DESIGN AND FEBRECATION OF A SOLAR FLAT PLATE COLLECTOR

A thesis report submitted to the department of mechanical engineering for the partial fulfillment of the degree of Bachelor of Science in Mechanical Engineering

A Thesis by

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APPROVAL

This is to certify that the project on **"Design and Fabrication of a Solar Flat Plate Collector".** By Anik Kumar Kundu (ID No: BME 1901017465), Md Quiyum Hossain (ID No: BME 1901017467), Saeed Ahmed Sarker (ID No: BME 1901017481), Md Shahab Uddin (ID No: BME 1901017490), Md Tarek Rahman (1803016042**)** has been carried out under our supervision. The project has been carried out in partial fulfillment of the requirements of the degree of Bachelor of Science (B.Sc.) in Mechanical Engineering of years of 2019 and has been approved as to its style and contents.

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DECLERATION

We, declare that the work presented in this project is the outcome of investigation and research of performed by us and under the supervision of **Md. Minhaz Uddin**, Lecturer, Department of Mechanical Engineering, Sonargaon University (SU). We also declare that no part of this project and thesis has been or is being submitted elsewhere for the award of any degree.

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ABSTRACT

In the present review paper the existing solar water heating systems are studied with their applications. Now a days hot water is used for domestic, commercial and industrial purposes. Various resources i. e coal, diesel, gas etc, are used to heat water and for steam production. Solar energy is the chief alternative to replace the conventional energy sources. The solar thermal water heating system is the technology to hardness the plenty amount of free available solar thermal energy. The solar thermal system is designed to meet the energy demands. The size of the system depends on availability of solar radiation, temperature requirement of consumer, geographical condition and arrangement of the solar system etc. Therefore, it is necessary to design the solar water heating system as per above parameters. The available literature is reviewed to understand the construction, arrangement, applications and sizing of the solar thermal system.

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Chapter 1

Introduction

1.1 General

In the post decode there has been a significant increase in the use of domestic solar water heaters around the world, with solar water heater production. Now a major industry in China, Australia, Greece, Israel and the USA. In recently the global pressure to reduce greenhouse gas emissions and the guest for sustainable energy solutions has realists domestic solar water market the revitalization has been aided by the strong commitment been made worldwide by government to make solar water heaters a more attractive product to consumers.

Which are consumers now have a wide range of products to choose from and the quality of products has improved. They continued growth of the domestic solar water market is dependent on an improvement not only is the quality of the product but also the performance domestic solar water heaters in the past have had a reputation for high initial cost and performance in winter when demand for hot water is typically highest. A novel design of solar collector has been proposed which addresses many of the issues associated with current.

1.2Objective:

A solar collector is a device that collects or concentrates solar radiation from the Sun. These devices are primarily used for active solar heating and allow for the heating of water for personal use. The flat plate solar collector is a type of solar thermal panel whose objective is to transform solar power into thermal energy. This type of thermal solar panel has a reasonable cost/effectiveness ratio in moderate climates and are well suited to a large number of thermal applications, such as: space heating, water heating and other many applications.

Chapter 2

LITERATURE REVIEW

2.1 Overview

One of the most common tools used for planning a successful project management is the STEEPLE analysis. One alternative for this analysis is the Swot, but Steeple is more advanced as it deals with greater detail and gives an overview of the external factors that would affect the feasibility of any project. It is an acronym of 7 words as follows in the following table 1:

Social	This part is known as socio-cultural factor, and it is basically about the trends, behaviors and attitudes of a population, by which the analysist or marketer should respect and take into consideration in order to understand the customer’s needs.
Technological	This part is about technology, as the business world has changed from what it was before and technology can be positive, as it can be negative if a business didn’t analyze the up to date advancement. In order to increase the profit margin, any business should monitor the technology industry and implement the latest advancement.
Economic	This part deals with the economy side of any business. Economy is in a constant change and as long as decision making is concerned, then this part should be well managed and studied for a better strategic plan.
Environmental	This part is about the environment that surrounds any

	business, and it is one of the crucial factors that may affect companies. It can either be positive or negative for the company, depending on whether the business affect positively or negatively the environment.
Political	This part deals with the laws or changes implemented by the governments. Any business should be aware and up to date with each law/ change stated by the government as it can affect the company’s stability.
Legal	This part focuses on laws and how much the business follows it. To operate in a legal manner, companies should follow every legal requirement regarding safety, health and other factors. That is why every business should be updated with the latest laws.
Ethical	This part is about ethic soft company, as it should respect the ethics of the societies and be socially responsible toward any population in order forth company to be better ethically.

Table 1: Overview of the Steeple Analysis (2.1)

2.2 Implementation of Steeple:

- Social Impact:

The main sources of heating the water in the Zoaria is wood burning, gas bottles and electrical boilers. These heating source bring indirectly a social problem which is school dropouts among fund the resources for heating water. My project will help a little bit with this social issue as the parents will save some money from using the solar water heater system,

- Technological impact:

In order to implement an energy efficient model house for the village, the solar water
Heater should be cheap because of the in habitant’s financial situations they cannot afford the expensive top line of such technologies. That is why my project will be cost efficient and with a reasonable performance for the villagers to profit from.

- Economic impact:

For this part, the annual cost of buying wood, gas bottles or paying for electricity to heat water consumed in the shower would decrease since solar water heaters is100% renewable, and uses the sun rays.

- Environmental impact:

This project is 100% renewable energy that uses solar radiations to heat the water, and it will save the environment by decreasing the CO2 emission caused by the use of gas bottles, electrical boilers and wood burning.

- Political impact:

Morocco vision is to encourage people to use more renewable energy technologies,

ndthisprojectismatchingthelong-termviewofthegovernmentwhenitcomesto the use of such technologies.

- Legal impact:

This project goes along with the laws and regulation of energy efficiency in the country.

- Ethical impact:

This project goes along with the ethics of the villagers as it does not touch or harm anyone privacy or ethical behavior of any of the inhabitants.

2.3 Steeple chart

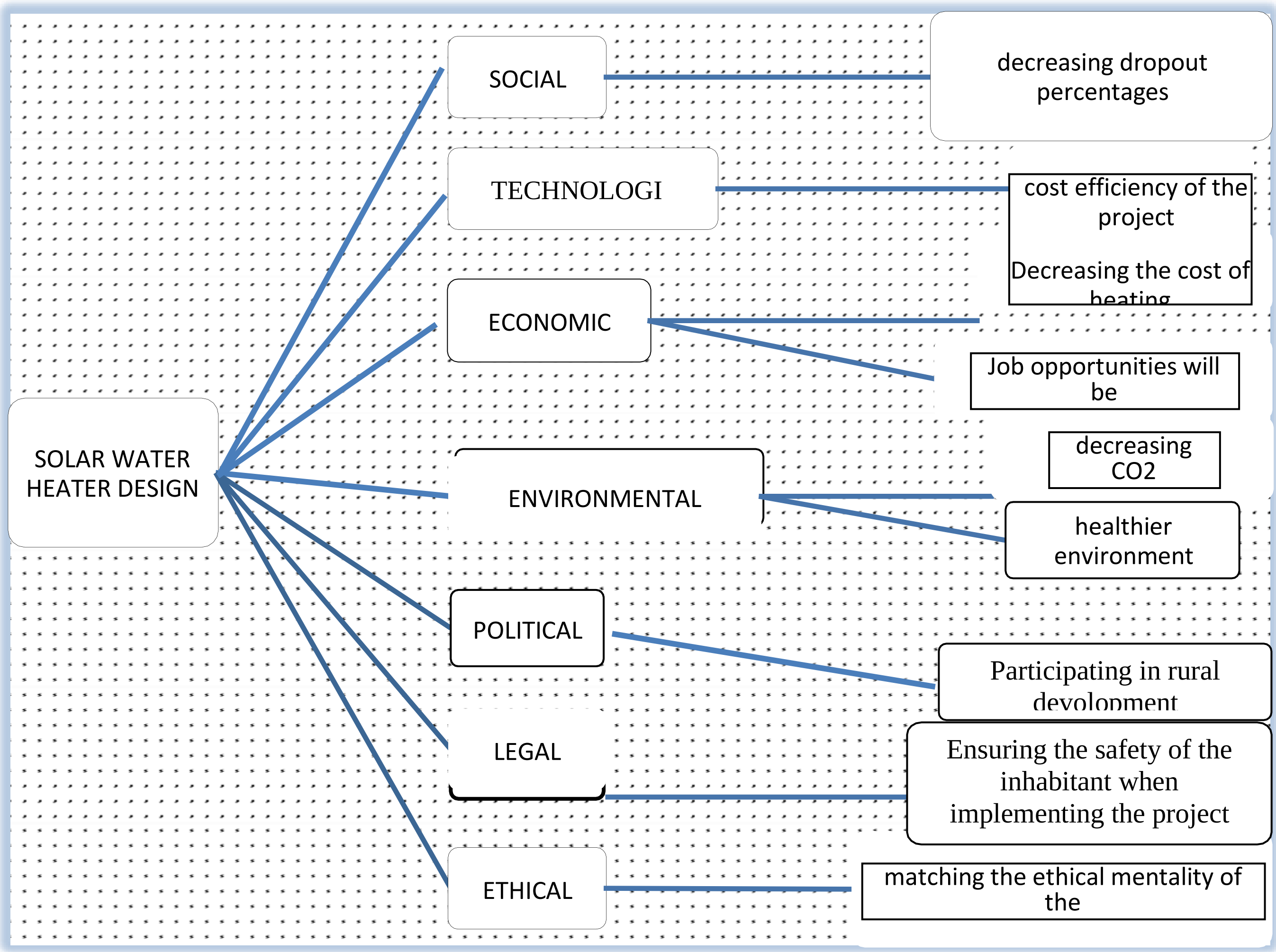


Figure 1: STEEPLE Impacts Chart (2.1)

2.4 Efficiency of Solar Water Heaters

Although solar water heaters have the same method of capturing solar radiations and transfer ring it into heating energy for various liquids, still each type differ from the other in the thermal efficiency rate because of its components, and materials that was used in order to build it. Each type of collectors has its own efficiency depending on the ambient temperature, where we distinguish three types of temperatures as follows:

- Low- temperature systems:
    - Usually uses unglazed collector.
    - Operates at low temperatures areas where it is up to 10°C.
    - Often used for heating swimming pools.
- Mid- temperature systems:
    - Usually uses flat plates collector.
    - Operates at temperatures between 10 °C and 20°C.
    - Used for indoor heating system and liquid heating.
- High- temperature systems:
    - Usually uses evacuated tubes collector.
    - Operates at temperatures more than 35 °C. Generally

used for absorption cooling, electricity generation and also as a water heating system.

2.5 The building of the flat plate collector

After going through all of the types of solar water heaters, I selected as I said before the flat plate collector as the model that I would be building for the model house in the Zoaria. So, I went to a blacksmith and I give him the size of the collector house that he will build for me as stated above in the figure since it is made of iron. The process of making the wood collector house took him around 5 days. After finishing the wood box, I went to by bought 6 meters of copper tubes, and a 2 meters square insulation material as indicated in the figures.

As we can see from the two figures, the insulation is of the purpose to decrease thermal losses and absorb the some of the energy lost and increase the flat plate collector efficiency, The copper tubes will circulate the water inside the collector and absorb the sun rays and turn them into useful heat for water. To increase the absorption rate of the copper tubes, they will be painted in black because black color has high absorption of sun rays. The copper tubes will be bended and reformed as a serpentine inside the collector. The final part is the glazing of the collector which is the cover glass that will cover the flat plate collector and protect the system form rain or snow. The type of glass to be used is the toughened glass of a thickness of 5mm.

CHAPTER 3

Methodology

STEP 1: MATERIALS REQUIRED

Here are the materials needed for this project are:

16-foot half inch copper pipes – Type L

16 half-inch 90-degree elbows

14 tube straps

21 X 24 half inch plywood for the back

15 X 21 half inch plywood for the pipe support

2 X 2 lumber at 20 and 35″ for the sides

4- and 3/8-inch square dowel rods for the glass

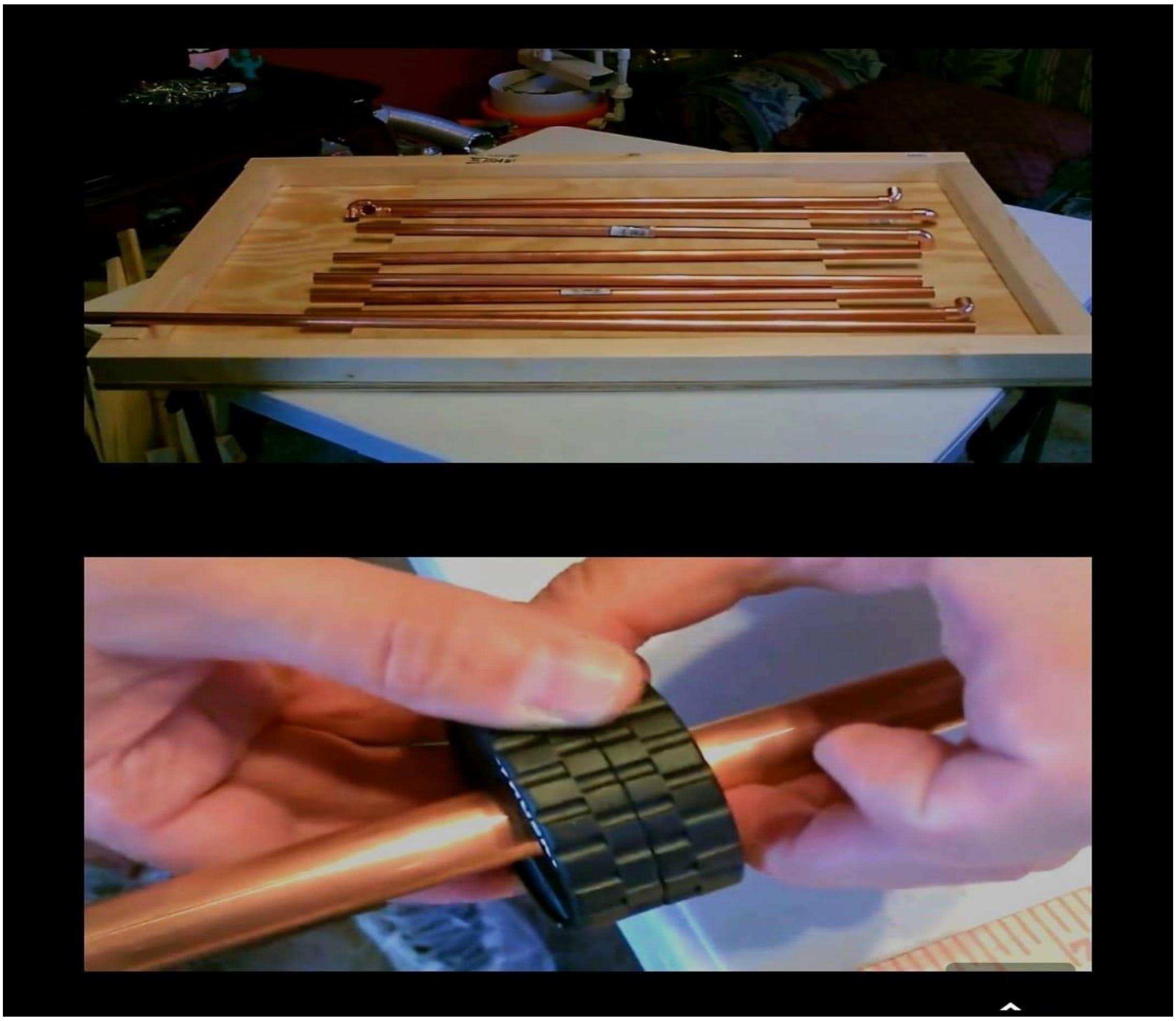
support 1/2-inch coupler

Fig. 2 Cover Pipe (3.1)

STEP 2 : CUTTING THE COPPER TUBE SECTIONS:

The first step is to cut down a bunch of two-foot sections out of the 16-foot sections using a copper cutter. We cut 7 of them and 2 more for the top and bottom which are 24 inches each.

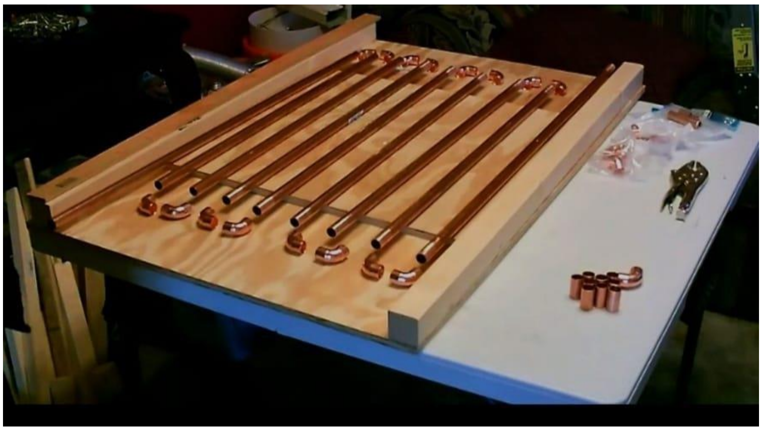
Fig 3. Copper pipe (3.2)



STEP 3: CUTTING PIECES FOR ELBOW JOINTS:

Next, we cut 8 sections of 1 1/8″ for the connector pieces between elbow joints. This allows the pipe to be spaced exactly two inches apart on the board evenly all the way up and down.

Fig 4. Copper pipe (3.3)



STEP 4: SOLDERING THE ELBOWS AND THE CONNECTOR:

Connect the pipes using a couple of elbows and a 2-inch connecter piece and solder then. Do it for the rest of the pipes.

Fig 5. Copper pipe (3.4)

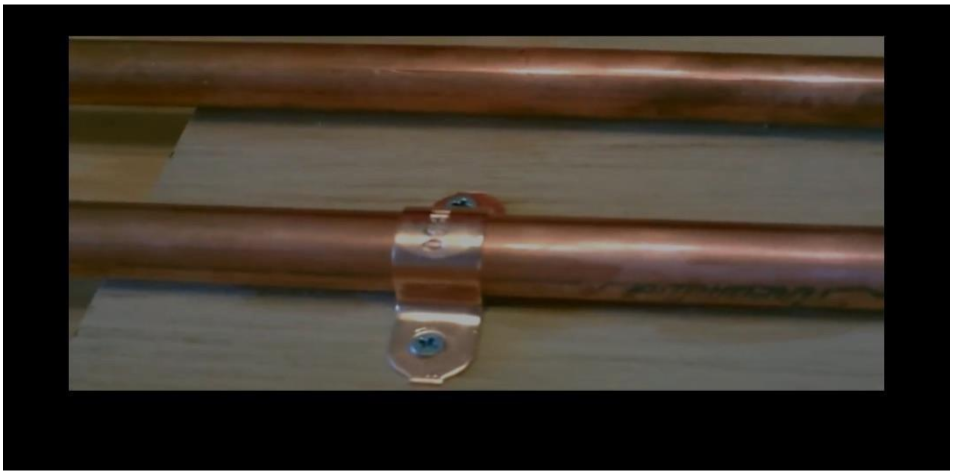
STEP 5: SECURING THE PIPES ONTO A PLYWOOD FRAME:

Slide the pipes into the plywood frame collector and fasten them onto it using 3/8-inch screws to be more secure. A small internal board is placed onto this frame which helps the pipe to lay flat inside. Also, it holds the pipe at the right height so that it exits through the right holes. It allows for the pipe to be easily removed from the collector frame.

Fig 6. Copper pipe (3.5)

STEP 6: ADD DOWEL RODS FOR SUPPORT:
Cut the wooden dowel rods and put them inside the collector to support the glass. Sand them a little bit so that the copper pipe will fit back through.

Fig 7. Copper pipe (3.6)



STEP 7: WELDING A STRAIGHT COUPLER TO THE OUTLET:

A straight coupler is welded onto the end of the outlet then you can add any pipe or connecter or wherever you want the water to go.

Fig 8. Copper pipe (3.7)

STEP : SECURING A BACK BOARD:

The inner board is secured to the backboard using some three-quarter-inch screws. The 4 corners of the 2 X 2 wood frame are secured using 2 and half-inch wood screws and the corners of the backboard is secured by one- and one-half inch screws.

Fig 9. Copper pipe (3.8)

STEP 9: ADDING A GLASS FRAME:

A 21 X 24 - inch glass is placed on the frame with the help of some silicone caulk around the edge. The highest piece of copper in there is an eighth of an inch away from the glass and its painted black.

Fig 10. Wood box (3.9)

3.1 Solar heating system:

Solar heating systems car be divided into two grips passive solar and active solar heating in essence it uses system harvest thermal energy from the sun and utilize the collected heart for space heating purposes or to heat domestic water passive solar systems rely on the structure of the building to concert leapt this child be in the form of a item or a roof orientation tart alcoves for laugher solar irradiance. on the contrary active solar lactating systems rely on heat pumps that transfer the collected heat from the solar collectors to the building. In contrast to photovoltaic panels that generate electricity thermal solar panels are used to capture energy from the sun and utilize it to provide the above-mentioned commodities. Normally the systems are not designed for standalone system due to the intermittency of the energy source and the lack viable storage options .However these systems can be complimentary to other existing can be heating systems powered by natural gas or other source.

3.2 Local Building and planning regulations:

Local building and planning regulators Solar heating systems must comply with local building and planning regulations. For example, if a collector is crested or a root fixed to a have it must be secure and not liable to be blower off in a high wind. It is also probable that some planning authorities would raise objections if solar heating panels made a substantial alternation to the visual appearance of a building. This would be particularly relevant in the case of older building of historic interest many people might object to the rather star appearance of swimming pool heaters and it may be necessary to site these behind a hedge or similar screening in conditions which are somewhat less than idea.

CHAPTER 4

Experimental Data Analysis

4.1 Thermal Efficiency of collector

After building the collector comes the calculations' part, where we can estimate the thermal efficiency of the collector using some formulas.

Thermal efficiency of solar water heaters is not static. It is calculated by the division of "useful energy out" over "energy available". Energy available is the radiation arriving to the collector's surface. And it is symbolled as AI.

Usefulenergyoutisthenetthermalenergyembodiedinthehotfluidleavingthecollectoroutlet pipe.

the thermal efficiency can be calculated using the formula:

$$\eta = \frac{Q_u}{AI}$$

where

- Q_u is the useful energy out

- A is the area of the collector in[m^2]
- *I* is the solar radiation in the collector plane in[W/m^2]

From equation, we need to calculate the Q_u using the following equation:

$$Q_u = m c_p (T_o - T_i)$$

where

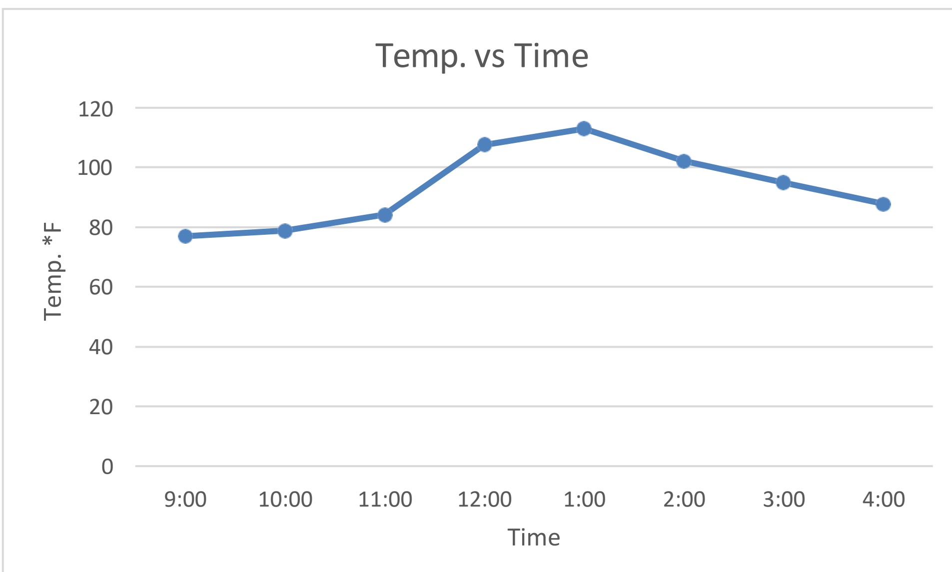
- m is the mass flow rate in kg/hr.
- C_p is the specific heat capacity [j/kg. K
- $T_o$is the outlet temperature ink
- $T_i$is the inlet temperature ink

4.2 Calculated Data and Graph for September 1:

Table2. Time and temperature data (4.1)

Time	Temp. (*F)
9:00 AM	77
10:00 AM	78.8
11:00 AM	84.2
12:00 PM	107.6
01:00 PM	113
02:00 PM	102.2
03:00 PM	95
04:00 PM	87.8

Fig 11. Temperature vs Time Graph (4.1)

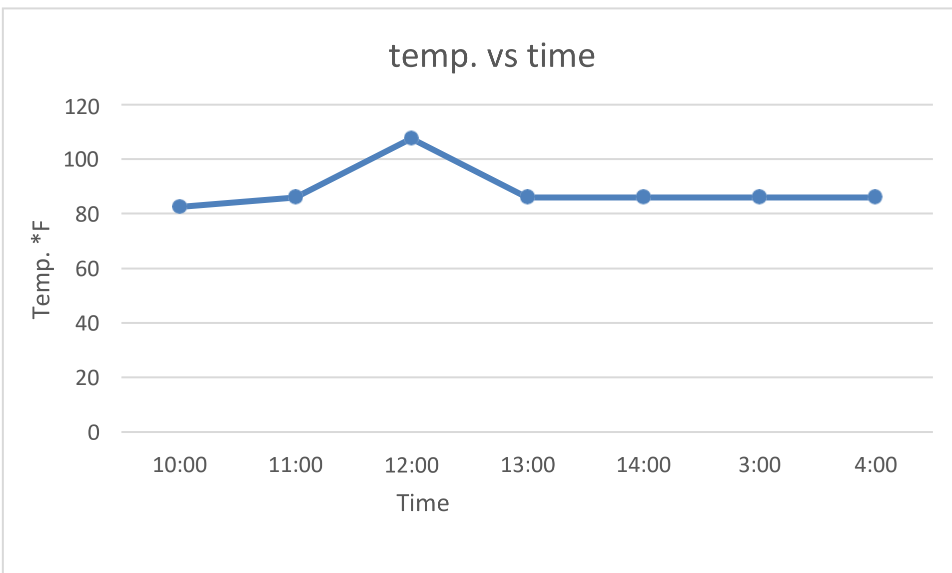


Calculated Data and Graph for September 2:

Table3. Time and temperature data (4.2)

Time	Temp. (*F)
10:00 AM	82.5
11:00 AM	86
12:00 PM	107.6
01:00 PM	111.2
02:00 PM	102.2
03:00 PM	96.8
04:00 PM	86

Fig 12. Temperature vs Time Graph (4.2)

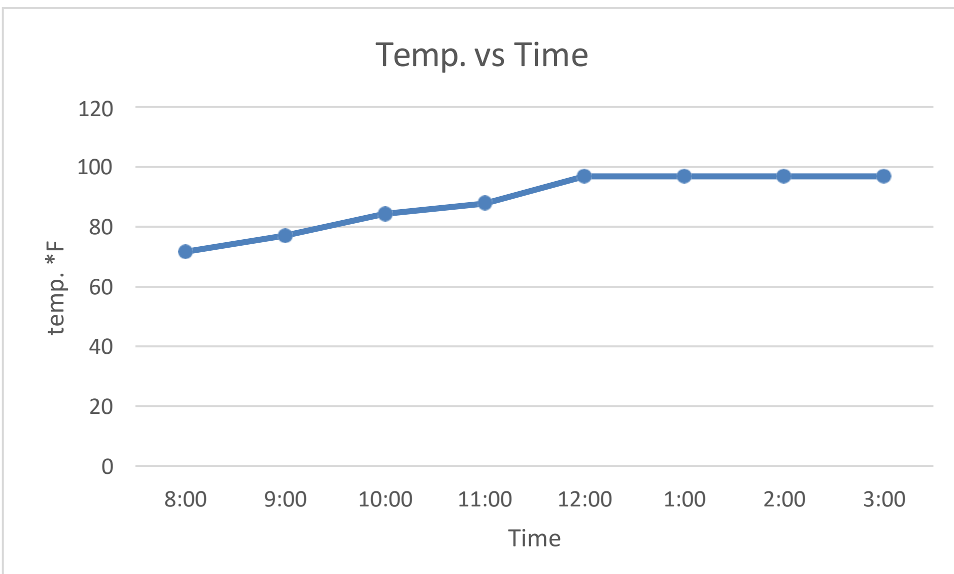


Calculated Data and Graph for September 3:

Table4. Time and temperature data (4.3)

Time	Temp. (*F)
8:00 AM	71.6
9:00 AM	77
10:00 AM	84.2
11:00 AM	87.8
12:00 PM	109.4
01:00 PM	107.6
02:00 PM	104
03:00 PM	96.8

Fig 13. Temperature vs Time Graph (4.3)

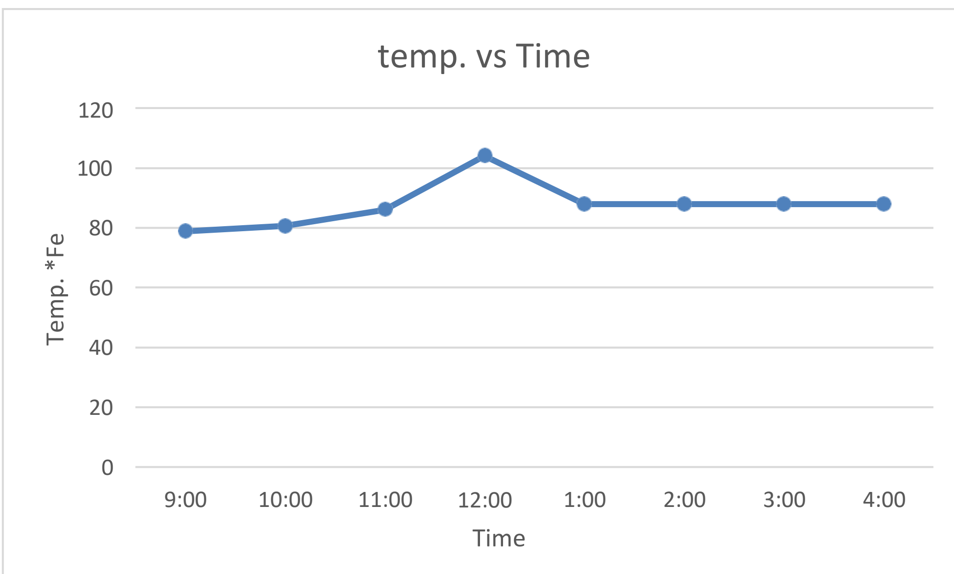


Calculated Data and Graph for September 4:

Table5. Time and temperature data (4.4)

Time	Temp. (*F)
9:00 AM	78.8
10:00 AM	80.6
11:00 AM	86
12:00 PM	104
01:00 PM	107.6
02:00 PM	100.4
03:00 PM	93.2
04:00 PM	87.8

Fig 14. Temperature vs Time Graph (4.4)

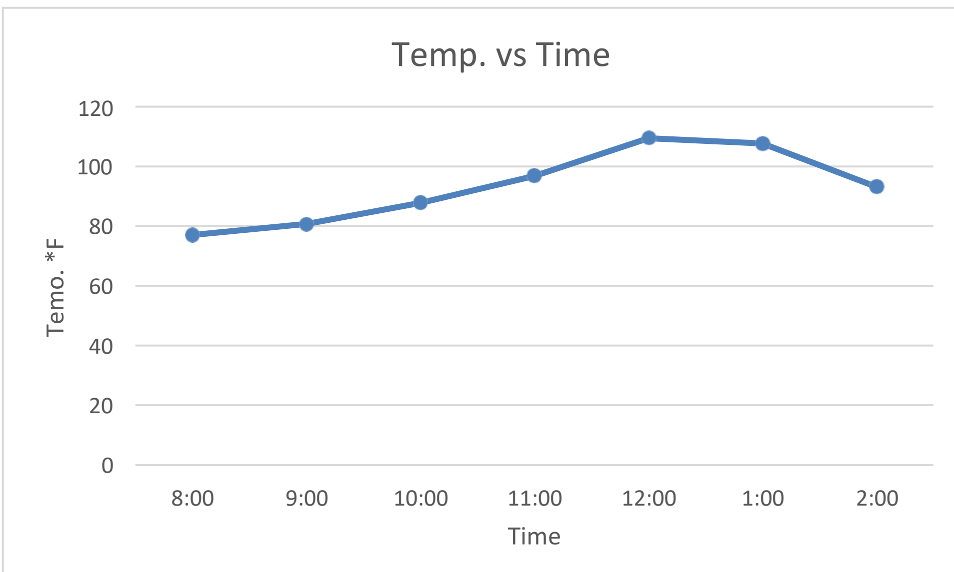


Calculated Data and Graph for September 5:

Table6. Time and temperature data (4.5)

Time	Temp. (*F)
8:00 AM	77
9:00 AM	80.6
10:00 AM	87.8
11:00 AM	96.8
12:00 PM	109.4
01:00 PM	107.6
02:00 PM	93.2

Fig 15. Temperature vs Time Graph (4.5)

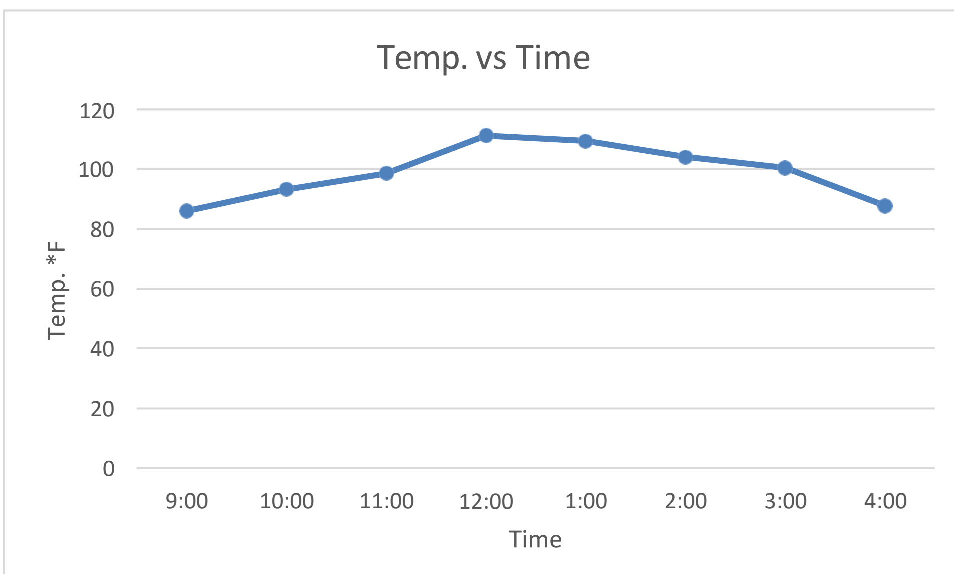


Calculated Data and Graph for September 6:

Table7. Time and temperature data (4.6)

Time	Temp. (*F)
9:00 AM	50
10:00 AM	59
11:00 AM	68
12:00 PM	86
01:00 PM	104
02:00 PM	95
03:00 PM	86
04:00 PM	77

Fig 16. Temperature vs Time Graph (4.6)



CHAPTER 5

Conclusion

Selecting the right solar water heating system for a facility depends on three key factors like climate, budget, and water usage requirements. Solar water heating systems are economical, especially in commercial buildings when the energy used to heat water is significant. Although, the sun is capable of heating, its applications in water heating will be much effective when various factors such as safety, maintainability, and also efficiency of the system are considered. Solar water heating systems are mounted with distinct settings and agreements at present. The fundamental technology of these devices is researched and it is discovered that there is a need to work on the produced layout method to pick, mount and track the solar water heating scheme according to accessibility.

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