

DESIGN AND CONSTRUCTION OF MINI SOLAR WATER HEATER

A report submitted to the Department of Mechanical, Sonargaon University of
Bangladesh in partial fulfillment of the requirements for the
Award of Degree of Bachelor of Science in Mechanical Engineering

Submitted By

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September 2023

LETTER OF TRANSMITTAL

September 2023

To

Nuruzzaman Rakib

Assistant Professor

Department of Mechanical Engineering

Sonargaon University of Bangladesh

Subject: Submission of Project Report.

Dear Sir,

We are pleased to submit the project report on “**Design and Construction of Mini Solar Water Heater**”. It was a great pleasure to work on such an important topic. This project has been done as per the instruction of our supervision and according to the requirement of Sonargaon University.

We expect that the project will be accepted by the concerned authority we will remain happy to further explanations that you may feel necessary in this regard.

Thanking You,

Md. Ershadul Hossain.

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Md. EmddulHaque.

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Declaration

We do hereby solemnly declare that the work presented here in this project report has been carried out by us and has not been previously submitted to any University/ Organization for the award of any degree or certificate.

We hereby ensure that the works that have been presented here don't breach any existing copyright.

We further undertake to indemnify the university against any loss or damage arising from a breach of the foregoing obligation.

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Certification

This is to certify that this project entitled “**Design and Construction of Mini Solar Water Heater**” is done by the following students under my direct supervision. This project work has been carried out by them in the laboratories of the Department of Mechanical Engineering under the Faculty of Engineering, Sonargaon University (SU) in partial fulfillment of the requirements for the degree of Bachelor of Science in Mechanical Engineering.

‘

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ACKNOWLEDGEENT

The report titled as on “**Design and Construction of Mini Solar Water Heater**” has been prepared to fulfill the requirement of our practicum program. In the process of doing and preparing our practicum report, we would like to pay our gratitude to some persons for their enormous help and vast co-operation.

At first, we would like to show our gratitude to the University authority to permit us to do our practicum. Specially, we would like to thank to our honorable teacher Nuruzzaman Rakib .Assistant Professor, Department of Mechanical Engineering, SU–Sonargaon University, Dhaka, for his valuable and patient advice, sympathetic assistance, co-operation, contribution of new idea. Deep theoretical and hardware knowledge & keen interest of our supervisor in this field influenced us to carry out this project. His endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior draft and correcting them at all stage have made it possible to complete this project.

Finally, we would like to thanks again to the respected Vice- Chancellor of SU, Professor Dr. Md. Abul Bashar, Thanks to Dean of Science & Engineering Brig. Gen. (Retd.) Prof Habibur Rahman Kamal, ndc, psc, also thanks to Head of Department of SU, Mechanical Engineering, and Professor Md. Mostofa Hossain because they are designated such an environment for learning through which we got the opportunity to acquire knowledge under BSc in ME program, and that will be very helpful for our prospective career.

We are, indeed, grateful to all those from whom we got sincere cooperation and help for the preparation of this report.

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List of Acronyms

Abbreviation	Name
A	Area of Pipe
CAD	Computer aided Design
K	Thermal Conductivity
L	Length of tubes
Q	Heat Transfer Rate
R	Radius of pipe
ΔT	Temperature change
Δr	Thickness of sheet

CHAPTER-1

INTRODUCTION

1.1 Project Definition

This project is intended to design a water heating system by using solar technology. There are design and production limitation for what but here we decided to create the opening order using the most common and efficient way. After designing such mechanism, the heater would be manufactured, and the results would be presented.

Solar energy technology is used in various places in different ways. But we have used solar energy to heat water. Solar systems are designed in such a way that water can be heated of any temperature. But at domestic levels water can be heated up to 60^o C. The mechanism of our solar heater will resemble as shown in figure 1.



Figure 1 Solar Heater system

1.2 Objectives of the project

The main objectives of the project are as follows:

- To study, design, and analysis of the active solar water heating system according to the domestic applications.
- To choose the economical and easily available techniques to design the solar heating system.
- To do design calculation where needed with the help of research and analysis.
- To fabricate the solar heating system with the economical and easily available materials.

1.3 Applications

Solar water heater can be used in domestic, commercial, and industrial applications. They are enlisted below:

- Domestic ally hot water is used in bathing, washing of utensils and clothes and cleaning floors. Water requirement for a house depends on the number of family members. For a 4 member's family, each consuming approximately 25 liters, on average above 100 liters is required.
- In commercial applications, a large quantity of water is required. For this purpose, large scale heating systems are used.
- In industries water is used to preheat the boiler water. Hot water is also used in food processing industries.

CHAPTER-2

LITERATURE REVIEW

2.1 Back ground

From the beginning of the life on earth, sun has been the most powerful force of nature. It is one of there as ones of the existence of life on earth and contributing lot as a basic energy source. Due to its large benefits and size; it is regarded as the go din some of the religions. In the past no major benefit was taken by humanity. But as the needs of the human are increasing and other reliable sources are decreasing. Now humans are shifting towards renewable energy sources and sun is one of the biggest sources of renewable energy. In the same way solar energy is used to heat water in the industries, steam is produced by using modern techniques. In California, first solar water heater was utilized to heat the pool water in 1970 (Bennet T,2007).

CHAPTER-3

SYSTEM DESIGN

3.1 Design Constraints

There are different design constraints which were considered while designing solar water heater.

This project is experimental based and would have following design constraints and then will be discussed one by one:

Following are the main components of the solar heater.

- Solar Collector
- Water Tank
- Pump
- Structure / Frame
- Control System
- Safety
- Cost
- Weight
- Serviceability
- Efficiency and Performance

3.1.1 Collector Panel.

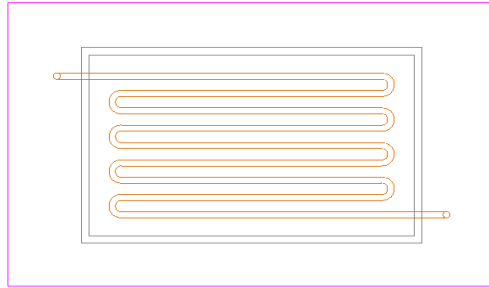


Figure - 2 Collector Panel

3.1.2 System Design

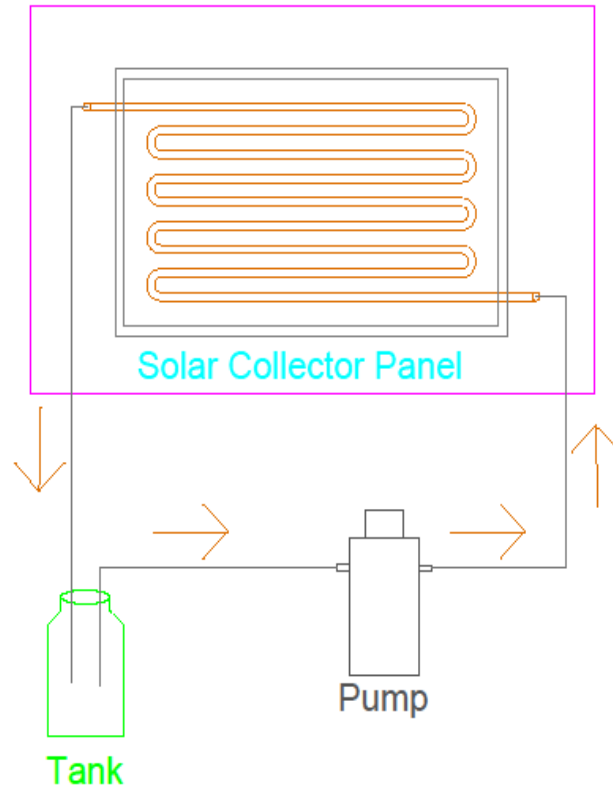


Figure-10 System Design

Following are the main components of the solar heater.

- Solar collector Panel
- Water tank
- Pump
- Structure/ Frame
- Control System

While the collector panel consists of a absorber plates, tubes, galzing, thermal insulations and casing.

3.1.3 Circuit diagram

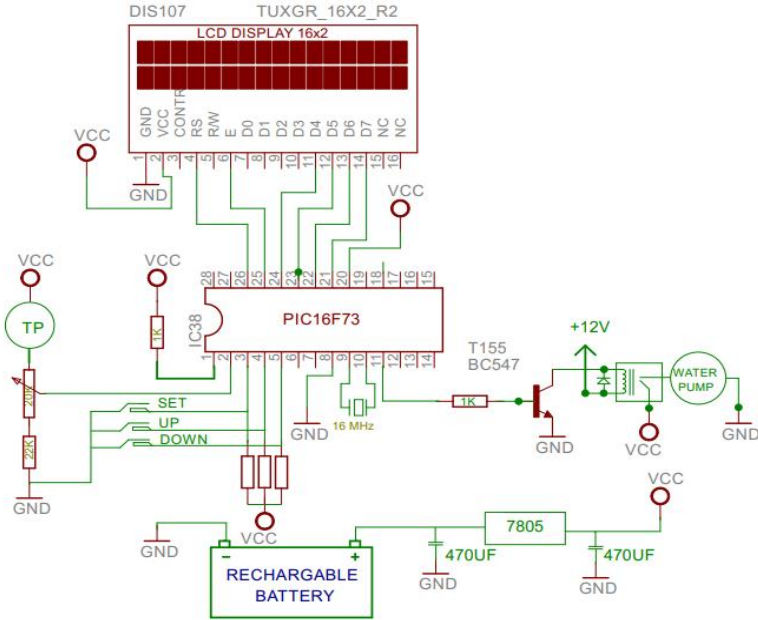


Figure - 3 circuit diagram

3.1.4 Block diagram

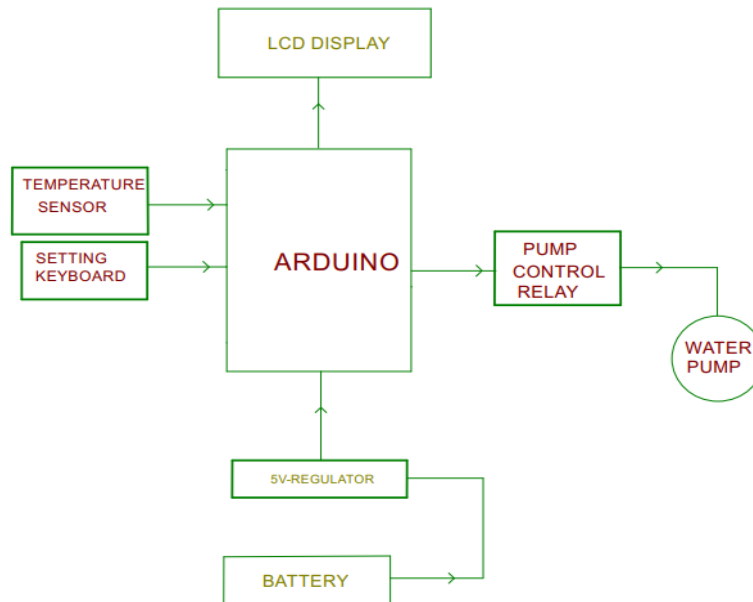


Figure 4 block diagram

- Solar water heater consists of many parts which will be discussed in the next section. On part which will collect the solar heat is called collector. Collector has its direction towards the sun. There is a possibility of damage to collectors as other parts will be within the housing. Collector material should have great strength which can bear the impact of possible winds and other damaging things.
- Solar water heater will be made using the locally available materials and manufacturing techniques. Those parts which are costlier to manufacture or not available locally would be purchased. The cost will be minimized by using machines which are available in the lab.
- Solar water heater will be placed on the roof or at a place where sunlight is available. So it

must be placed in open. Extensive winds or wind blows can damage the solar heater. It must have sufficient weight so that it can be firmly placed on the ground. It is stated earlier that all the materials and parts will be purchased from the local markets.

- Manufacturing processes will also be carefully choosing which have low manufacturing cost. Quality was enhanced by purchasing the parts which can be manufactured locally. Materials will be chosen which have high efficiency and more capacity of absorbing heat.

3.2 Risk Factors

There are many factors which can be considered as damaging factors for the design of solar water heater. Some of which are listed below:

- Cost
- Safety
- Leakage
- Corrosion

Solar water heater would be manufactured using the local sources. Some of the parts which cannot be manufactured will be bought either from the local market or international. These parts will increase the cost of the water heater. In the lab we do not have big machines which can manufacture complex geometries. So, these parts will be manufactured by local vendors. So, cost might be higher due to this reason.

Solar water heater will be kept outside in the sunlight. There is a chance of damage from violent winds and some other factors. Leakage is another big problem which can occur due to poor welding. Corrosion is another big problem which can damage the metal parts and also the heat exchanger.

3.3 Design Methodology

There are many components involved which make up solar water heater. But in this project collector is specifically designed to increase the efficiency of solar heater. Following are steps which will be followed to design the collector of solar water heater:

- Material Selection
- CAD Model
- Design Specifications

Design process starts with the selection of appropriate materials which give sufficient tent hand have better efficiency. As stated earlier that material will be searched in the local market. Then according to our needs, dimensions will be chosen. Then CAD model will be developed and at last design specifications of other components will be enlisted. Figure 4 shows the performance of different types of collectors.

3.4 Material Selection

It is the basic step in the design process. The performance of solar water heater mainly depends on the material of collector. Collector consists of transparent cover, Heat transfer medium, absorber plate, insulation, and housing. Transparent cover traps the radiations inside the housing and increase the efficiency of heater.

3.5 Structure CAD Model

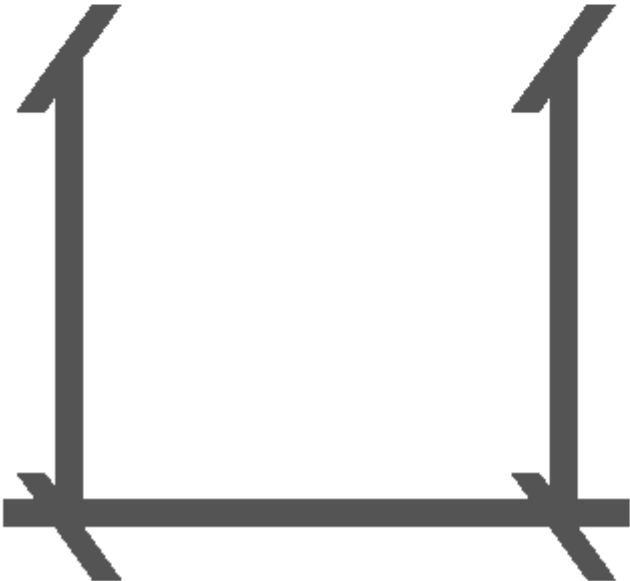


Figure – 5 Frame Design



Figure - 6 Solar water heater designs

3.6. Design Specifications

S.N	Part Name	Dimension	Qty
1	Beam L (Laminate Section -25mmX2.5mm)	500mm	1
2	Beam L (Laminate Section -25mmX2.5mm)	500mm	2
3	Beam L (Laminate Section -25mmX2.5mm)	300mm	2
4	Flat (Laminate Section -25mmX2.5mm)	300mm	2
5	Screw -3mmX25mm	25mm	8
6	Screw Washer	3mm	8

Figure - 7 Frame Dimensions

3.7 Assembled Model

Each component was fitted with in the frame of solar water heater. Collector was place data angle to catch the heat from the sun. Storage tank and piping system are also attached. Fully assembled model is given in the figure.



Figure – 8 Assembled Models

CHAPTER -4

PROJECT MANAGEMENT

This chapter deals with the different tasks related to the project. These include project plan, tasks completed by individuals and budgeting.

4.1 Project Plan

This section deals with the different tasks related to the project from the start to the end. It shows the planning and management associated with the task from preparing proposal to the final presentation and report submission. It is a senior design project, and it took around 16 days for completion. Following figure shows the project plan.

4.2 Contributions of the team members

It is a senior design project, so four members are doing this project. In the table given below, students name and there IDs are listed below.

Table 2 Name and IDs of Team members

ID Number	Member Name
2001020247	Md. Ershadul Hossain.
2001020103	Md. Amirul Islam
2001020170	Johirul Islam
2001020443	Md. EmdadulHaque

Project was carried in such a way that it was divided into different tasks. These tasks were completed one by one. Each member contributed in different tasks. Some of the mere completed individually while mostly tasks included collective contribution of team members. Following table shows the tasks and members.

Table 3 Tasks and final execution of the project

Tasks	Team members Assigned
Designing	Ershadul, Johirul
Manufacturing	Ershadul
Economic Evaluation of project	Ershadul, Johirul, Amirul
Report writing	Ershadul, Johirul, Amirul, Emdadul.
Final Presentation	Johirul, Amirul, Ershadul.

4.3 Project Budgeting

This part covers the budget of the project related only to the components. It also includes all the manufacturing and assembling of the different parts. As mentioned earlier that some components needed to be purchased and others were machined in local markets. At the end of the project, is coasted about 11,500 (BDT) in total. Details are given in the following table 4.

Table 4 Project Budgeting (Bill of materials)

Design and Engineering	Cost (BDT)
Structure	1000
Copper tube	4300
Pump	1200
Reserve tank	300
Control Systems	2000
Aluminum sheet	1200
Gorgon ply	600
Others	900
Total Cost	= 11,500

CHAPTER-5

Results and Discussion

5.1 Project Overview

This project gave us good experience in terms of technical and engineering knowledge.

Overall, it was good while working on a project like this. We go to know new things and learnt unseen things. We improved our research skills like management and software knowledge base. Following are experiences which we came across in our journey of this project



Fig: 9 Project over view

- In the initial phase of the project, design section of the project was most challenging one. First of all, we studied literature review. We got many designs and, in these designs, to find the best suited one for our conditions and required results was difficult part. Design process became complicated as we were using materials and manufacturing methods from the local markets. At last, we choose a feasible and reliable design for our solar water heater. The project was chosen such that it can be completed within 4 months. We modified some of the components according to availability and requirements and applied reverse engineering.
- Purchasing materials and manufacturing required parts from local venders and machinist was terrible experience. In the era of COVID19, it became difficult to meet the deadlines. Somehow, we managed it also. In designing, it was ensured at materials were selected which were easily available and can give same performance if original or standard material was not available at that time.

5.2 Table of Result

Date: 18-09-2023

Water Normal Temperature	Setting Temperature	Start Time	End Time	Amount of Water in Litter	Remark
29 °C	33 °C	2:30PM	2:45PM	5 LTR	15 Minutes
29 °C	36 °C	2:50PM	3:15PM	5 LTR	25 Minutes
29 °C	38 °C	3:20PM	4:05PM	5 LTR	45 Minutes

Date: 19-09-2023

Water Normal Temperature	Setting Temperature	Start Time	End Time	Amount of Water in Litter	Remark
29 °C	32 °C	11:30AM	11:50AM	5 LTR	20 Minutes
29 °C	34 °C	12:00PM	12:35PM	5 LTR	35 Minutes
29 °C	36 °C	12:45PM	1:30PM	5 LTR	45 Minutes

5.3 Impact of our Project

It has been discussed in the literature review that renewable technologies are increasing day by day. These technologies provide safe, reliable, and cheap sources of energy solar technologies are improving and became famous in every field. Solar water heaters are becoming famous in Saudi Arabia also. Impact of solar water heater is discussed on social, economic, and environmental grounds.

- **Social:** Hot water is the need of almost every person. It is used in bathing, cleaning, and cooking. Solar technology is ever growing field which have great opportunities. So, solar water heaters provide social benefits like health, and advancement of technologies. It improves the social standards of people, education and provides opportunities to communicate.
- **Economic:** It is one of the forms of renewable energy consumption. It also uses its own source which is the Sun and does not depend on energy sources of the state. It is cheaper and utilizes local sources which increase the productivity of the local markets. It reduces the risks of energy shortages. It also lowers the burden on fossil fuels like gas and oil. Renewable energy technologies like this one can have great imp action economy of regions. It can increase regional development and create jobs for the locals. Only drawback is the high initial investment in these projects. One it is installed; it can serve for 10 to 20 years without much maintenance.
- **Environmental:** Solar water heaters have a great impact on improving the environment. It reduces the carbon emissions by using the clean energy. It creates awareness about climate change by using renewable technology and discouraging oil and gas. Solar water heater can limit green house gases and reduces the water and air pollution.

CHAPTER-6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

It was a senior design project and intended to design and fabricate solar water heater. This project was completed by following the research and the or epical knowledge. A reliable and low-cost solar water heater according to the local needs was developed as stated in the objectives. It involved great research knowledge while designing the components and management skills. A critical study was made, and survey of local markets was done to ensure the availability of materials and manufacturing methods. All the parts were manufactured and assembled to achieve the desired results by using the local materials and technologies.

As stated earlier that project was designed and completed with local needs, it helps a lot to reduce the cost of project. It reduces the time and cost of the materials and manufacturing. It was a good project which involved four people.

It was a great privilege for us to work in this project and complete it within time. We leant many research skills from our Professor which were used in achieving goals of the project. Cost effectiveness was the main objective which was fulfilled throughout the project. We learnt to work more in less time. New software's were learnt and new experiences were faced.

6.2 Recommendations

There are many design improvement ideas which can be implemented. Some of it are given below:

- Collector material and design should be improved which can provide better efficiency in low sunny areas.
- Heat exchanger can be designed with regional needs and according to the type of applications.
- Such materials should be developed which do not overheat. Over heating affects the performance of solar water heater.

APPENDIX A: PROGRESS REPORT

SEMESTER:	11th	ACADEMIC YEAR:	2023
PROJECT TITLE	DESIGN AND CONSTRUCTION OF MINI SOLAR WATER HEATER.		
SUPERVISORS	NuruzzamanRakib (Assistant Professor of SU)		

Student Group

ID Number	Member Name
2001020247	Md. Ershadul Hossain.
2001020103	Md. Amirul Islam.
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Task Distribution

Tasks	Team members Assigned
Designing	Ershadul, Johirul
Manufacturing	Ershadul
Economic Evaluation of project	Ershadul, Johirul, Amirul
Report writing	Ershadul, Johirul, Amirul, Emdadul.
Final Presentation	Johirul, Amirul, Ershadul.

APPENDIX B: PROJECT BUDGETING

Design and Engineering	Cost (BDT)
Structure	1000
Copper tube	4300
Pump	1200
Reserve tank	300
Control Systems	2000
Aluminum sheet	1200
Gorgon ply	600
Others	900
Total Cost	= 11,500

APPENDIX C: DESIGN SHEET

Frame Dimensions

S.N	Part Name	Dimension	Qty
1	MS Angle -25mmX2.5mm	500mm	1
2	MS Angle -25mmX2.5mm	500mm	2
3	MS Angle -25mmX2.5mm	300mm	2
4	MS Flat -25mmX2.5mm	300mm	2
5	Screw -3mmX25mm	25mm	8
6	Screw Washer	3mm	8