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# Water Cooler Integrated With Dual Axis Solar Tracker

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***Abstract:*** *We are aware of the fact that energy is broadly classified into two main parts,that is Conventional and Non Conventional.The cost of conventional energy is increasing day by day due to its shortage.So we need to focus more on more utilisation of non conventional Energy Resources.Nowdays,temperature is also very high in summer seasons,So we need to have appliances like water cooler in commercial buildings(Like Schools,Colleges,Hospitals,Offices,etc).These water coolers are generally opearted on a cycle VCRS(Vapour Compression Refrigeration System).These water coolers because of involvement of compressor,consumes high power.In this Project,our aim is to Design and Fabricate water cooler runnning on Peltier Effect assisted with automatic dual axes solar tracker for efficient harvesting of solar energy.Conventional Water coolersare mostly based on VCRS and due to involvement of compressor it costs high electricity bill.*

***Keywords:*** *Thermoelectric cooler, Peltier Module, Photovoltaic cell,Cooling rate,Water cooler, COP, Arduino uno.*

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## I. Introduction:

Refrigeration is a process of cooling or maintaining lower temperature than the surrounding. In this process heat is extracted from the place which is to be cooled and dissipated to another place (mostly Atmosphere),by providing external Energy Input. Refrigeration can be done by various methods some of which are , Non-Cyclic Refrigeration( cooling with Dry Ice), Cyclic-Refrigeration(VCRS,VARS), Thermoelectric Refrigeration etc.

In our model we are using peltier effect so as to extract the heat from the water tank , the Peltier effect is a temperature difference created by applying a voltage between two electrodes connected to a sample of semiconductor material, any moving parts like compressor and condenser which consume more energy are absent here . Also the system do not require refrigerants instead peltier is used which directly extract the heat from the surrounding water and releases out to the heat sink.

Now to provide the power to the peltier we are using the dual axis solar tracker . By harnessing the renewable energy i.e. sunlight we are charging our secondary battery . And the battery is used so as to drive our solar tracker's motor . There are LDR on the solar panel which are use to sense the intensity of light and sends these signals to arudino uno which helps to rotate the solar panel in two perpendicular plane according to the changing intensity of light during a day .

The secondary battery in the model is used so as to create potential drop between two peltier electrode which creates a temperature difference at the junction of module .The inner junction of our system gets cold and outer reject heat to the heat sink.[1]Hossein Mousazadeh et Al.,[ (2011), Journal of Solar Energy Engineering,Vol.133 ] studied and investigated maximization of collected energy from an on-board PV array, on a solar assist plug-in hybrid electric tractor (SAPHT). Using four light dependent resistive sensors a suntracking system on a mobile structure was constructed and evaluated. The experimental tests using the sun-tracking system showed that 30% more energy was collected in comparison to that of the horizontally fixed mode.[2]K.S. Madhu et al., (2012) International Journal of Scientific & Engineering Research vol. 3, 2229–5518, states that a single axis tracker tracks the sun east to west, and a two-axis tracker tracks the daily east to west movement of the sun and the seasonal declination movement of the sun.Test results indicate that the increase in power efficiency of tracking solar plate in normal days is 26 to 38% compared to fixed plate. And during cloudy or rainy days it's varies at any level.[3]AkshendraSoni (2016) International Advanced Research Journal in Science,Engineering and Technology, vol.3 states that In this study result are evaluated on basis of TOTAL HEAT DISSIPATION under fixed volume condition.In the present study, thermal performances of plate-fin and pin-fin and elliptical fin heat sinks were compared for the fixed base plate dimensions and fin height under fixed volume condition. When objective function is considered plate fin performs better than pin fins. Thermal performances of plate-fin and pin-fin heat sinks werecompared for the fixed base plate dimensions

and fin diameter.[4]M.Mirmanto et al., (2018) Engineering Science and Technology, an International Journal states that The study of the thermoelectric cooler box with TE positionswas performed to know the effect of TE positions on the coolerbox performance. The positions of the TE were on Top, on Bottom, on Wall Sideat the same power and wall side position was found to be the best position for TE.

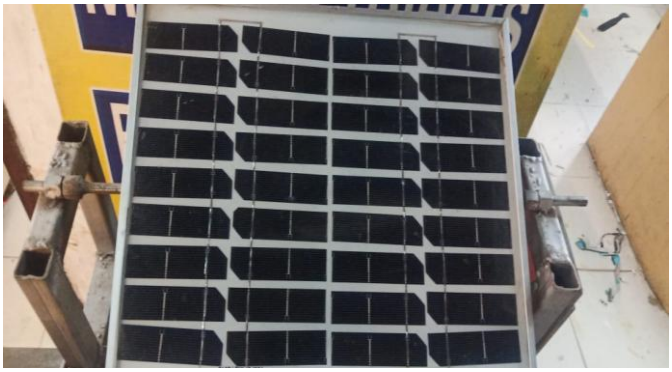
**Problem Statement:**

- Water coolers which are using electricity have high running cost due to use of conventional energy.
- Problem with most of the solar panels is that they are not effective in rainy and winter season,but since we are concerned with water cooling which is not very essential in winter and rainy season due to decrease in ambient temperature,hence it is efficient to use Water Coolers running on Peltier Effect integrated with solar tracker.

**List of Components Required:**

**1)Solar cell:**

Solar cell are used to harness the solar energy of sun which is then stored in batteries.



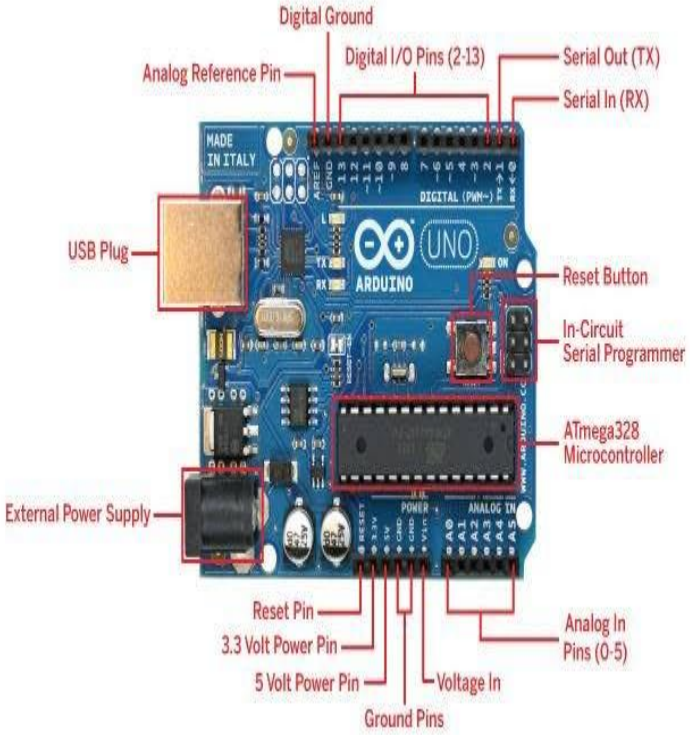
**2)D.C.gear motor:**

D.c. gear motors are used to rotate the Solar Panelstaking the input from Arudino Uno .

**3)Photoresistor:**

Photoresistor is an electronic component whose resistance decreases with increasing intensity of light.

**4)Arudino Uno:**
Arudino uno is a microcontroller based on microchip which senses the light and calculatesexact angle for the rotation of solar cell. Model name ATmega328.




**5)Battery:**
Solar energy is converted in the form of electricity which is stored in the battery.The energy stored is then used in the cooling phenomenon.Lead Acid secondary battery 12V-7A.

**6)Castor wheel:**
This wheel is attached at the base of the system to provide movement to the system.

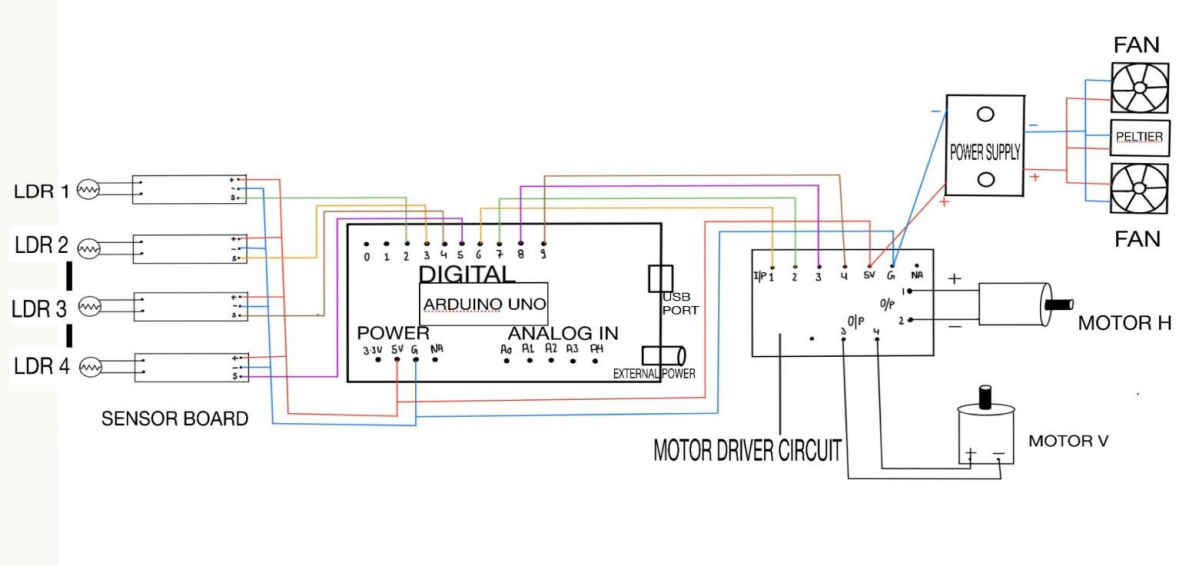
**7)Peltier module:**
When current is passed to the junction of the module the temperature difference will be created to both of the junction.Thermoelectric cooler model name , TEC1-12706


**8)Cooling fan:**
This fan is used to remove the heat from the hot side of module.Axial sleeve bearing fan 12V - .18A DC


**9)Heat sink:**
Heat sink acts as heat exchanger used to remove the heat from module.

**10)Insulated box:**
This box is used to store and cool the water and the peltier module is attached at this box.

**Circuit Diagram of Water Cooler integrated with Dual Axis Solar Tracker:**




**Explanation of Circuit Diagram:**

Here in the circuit diagram we are having 4LDRs which are connected with the input terminals of sensor boards.Sensor boards are having other 3 terminals which are positive, ground and signal terminals.Positive of all sensor boards are connected with the 5V pin on Arduino Uno.In the same way ground of all sensor boards are connected with ground pin on Arduino. The remaining 4 signal terminals of sensor boards are connected one by one with pin numbers **2,3,4** and **5** respectively on the Arduino.These are the output terminals of sensor boards and at the same time input terminals for Arduino. We are having a motor driver which can control two motors at a time. Input terminals **1,2,3,**and **4** of motor driver are connected with pins **6,7,8** and **9** on the Arduino .Thus the motor driver is receiving the output of arduino through thesee terminals.Motor driver is having 4 output terminals, output terminals corresponding to input terminals **1** and **2** are connected with horizontal motor and other two output terminals corresponding to input terminals **3** and **4** are connected with vertical motor . For power supply to whole circuit 5V and ground terminals of motor driver are firstly connected with 5V and ground pins on arduino and then to positive and negative terminals of battery. Battery's positive and negative terminals are further connected with thermoelectric module and cooling fans to give them power supply.

**Fabrication and Design:**

**Fabrication Steps**

Project fabrication consists of two parts,fabrication of dual axis solar tracker and fabrication of water cooler's refrigerating unit.After the fabrication of two individual units they can be combined easily without any fabrication complications. So, here are the steps involved in the fabrication.

**Step1:** As we are having the circuit diagram for the dual axis solar tracker and after close observation of it,we decided to complete the connections for input signals from LDR sensors to arduino first and then to complete it for the output signals from arduino to motor driver.

**Step2:** The wires were soldered to the respective terminals as per the circuit diagram and thus the connections for the input were done, following the same procedure the output connections were made too.

**Step3:** Meanwhile the frame for supporting the solar panel ,dc motors as well as the remaining electronic components was prepared. For dimensions simple ruler , for cutting hacksaw blades , for giving it the final shape and to fasten the frame parts fevicole was used.

**Step4:** The dual axis solar tracker's fabrication done, now we started for the refrigerating unit. First we took our icebox and made a through hole to fix the peltier and heat sink. Peltier was glued to heat sink's surface using thermal glue.

**Step5:** After fixing the peltier and heat sink , cooling fans were screwed to the holes already there on the heat sink's surface.

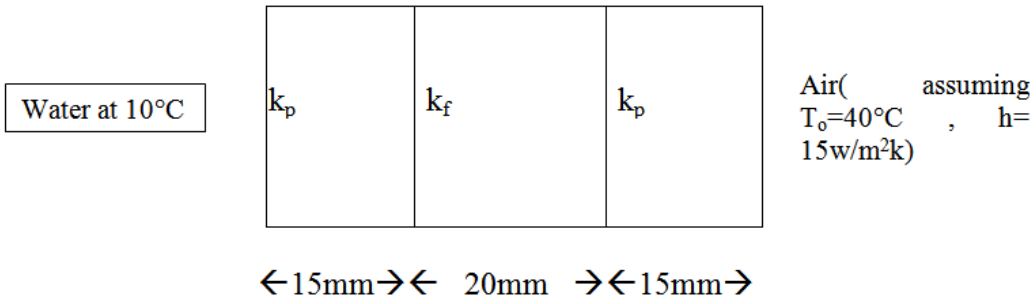
**Step6:** After getting the refrigerating unit's body i.e. water cooler's body ready , we did the rest of the connections to complete the circuit.

**Step7:** As the peltier modules , and cooling fans get electrically connected to dual axis solar tracker and so to the power supply , our prototype is ready to work.

**Design:**

**Heat Load Calculation**

Mass of water to be cooled = 500 ml or 0.5kg
Assuming max temp of water to be cooled ( Th ) = 50°C
Desired temp of water ( Tc ) = 10°C
Temp diff ( ΔT ) = 40°C
Amount of heat to be removed from water ( Qw) =MCΔT
= 0.5*4.18*40
=83.6 kJ
Various heat losses (conduction , convection and neglecting radiation )




$k_p$ (Thermal conductivity of plastic ) = 0.25 W/mk
$k_f$ (Thermal conductivity of Styrofoam) = 0.033 W/mk
so,
Thermal resistance per unit area :
$R= 1/h_{air} + l_1/k_p + l_2/k_f + l_3/k_p$
= 1/15 + .015/.25 + .02/.033 + .015/.25
= 0.793 $m^2k/W$
Rate of heat loss = ΔT/R
= (40-10)/0.793
$Q_{loss}$ = 37.83 $W/m^2$

Dimension of cooling box
Volume = l * b * h
= 30 * 15 * 15 $cm^3$
Total area = 2 * ( l*b + b*h + l*h )
= 2 * ( 30*15 + 15*15 + 30*15 )
= 2250 $cm^2$ or 0.225 $m^2$
Total heat loss = 37.83*0.225
$Q_{loss}$ =8.51 W
Heat load result:
$Q_W$ = 83.6 kJ
$Q_{LOSS}$ = 8.51W

Calculation for peltier module
$Q_c = ( \alpha_m I T_c ) – ( .5I^2R ) – K_m ( T_h – T_c )$
$Q_h = ( \alpha_m I T_h ) + ( .5I^2R )$

Where
$\alpha_m = v_{max}/T_h$
= 12/323°K
= .037 V/K

$R_m = ( T_h - \Delta T_{max} ) / T_h$
=1.56 Ω

$K_m = ( T_h - \Delta T_{max} )* V_{max}*I_{max} / ( 2*\Delta T_{max}*T_h )$
= 0.0193 W/k
So,
$Q_c$ = 34 J

$Q_h$ = 100 J

Now, energy input required to peltier for producing $Q_c$ = 34 J & $Q_h$ = 100 J can be calculated by formula :

$Q_h = Q_c$ + Energy input

$100 = 34 + E_{input}$

So,

$E_{input}$ = 66 J

Now, since each peltier module having the max power output as (12 V *6 amp) = 72 W
So, time required = 66/72
= 0.92 s
Cooling rate = $Q_c$/Time required
= 34/0.92
= 37 W
Now, taking $Q_{load}$ to be 100kJ (by including $Q_{loss}$ and other losses) in place of 83.6kJ.
So, total time required to cool water from 50°C to 10°C is given as:

$$\frac{\text{Total heat load}}{\text{Cooling rate}} = \frac{100*1000}{37*60}$$

= 45 min

Since, we are using 2 peltier module so the time of cooling will be 45/2 i.e. 22.5 min.

**COP of refrigeration system:**

Cooling rate = 37 W
Power input = 72 W

So,

$$COP = \frac{\text{COOLING RATE}}{\text{POWER INPUT}}$$

$$= \frac{37}{72}$$

$$COP = 0.5138$$

The calculated COP of system is thus 0.5138 but due to weather condition experimental COP of system may vary between 0.250 to 0.513(max).

**COP value during experiment:**

| **Day** | **Initial temperature °C** | **Minimum temperature °C** | **Cooling time (Minute)** | **COP** |
|---|---|---|---|---|
| **1** | 39.82 | 16.48 | 19 | **.297** |
| **2** | 39.02 | 15.78 | 22 | **.255** |
| **3** | 38.70 | 14.02 | 21 | **.284** |
| **4** | 40.12 | 18.68 | 17 | **.305** |
| **5** | 37.63 | 12.73 | 18 | **.333** |

## II. Result and Discussion

Experiment was performed and COP was calculated for the successive five days in the summer season.The cop varies between 0.255 to 0.333. The average COP of the system is 0.295.

## III. Conclusion

A water cooler integrated with dual axis solar tracker was fabricated and tested for the purpose of cooling. The system was designed on the basis of principle of thermoelectric which makes one side cool and other side hot , heat sinks are used to absorb the heat and cooling fans are used to reject it into atmosphere , the

amount of this heat is very less as compared to compressor based water coolers . This system does not use CFC's and HCFC's so it is environment friendly. This system is equipped with dual axis solar tracker for harvesting renewable energy and to escape from high electricity bills. The system is not having any movable part so the dynamics of the system is balanced and the maintenance is easy also the reliability of the components is more and system is noiseless. Major problem with solar energy operated systems is drastic decrease in their efficiency and effectiveness during winter season. But since we are dealing with cooling the water and there is no need for the same in winter season ,so we are not going to face this problem. This system can be marketed in the coming future to replace compressor based water coolersafter some advancements in its COP and COST .The COP and the cost of the system is dependent on other parts like peltier module, solar panel and battery performance.With the future advancements of these parts the COP the system will be improved and by increasing the number of modules cooling effect can be increased also the work can be done in the future for making it more cost effective.

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