DESIGN, CONSTRUCTION AND PERFORMANCE STUDY OF A FLAT PLATE SERPENTINE SOLAR THERMAL COLLECTOR

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CANDIDATE'S DECLARATION

The is to certify that the work presented in this thesis, "Design, construction and performance study of a flat-plate serpentine solar thermal collector", is the outcome of the investigation and research carried out by us under the supervision of Dr. Md. Rezwanul Karim, Associate Professor It is also declared that neither this thesis nor any part of it has been submitted elsewhere for the award of any Degree or Diploma.

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RECOMMENDATION OF THE BOARD OF EXAMINERS

The thesis tittle “Design, construction and study of performance of a flat-plate serpentine solar thermal collector” submitted by Abdoulie Fatty. Ansumana Fofana and Lamin Jawneh has been accepted as satisfactory in fulfillment of the requirement for the degree of BScTE in Mechanical Engineering.

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ABSTRACT

Rising conventional fuel prices, rising energy demand, worries about climate change, and pollution from burning fossil fuels have all spurred interest in various renewable energy solutions. The energy demand related with cooling air for different sectors is quite important. Renewable energy has been used for water heating and air heating for domestic and industrial use. Flat plate solar collector has been used for multiple purposes such as water heating for refrigeration and air heating. This project introduces design and technical evaluation of solar thermal collector to be used for Vapor Absorption Refrigeration System. With the area of 0.84 m^2, one will be able to get a better performance for the system. For the surface coating (generally a mat black) on a mild steel sheet a selective coating system is suggested. A single glazing system minimizes heat losses through convection and radiation from the collector plate. The experiment of this project was carried out at the Mechanical workshop of Islamic University of Technology under Gazipur prevailing weather conditions during the summer months of April and May. Data were gathered hourly between the hours of 8:00 am and 5:00 pm. With the ground flat, the collector was set at an angle of 23.0° to allow more solar radiation into the surface of the collector. The inlet (T_{in}) and the outlet (Tout) temperatures were measured by using glass tube thermometer. It has been found that, this collector can heat up water up to 52° C.

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NOMENCLATURES AND SYMBOLS

A_c	Area of the collector (m^2)
C_p	Specific heat of air (kJ/kg. K)
I	Solar radiation (w/m^2)
M	mass flow rate (kg/s)
T_{out}	Outlet temperature (K)
T_{in}	Inlet temperature (K)
T_f	the film air temperature between the outlet and inlet $(T_{out} + T_{in})/2$
DT	Temperature difference $(T_{out} - T_{in})$ (K)
$DT_{b.}$	Bed temperature difference $(T_b - T_{in})$ (K)
DT_g	Glass temperature difference $(T_g - T_{in})$ (K)
h	Efficiency of the solar collector
Q	Volume flow rate (m^3/s).
ΔP	Pressure difference, (N/m^2).

CHAPTER 1: INTRODUCTION

1.1 Background of the study

The world is developing, and the consumption of fossil fuels is rising quickly. As fossil fuels are limited, scientists are becoming eager to find alternate sources of energy. Today, a variety of renewable energy sources are widely used to satisfy the needs of business, households, etc. The most widely available renewable energy source is solar energy. Energy consumption is increasing while conventional energy supplies are nearly finished, there is rising demand for new technologies in renewable sector. Solar thermal energy consists of the sun's radiation to produce thermal energy which can be applied for different uses, such as generating electricity, domestic uses, irrigation purposes and so on. The energy conversion in solar thermal collector is from solar energy to heat energy. Various types of solar collectors are used to trap solar radiation in both household and factories. Now widely utilized are conventional solar thermal collectors, but they have low thermal efficiency. On a regular basis, studies are carried out to improve solar thermal collectors. A solar collector with clear windows and the collector's frame enclosing the working fluid inside the collector. The working fluid absorbs solar light.

The system can be developed to be deployed in a Solar Vapor Absorption Refrigeration System

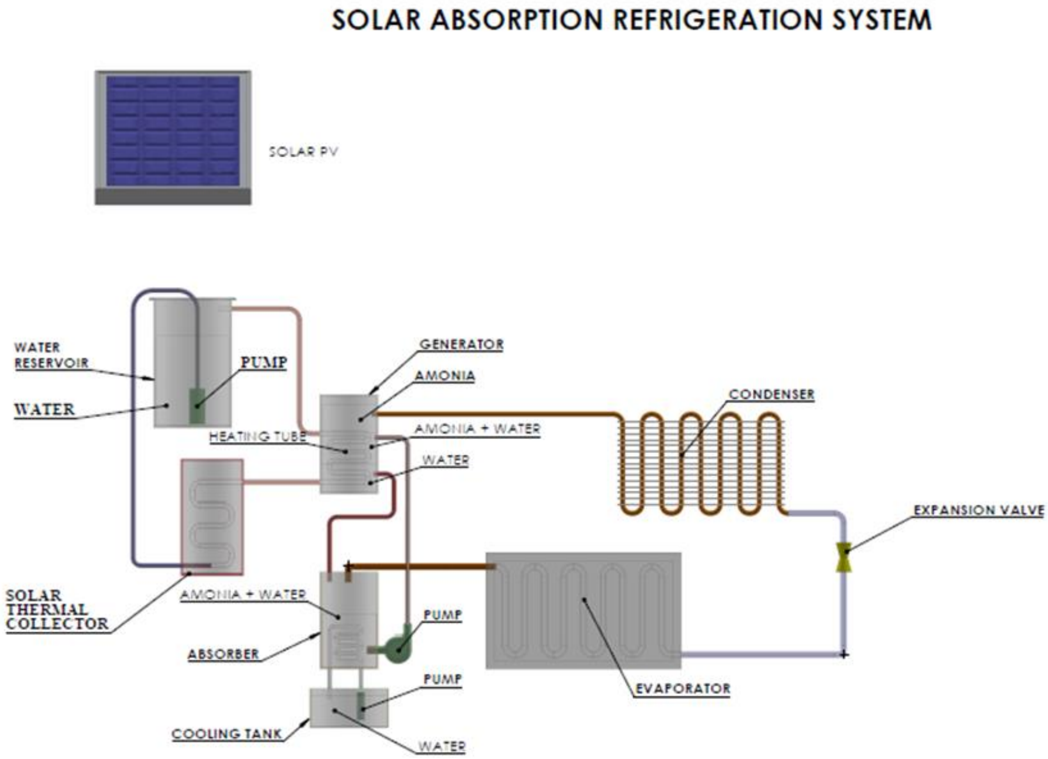

Figure 1.1 Solar Vapor Absorption Refrigeration System

1.2 Vapor Absorption Refrigeration System

1.2.1 The absorption stages

The first component is an absorber, which contains a solution of water and ammonia (NH3). We are using a solar thermal collector as our heater collector because we have a water tank that is filled with water and a submerged pump installed inside the tank. The tank's purpose is to travel the water coming from the water tank by means of the thermal collector and then through the absorber tank to where it will carry the heat generated by the thermal collector before returning to the water tank. There are copper coils that are round within the absorber tank into which the heated water passes, and the goal of coiling the copper tube is to boost the effectiveness of the heating process. Ammonia will generate vapor as the heat exchange occurs, and since we already know that it prefers a warm environment, ammonia will form vapor as the heat moves through the absorber tank where the ammonia is located. Ammonia will also tend to evaporate at greater temperatures and pressures. There is a pipe at the absorber tank that runs through to the condenser, where the ammonia that is prone to evaporation in the absorber tank will flow through the tube to the condenser and the resulting ammonia vapor is subsequently condensed.

1.2.2 Condensation state

Ammonia releases heat that is latent to the atmosphere at the condenser, when it turns into liquid. The heat generated by the partially liquid ammonia will be absorbed by the cold condenser, which can also be cooled from outside. The refrigerant is in a vapor phase before it enters the condenser, but after going through the process there, it eventually loses the heat that is latent of vaporization and turns into a liquid. The high liquid ammonia from the condenser will exit the condenser through a conduit and flow through an expansion valve. The pressure between molecules will decrease at the expansion valve, causing a drop in temperature. This high-pressure region liquid ammonia will condense into a low-pressure, low-temperature liquid that becomes extremely cold and travels along the tube to the evaporator, where the majority of cooling occurs.

1.2.3 Evaporation state

The latent heat of vaporization that exists on the surface of the coils of the evaporator will be completely absorbed by the low pressure, extremely cold, low temperature ammonia when it enters the coils by taking in all the heat from the surface. The extremely cold, low temperature, low pressure ammonia will then change into low pressure. The cooling action or refrigeration effect causes the ammonia vapor within this coil and the outer layer of the evaporator where it is located to become chilly. Following this, low-pressure ammonia will escape the evaporator and approach the absorber container through the line connected from the evaporator. It will then mix with the water still present at the evaporator to produce a solution, and the cycle will repeat repeatedly.

1.3 Solar Energy and Its Availability

All of the energy necessities for human use may be directly met by solar energy. The whole energy needs of the human population might be met by solar energy if it could be harnessed from just 1% of the planet's surface (Kalogirou, 2009). The amount of solar radiation reaching the surface of the planet is likewise considerably smaller than that reaching the planet's surface from space. The outer atmosphere of the earth blocks between 25 and 50 percent of the radiation from the sun that enters it. Much of the energy that is radiated to the planet is reflected and absorbed by greenhouse gases as well as water vapor. (Goswami et al. 2000)

1.4 Solar Energy Utilization

Since 1970, interest in using solar energy has increased, largely as a result of the increasing expense of energy through conventional sources. The world's most plentiful and reliable energy source is solar radiation. There are numerous applications for solar energy, including:

- Industrial process heating
- Electricity generation (Solar thermal power plant, photovoltaic systems)
- Greenhouse heating
- Swimming pool heating
- Domestic hot water heating: Evacuated-tube solar collectors, integralcollector- storage systems, flat-plate collector Space heating and cooling.

1.5 Objectives of the study

- To design and construct a serpentine tube flat plate solar collector.
- To study the performance of serpentine flat plate solar collector.
- To evaluate the amount of heat generated by the system.

CHAPTER 2. LITERATURE REVIEW

The installation of a flat-plate solar collector and design study are urgently needed since their integration into the current system will lessen the reliance on finite conventional energy sources. On the contrary, sources of environmentally friendly energy are limitless and will be around for as long as there is life on Earth. The primary function of a solar thermal collector is to capture heat from the sun in order to raise the temperature of fluid passing through the collection tube. This heat can then be used for a variety of purposes, such as heating water or a room during a cool period. In order to maximize the flat plate collector's ability to absorb solar radiation, this page aims at offering a breakdown of the many methods and advancements. Insufficient research has been done on the impacts of selected varnish absorbers sheets on the efficiency of flat plate solar collectors, according to the literature review, which highlights the significant impact of coating on material absorptivity. In the current study, the effects of utilizing black-painted absorber plates were examined on the thermal efficiency of flat plate collectors (FPC) in order to achieve this goal. The coatings were chosen, it should be emphasized, because to their strong the absorption at narrow wavelengths and low emissions at long wavelengths, which enhances the collection of heat energy [1, 2, 3]. Additionally, it is chosen because of its excellent accessibility, strong thermal conductivity, and good optical characteristics. To the best of our understanding, there hasn't been much research done on the impact that black paint has on the absorption plate of collectors with flat plates (FPC). According to ASHRAE Standard 93 [4], the flat plat collector's (FPC) performance was evaluated. Additionally, the thermal performance of flat plate collectors (FPC) with variously polished absorber sheets at varied flow rates was contrasted. The explanation of the absorbed and released power characteristics as well as the effect of various coatings on these parameters' values were provided. Since this study has never been done previously, it is important to take into account how the black paint would affect the flat plate collector's thermal efficiency [5].

A serpentine duct has been manually constructed in sequence with the flat-plate thermal collector for solar energy to provide a total exposed face area of 0.0084m2. The panel was electro anodized with matt black after being welded in the borders using a non-consumable tungsten electrode arc welding technique, and the space between the ducts after being soldered in four places using a metal inert gas (MIG) welding process [6]. Handmade connectors were used on the collector was made of copper, and it was put within an aluminum container with glass that had a low iron content. The roughness can have a significant impact on the directional characteristics as an outcome of scattering effects. As a result of capturing light and preventing reflection, the carbon covering has a high absorption rate. More light is trapped when the porosity is increased [7, 8, 9, 10].

Solar energy is a type of energy that has been highly studied because it is accessible, has minimal environmental effects, and has no impact on global warming, according to Duffie JA, Beckman WA, Solar engineering of thermal processes, New York: Wiley; 2013. Solar systems called flat-plate collectors (FPCs) capture solar radiation and transmit it to a working fluid. They are frequently utilized in low-temperature applications like those for producing hot water and heating rooms. Heating of water and heating of spaces can be enhanced with the plentiful solar radiation and the limited resources at hand to produce a highly desired result.

Maximum solar energy collection by a solar heat collector and an increase in the thermal disposal coefficient through optimal constituent setup and sizing are required for a solar collector to operate reliably and with good performance. The aforementioned work offers a parametric investigation to ascertain how the copper tube distance, within copper tune size absorber plate thickness, protection substance, covering of glass dimension, color coding, and collector tilt angle affect the heat the elimination factor and solar energy obtained on the collector for solar energy.

The techniques for the purpose of thermal performance improvement of flat plat collector (FPC) can be divided into two primary categories: i) passive methods and ii) active methods. Over the past ten years, numerous studies have been conducted in the field to improve the transfer of heat and heating efficiency of flat plat collector (FPC). No outside pressures have been applied in passive approaches. It consequently draws more attention. Tabulators such wire coils, drives, and tape with twists were employed in passive approaches (Jaisankar, 10/2009).

CHAPTER 3: DESCRIPTION OF THE MODEL/SYSTEM

3.1 Design of a flat plate solar collector

The tradeoff analysis between efficiency, power need, ideal operation temperature, array size, air ducting, and total air volume to be handled is necessary when designing flat plat solar collector systems for a specific application. The following illustration illustrates the specific design factors for flat plate solar collectors: For the purpose of analysis, the design can be divided into its constituent parts. Identification of potential materials and selection of the components that best satisfy the criteria are crucial. Insulation, glazing, absorber plate, and absorber coating were the materials used for the evaluation.

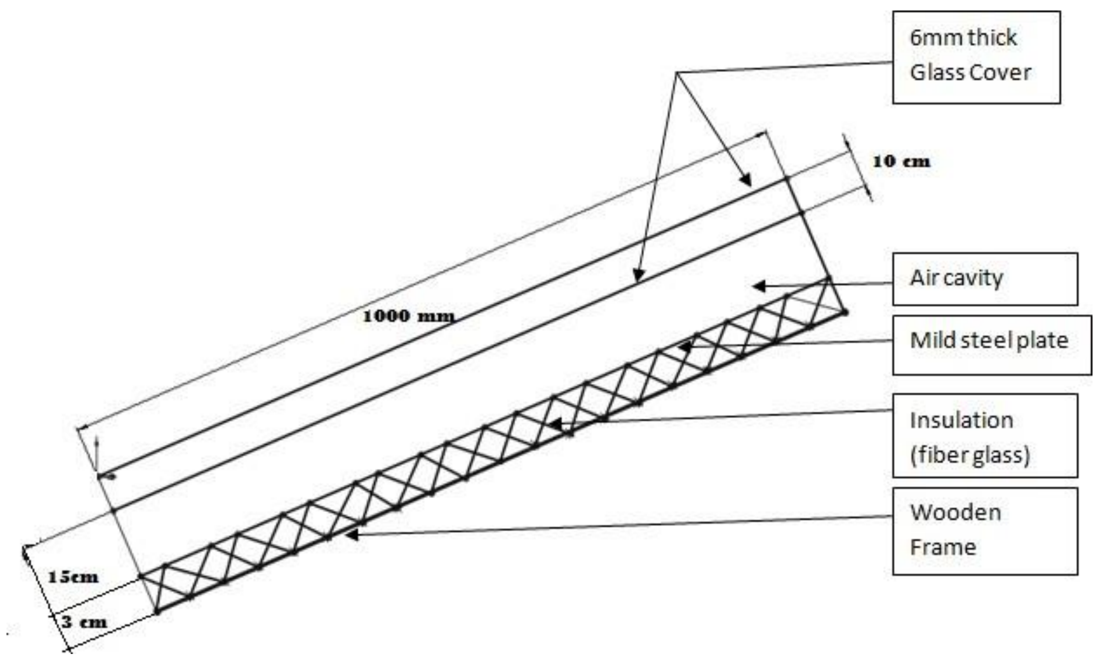

Figure 3.1: Design concept of solar collator

Figure 3.1 showing the view of serpentine flat plate collector with the outer frame made up of plastic wood that serve as the housing of the whole system with the length, breadth and the width of 25 cm, 70 cm and 120 cm respectively. The housing contains an insulation fiber that prevent heat lost from the collector. The mild steel plate act as the absorber plate to absorb more heat from the sun radiation and this heat is being transferred to the working fluid, the air cavity in the system is there to accumulate more heat in the system and the glass cover for transmitting the sun radiation and also act as the dust cover to prevent foreign materials to enter the casing that may hinder the transfer of heat to the collector copper tubes.

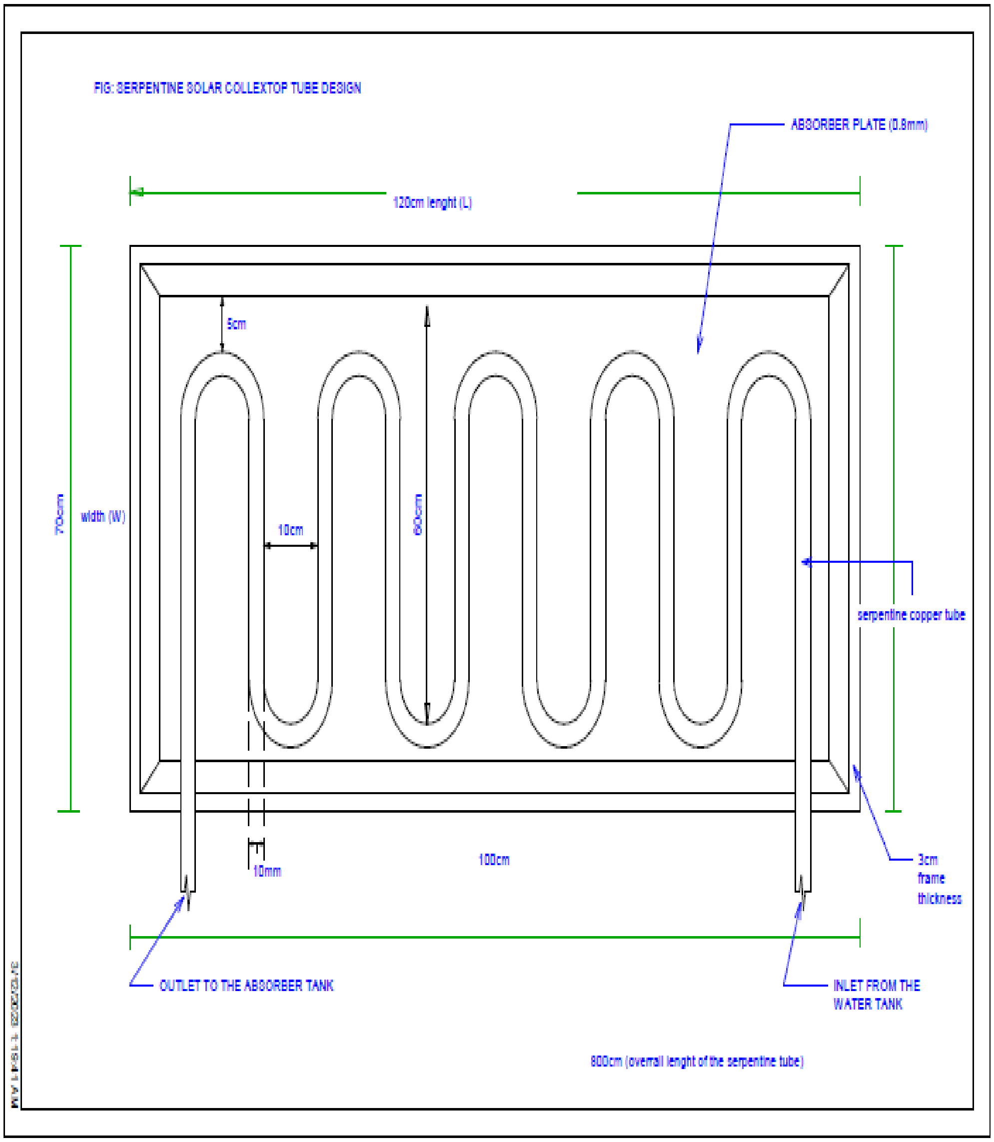

Figure 3.2: Serpentine flat plate collector with dimensions

Figure 3.2 shows the copper tube of the serpentine flat plate collector with dimensions. Length of One serpentine segment 60cm, distance between the tubes 10cm, distance between the collector and the frame 5cm and the diameter of the copper tube 10mm.

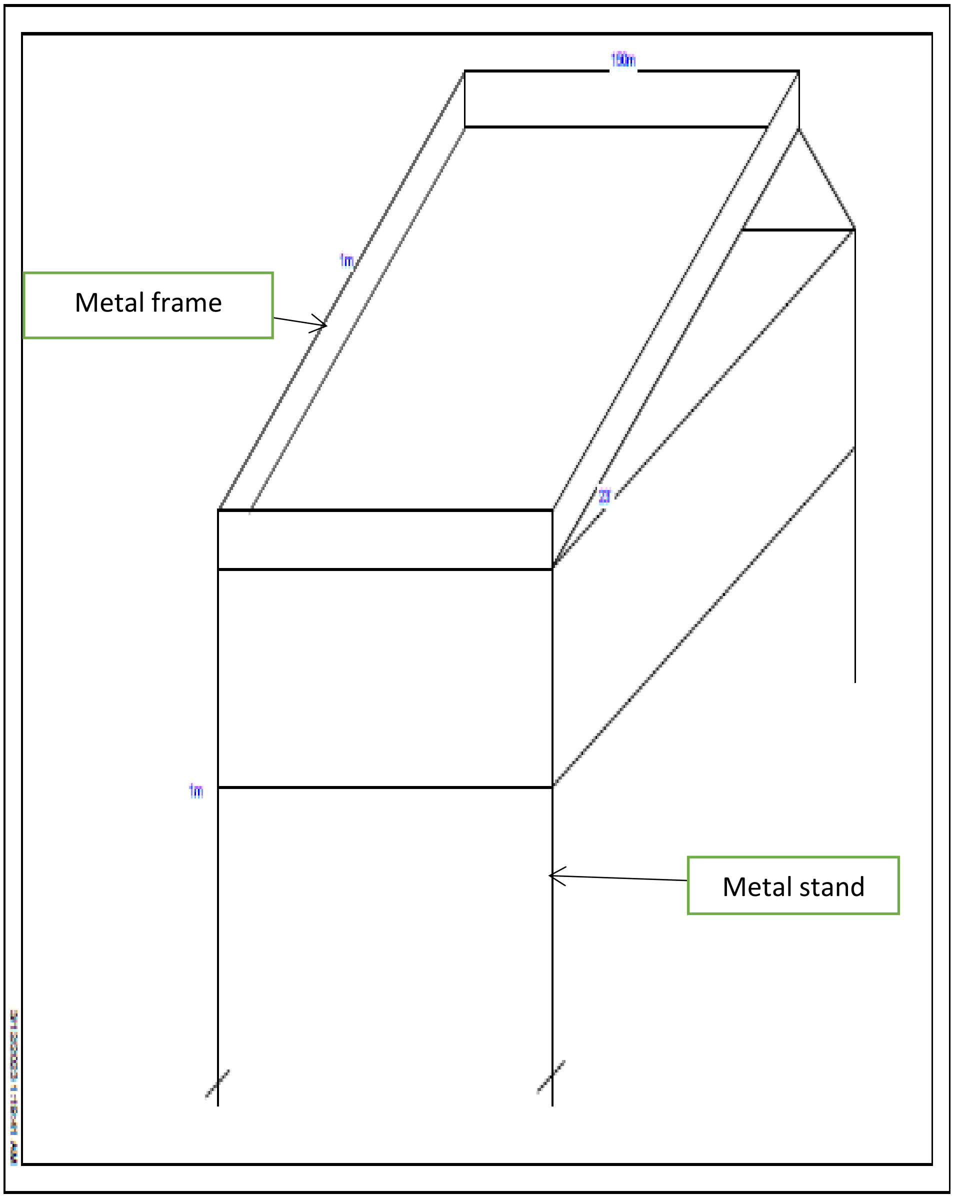

Figure 3.3: Serpentine flat plate collector stand

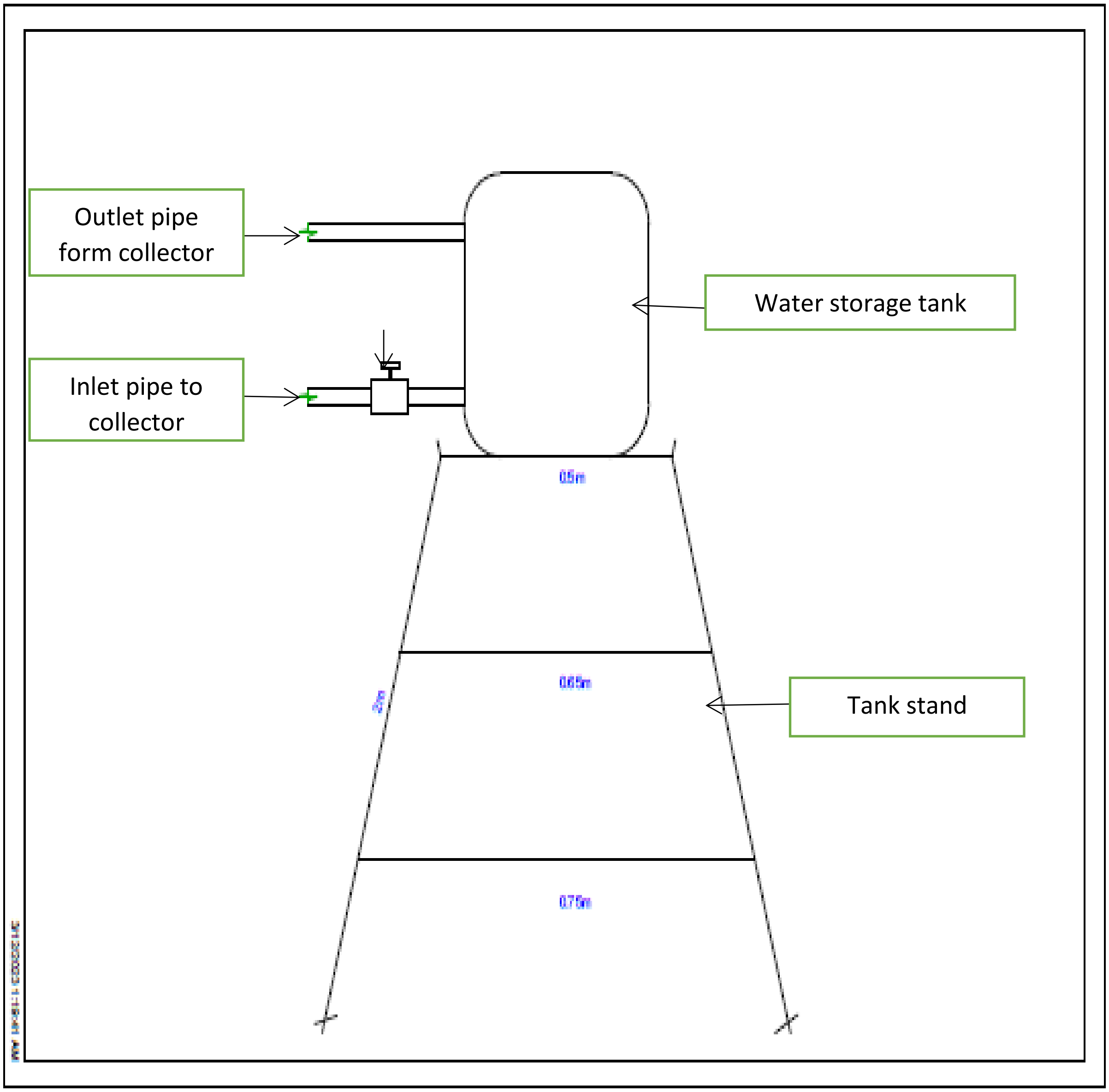

Figure 3.4: Water storage tank and stand

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i. Absorber plate

The absorber plate's temperature increases as a result of solar energy hitting it surface. The operating fluid receives this thermal energy transfer from this energy hitting the surface of the thermal collector. The operational temperature range, maximum stagnation temperature, operational flow rate, cost, and other factors are taken into account when designing the absorber plate. The materials and characteristics of absorber plates have been the subject of extensive research. Metals like copper, aluminum, and iron are the most used plate materials. Because of its strong corrosion resistance, thermal conductivity of.018 w/m C, specific heat of 0909 cal/gm'C, and thermal conductivity of.018 w/mC, copper is the best material out of the bunch. The temperature at which it melts and boils is 1083°C and 2380°C, respectively.

ii. Absorber coating

A surface coating (generally mat black) is placed on the absorber plate to maximize the absorption of solar energy. The quality of the coating should be such that it absorbs maximum energy and emits the minimum. An ordinary blackened surface absorbs maximum solar radiation but its emittance is also high. Thus, it is not suitable for high temperature applications. For efficient solar air collectors selective coating technique is used for absorber coating.

ii. Glazing or cover plate

The function of the cover plate or glazing is to minimize the loss of heat from the collector plate which occur due to convection and radiation. The cover plate has the following properties:

a) Low refraction and high transmittance for visible solar light.

b) High refraction and low transmittance for heat radiation ranges.

c) Low absorption across the board.

d) Outstanding weather resistance and durability.

For cover plates, a variety of transparent materials can be utilized. More often than plastic or any other material, glass is used. Despite being extremely weak, it is resistant to the majority of chemicals and alkalis. It uniformly transmits at 90%, absorbs at 6% in the visible spectrum, and is nearly opaque in the infrared range.

iv. Insulation

Insulation is a crucial element that significantly contributes to reducing heat losses from the collection plate's lower surface and its lateral edges. If insulation is present, heat losses depend on the thermal conductivity and thickness of the insulating material. Low thermal conductivity, the absence of deterioration, the absence of outgassing or fuming at high temperatures of around 200 C and owing to frequent thermal cycling up to 150 C, as well as hydrophobicity, are desirable design requirements for an insulation material in a collector.

You might use glass wool or rock wool for this.

v. Bottom Side Frame

Due to its durability to conditions in different seasonal fluctuations, its cost advantage over aluminum, and its preference for research work, the flat plate solar collector's body is typically built of plastic wood.

vi. Water storage tank

The water storage tank has a 30-liter capacity. Heavy insulation is used in plastic drums to store hot water in order to both minimize heat loss to the environment and maintain the water's heat.

vii. Steel frame and stand

A supporting steel structure is made for collectors and storage tank. An angular steel of size 40mm was used for the construction of both frames and a flat being used as a setting basin.

viii. Copper tube

Copper has several properties that make it an attractive material in the field of science. One of these is its high heat conductivity. Copper has become an important component in solar water heaters due to this property.

The tube that connects the collector to the building's water storage and distribution system is made of copper. The copper lining absorbs heat and transfers it to the water as the sun shines on the water inside the collector, heating it in the process. The circulating pump adjusts its speed as the intensity of the sun changes throughout the day. Copper is regarded as one of the best metals for thermal conductivity. It is such a good heat conductor that if you heat one end, the other end will heat up.

Table 3.1 The technical specification of flat plat solar collector.

Parameter (units)	**Symbol**	**Dimensions**
Collector Length (cm)	L	120
Collector Breadth (cm)	b	70
Collector Area (m^2)	A	8.4
Absorber Thickness (mm)	t	1.00
Hydraulic tube diameter (mm)	dh	10
Tube spacing (mm)	w	10
Tube width (mm)	d	10
Length of one serpentine segment (mm)	L	70

Figure 3.5: Materials used for the collector

Table 3.2 The list of components required for the construction of serpentine flat plate collector and it axillary components.

Table 3.2 Materials used for the design

	COMPONENTS	QUANTITY
1	Water Tank 25 liter	1 piece
2	8 watts DC pump	1 piece
3	Serpentine copper tube (½ inches)	35ft
4	MS sheet plate (8” by 4”)	1 sheet
5	Plastic wood (8ft/ 4ft)	2 sheets
6	Plane glass (8” by 4”)	1 sheet
7	MS angle (1.5”by1.5”) 3mm 40kg	121ft (40kg)
8	MS Flat bar 1inches (3mm) 40kg	29ft (40kg)
9	Hose pipe (plastic/ nylon)	28ft
10	Gate valve 1 inches (2.5mm)	1 piece
11	Glass tube thermometer	2 pieces
12	Coper tube U-bend	10 pieces
13	Silicon gum	2 bottles
14	G.I clamp/ s.s clamp	12 nuts
15	Silver brazing stick (rod)	25 stick
16	Insulation materials	Available at the lab
17	MISC	

3.2 Fabrication of serpentine tube solar collector

Following the design, a serpentine tube solar collector has been fabricated in IUT Workshop and a performance study will be carried out. Figure 3.6 shows the collector set up installed at IUT Campus. Figure 3.7 shows the measurement of temperature data during performance study.

Figure 3.6: Experimental setup of the Serpentine Tube Solar Collector built at IUT, Gazipur.

Figure 3.7: Placement of the thermometers used to gauge water temperature from the solar collector's entrance to its outflow.

CHAPTER 4: METHODOLOGY

4.1 Experimental Methods

During experimentation of the system, the solar thermal collector and the water storage tank were connected together means of pipes as inlet and outlet pipes, the submersible water pump was connected to a 12 volts battery that provide electrical power to energized the submersible pump inside the tank, the submersible pump is responsible for the circulation of water in the system. A glass tube thermometer was fixed in the inlet of the collector and outlet to measurement the temperature of the water entering and leaving the collector.

Already we have made some development during our consultation with our supervisors. We have come up with a design that comprises of a water storage tank, submersible water pump, solar thermal collector, absorber tank, generator and phase change materials such as the condenser, expansion valve and evaporator.

However, during our research, we have come up an idea that there should be a need for a coolant tank in the system to control the temperature of the ammonia water solution in the absorber tank, the reason for this been that ammonia does not need too much of heat to vaporized in the absorber tank before finding its way to the different phase change materials to produce the desire output (Refrigerating effect).

Above all, we are now working on the solar thermal collector design, a component responsible for producing the desire heat in the system. The collector receive heat from the sun's radiation that spread on the surface area of the absorber plate to add more heat to the copper tubes and the heat is transfer to the water passing through the collector with the aid of a submersible pump position in the water storage tank, this submersible pump supply heated water to the generator where the heat exchange take place. The strong ammonia and water solution in the generator come into contact with the heated water in the copper tube of the thermal collector and this cause the ammonia and water solution to vaporized (this due to fact that at certain higher temperature not only ammonia will evaporate but together with water) in the generator and the ammonia vapor evaporate through the tube connected to condenser and the water return back to the storage tank.

At the condenser, the ammonia will lose its latent heat to the atmosphere and become liquid, this cold condenser will absorb all the heat from the partial liquid ammonia and the condenser can be cooled by an external source. Before the refrigerant (ammonia) enters the condenser, it is in a vapor phase but after the process it ultimately becomes liquid by losing its latent heat of vaporization. From the condenser this higher temperature higher pressure ammonia will leave the condenser and enter the expansion valve. At the expansion valve the pressure between the molecules will decreases and which is a temperature fall. This higher-pressure liquid ammonia will expand to low pressure, low temperature liquid which will get very cold and it will pass through the pipe to the evaporator where the main cooling take place.

At the evaporator the low-pressure, low temperature enters the evaporator coils it will absorb all the latent heat of vaporization present in the surface of the evaporator coils and this ammonia will turn in to a low pressure. The ammonia vapor inside this coil and its surrounding surface of the evaporator and will become cold by losing the heat to this liquid that is the cooling effect or refrigeration effect. After this low-pressure ammonia will leave the evaporator and enter the absorber tank through the pipe connected to the evaporator and will mixed with the water left present at the evaporator and the process will continue again and again.

4.2 Governing Equations

The equation below can be used to calculate the amount of heat absorbed by the collector

$Q_{ab}=mCp(T_2-T_1)$ ………………………………………………. (1)

Where C_p = specific heat capacity (J/kg.K)

m= mass flowrate (kg/s)

T_1= inlet temperature (°C)

T_2 = Outlet temperature (°C)

Efficiency:

The solar collector efficiency represents the ratio of the heat absorbed by the solar receiver Q_{ab} and the incident solar radiation I, normal on the collector's aperture of area A_a.

$\eta = Q_{ab}/GA_c = mCp\ (T_{in} - T_{out})/GA_c$…………………… (2)

η_{th}= Efficiency

Q_{ab}= Heat absorb (W)

G = Solar radiation on the collector (W/m^2)

A_c= Area of the collector (m^2)

m= mass flowrate (kg/s)

Cp= specific heat capacity (J/kgK)

4.3 System performance calculations on hourly basis

4.3.1: The heat absorbed by the collector (Q_{ab}) in Joule

Q_{ab}=m Cp (T_2-T_1)

where: m = 25 kg

Cp = 4180 J/kg. K

(T_2-T_1) = 4 K [Temperature difference taken from Table 4.2 at 11:00 am to 12:00 pm]

A = 0.84 m^2

Now to find Q_{ab},

Q_{ab} = {25 × 4180 × 4}

Q_{ab}= 418,000 J

And solar radiation received in one hour from 11 AM to 12 PM,

I = {G × A_a × 3600} (Joule)

I = {620× 0.84× 3600}

I = 1874,880 J

4.3.2: Calculating the Efficiency on hourly basis.

η_{th} = Q_{ab}/ I

η_{th} = 418,000/1874,880 η_{th} = 22.3%. (Hourly Efficiency)

4.4 Experimental Procedure

The experimental work was carried out at the Islamic University of Technology outside the mechanical workshop during the hotter months of April and May in Gazipur. Data were collected hourly between the hours of 8:00 am and 5:00 pm. The collector was slanted at a 23° angle because the ground was flat.

From May through August, the sky at Gazipur was often clear, occasionally becoming cloudy or partially cloudy. The data that was gathered during more consistent weather conditions was examined and taken into consideration in order to obtain an accurate result.

However, due to the weather, several days were excluded from the analysis. The average mean value of the wind speed and relative humidity ratio, which are instantaneous readings, were obtained from the city office and were hourly recoded. Tin, Tout, wind speed, relative humidity ratio, solar radiation intensity, and the temperatures of three separate, equal locations along the collector were the factors that were measured.

The Following tables are showing the data of Inlet (T_{in}) and outlet (T_{out}) temperature of the solar collector design for this project.

Table 4.1 Data Table 1 for 24 May 2023

Date of performance: 24 may 2023			**Location: IUT, Gazipur**		
No. of Obs.	**Time (hour)**	**Temperature of water in the collector**			**Ambient Temp (in ^{0} C)**
		Inlet temp. (in ^{0} C)	Outlet temp. (in ^{0} C)	Ave. temp. (in ^{0} C)	
1.	8:00 am	26	30	28	25
2.	9:00 am	34	38	36	26
3.	10:00 am	40	45	42.5	27
4.	11:00 am	43	47	45	28
5.	12:00 pm	45	48	46.5	29
6.	1:00 pm	45	48	46.5	29
7	2:00 pm	45	48	46.5	29
8	3:00 pm	48	52	50	30
9	4:00 pm	48	51	49.5	31
10	5:00 pm	45	48	46.5	32

Table 4.2 Data Table 2 for 26 May 2023

Date of performance: 26 may 2023		**Location: IUT, Gazipur**			
No. of Obs.	Time (hour)	Temperature of water in the collector			Ambient Temp (in ^{0} C)
		Inlet temp. (in ^{0} C)	Outlet temp. (in ^{0} C)	Ave. temp. (in ^{0} C)	
1	8:00	26	30	28	25
2	9:00	28	32	30	27
3	10:00	32	36	34	29
4	11:00	41	45	43	33
5	12:00	34	38	36	34
6	1:00	37	41	39	34
7	2:00 PM	36	40	38	35
8	3:00 PM	37	41	39	35
9	4:00 PM	38	42	40	34
10	5:00 PM	36	38	37	32

CHAPTER 5: RESULTS AND DISCUSSION

The Figure 5.1 shows the data collected on the 24th May 2023 with temperature against time.

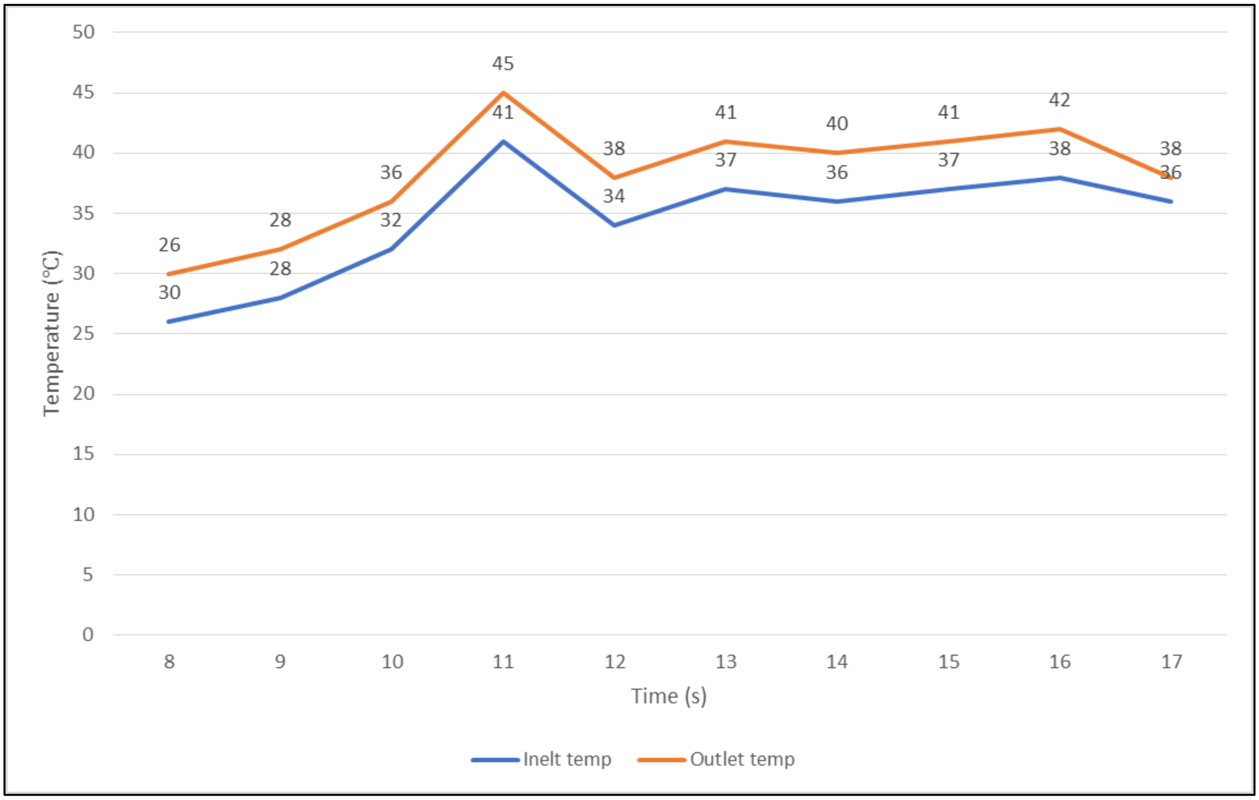

Figure: 5.1 Temperature vs Time graph for 24 May 2023

The Figure 5.2 shows the data collected on the 26th May 2023 with temperature against time.

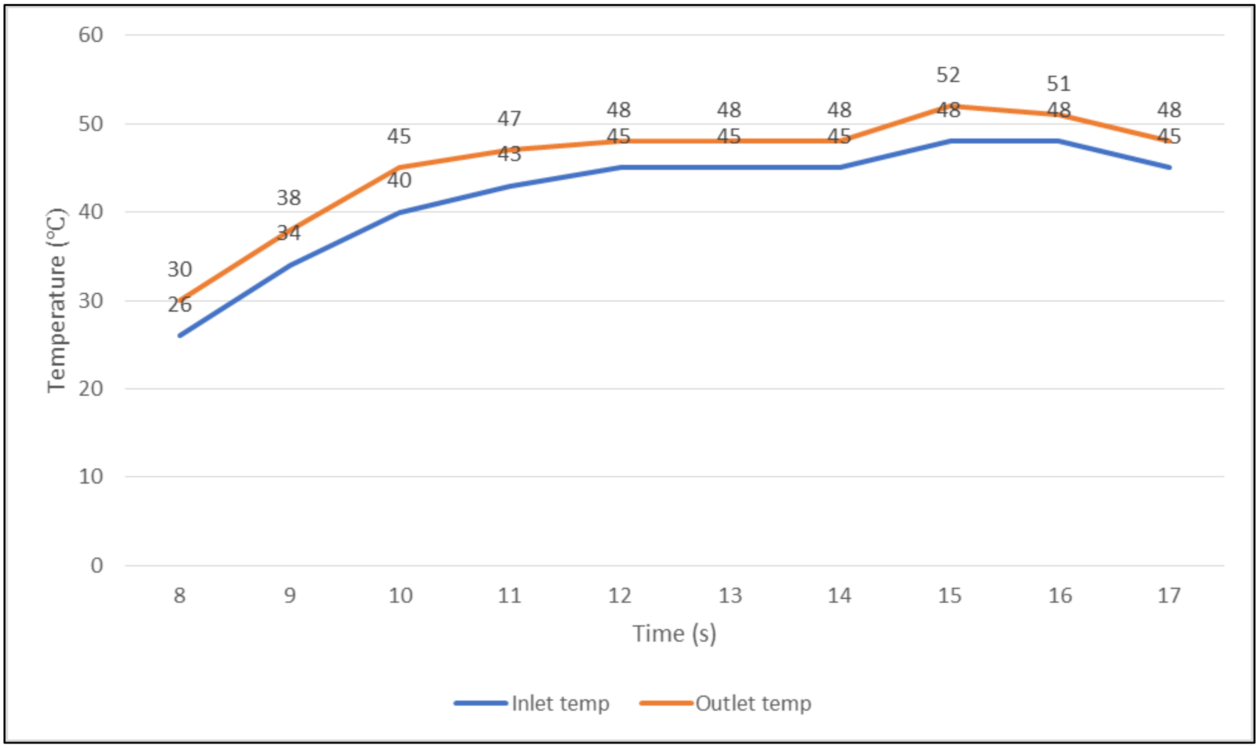

Figure: 5.2 Temperature vs Time graph for 26 May 2023

Based on the above analysis, results have been taken on two separate days on different weather conditions. The design condition of a solar Vapor Absorption System depends on the application. Since flat plate collectors are of are of the stationary type and thus need to be oriented appropriately to achieve maximum collection of solar radiation energy.

The relative ranking of the basic attributes is done based on the rules given in Table 5.1 and Table 5.2, this table give the average water temperatures collected on a cloudy day and a sunny day.

Figure 5.1 and 5.2 shows the graph of temperature and time that the solar thermal collector received from 8 am to 5 pm. In this experiment, the highest temperatures are received from 12 pm to 3 pm at temperatures around 48^0 C to 52^0 C which is enough to get the required temperature needed to heat the water to the desired temperature, this hot water can be used for domestic used as well as refrigeration purpose.

However, our project is design to be deployed for the solar vapor absorption refrigeration system where water (H_2O) and ammonia (NH_3) are used as a working fluid; Ammonia has a low boiling point to vaporize when heat is added to it from any heat source. It is estimated that Ammonia starts to evaporate from 46^0 C and above since the system did not have an analyzer which is use for the purpose of detecting the presence of water particular and send them back to the absorber, for this reason the design fabricated for this project can serve the purpose of Solar Vapor Absorption refrigeration (VAR).

CHAPTER 6: CONCLUSION

Serpentine tube collector-based solar heating systems have demonstrated the ability to use less energy than more traditional standard options. The system's design and operation have a significant impact on the amount of energy savings realized. In this study, the design, construction and performance study of a flat plate serpentine solar thermal collector has been carried out. The performance study was carried out at IUT Campus during Summer days from 8 Am to 5 PM. It has been found that, the flat plate serpentine solar thermal collector is efficient in heating water up to 52°C. However, in favorable weather conditions the temperature can rise up to 60 and above as found from the literature. This type of economic collector can be used for domestic purposes. Also, it can be used as a collector in Solar Absorption Refrigeration System.

6.1 Recommendations for Future Work

The efficiency of flat plate serpentine solar thermal collector can be improved by the use of advanced absorbing techniques and use of high capacity nanofluids instead of water. To develop and incorporate the collector into daily life successfully, there are various issues that must be taken into account.

- Debris and dust clearance prior to a roof installation
- It is preferable to utilize a variable speed solar fan.
- Test the system using various glazing materials, not just regular glass.
- Performance comparisons can be made using more precise measuring equipment.

Solar heating has grown in popularity and system efficiency from earlier investigations of its viability to more recent, more effective uses. Technology should grow and must be utilized without affecting the environment and the only way to achieve this is to move toward renewable energy resources. Renewable energy resources are the energy of the future.

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