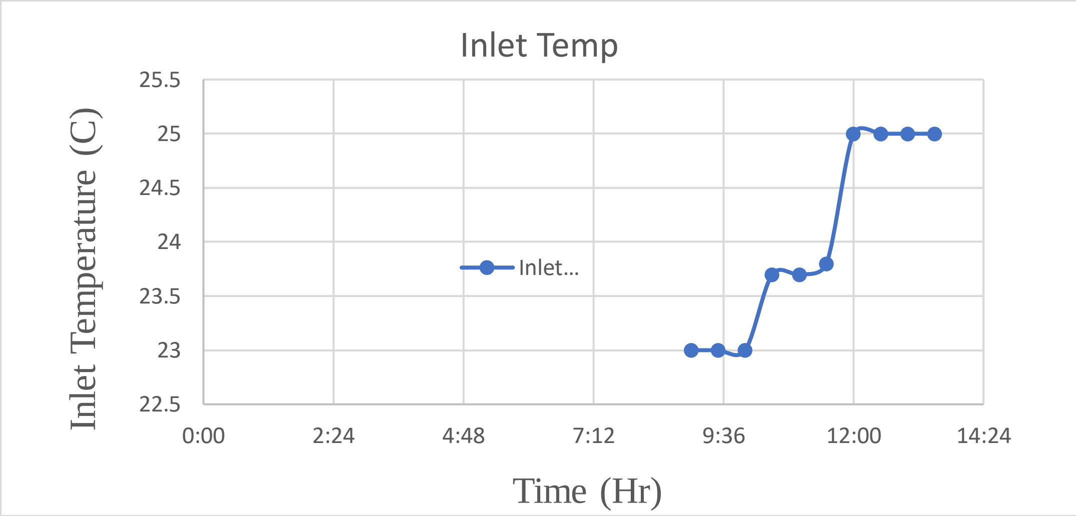


Figure 5.3.1: Inlet temperature with respect to time.

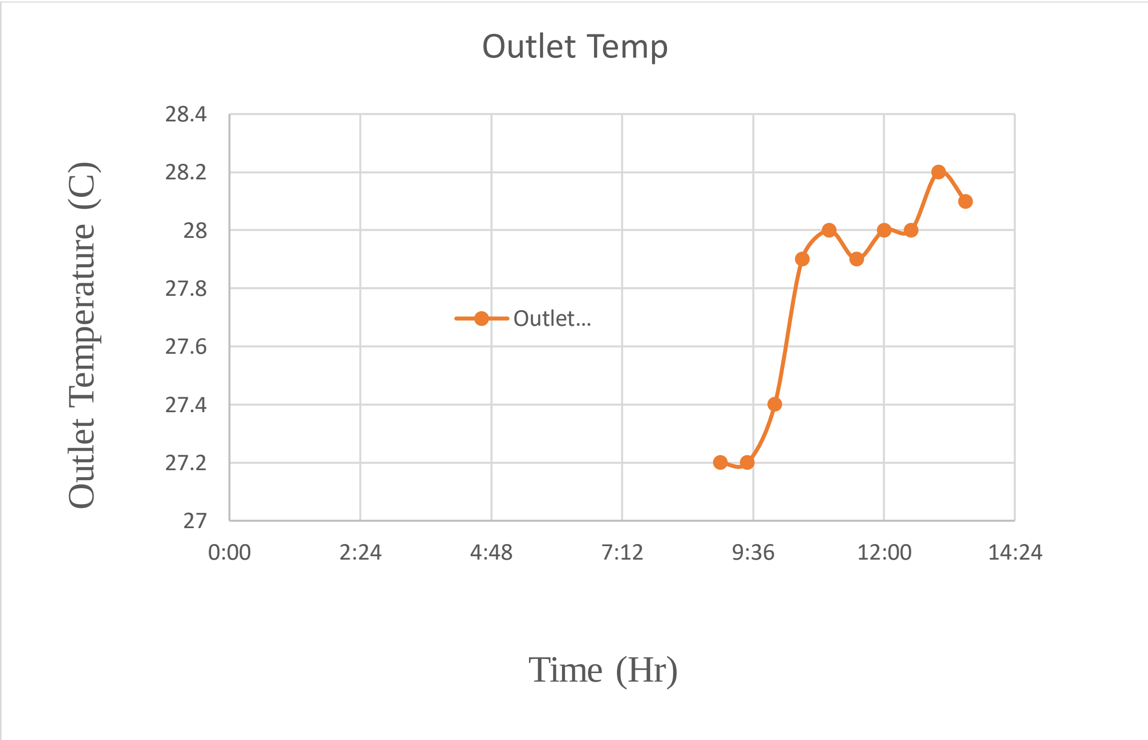


Figure5.3.2: Outlet temperature with respect to time.

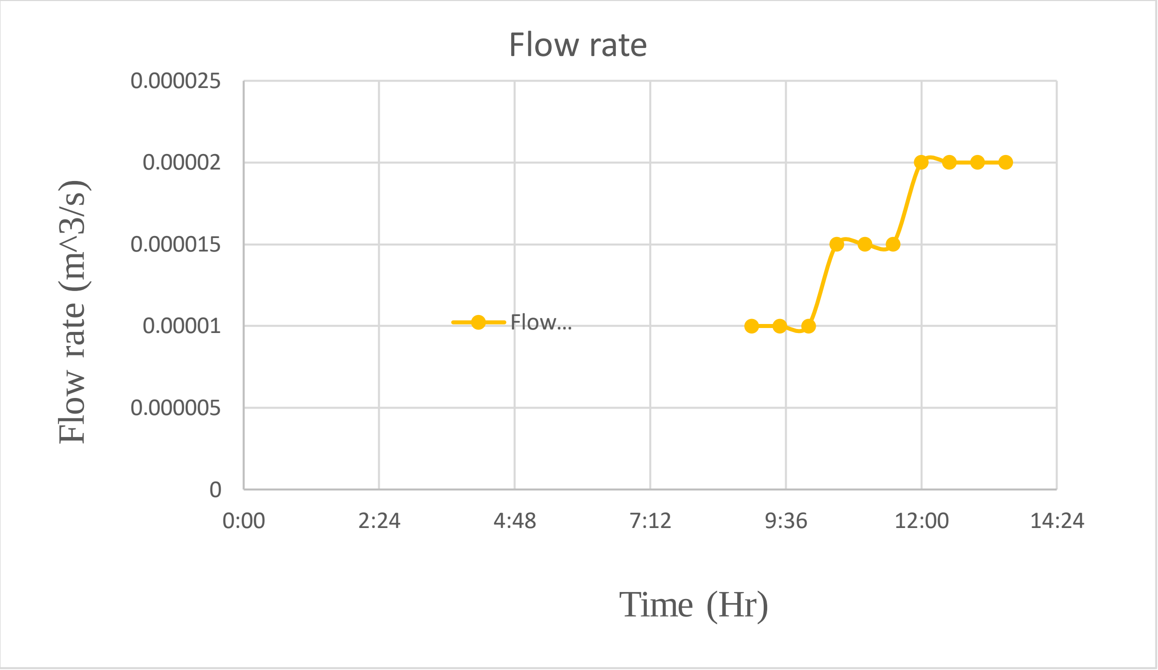


Figure5.3.3: Flow Rate with respect to time.

CHAPTER VI
DISCUSSION & CONCLUSION

6.1 Discussion

The Sun emits enough power onto Earth each second to satisfy the entire human energy demand for over two hours. Given that it is readily available and renewable, solar power is an attractive source of energy. However, as of 2018, less than two percent of the world's energy came from solar. Historically, solar energy harvesting has been expensive and relatively inefficient. Even this meager solar usage, though, is an improvement over the previous two decades, as the amount of power collected from solar energy worldwide increased over 300-fold from 2000 to 2020. New technological advances over the last twenty years have driven this increased reliance on solar by decreasing costs, and new technological developments promise to augment this solar usage by further decreasing costs and increasing solar panel efficiency.Today, hundreds of thousands of modern solar water heaters are in use throughout the world. While the initial purchase and installation cost of a solar water heater is higher than an equivalent conventional water heater this extra cost can be recovered over a period of time through lower energy bills. Solar energy can reduce the national demand for conventional fuels, reduce the damage to the environment, as it is a non-polluting free energy, and reduce the need to build new power stations which require huge investment.

6.2Future Scope

- In the future it can be improved by using more sensors.
- In the future, controlling & monitoring the Internet can be done to improve it.

6.3 Conclusion

A cylindrical solar water heater has been designed and its performance evaluated. A maximum temperature difference of 4.3^0C between inlet and outlet at water mass flow rate of 2.52×10^{-6} m^3/secwas observed. The efficiency of the cylindrical solar water heater was calculated. The maximum value during the experimental period was found to be 31.6%. This strongly suggests a good capability of the system to convert the solar energy to heat which can be used for heating water. A major advantage of this system is that it is not necessary to direct it to the sun because of its circular shape, whereas the flat plate collector should always be directed to face the sun with a certain tilted angle to get the best efficiency. Furthermore, it has an additional advantage of having a lower heat loss because it is composed of a glass tube and a copper coil.

References

[1] https://www.researchgate.net/publication/239369583_The_performance_of_a_cylindrical_solar_water_heater.

[2] Ministry of Electricity and Water Annual Report for 2002, Kingdom of Bahrain.

[3] Gupta HP, Garg HP. System designs in solar water heaters with natural circulation. Sol Energy 1968;12:163–82.

[4] Morrison JE, Braun JE. System modeling and operation characteristics of thermosyphon solar water heater. Sol Energy 1985;34:389–405.

[5] Norton B, Probert JT, Gindy JT. Diurnal performance of thermosyphonic solar water heaters, an empirical prediction method. Sol Energy 1987;39:251–65.

[6] Nahar NM. Energy conservation and payback periods of natural circulation type solar water heaters. Int J Energy Res 1992;16:445–52.

[7] Kalogirou AS, Dentsoras AP. Modelling of solar domestic water heating systems. Sol Energy 1999; 65:335–42.

[8] Karaghouli AA, Alnaser WE. Experimental study on thermosyphon solar water heater in Bahrain. Renew Energy 2001;24:389–96.

[9] Chang JM, Shen MC, Huang BJ. A criterion study of solar irradiation patterns for the performance testing of thermosyphon solar water heaters. Sol Energy 2002;73:287–92.

[10] Nahar NM. Year round performance and potential of a natural circulation type of solar water heater in India. Energy Buildings 2003;35:239–47.

[11] Kudish AI, Evseev EG, Walter G, Preiebe T. Coaxial tubular solar collector constructed from polymeric materials: an experimental and transient simulation study. Energy Convers Manage 2003;44:2549–66.

[12] Chun W, Kang YH, Kwak HY, Lee YS. An experimental study of the utilization of heat pipes for solar water heaters. Appl ThermEng1999;19:807–17.