Parabolic Through Solar Water Heater

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ABSTRACT

A solar collector is a device that transforms solar radiation from the Sun into heat, which is then transferred to the working fluid. The use of solar collectors reduces energy costs over time as they do not use fossil fuels or electricity like that in traditional water heating. As well as in domestic settings, a large number of these collectors can be combined in an array and used to generate electricity in solar thermal power plants. There are several different types of solar collector designs that use the energy of the sun to heat working fluid. Each design whether a basic blackened flat panel collector or a more advanced evacuated tube collector all have their advantages and disadvantages. Parabolic trough reflector provides a better alternative way to generate higher temperatures with better efficiency. The parabolic trough reflector is a solar energy collector designed to capture the sun's direct solar radiation over a large surface area and focus or "concentrate it" onto a small focal point area, increasing the solar energy received by more than a factor of two. Connecting parabolic troughs to form collector fields requires large areas of land for the installation. Also, parabolic troughs have a small absorber area and have efficiencies of around 12% with a smaller angle of view. Convective heat transfer can be enhanced passively by enhancing the thermal conductivity of the fluid. Modern nanotechnology provides new possibilities to enhance heat transfer performance compared to pure liquids. Nanofluids are engineered colloidal suspension of Nano meter-sized particles called Nanoparticles in a base fluid.

Metals, oxides, carbides, or carbon nanotubes are the general precursors for nanoparticles. Common base fluids include water, ethylene glycol, and oil. Nanofluids exhibit enhanced thermal conductivity due to large area-to-volume ratio and high turbulence properties. Due to their novel properties nanofluids find their applications in many fields of heat transfer, including microelectronics, fuel cells, pharmaceutical processes, and hybrid-powered engines, in grinding, machining, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger and in boiler flue gas temperature reduction. Knowledge of the rheological behavior of Nanofluids is found to be very critical in deciding their suitability for convective heat transfer applications.

PROBLEM STATEMENT

Our world is shrinking as we are becoming more connected but the energy demand is increasing exponentially. More than 80% of the world's population still depends on conventional fuels but the problems related to conventional energy sources are, that they are non-renewable and polluting in nature. The burning of fossil fuels produces around 21.3 billion tons of carbon dioxide per year but still around 1.2 billion (16% of the world's population) do not have access to electricity and many more suffer from supply that is of poor quality. Therefore, the dire need of the situation is energy, which is renewable, sustainable, reliable, non-polluting, and readily available.

OBJECTIVES

To improve the efficiency of the Parabolic Trough Collector with integrated storage by 10%.

To maintain outlet water temperature in low radiative situations up to certain hours.

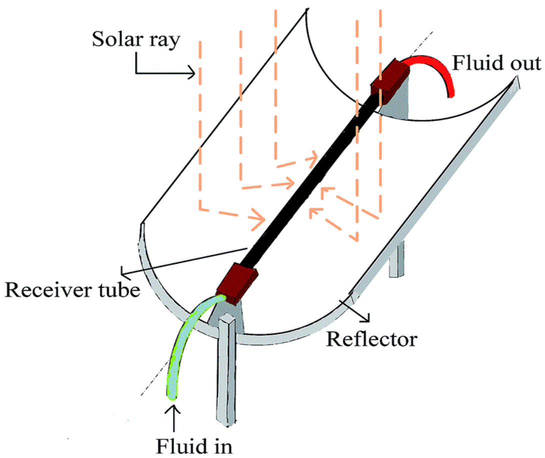
To evaluate the improved performance of solar Parabolic Trough Collector with thermal storage with Erythritol as PCM.

To evaluate charging & discharging time and backup period of thermal storage.

LITERATURE SURVEY

Although the costs of solar energy have gone down and continue to fall, the levelized costs of solar energy are still much higher than conventional energy. The levelized cost of solar concentrated power (CSP) is four times that of supercritical coal without carbon capture and storage [1]. Cost is one of the major factors inhibiting the development of trough collectors. Increasing the efficiency of the solar collector systems can in part alleviate this problem. Many attempts have been made to improve the performance of these systems [2–5]. Heat transfer can be enhanced by increasing the thermal conductivity of the heat transfer fluid (HTF). The thermal conductivity of metallic particles, metallic oxides, and nanotubes is relatively higher than that of liquids. The addition of fine particles into heat transfer fluids (thus forming nanofluids) can significantly increase the heat transfer rate [6–8]. Many studies have been carried out on the performances of PTCs using synthetic oils and nanofluids as heat transfer fluids. The latter is formed by suspending nanoparticles (1nm100nm) in a traditional heat transfer fluid. These so-called nanofluids display good thermal properties compared with fluids conventionally used [9] Choi was the first to use the nanofluid term at the 1995 annual winter meeting of the American Society of Mechanical Engineers as he presented the possibility of doubling the convection heat transfer coefficients using nano-fluids. In addition to this work, researchers in Japan and Germany have published articles concerning similar fluids (Massuda et al 1993, Grimm 1993) [10]. Heris et al conducted experiments with the Al2O3 and CuO nanoparticles suspended in water under laminar flow. They found that the heat transfers could increase by about 40% while the improvement of thermal conductivity doesn't exceed 15% [11]. Tyagi et al studied theoretically the efficiency of a low-temperature nanofluid-based direct absorption solar collector using a mixture of water and aluminum, where the nanoparticle volume fraction varies from 0.1 % to 5%. They found that the efficiency increases significantly for low-volume fractions of nanoparticles, whereas for values higher than 2% the efficiency levels off. They also investigated the size of nanoparticles (1nm-20nm) at the volume fraction of 0.8%: the efficiency increases slightly with increasing size of nanoparticles [12]. In 2010, Otanicar et al studied both experimentally and numerically the effect of different nanofluids (carbon nanotubes, graphite, and silver) on the performances of a micro-scale direct absorption solar collector. Their results showed that the suspension of a slight amount (less than 0.5%) of nanoparticles remarkably improves efficiency. However, for a volume fraction higher than 0.5%, the efficiency remains constant and even begins to decrease with 12 increasing volume fraction. They also found that the efficiency increases with decreasing size of nanoparticles [13]. Khular et al investigated theoretically in 2012 the thermal efficiency of a nanofluid-based direct absorption solar parabolic trough collector. They used aluminum nanoparticles at the volume fraction of 0.05% suspended in the base fluid Therminol-VP1. Their results showed that thermal efficiency increases compared to a conventional PTC by 10 % at low temperatures and by 5% at high temperatures. [14]

PROPOSED METHODOLOGY

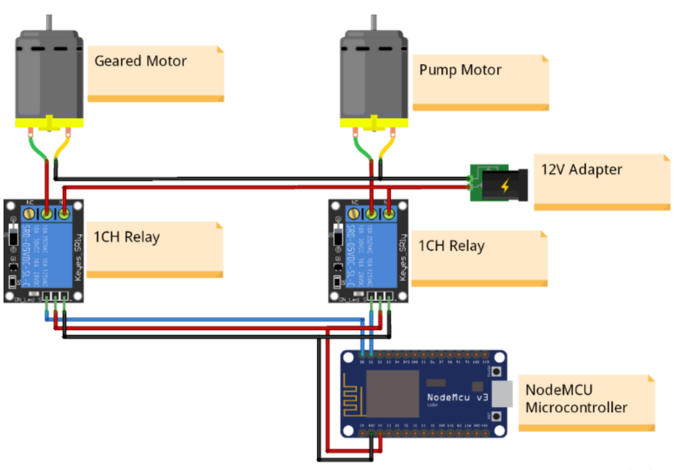


1. **The foundation and metallic framework**: This supports the trough collectors and fastens them to the ground so that the entire apparatus can sustain the weight of the collector.
2. **Parabolic Trough Reflector**: This is the collector's focusing component. It transmits the sunlight to the receiving tube by reflecting it. Silver and aluminum are the two most common reflective materials utilized, often mounted on a glass surface.
3.
4. **Receiving tube or absorber**: This device transforms focused light energy into thermal energy in a heat transfer fluid. To optimize the process of converting energy, it offers only certain functions.
5. **Operating fluid**: Thermal oil is the primary fluid in many Solar-driven systems for heat transfer. But other substances, like water or steam, can also be applied. This fluid provides the heat energy needed to create the steam. In turn, the steam helps operate the turbine and ultimately produces electricity.

The parabolic collectors work as described below:

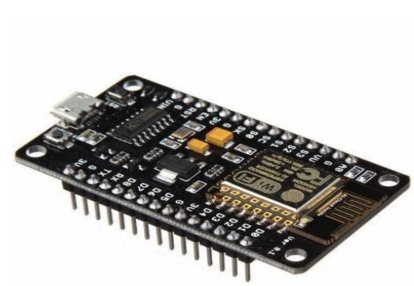
1. Heat transfer occurs when the solar panels warm the operating fluid, such as thermal oil. To create high-pressure steam, this transfer fluid is circulated through several absorbers. In a typical steam generator, the heat contained in this steam is turned into electricity. The fundamental structure is identical to that of a solar cooker.
2. The functioning of these solar power plants is also comparable to that of other power plants. They use heat to create steam, which powers engines and produces energy. The way that each power plant obtains heat differs from the other.

CIRCUIT DIAGRAM



HARDWARE USED

1. NodeMCU Microcontroller



NodeMCU is an open-source IoT platform. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware that is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open-source projects, such as lua-Jason and SPIFFS.

- Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106
- Operating Voltage: 3.3V
- Input Voltage: 7-12V
- Digital I/O Pins (DIO): 16
- Analog Input Pins (ADC): 1
- UARTs: 1
- SPIs: 1
- I2Cs: 1
- Flash Memory: 4 MB
- SRAM: 64 KB
- Clock Speed: 80 MHz
- USB-TTL based on CP2102 is included onboard, Enabling Plug n-Play
- PCB Antenna

2. 1CH Relay

A relay is an electrically operated switch. It consists of a set of input terminals for single or multiple control signals and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof. Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal.

- 1 channel relay board
- Operating Voltage 5V
- Max Current: 20mA
- Relay Contact Current Capacity at AC250V: 10A
- Relay Contact Current Capacity at DC5V: 10A
- One normally closed contact and one normally open contact
- Triode drive, increasing relay coil
- High-impedance controller pin
- Pull-down circuit for avoidance of malfunction

3. 12V Adapter

The 12 Volt Adapter Power Supply is used in Pads, Laptop computers, lighting, mobile equipment, and many more. Here we have used it for supplying power to DC Water Pump.

4. Pump Motor

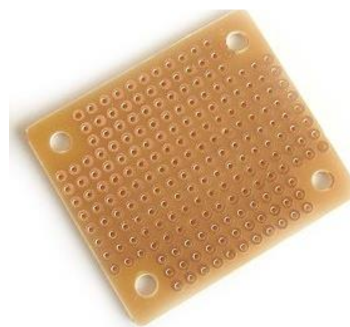
This is a 550 Diaphragm Pump 12V Water Pump for supplying water to the inner tube of the parabolic collector. The configuration of the bath is according to the saving configuration: 12V2A power supply, bus connector, 4m 7 x 10 silicone tube, and a 550 water pump.

- Watering configuration: much the same, additional sprinklers and timers are required
- 12V DC reflux diaphragm pump 550, the price is the price of a pump, without other accessories
- Maximum pressure: 0.48MP.
- Voltage: 12V, current: at least 2A, measured 1A is not able to bring
- Suction: 3 meters or so, preferably 2 meters (no problem if the vertical height is 1.5 meters).
- Head: 4-5 meters (head is not shot)
- The highest temperature resistance is 55°
- Flow rate: 3.5L/min

5. Connecting Wires

Since the stranded wire is more flexible than the solid core wire of equal size, it can be used when the wire needs to move around frequently.

6. Zero PCB



Perfboard or Zero Pcb is a material for prototyping electronic circuits (also called DOT PCB). It is a thin, rigid sheet with holes pre-drilled at standard intervals across a grid, usually a square grid of 0.1 inches (2.54 mm) spacing. These holes are ringed by round or square copper pads, though bare boards are also available. Inexpensive perfboard may have pads on only one side of the board, while better quality perfboard can have pads on both sides (plate-through holes). Since each pad is electrically isolated, the builder makes all connections with either wire wrap or miniature point-to-point wiring techniques. Discrete components are soldered to the prototype board such as resistors, capacitors, and integrated circuits. The substrate is typically made of paper laminated with phenolic resin (such as FR-2) or a fiberglass-reinforced epoxy laminate (FR-4).

7. Male Headers

Pin headers are stiff metallic connectors that are soldered to a circuit board and stick up to receive a connection from a female socket. While pin headers (often called PH, or headers) are male by definition, female equivalents are also quite common, and we refer to them as female headers (FH) or header connectors.

8. Female Headers

The *female connector* is generally a receptacle that receives and holds the male *connector*.

9. Jumper Wires

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points without soldering. Jumper wires are typically used with breadboards and other prototyping tools to make it easy to change a circuit as needed.

10. USB Cable

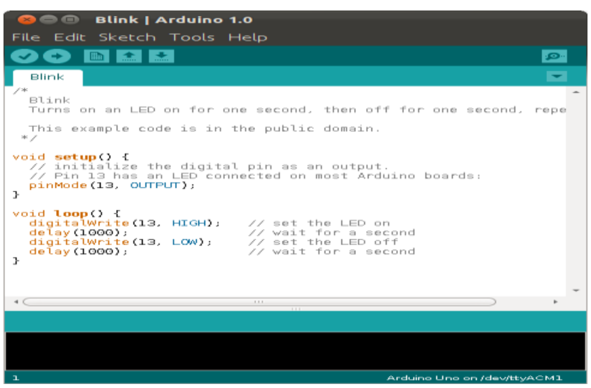
USB stands for Universal Serial Bus. It is used as a data cable for programming as well as for supplying power.

11. DC Geared Motor

DC Motor – 200RPM – 12Volts geared motors are generally simple DC motors with a gearbox attached to them. This can be used in all-terrain robots and a variety of robotic applications. These motors have a 3 mm threaded drill hole in the middle of the shaft thus making it simple to connect it to the wheels or any other mechanical assembly.200 RPM 12V DC geared motors widely used for robotics applications. Very easy to use and available in standard size. Also, you don't have to spend a lot of money to control motors with an Arduino or compatible board. The most popular L298N H-bridge module with an onboard voltage regulator motor driver can be used with this motor that has a voltage of between 5 and 35V DC or you can choose the most precise motor diver module from the wide range available in our Motor drivers' category as per your specific requirements.

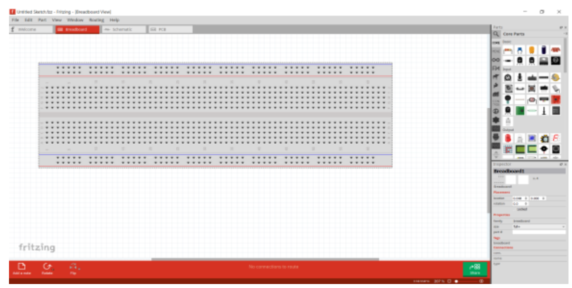
SOFTWARE USED

ARDUINO IDE



The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in the programming language Java. It is used to write and upload programs to the Arduino board. The source code for the IDE is released under the GNU General Public License, version. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that is compiled and linked with a program stub main() into an executable cyclic executive program with the toolchain, also included with the IDE distribution. The Arduino IDE employs the program Avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

FERTILIZING



Fritzing is an open-source hardware initiative that makes electronics accessible as creative material for anyone. We offer a software tool, a community website, and services in the spirit of Processing and Arduino, fostering a creative ecosystem that allows users to document their prototypes, share them with others, teach electronics in a classroom, and layout and manufacture professional PCs.

MISCELLANEOUS ITEMS

- MS Sheets
- Iron Angles
- Nuts & Bolts
- Aluminium Foil
- Aluminium Rod
- Container
- Transparent Pipe

CALCULATION

1. m $= V/\rho$

$= 5000/1000$

$= \mathbf{5}$ kg

2. Q $= m*Cp*(To-Ti)/t$

$= 5 * 4187 * (31 - 28)/3600$

$= \mathbf{17.433}$ W

3. Q $= h * A * (Tw - Tb)$

h $= Q / A * (Tw - Tb)$

$= 17.433 / 0.039898 * (37 - 33)$

$= \mathbf{145.649\ W/m^2}$K

4. Re $= \rho UL / \mu$

$= 0.46685 * 0.01 / 6.5269 * 10^{-7}$

$= 7152.7065$

5. Nu $= hl / k$

$= 141.353138 * 0.01\ 0.63777$

$= 2.21636$

6. *The standard form for a parabola is given by,*

$$4p(y-k) = (x-h)^2 \quad \dots(i)$$

Assuming Focus point to be 300 mm above the origin

$$P = Focal\ Length = 300\ mm$$

$$Vertex = (h,k) = (0,0)$$

Substituting the values of P, h, k in (i),

$$\therefore 4(30)(y-0) = (x-0)^2$$

$$\therefore 120y = x^2$$

After Putting the values of y, we obtain the above curve.

$$Rim\ Angle = 90^0$$

FORMULAE USED

1. $Q = m*Cp*(To-Ti) / t$

Where,

Q = Heat in W m = Mass of water (5 kg)

Cp = Specific heat of water (4184 J/kg-K)

To = Outlet temperature of water

Ti = Inlet temperature of water

t = Time taken (1 hour)

2. $Q = h * A * (Tw - Tb)$

Where,

Q = Heat in W

h = Heat transfer coefficient in W/m2K

A = πdL = Area of the receiver pipe (d = 0.5 inch; L = 1m)

Tw = Surface temperature of receiver pipe

$Tb = (Ti + To)/2$

3. $Re = \rho UL / \mu = UL / V$

Re - Reynolds number

ρ - Density of the fluid

u - Mean velocity of a fluid object

L - Characteristic length

μ - Dynamic Viscosity of fluid

4. $Nu = hl/k$

Nu - Nusselt number

h - Convective heat transfer coefficient of fluid

k - Thermal conductivity of fluid

L - Characteristic length

ADVANTAGES

1. The most significant benefit of parabolic trough collectors is that it's inexpensive. Solar parabolic troughs are now one of the cheapest devices to produce power from the Sun.
2. They create extremely high temperatures, which are useful for producing steam. At night, power can be supplied by the reserves stored in heavy, insulated tanks.
3. Solar Photovoltaic is expensive, while parabolic troughs, which use cheaper reflectors, may span a larger area.

DISADVANTAGES

1. Sun tracking is required to sustain solar collecting using parabolic trough collectors. Otherwise, the production would decrease. This raises the expense and upkeep associated with movable structures.
2. A high concentration of sunlight is required for a parabolic trough collector to function properly. In scattered light, sunlight cannot be focused effectively, and production drops substantially. Solar cells can produce energy even in dispersed light, but solar parabolic troughs cannot.
3. As discussed earlier, solar photovoltaics (PV) may be placed on roofs. However, parabolic trough collectors demand a considerable quantity of land.

CONCLUSION

A solar collector is a device that absorbs solar radiation and transforms it into electricity or heat energy. The materials used in solar collectors vary to maximise the absorption of solar energy. One such type of collector is the parabolic concentrator. It contains reflective material that returns solar energy onto a specially constructed absorber tube running along its centre. The reflective material is mainly made from aluminum atop a large parabolic mirror. The efficiency of the system is increased by the apparatus selected for this project.

FUTURE SCOPE

Tracking Mechanism can be incorporated.

Graphene Coating on Collector.

Different nanofluids can be used.

Different flow rates to determine the optimum flow rate.

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