Modification of Solar Water Heater System to avoid Troubleshooting

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Abstract— *The water-in-glass evacuated tube is an integral part of evacuated tube solar water heater. Solar water heaters with evacuated tube collectors perform better than that of flat plate collector. The usage of evacuated tube collectors is increasing day by day The solar thermal water heating system is the technology to harness the plenty amount of free available solar thermal energy. The solar thermal system is designed to meet the energy demands, but the energy demands are met in only the sunny days, and in cloudy days the system does not give the satisfactory results. To avail the drawback electric water heater backup is given to the SWH system. But use of electric water heater leads to excess heating which results into damaging the tank , Gaskets which in turn will damage the evacuated tubes which are too much fragile. This small mistake may lead to failure of system so to avoid modification are necessary.*

Keywords— Solar water heater, water tank, solar energy.

I. INTRODUCTION

The solar energy is the most capable of the alternative energy sources. Due to increasing Demand for energy and rising cost of fossil type fuels (i.e., gas or oil)solar energy is considered an attractive source of renewable energy that can be used for water hearing in both homes and industry. Heating water consumes nearly 20% of total energy consumption for an average family. Solar water heating systems are the cheapest and most easily affordable clean energy available to homeowners that may provide most of hot water required by a family. Solar energy is the energy which is coming from sun in the form of solar radiations in infinite amount, when these solar radiations falls on absorbing surface, then they gets converted into the heat, this heat is used for heating the water. This type of thermal collector suffers from heat losses due to radiation and convection. Such losses increase rapidly as the temperature of the working fluid increases.SWH systems are generally very simple using only sunlight to heat water. A working fluid is brought into contact with a dark surface expoed to sunlight which causes the temperature of the fluid to rise. passed through some form of heat exchanger called an indirect system.

1.1. Components of solar water heating system

SWH generally consists of a solar radiation collector panel, a storage tank, a pump, a heat exchanger, piping units, and auxiliary heating unit. Some of important components are described in the next sections.

1.1.1. Solar water tank

Most commercially available solar water heaters require a well-insulated storage tank. Thermal storage tank is made of high pressure resisted stainless steel covered with the insulated fiber and aluminum foil. Some solar water heaters use pumps to recirculate warm water from storage tanks through collectors and exposed piping. This is generally to protect the pipes from freezing when outside temperatures drop to freezing or below

1.1.2. Solar Collectors

The choice of collector is determined by the heating requirements and the environmental conditions in which it is employed. There are mainly two types of solar collectors like

A. Flat plate solar collector
B. Evacuated tube solar collector

Evacuated-Tube Collectors

Evacuated-Tube Collectors are made up of rows of parallel, transparent glass tubes. Each tube consists of a glass outer tube and an inner tube, or absorber, covered with a selective coating that absorbs solar energy well but inhibits radiative heat loss. The air is withdrawn (“evacuated”) from the space between the tubes to form a vacuum, which eliminates conductive and convective heat loss. They are most suited to extremely cold ambient temperatures or in situations of consistently low-light. They are also used in industrial applications, where high water temperatures or steam need to be generated where they become more cost effective.

Fig 1.1. Manufactured Evacauted tube type collector

II. PROBLEM DEFINITION

Following are the issues that affect the working of solar water heater

1.2. Weather condition

The amount of incident radiation determines the absorbed solar radiation by the collector while the ambient temperature determines the thermal losses from the collector. Cloudy conditions limit the beam isolation levels and thus the radiation absorbed by the collector especially the concentrating collectors

This is the biggest problem affecting the solar water heater system is weather conditions. Solar collector absorbs the most electricity on clear days with abundant sunshine (not surprisingly). On a cloudy day, typical solar collector can produce 10-25% of their rated capacity. The exact amount will vary depending on the density of the clouds. According to the MNRE the solar collector should provide about 60% of your hot water needs as an annual average, with about 90% during the height of summer, and about 25% during the winter. Solar collector is affected by the loss of direct sunlight a bit more than PV and realistically you should cannot expect too much from your solar thermal during winter. They are also affected by cloud considerably more than solar PV, so a cloudy winter day you should cnnot expect your solar thermal to do much at all. So while purchasing the SWH system the weather conditions is the most important factor. And the same reason leads to dissatisfaction of the customer.

1.3. Excessive heating

If also the system is given electric heater backup we cannot check the temperature inside the tank which may lead to excessive heating of tank and result in to leakage of the water tank, and also damages the gasket. If gasket gets damaged it may cause pilferage of water from the tank .The damaged gasket may also cause breakage of evacuated tube which are very fragile. So sometimes excessive heating also may lead to customer satisfaction.

III. DESIGN AND MODIFICATION

a. System design requirements

The type, complexity, and size of a solar water heating system is mostly determined by selection of capacity Changes in ambient temperature and solar radiation between summer and winter.

• The changes in ambient temperature during the day night cycle.

• The possibility of the potable water or collector fluid overheating.

• The possibility of the potable water or collector fluid freezing.

b. Overheat protection

When no hot water has been used for a day or two, the fluid in the collectors and storage can reach very high temperatures in all systems except for those of the drain back variety. When the storage tank in a drain back system reaches its desired temperature, the pumps are shut off, putting an end to the heating process and thus preventing the storage tank from overheating. One method of providing over heat protection is to dump the heat into a hot tub. Some active systems deliberately cool the water in the storage tank by circulating hot water through the collector at times when there is little sunlight or at night, causing increased heat loss. This is most effective in direct or thermal store plumbing and is virtually ineffective in systems that use evacuated tube collectors, due to their superior insulation. No matter the collector type, however, they may still overheat. High pressured sealed solar thermal systems versions ultimately rely on the operation of temperature and pressure relief valves. Low pressure, open vented ones have simpler, more reliable safety controls, typically an open vent

c. Technique and design concept

In order to heat water using solar energy, a collector is fastened to the roof of a building, or on a wall facing the sun. In some cases, the collector may be freestanding. The collector could be made of a simple glass topped insulated box with a flat solar absorber made of sheet attached to copper pipes and painted black, or a set of metal tubes surrounded by an evacuated glass cylinder. A simple water heating system would pump cold water out to a collector to be heated water flows back to a collection tank. The typical 50 gallon electric water heater uses 11.1 barrels of oil a year, which translates into the same amount of oil used by a typical 4-door sedan driven by the average consumer. Electrical utility companies often provide electricity by burning and releasing energy from fuels such as oil, coal and nuclear energy. An electrical home hot water heater sits on an electrical grid and may be driving the use of unclean fuels on the other end of the grid. So using the solar water heaters to heat water is much reliable and appropriate thing than using our preciously nonrenewable fuels, But in cloudy days or the days when the intensity of sun is less we don't have any other option to heat water other than electric heater, but rather than wasting the electricity we need to use the electricity in the optimum way so that water is heated without wasting electricity

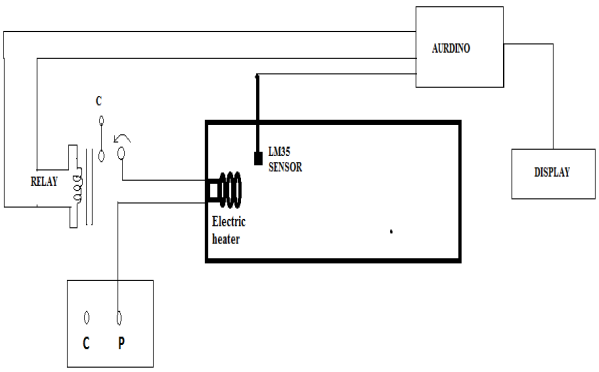


Fig 3.1. schematic representation of the technique design..

d. Components required for set up of Evacuated Tube type SWH system-

A. Evacuated Tubes
B. Water Tank
C. Insulation
D. Support Structure
E. Gasket

e. Specification of components

Specification of different parts of ETC type SWH is as below. This specifications is taken according to INDIAN STANDARD (IS 12933 PART : 5)

i. Evacuated tubes

The tube is made of borosilicate glass. The diameter of the tube is 58mm and the length is 1800mm. Figure 1 shows the detail parts of the evacuated tube.

- Dia- 58mm
- Length -1800mm
- Number of tubes required - 10nos(for 100 LPD)

Fig 3.2. Evaacuated tube

ii. Watertank

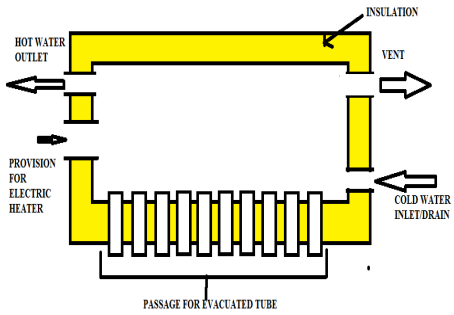


Fig 3.3. schematic representation of water tank.

As we need tank which will provide 100 litres of hot water every day.

Length=1000mm= 1m

capacity -100 litres

So now we don't know the dia of solar water heater so for dia

$V = (22/7)*d^2 *l$

V=Volume of water tank =100litres*10-3

length tank = 1000 mm

so,now putting in the formula.

$V = (22/7)*d^2 *l$

$100*10^{-3}= (22/7)*d^2 *1$

d = 0.356m

- The storage tank has 3 opening.
  1 For cold inlet(from cold water tank)
  2 For hot water outlet (for use)
  3. Ventilation

iii. Insulation

Polyurethane foam(PUF)
Density- 36+2kg/m
Thermal conductivity-0.021w/mk
Temp limit- +110-180ºC

iv. Gasket

Name-SILLICON GASKET
Dia -58mm X 10 nos
Can sustain temp range- -50^0 to 150^0

IV. MODIFICATION

Modification in SWH to Operate Electric heater with optimum use following components are required

A. Aurdino kit
B. Relay drivers
C. LM35 sensors
D. Heater

a. Ardiuno Kit

Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

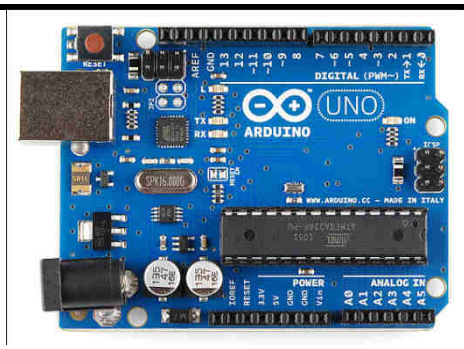


Fig 4.1. Arduino kit

There are many other microcontrollers and microcontroller platforms available for physical computing. Parallax Basic Stamp, Netmedia's BX-24, Phidgets, MIT's Handyboard, and many others offer similar functionality. All of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems:

a. Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $50
b. Cross-platform - The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.
c. Simple, clear programming environment - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with how the Arduino IDE works.
d. Open source and extensible software - The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.
e. Open source and extensible hardware - The plans of the Arduino boards are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money.

b. Relay driver

Interfacing the relay modules to the Arduino. A Relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate the switch and provide electrical isolation between two circuits. In this project there is no real need to isolate one circuit from the other, but we will use an Arduino UNO to control the relay.

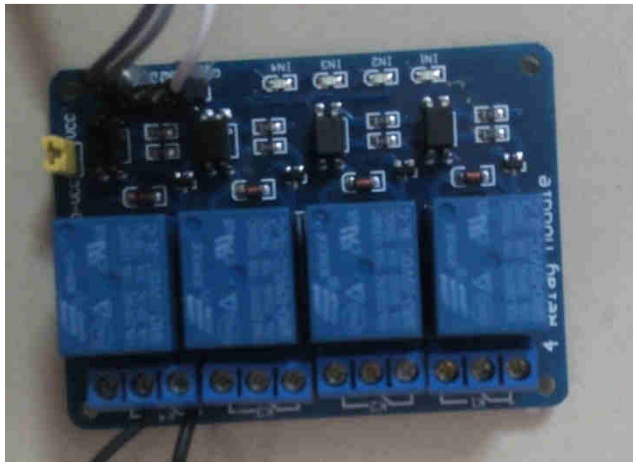


Fig 4.2. Relay Driver

c. LM35 SENSOR

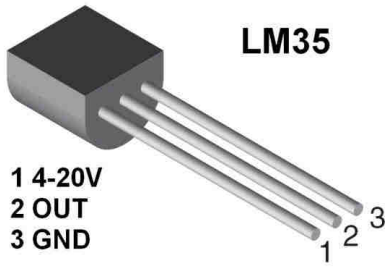


Fig 4.3. LM35 sensor

LM35 is a precision IC temperature sensor with its output proportional to the temperature (in ^{0}C) With LM35, temperature can be measured more accurately than with a thermistor. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response . The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in^{o}C) It has an output voltage that is proportional to the Celsius temperature. The scale factor is .01V/^{0}C. The working can be displayed as follows there are two transistors in the center of the drawing. One has ten times the emitter area of the other. This means it has one tenth of the current density, since the same current is going through both transistors.. The integrated circuit has many transistors in it -- two in the middle, some in each amplifier, some in the constant current source, and some in the curvature compensation circuit. All of that is fit into the tiny package with three leads

d. WORKING OF CIRCUIT

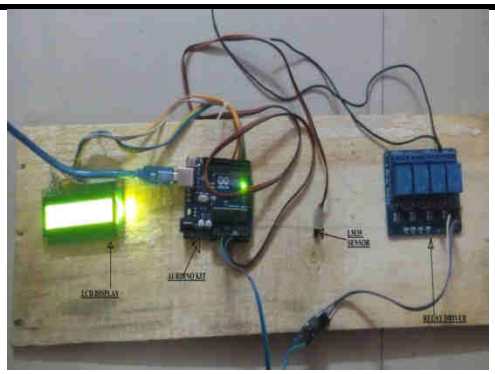


Fig 4.4 showing circuit diagram

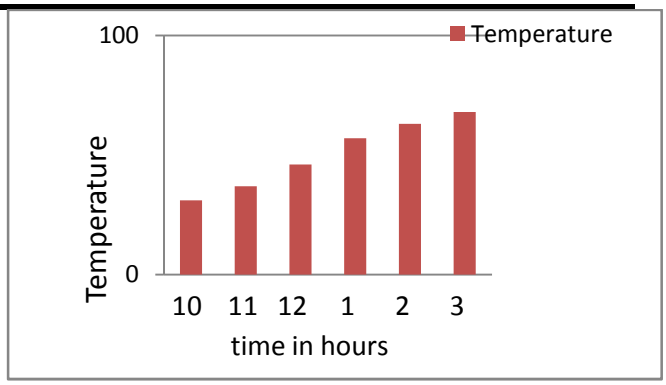
Working of the system is very simple, according to our need the program is dubbed in the aurdino kit Which is connected to relay drivers and the 16*4 LCD display. And the temperature sensors. And the relay driver is connected to Electric heater. As the supply is given to the aurdino kit the sensor will sense the temperature and will be shown on the LCD display. As per the program feeded to the aurdino kit the temperature range is fixed at 50^0C (can be flexible) and according to the sensor if the temperature is below 50^0C the relay will actuate the heater, and "HEATER ON" command will be displayed on the LCD display.As the heater heats the water slowly the water temperature will increase the gradual increase in temperature will be shown on the display. when the temperature will reach 50^0C the according to the program the sensor will sense the temp and will send to aurdino in order to that the the relay driver will deactivate the heater and the command will be shown on the display "HEATER OFF" and the heater will stop heating water.

V. TESTING RESULT

5.1. Test 1-These are the testing result taken on the sunny day without using heater. The results are as follows, the testing was taken from morning 10am to afternoon 3pm

Table 5.1 showing testing results taken on sunny day

Time in hours	Temperature
10	31
11	37
12	46
1	57
2	63
3	68



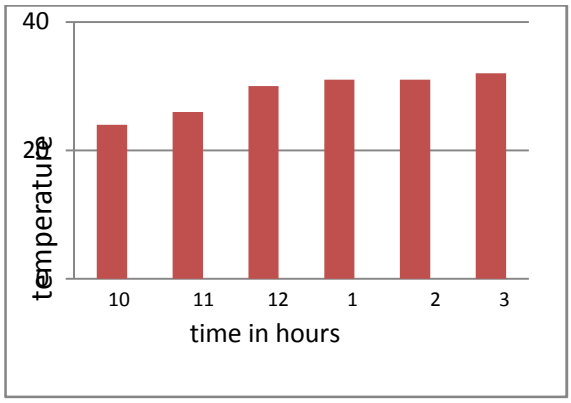
Graph 5.1. showing testing results taken on sunny days

5.2. Test 2

The testing was also carried out in cloudy days and the results are as follows-

Table 5.2. testing results carried out on a cloudy day

Time in hours	Temperature
10	24
11	26
12	30
1	31
2	31
3	32



Graph 5.2 table showing testing results carried out on a cloudy day

5.3. TEST 3

The third test was carried out after mounting the circuit to the solar water heating system. And the results were as follows. Time Required To Heat The Water Using 3kw Heater For 100 Lpd

temperature	TIME REQUIRED IN SECONDS
35-40	303
40-45	297
45-50	293
50-55	318
55-60	309

60-65	313
65-70	379
TOTAL TIME REQUIRED	2212= 36.8 minutes

Table 5.3. showing the time required to heat the 100 litres of water using the electric heater.

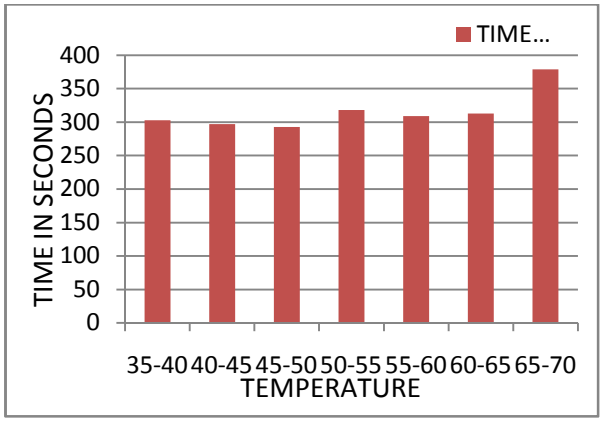


Table 5.3. showing the time required to heat the 100 litres of water using the electric heater.

VI. CONCLUSION

By putting above modification in solar water heating systems and doing a comparative study shows those in cloudy days we too are able to get hot water with this modification. This tendered to avoid the trouble shooting of not getting the hot water in rainy season. So using electric heater we can heat water in cloudy days without damaging the water tank, gasket and the other fragile parts of the system also one more advantage is we can heat water with using optimum electricity.

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