جامعة الأمير محمد بن فهد
PRINCE MOHAMMAD BIN FAHD UNIVERSITY

College of Engineering

Department of Mechanical Engineering

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Senior Design Project Report

Solar Water Heater Geyser

In partial fulfillment of the requirements for the Degree of Bachelor of Science in Mechanical Engineering

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Abstract

Solar water geyser is a heating device that uses the power of the sun to generate heat. A solar geyser uses the power form the sun light which is collected using a thermal heat collector. The thermal collector intensifies and encloses the solar radiation from the sun inside the solar geyser system. Solar geyser systems operate in many ways; we chose a process that is called active solar geyser. An active solar geyser refers to the circulation of water inside the system between the tank and the collector using the help of a pump. This project is to design and fabricate solar geyser for residential use.

Acknowledgments

First, we would like to thank our PMU faculty members specially our advisor Dr. Waqar Khan for their continuous help and support we recieved during our work on this project. Further more, we would like to express our gratatude for their efforts in teaching us the knowledge and skills needed to accomplish this project.

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Chapter 1: Introduction

1.1 Project Definition

The project aims to develop a solar water heater geyser in CAD software. A solar thermal unit absorbs and converts the solar heat energy required to satisfy heat needs in various temperature ranges. The solar thermal energy absorbed by the collectors heats the water in a typical solar water heating system. The low-density heated water rises, and cold water rises from the tank because of the gravity head and higher density. The solar water heater is designed and analyzed in this project to get the simulation of the system to enhances the effectiveness of the solar water heater.

1.2 Project Objectives

- The main objective of the project is to increase the performance of the solar thermal geyser water heating system.
- There has been little research in this project on how the system can be optimized to increase its efficiency.
- For this purpose, the whole heating system is designed by using SolidWorks to simulate the 3D model of a system and it has been analyzed thoroughly.

1.3 Project Specifications

Researchers are also researching alternative energy technology, including wind and solar, as many countries are seeking to minimize reliance on non-renewable energy sources (i.e., fossil fuels). The huge use of conventional non-renewable energy emits greenhouse gases that are major contributors to climate change. On the other hand, renewable sources of electricity, such as solar and wind, do not make greenhouse emissions. They are durable and cost-free. The key goal of the project is to improve the effectiveness of the solar heat heating system. In this project little study has been carried out on improving the device to improve its efficiency. To replicate the 3D model system, the whole heating system is designed using SolidWorks and has been carefully analyzed.

1.4 Applications

The applications of the solar water heater geyser are given below:

- The solar water heater geyser is installed and utilized for domestic usages such as apartments, houses, flats, and Bungalows.
- The solar water heater geyser is installed and utilized for commercial usages such as hospitals, hostel, restaurants, hotels, and hospitals
- The solar water heater geyser is installed and utilized for industrial usage too such as Process Industries and Preheating boiler feed water.
- Hot water for bathing, washing garments, and utensils, etc. is used in the domestic field. However, the criteria may differ according to the season of the year and the family number.
- On average, 30 to 35 liters of water is observed in our experience at 50 to 55C. It's a human eaten. 125 LPD Solar Water Heating System is therefore very adequate for a family of 4 members.
- Solar Water Heating Systems is designed to satisfy the above requirements in commercial & industrial sectors, where large quantities of water are needed at reasonably high temperatures. The system can be either a modular or a high-capacity single tank system based on the delivery pattern of hot water.

Chapter 2: Literature Review

2.1 Project background

The solar water heater collects light with a collector on the roof and turns them into gas. Then the heat is transferred by a rotating pump to a water tank. The thermal regulator activates this exchange, but only when the collector is cooler than water in the reservoir. Not only does it eliminate the use of electricity without the need for rotating pumps, but it also avoids overheating. Where the sunshine is inadequate, the water will be preheated, and a back-up mechanism will take over to get the water to the appropriate temperature. Thus, this device can be used during the year at a stable temperature.

Solar water heating system is an effective application for the thermal energy transfer of solar energy. In comparison to the solar electric direct conversion method with an efficiency of just 17%, solar thermal conversion efficiency stands at about 70%. Thus, in domestic as well as industrial applications, solar water heaters play a critical role because of the ease of service and quick maintenance. Extensive work has contributed to strategies to increase the thermal performance of solar water thermal heaters. To improve convective heat transfer, the passive technique was used. As used in solar water heaters, these techniques demonstrated a major increase in overall thermal efficiency. The solar water heater is presented in Figure 1.

Figure 1 Components of the Solar Heater

Solar thermal water heating systems (STWH) are cost-efficient as well as energy effective. The STWH systems are ideally suited for hot weather and direct sunshine but are still very well suited in cooler weather in the United States. The challenges, such as freezing, are solved by different principles of the STWH structures. Most systems of STWH have a solar collector on the roof of the residence facing south. Flat plate solar panels contain four parts: translucent covers for reduced convection and heat loss radiation; dark-color, flat plate panels for optimum heat absorption; heat transfer fluid conducting pipes extracting heat from the sensor; and heat-isolated backpacks to avoid conductive conduction.

Loss of sun. There is a network of black tubes that flow water or some other fluid within this collector. The fluid in the tube is rarely cold in the panel and heated by the panel while the black outside of the tubes receives heat from the light. The heat transfer fluid and the chosen materials for the tubes are critical criteria for the device to resist drastic frosting and overheating temperatures. When the substance is water, it joins a hot water holding tank straight away. The heat is then moved from the working fluid to the water in the hot water tank using another working fluid by heat exchange in the tank.

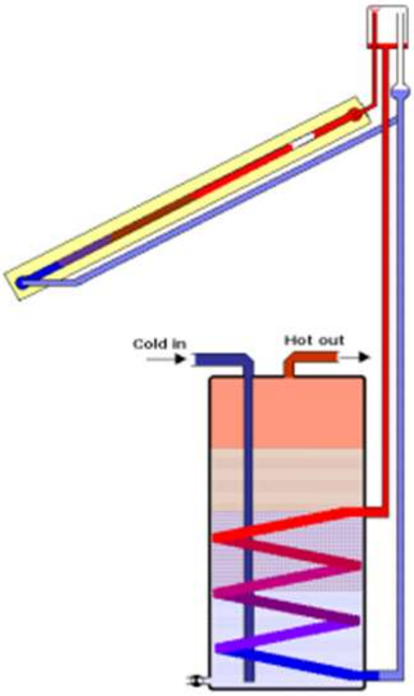


Figure 2 Schematics of the Geyser Pump Flow

An upgraded variant of a closed-loop thermosiphon mechanism is a bubble pump, also called a geyser, STWH system as seen in Figure 2. It's not an active system, it functions as an active system. The system's special architecture is pump-like but does not require mechanical work as an input for pump operation.

The liquid work fluid vaporizes as heat is applied to the device which produces a two-phase flow. Gas boosts produce a pump-like effect that moves the boiling working fluid upwards. The tank location does not depend on the solar panel, unlike the thermosiphon system. Modeling and simulation are crucial methods to solve complex problems. It is about 300 years after the launch of modeling and simulation. Comte de Buffon, a popular French naturalist, originated the technique (1707-1788). He is regarded as the first example of a simulation with his needle-throwing problem. The needle throwing technique in the Buffon is resurrected in 1946 with the concept of the hydrogen bomb by eminent mathematicians Jon Von Neumann and Stanislaw Ulam. Hit and research methods to solve the problem of the neutron puzzle were found to be incredibly expensive. The roulette wheel technology was then used to solve the problem effectively and successfully.

2.2 Previous Work

Solar thermal applications began in China in the 1970s. By the end of the 1980s, China started producing flat platform solar water heaters by launching the Canadian copper-aluminum flat screen composite absorber production lines and by creating its production line of anodic selective coatings. However, because of issues such as cost and compatibilities in winter, development was slow. Significant technical and product breakthroughs made in the 1990s in vacuum pipe production allowed China to build a self-designed vacuum pipes production line and to mass-produce a solar water heater with a vacuum piping system. Such accomplishments in technology and research have led to the continuous development of solar collector and heater efficiency with the vacuum tube and heat pipe all-glass and reduced expense. It brings considerable impetus to the Chinese solar thermal industry's industrialization.

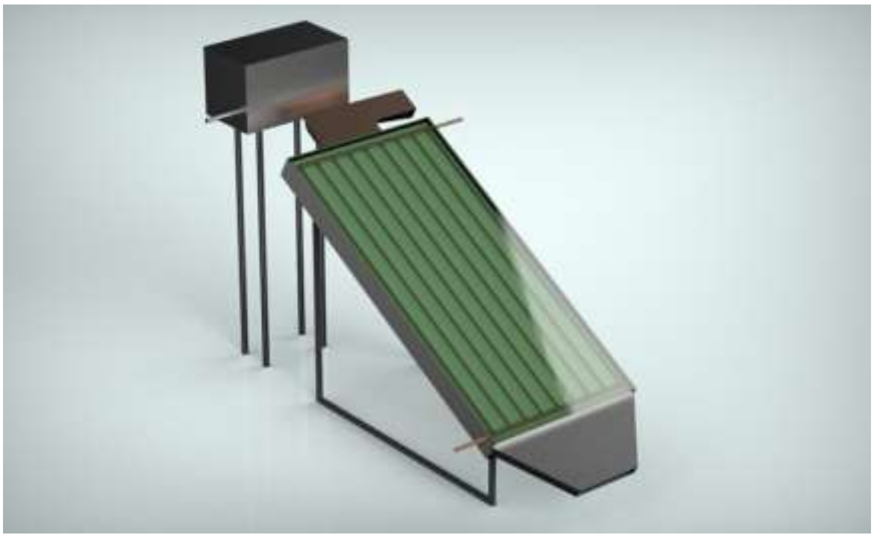


Figure 3 3D Model of Solar Water Heater

A CAD model of a Solar Water heater is illustrated in Figure 3. It shows the collector and frame of the solar water heater. The tubes are designed inside the collector which contains the hot water which goes to the tank and from there, the cold water comes to the tubes to get the heater through the solar energy. Since the mid-1920s impressive advances have been recorded in modeling and simulation technologies. The mechanical differential analyzer was also used to solve only a small number of ordinary differential equations. In the 1950s, as electronics replaced cumbersome equipment, significant technical change was recorded. The simulation was eventually encouraged by broad-based growth and industrialization.

Figure 4 Solar Collector

In the 1960s, electronic development is the year in which digital computers had been replaced by analog computers. The development was also witnessed by the modeling and simulation. The simulation was user-friendly since computer graphics were commercially released on the market in the 1990s.

2.3 Comparative Study

The goal of the present project is to test the efficiency of the design and development of a solar water heater. The findings reflect the domestic use of solar energy and enable the public to use the same devices. The difference between the previous work done on the solar water heater and this project is that in this project, each aspect is thoroughly analyzed, and simulation has been done which plays an important role in the design and manufacturing processes. Researchers are trying to resolve an issue by doing various experiments. However, it is very difficult to follow the experimental methodology because of numerous techno-commercial constraints. Due to long-term research, modeling and simulation have proven to be viable solutions for dramatically minimizing the number of repeated and iterative tests. Simulation can be considered a numerical experiment, as is the physical experiment.

Chapter 3: System Design

3.1 Design Constraints and Design Methodology:

First of all, draw a 3d model of Water Solar Heater Geyser, then make a practical model and define its Design Constraints and Design Methodology. Its Design Constraints are following:

Geometric Constrains:

Geometric Constrains are dimensional conditions imposed on Design Methodology.

- Length of the Tubes 1800mm.
- Distance between two tubes is 125mm.
- Diameter of tube if 58mm.
- Geometric constraints are applied for designing the Design Methodology.

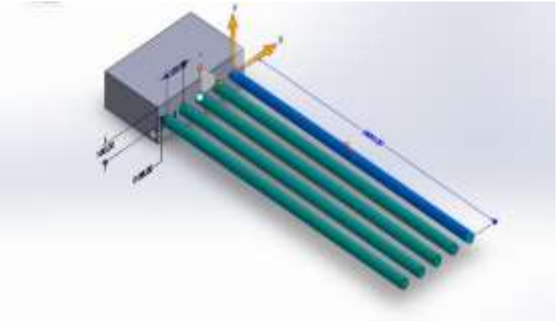


Figure 5 Solar Water Heating Geyser

Sustainability Constraints:

This project is basically the related to energy sustainability, so sustainability constraints are taken into account.

- We are using Solar Energy.
- Use of renewable energy.

Economic Constraints:

Purpose of economic constrain is to make the product market compatible.

- Economical material is being used for this model.
- Material used in this project is easily available in market.

Environmental Constraints:

The purpose of Environment Constraints is to limits the production which may cause pollution in environment.

- This project is environment friendly, and it does not have any negative impact on the environment.
- No noise pollution, no air or land pollution.
- This product will help to keep the environment clean because it makes use of the renewable energy instead of the fuel for heating which causes some air pollution.

Health and Safety Constraints:

Health and Safety Constraint is implemented for limiting the manufacturing of such products which may be harmful with respect to Health and Safety.

- This project makes use of the renewable energy instead of fuel for the heat generators, causing the environment safe and healthy.

Manufacturability Constraints:

Concern of the Manufacturability constraint is to assure the design methodology which is easy to manufacture in bulk quantity.

- Solar heater is manufacture in the possible easiest way for bulk production,
- Material used in the product is easily available in the market.

Social Constraints:

Purpose of social constraint is to design the product which is according to the requirements of human and it should address some social issues.

- This project has addressed the issues of Sustainable energy and Air pollution.

Ethical Constraints:

Ethical constraint is applied to limit the product which may hurt the feelings of people. Its purpose is to provide the user with expected results without the breach on any ethical boundaries.

- Design of the Solar Heater is under the define ethical constraint.

Risk Analysis:

When assessing the risk on a solar water geyser we look for aspects where the product can harm properties and human life. The risk we avoid pressurizing the system to avoid burst in the system. Furthermore, we choose metals that would avoid corrosion and metal toxicity.

3.2 Engineering Design standards

Engineering Standards for the Manufacturing of Solar Water Heater Geyser are following:

- NFPA 70: National Electrical Code®
- SAES-W-012 (welding)
- ASTM A193 / A193M – 20 (Steel alloy)
- ASME B31 - Pressure Piping
- ISO 2858:1975 (for pump)
- ASTM A354 Quenched and tempered alloy bolts
- ANSI MC96.1-1982 (temperature gauge)

3.3 Theory and Theoretical Calculations

Solar Water Heating Geyser:

It is a geyser which is being operated by the solar energy.
It depends on the phenomenon of the natural convection, which circulate the water through the vacuum tubes to the hot water tank.

Solar Water Heating:

There are some collectors, which are used to collect the or capture heat from the sun. Then, they retain it and then transfer it to the liquid. Solar thermal heat is capture by the phenomenon of greenhouse effect (ability of the reflective surface to reflect the longer waves and transmit the short waves radiations. Heat is produced when light with shorter wave radiation hits the collector's absorber. Which then trap inside the collector.
There are two type of collectors: Flat Plate and Evacuated Tube.

Flat Plate and Evacuated Tube Solar Collectors

A flat plate collector consists of multiple vertical copper tubes which are arranged in parallel configuration, these tubes are connected from the top and the bottom with copper tubes usually larger in diameter. The larger diameter tubes are perpendicular to the smaller tubes, this gives the plate a rectangular shape. The tubes are enclosed inside a well-insulated box with a cover made out of tempered glass.

The Flat collector plate is usually connected to risers, the heat is gained by collecting the solar energy from the sun which gets absorbed by the copper to heat the circulating water. (p. 1)

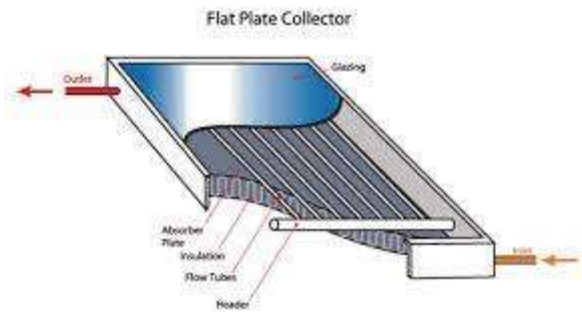


Figure 6 Flat Plate Collector

Evacuated tubes are made of vacuum tubes. They are tubes with an inner and an outer layer of glass, the tube then is vacuumed. These tubes are fitted with a copper heat pipe filled with a non-toxic liquid.

The Evacuated tube is a poor heat conductor, but the vacuum between the layers ensures that the solar radiation is almost fully absorbed and intraped inside it. The energy gets absorbed by the copper heat pipe inside the tube, which in return heats the circulating water manifold.

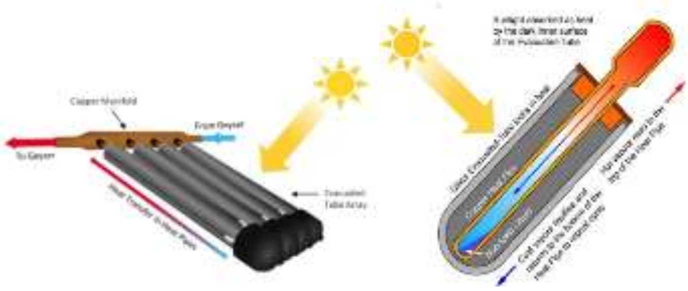


Figure 7 Evacuated Tube Collector

Direct and Indirect Solar Configurations

In Direct configuration, the water circulates form the tank to the solar collector directly. The water gets passed through the collector where it gets heated.

In Indirect configuration the fluid which flows to the solar collector is not the actual geyser water itself rather it is a glycol mixture, which is contained in a closed loop, running from the geyser to the collector and back again.

Active & Passive Configuration

Passive and Active explains how the system water circulates from tank to the heat collector.

In a passive configuration water is being circulated by phenomenon of natural convection. In this configuration geyser is located above the solar collector. In Passive configuration, the hot water rises to the top of the system where it is collected, the denser cold water moves to the lower part of the tank to get heated.

Active configuration is also known as Pumped Configuration. In this configuration the geyser is located below the solar collector. This system make use of the circulation pump, to pump to move the water in the system from the tank to the collector and vice versa. (p. 2)

Calculations:

For evaluation of performance of solar water heater, we need to calculate its efficiency. Collector efficiency is the ratio between the rates of useful heat (QU) transferred by solar radiation on the cover plate. Efficiency can be shown in the equation as follows:

$$Efficiency = \eta = \frac{Heat\ Energy\ Out}{Heat\ Energy\ In} = \frac{Q_{out}}{Q_{in}}$$

Q out is the heat energy absorbed by the water from to the collector.

$$Q\ out = m * cp * \Delta T \quad (2)$$

m = mass flow rate (kg/s)

cp = specific heat (kj/kg.k)

ΔT = temperature difference in manifold (k)

$$m = \rho * A * V$$

Conductive heat loss through the wall of a cylinder or pipe can be expressed as

$$Qin = Q\ conduction - Q\ loss \quad (3)$$

$$Q\ conduction = 2\ \pi\ k\ L\ (t_1 - t_2) / \ln(r_2 / r_1) \quad (4)$$

Q = heat transfer from manifold (w)

k = thermal conductivity of stainless steel (w/m.k)

L = length of manifold (m)

π = pi = 3.14...

t_1 *= manifold fluid temperature (k)*

t_2 *= copper temperature (k)*

ln = the natural logarithm

r_2 *= manifold outside radius (m)*

r_1 *= manifold inside radius (m)*

$$Q\ loss = 2\ \pi\ L\ (t_i - t_o) / [\ln(r_o / r_i) / k] \quad (5)$$

Q = heat transfer from cylinder (w)

k = thermal conductivity of stainless steel (w/m.k)

L = length of manifold (m)

π = pi = 3.14...

t_o *= surface temperature (k)*

t_i *= manifold fluid temperature (k)*

ln = the natural logarithm

r_o *= manifold outside radius (m)*

r_i *= manifold inside radius (m)*

*m = ρ * A * V*

m = 998(π/4)(0.17)^2(0.146)

m = 3.3 kg/s

*Q out = m * cp * ΔT*

Q out = (3.3)(1.5616)(71-61)

Q out = 51.33 w

Qin = Q conduction – Q loss

$Q\ loss = 2 \pi k L (t_i - t_o) / [\ln(r_o / r_i)]$

$Q\ conduction = 2 \pi k L (t_1 – t_2) / \ln(r_2 / r_1)$

Qin = 2 π (15) (0.6) (353 – 344) / ln(0.08 / 0.085)- 2 π (15) (0.6)(344-334) / [ln(0.085 / 0.08)]

Qin = 63.95 w

$$Efficiency = \eta = \frac{Heat\ Energy\ Out}{Heat\ Energy\ In} = \frac{Q_{out}}{Q_{in}}$$

*Ŋ = (51.53/63.95)*100 = 80.5 %*

3.4 Product Subsystems and selection of Components

Major Components of the Solar Water Heating Geyser are Following:

- Circulation Pump

Figure 8: pump

- Control System
- Hot Water Tank

Figure 9: Water Tank

- Evacuated Tubes

Figure 10: Evacuated tubes

- Manifold

Figure 11: Manifold

- Sensor

Figure:12 Temperature Sensor

The Major selection was the type of the tubes.
There were two options available:

- Flat Plate Tube
- Evacuated Tube

We select the Evacuated tubes because of its reliability, longevity, better performance. Moreover, evacuated tube is the latest technology in the market.
We select the copper manifold because of its resistance to the heat and corrosion.
There were two options for circulating system:

- Passive
- Active

In active system, circulation of water is done with the help of a pump system.
We chose this system because they have some advantages which are following:

- Long term durability and reliability
- Ease of repair of collectors
- Low risk of corrosion
- Good performance even in the windy conditions.
- Least expensive installation.

3.5 Manufacturing and assembly (Implementation)

Assembly of the Solar Water Heating Geyser is following

- First step is to fix the evacuated tubes in the copper manifold (heat collector).
- Second step, design and fabricate water tank
- Third step, attach the heat collector with the tank.
- After that, add water pump between the collector and the tank to circulate the water (closed loop).
- Then, add a controller system to the pump.

Here is the schematic diagram of the solar water heating geyser and this is how we assemble it.

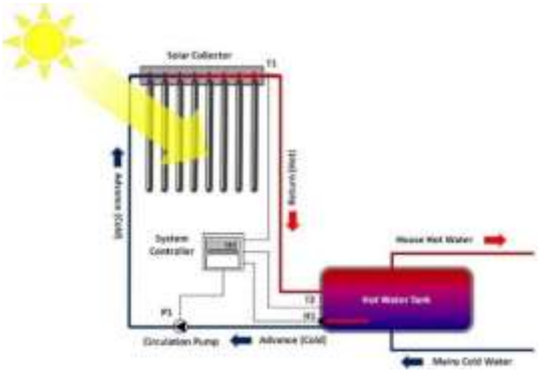
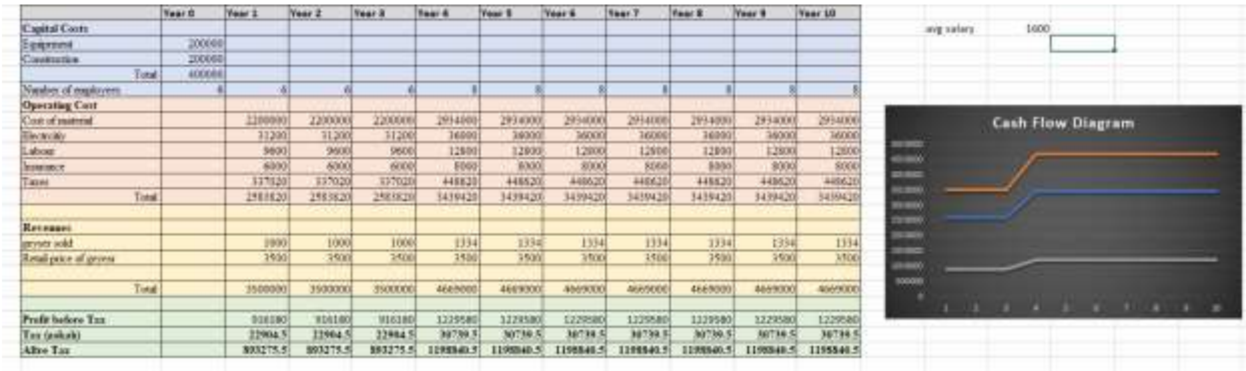


Figure 13: Schematic diagram of the solar water heating geyser

3.6 Economic Evaluation



	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital Costs											
Equipment	200000										
Construction	200000										
Total	400000										
Number of employees	6	6	6	6	8	8	8	8	8	8	8
Operating Cost											
Cost of material		2200000	2200000	2200000	2934000	2934000	2934000	2934000	2934000	2934000	2934000
Electricity		31200	31200	31200	36000	36000	36000	36000	36000	36000	36000
Labour		9600	9600	9600	12800	12800	12800	12800	12800	12800	12800
Insurance		6000	6000	6000	8000	8000	8000	8000	8000	8000	8000
Taxes		337020	337020	337020	448620	448620	448620	448620	448620	448620	448620
Total		2583820	2583820	2583820	3439420	3439420	3439420	3439420	3439420	3439420	3439420
Revenues											
geyser sold		1000	1000	1000	1334	1334	1334	1334	1334	1334	1334
Retail price of geyser		3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
Total		3500000	3500000	3500000	4669000	4669000	4669000	4669000	4669000	4669000	4669000
Profit before Tax		916180	916180	916180	1229580	1229580	1229580	1229580	1229580	1229580	1229580
Tax (zakah)		22904.5	22904.5	22904.5	30739.5	30739.5	30739.5	30739.5	30739.5	30739.5	30739.5
After Tax		893275.5	893275.5	893275.5	1198840.5	1198840.5	1198840.5	1198840.5	1198840.5	1198840.5	1198840.5

Figure 14: Economic Evaluation

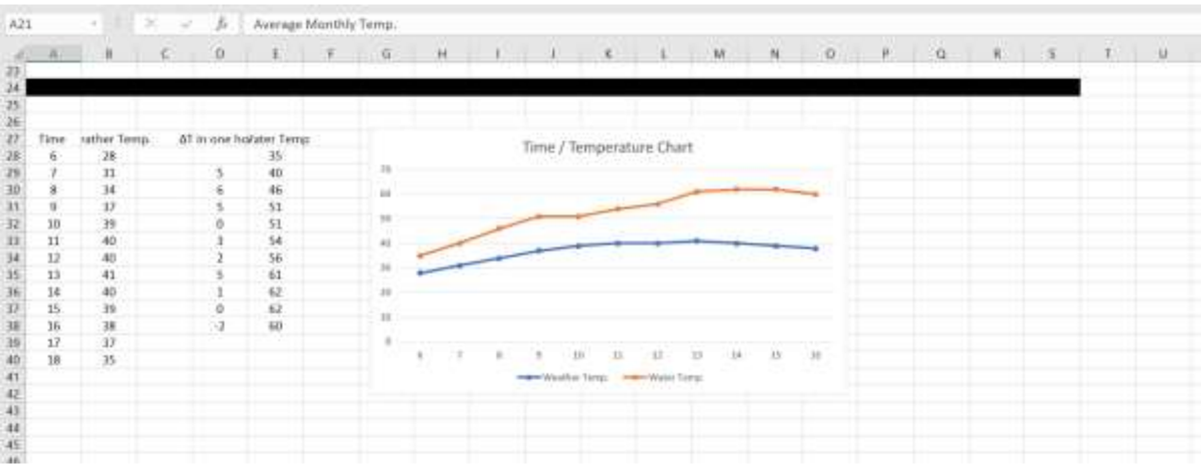
Chapter 4: System Testing and Analysis

4.1 Experimental Setup, Sensors and data acquisition system

The system was placed in its correct position which is to the south for maximum sun exposure, the system testing started at 6am and ended at 4pm with a one hour increments for more accurate results. The sensor was placed at the left side of the manifold where the old water enters the manifold, the water circulates from the manifold to the system every hour. The data was registered manually every hour while circulating the water.

Figure 15: Sensor Location

4.2 Results, Analysis and Discussion



A21 Average Monthly Temp.

[redacted]

Time	ather Temp.	ΔT in one ho	ater Temp
6	28		35
7	31	5	40
8	34	6	46
9	37	5	51
10	39	0	51
11	40	3	54
12	40	2	56
13	41	5	61
14	40	1	62
15	39	0	62
16	38	-2	60
17	37		
18	35		

Figure 16: Test Results

The results of the test were depending on the temperatures we were seeing on the temperature gauge. The goal is to reach the temperature of 50 C° up to 70 C° on the temperature gauge.

As the data showing in figure 16 the results show that in the first three hours during the testing we reached our goal. The temperature kept on raising each hour until the system reached its highest temperature of 62 C˚ at 1pm. As shown on the left the change of temperature in each hour was in the expected region, except for the hours of 10 Am and 4 Pm were the temperature of the tank never changed or showed a decrease which may be a result of inaccurate reading due to the gauge being analog or because the weather temperature did not change.

Chapter 5: Project Management

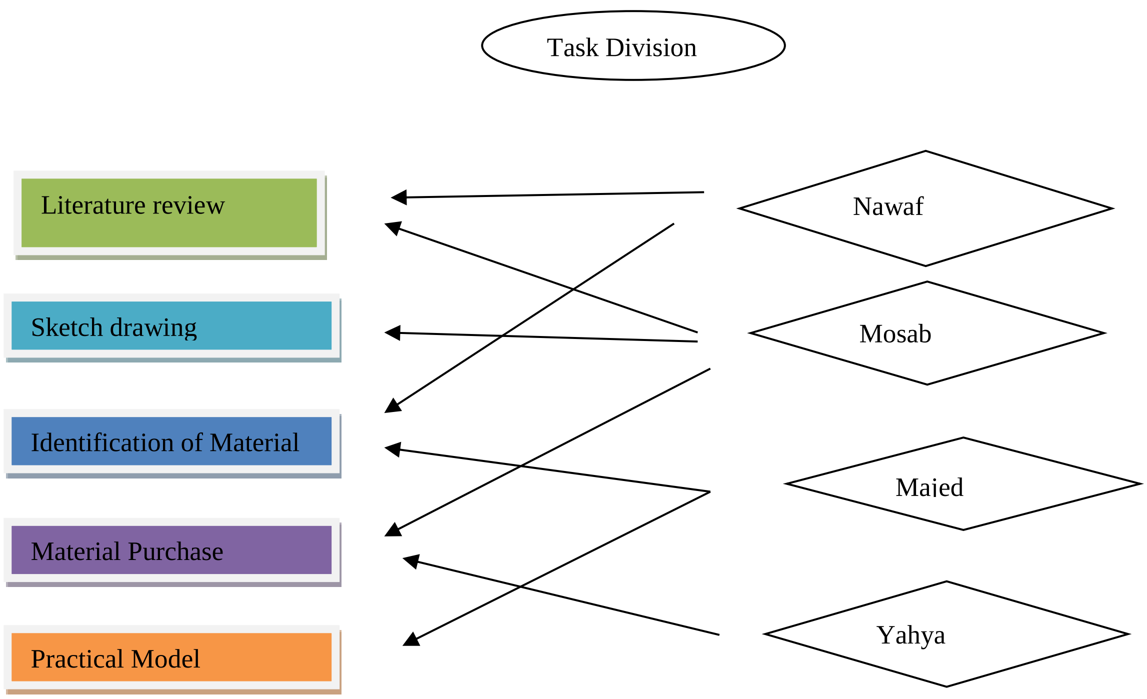
5.1 Project Plan

Break Down of Tasks:

We have divided the task into 8 tasks

- Literature review, methodology
- 3D modeling
- Choosing appropriate material
- Purchasing of material
- Fabricating the prototype
- Testing
- Concluding the project
- Writing the reports

Map tasks to team members.



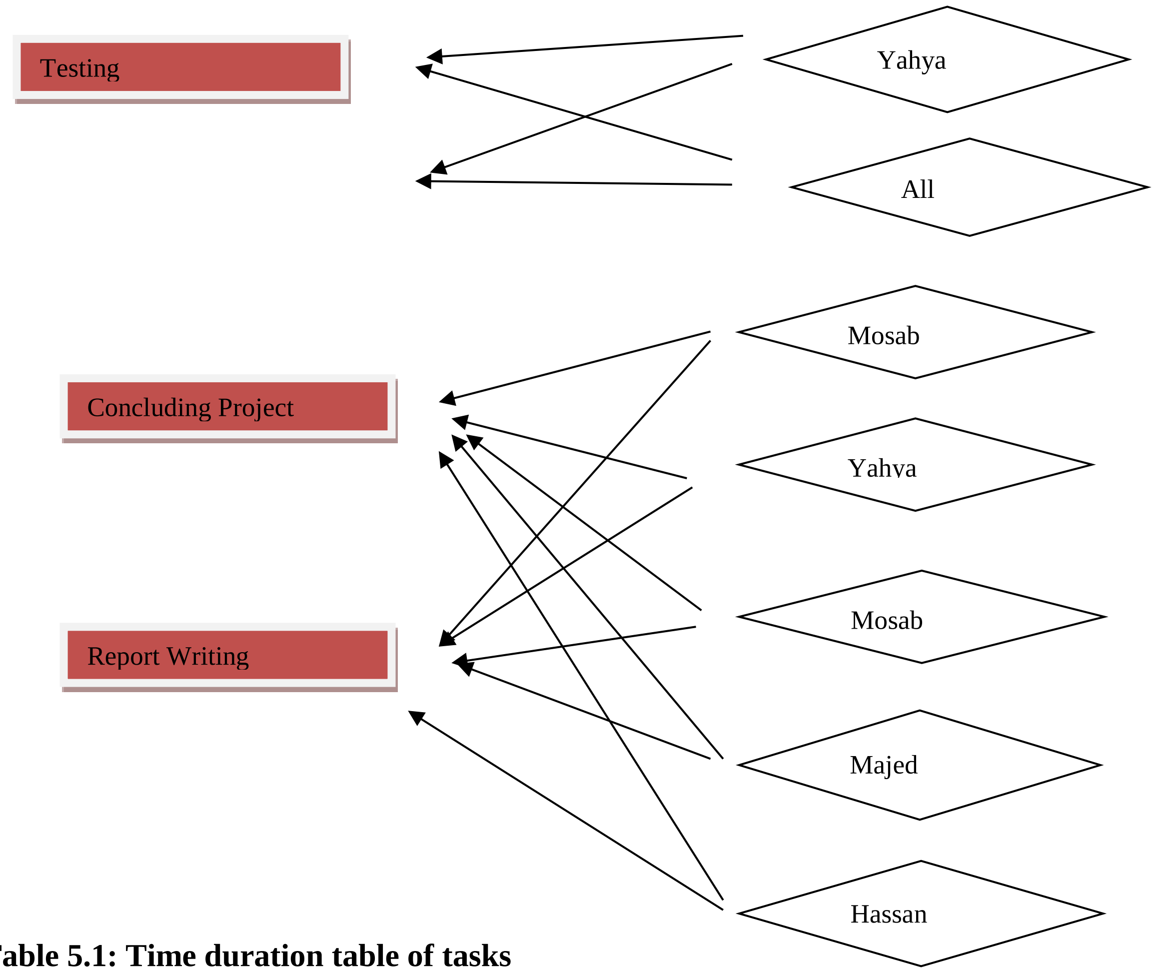
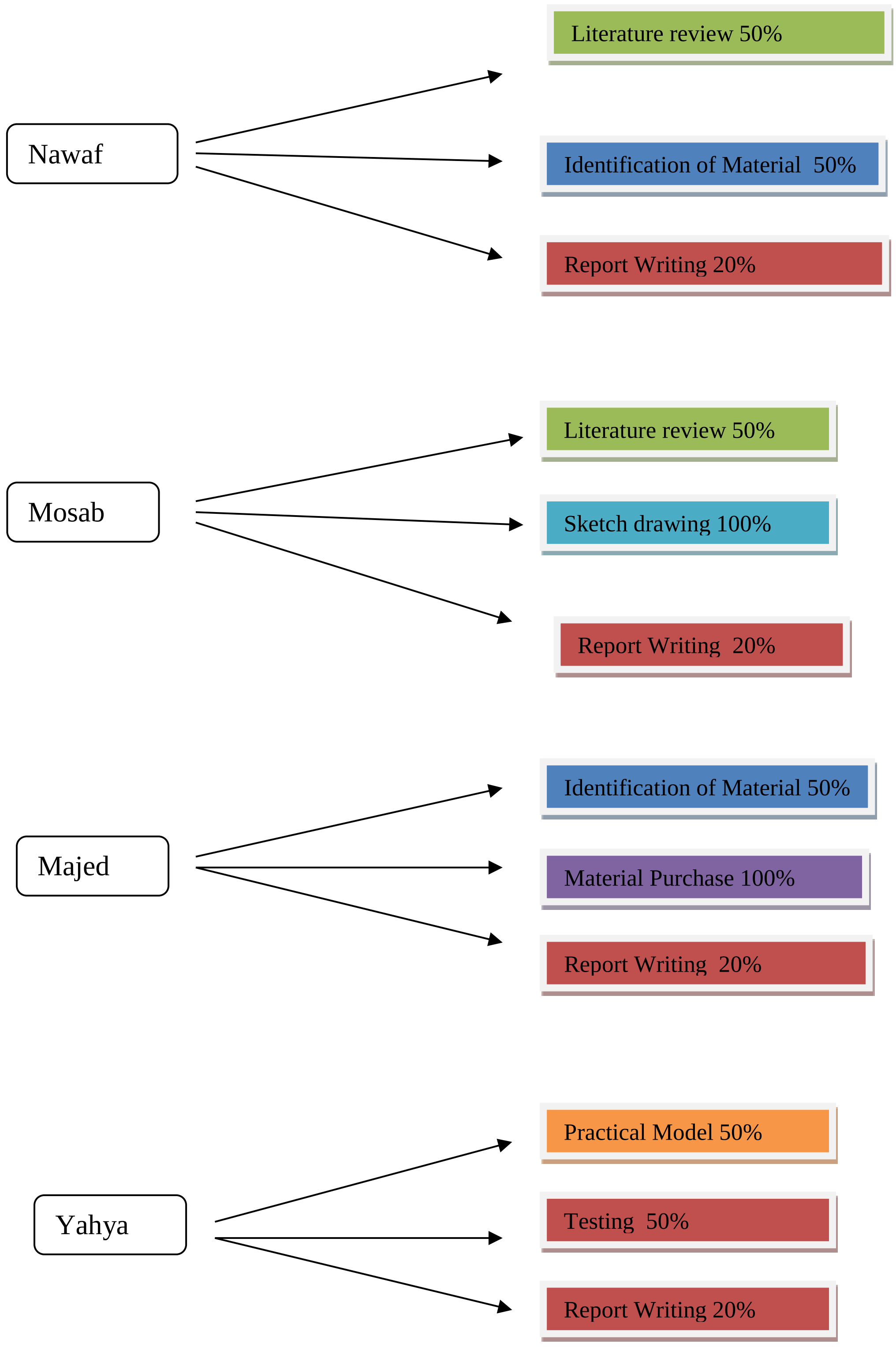
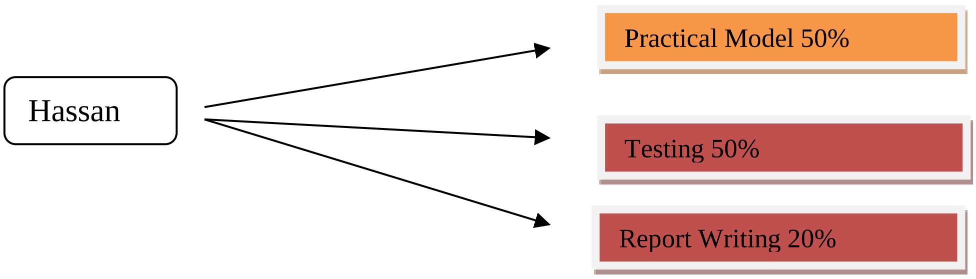


Table 5.1: Time duration table of tasks

Task	February	March	April	May	June
Task 1	**Literature review**				
Task 2	**Modeling**	**Modeling**			
Task 3	**Material Identification**				
Task 4	**Material Purchase**	**Material Purchase**	**Material Purchase**		
Task 5				**Practical Model**	
Task 6				**Testing**	
Task 7	**Report Writing**				

5.2: Contribution of members: (out of 100%)





5.3 Project Execution Monitoring

- Zoom Meeting with Advisor
- Zoom Meeting with Team members
- Testing

5.4 Challenges and Decision Making

- We faced problems with finding the Evacuated tubes in Saudi Arabia, so we reached out to our connections in the renewable energy sector to help us with finding a supplier.
- The Evacuated tubes arrived a week before the deadline
- The fabrication shops were very hesitant to work with us due to the complication of the prototype.
- The fabricating shop kept on making mistakes and modifying the design without our consolation.

5.5 Project Bill of Materials and Budget

The budget for this project was set at 5000 SAR, but unfortunately we went over the budget. The Evacuated Tubes cost 2025, the fabrication cost is 3500 SAR, the pump cost is 380 SAR, the tank cost 250 SAR, brochure, and banner cost 400 SAR, and the (DC to AC inverter) which cost 90 SAR. The inverter purpose is to cut cost due to us going over budget, for this resume the pump is working with an inventor. Furthermore, the Evacuated Tubes cost was overpriced due to the us asking for express shipping, also the fabrication cost was expensive and the reason behind that was the short amount of time available to execute the job. The total expenses sum up to 6645 SAR.

Chapter 6: Project Analysis

6.1 Life-long Learning

- Knowledge in how the fabricating industry work in Saudi Arabia.
- We gained more knowledge in the solar energy& renewable energy field.
- Our time management skills improved.
- Project management skills improved.
- Research on different types of materials that are suitable for human use.
- Handel work under pressure.
- Couple of engineering books from: Thermodynamics, Heat Transfer, Manufacturing Methods in Design.
- Couple of e-Journals using Google Scholar.

6.2 Impact of Engineering Solutions

The solar water heater has many positive impacts in various ways. In the case of:

- Society: helps the community to get access to hot water especially the people living in rural areas of Saudi Arabia.
- Economy: This provides an economical solution to have a product that helps with their needs and the ability to work without an electrical grid nearby.
- Environment: It helps in reducing the pollution and provide people with products that work on renewable energy, and this goes hand to hand with Saudi vision 2030.

6.3 Contemporary Issues Addressed

The lack of renewable energy products: The Saudi Arabia vision 2030 is promoting the use of renewable energy in Saudi households, such as the use of solar panels to power some parts of their resident and utilizing solar energy to power solar water heater.

Chapter 7: Conclusions and Future Recommendations

7.1 Conclusions

In conclusion, the solar geyser showed how efficient it is to be used in Saudi Arabia. The system reached its goal of 50 C˚ three hours into sunrise and kept rising until it reached its maximum temperature of 62 C˚ at 1 PM and it stayed relatively constant for the rest of the night. One of the challenges the team encountered is to finish the project in 8 days and that required us to almost perfect our time management in order to fit into Ramadan odd working hours, and that shortage of time happened to be due to shipment delay from the supplier side. We gained knowledge and huge team work skills. We learned various renewable energy systems and especially solar energy technologies available around the globe. The knowledge we acquired is one of the stepping stone to the future of renewable energy. The work has been divided among team members in such a way where each team member got a task that suits his strength points.

7.2 Future Recommendations

- Change the system from an active solar water heater to passive one.
- Change the position of the water tank and making it the highest point (above the manifold).
- Finding a better reseller or fabricating the Evacuated Tubes.
- Adding a thermocouple connected to a control panel to automate the duration of water circulation.

8. References

Brothers, H. (2019, September). Solar Water Heater. *Renewable Energy*. Retrieved March, 2021 from https://www.haroonbrothers.com/renewable-energy/solar/solar-water-heater/

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Appendix A: Progress Reports

Includes copies of what you have already submitted.

SDP – MONTHLY MEETING REPORT

Department of Mechanical Engineering
Prince Mohammad bin Fahd University

SEMESTER:	**Spring**	**ACADEMIC YEAR:**	**2021**
PROJECT TITLE	**Design of Solar Geyser**		
SUPERVISORS	**Dr. Waqar Khan**		

Month 2: March

ID Number	Member Name
Yahya Al Faifi	**201600079**
Mosab Al Shammari	**201502336**
Majed Al Daghreer	**201502930**
Hassan Qudrah	**201601514**
Nawaf Al Nuaim	**201600036**

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	**Software Design**	Mosab	100%	
2	**Literature Review**	Majed / Nawaf	100%	
3	**Calculations**	Hassan / Yahya	75%	
4	**Design Methodology**	All	100%	

List the tasks planned for the month of April and the team member/s assigned to conduct these tasks

#	Task description	Team member/s assigned
1	**Fabrication**	Mosab / Yahya
2	**Assembly**	Nawaf / Majed
3	**Calculations**	Hassan / Yahya
4	**Prototype Testing and Analysis**	Majed / Nawaf / Hassan
5	**Report Completion**	All
6	**Final Presentation**	All

#	Name	Criteria (MEEN4A)	Criteria (MEEN5A)	Criteria (MEEN5B)	Criteria (MEEN5C)
1	Mosab Al Shammari	4	3	4	4
2	Majed Al Daghreer	4	4	4	4
3	Hassan Qudrah	4	3	4	4
4	Nawaf Al Nuaim	3	4	3	3

Comments on individual members

Name	Comments
Mosab Al Shammari	Need to put more effort into time management.
Majed Al Daghreer	Overall vital team member and well organized in team meetings.
Hassan Qudrah	Need to work more on developing plans on an individual level.
Nawaf Al Nuaim	Great team member but need to work more on communicating with group members.

SDP – MONTHLY MEETING REPORT

Department of Mechanical Engineering
Prince Mohammad bin Fahd University

SEMESTER:	**Spring**	**ACADEMIC YEAR:**	**2021**
PROJECT TITLE	**Design of Solar Geyser**		
SUPERVISORS	**Dr. Waqar Khan**		

Month 3: April

ID Number	Member Name
Yahya Al Faifi	**201600079**
Mosab Al Shammari	**201502336**
Majed Al Daghreer	**201502930**
Hassan Qudrah	**201601514**
Nawaf Al Nuaim	**201600036**

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	**Software Design**	Mosab	100%	
2	**Literature Review**	Majed / Nawaf	100%	
3	**Calculations**	Hassan / Yahya	75%	

4	**Design Methodology**	All	100%	

List the tasks planned for the month of April and the team member/s assigned to conduct these tasks

#	Task description	Team member/s assigned
1	**Fabrication**	Mosab / Yahya
2	**Assembly**	Nawaf / Majed
3	**Calculations**	Hassan / Yahya
4	**Prototype Testing and Analysis**	Majed / Nawaf / Hassan
5	**Report Completion**	All
6	**Final Presentation**	All

#	Name	Criteria (MEEN4A)	Criteria (MEEN5A)	Criteria (MEEN5B)	Criteria (MEEN5C)
1	Mosab Al Shammari	4	3	4	4
2	Majed Al Daghreer	4	4	4	4
3	Hassan Qudrah	4	3	3	3
4	Nawaf Al Nuaim	3	4	3	4

Comments on individual members

Name	Comments
Mosab Al Shammari	Need to work more on developing plans on an individual level.
Majed Al Daghreer	Overall vital team member and well organized in team meetings.
Hassan Qudrah	Need to put more effort into time management, also need to work more on communicating with group members
Nawaf Al Nuaim	Great team member but need to work more on communicating with group members.

SDP – MONTHLY MEETING REPORT

Department of Mechanical Engineering
Prince Mohammad bin Fahd University

SEMESTER:	**Spring**	**ACADEMIC YEAR:**	**2021**

PROJECT TITLE	Design of Solar Geyser
SUPERVISORS	Dr. Waqar Khan

Month 4: May

ID Number	Member Name
Yahya Al Faifi	201600079
Mosab Al Shammari	201502336
Majed Al Daghreer	201502930
Hassan Qudrah	201601514
Nawaf Al Nuaim	201600036

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1	Software Design	Mosab	100%	
2	Literature Review	Majed / Nawaf	100%	
3	Calculations	Hassan / Yahya	100%	
4	Design Methodology	All	100%	

List the tasks planned for the month of April and the team member/s assigned to conduct these tasks

#	Task description	Team member/s assigned
1	Fabrication	Mosab / Yahya
2	Assembly	Nawaf / Majed
3	Calculations	Hassan / Yahya
4	Prototype Testing and Analysis	Majed / Nawaf / Hassan
5	Report Completion	All
6	Final Presentation	All

#	Name	Criteria (MEEN4A)	Criteria (MEEN5A)	Criteria (MEEN5B)	Criteria (MEEN5C)
1	Mosab Al Shammari	4	4	4	4
2	Majed Al Daghreer	4	4	4	4
3	Hassan Qudrah	4	3	4	4
4	Nawaf Al Nuaim	3	4	3	4

Comments on individual members

Name	Comments
Mosab Al Shammari	Showed high level of time management.
Majed Al Daghreer	Overall vital team member and well organized in team meetings.
Hassan Qudrah	Need to work on time management, also need communicate with group members
Nawaf Al Nuaim	Showed more effort in working with the group and communicating.

Appendix B: Engineering standards (Local and International)

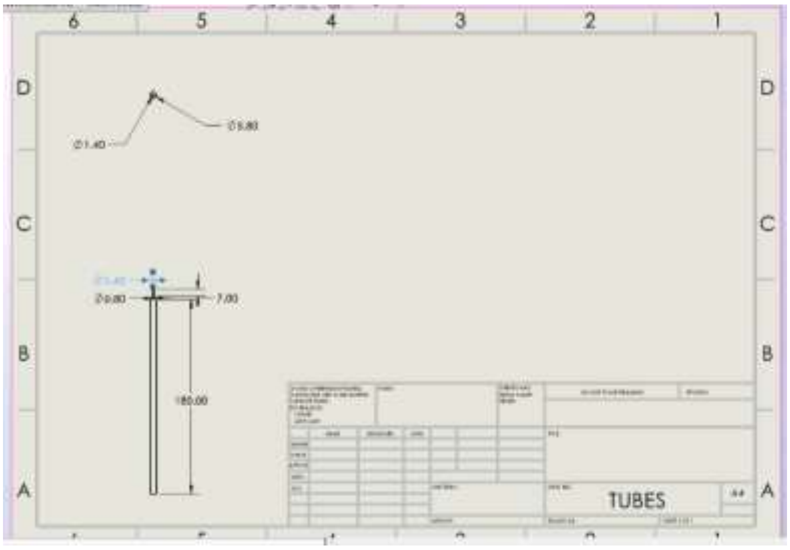
International

- **SAES-W-012 (welding)**
- **NFPA 70: National Electrical Code®**
- **ASTM A1049**
- **ISO 9001-2015(Tank)**

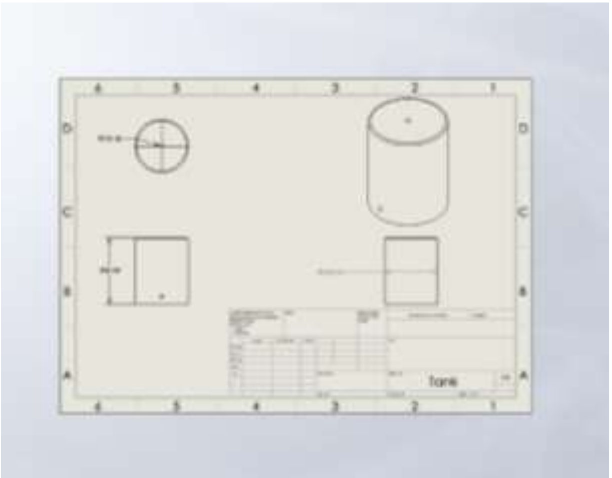
Local

SASO 2884 .2017

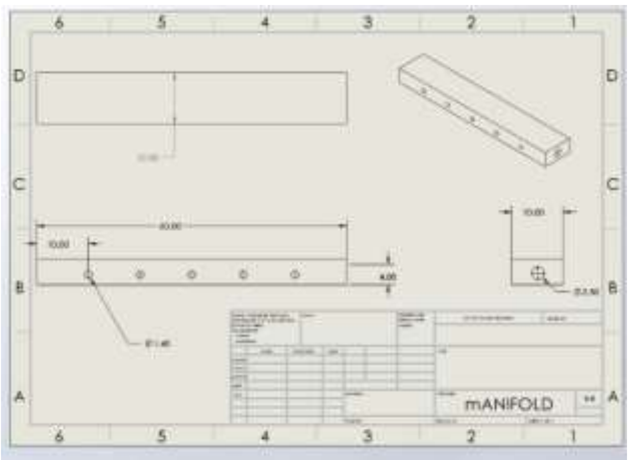
Appendix C: CAD drawings and Bill of Materials

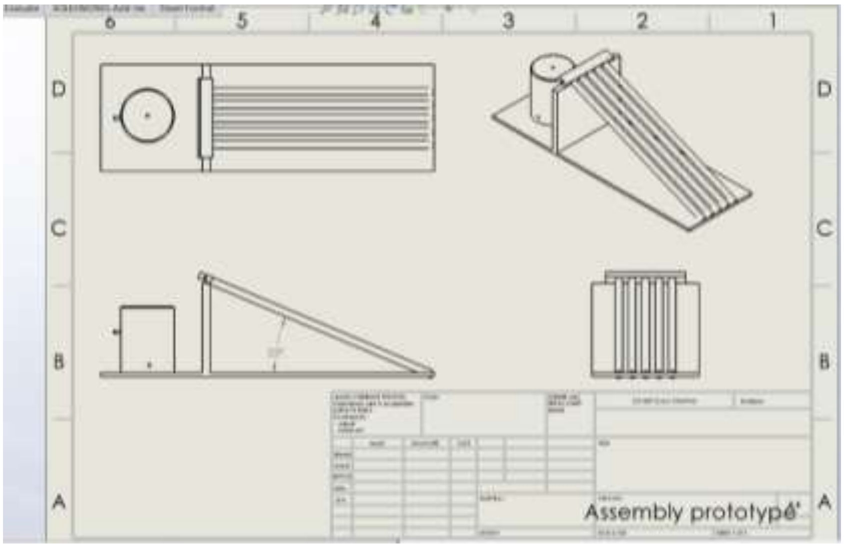


402.5 x (5 tubes) = 2025

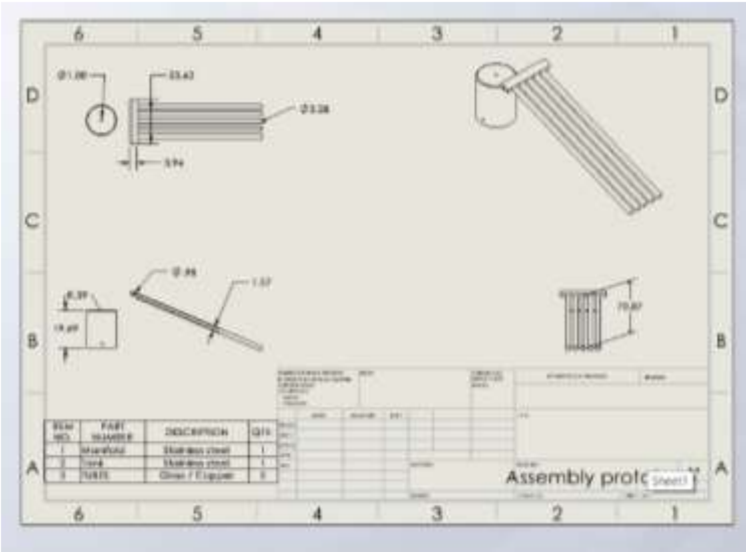


Tank = 250 SAR

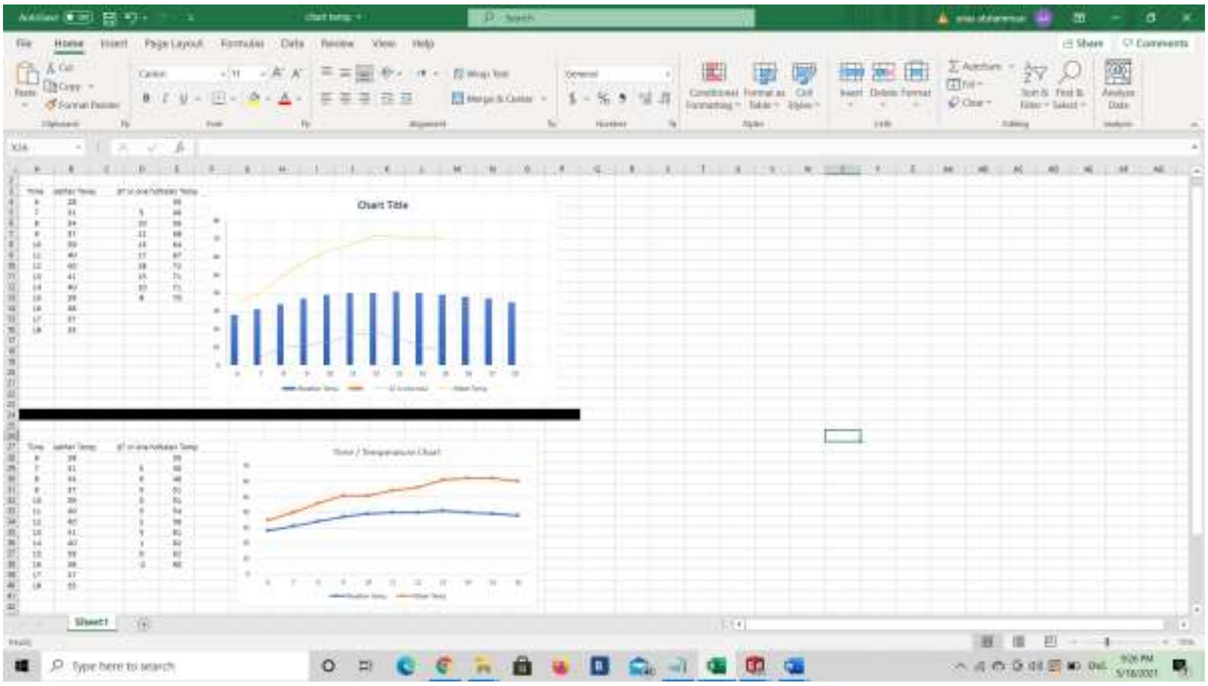




Manifold and Stand = 3500 SAR



Appendix D: Datasheets



Appendix E: Operation Manual

- Wipe down the evacuated tubes from any dirt or debris.
- Find the direction of South using a compass.
- Direct the end of the tubes towards the South.
- Fill the system with water from the inlet valve (on left side of the manifold).
- Keep the system under the sunlight for at least one FULL hour.
- Plug the pump into the power supply.
- Run the pump for 30 seconds (or until the temperature gauge stays at constant temperature for at least two seconds) every hour.
- Open the water valve to get hot water out of the system when needed.