# ijRASET

# INTERNATIONAL JOURNAL
# FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

# Design and Fabrication of Atmospheric Water Collector

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Abstract: There are many rural areas in India where water scarcity and inadequate electricity is one of the major issue. Such issues are not only faced in India but also in other parts of the world. As we know that around 71% of the earth's surface is covered with water of which 96% is saline and only 4% is fresh water. The fresh water is stored in sources like atmosphere, rivers, ponds, glaciers, even though there is fresh water to locally meet human demands. The main aim of our project is to provide fresh drinking water to people who face water crises. This paper explains the method of condensing atmospheric air using a Peltier module (Thermo Electric Cooler) and extracting fresh water from air using solar energy.
Keywords: Peltier module, solar energy, Condensation, Thermo-Electric Cooler, Atmosphere.

## I. INTRODUCTION

Fresh drinking water is essential for our survival. It is said that around 60% of our body is water hence we won't survive without it. As we know the atmosphere contains large amount of fresh water which is stored in the form of water vapour. So in our project we will be extracting water with the help of an atmospheric water generator. The atmospheric water generator is a device which is used to convert the humid air from the atmosphere to water. The device will cool up to the dew temperature. The quantity of water obtained from the device will depend on the relative humidity and the dry bulb temperature of the atmospheric air. The amount of moisture present in the atmosphere at the given point of time can be found using a Psychometric chart which will be explained later in the paper. In coastal regions we can obtain highest amount of water as the humidity is very high about (65%-80% at 35°C). Where as in places like Rajasthan, Uttar Pradesh, Andhra Pradesh etc., the water obtained will be less as the humidity in these places is comparatively low (40%-55% at 35°C). The atmospheric water generator will work with a minimum of (30% at 35°C). The atmospheric water generators main principle is to use the latent heat to condense the vapour form of water into water droplets. In this device we are making use of Peltier module which is a very small module which reduces making use of big components such a compressor, condenser etc. which in turn reduces the size and makes it a compact device.

The main purpose of the atmospheric water generator is to ensure the following requirement such as

A. Clean drinking water.
B. Easy to use.
C. It should be hazard free.
D. Must be easily portable.

## II. WORKING PARTS

### A. Peltier Module

The Peltier module is a thermo-electric device, it has two sides that is the p-type and the n-type semiconductor. The semiconductors are sandwiched between the two ceramic plates. When the Peltier is made to run on DC supply the one side of the Peltier becomes hot and the other becomes cold, but if the polarity is interchanged the direction of electric current will change resulting in the change of cold and hot side. It consists of a heat sink and a fan combination where the Peltier are attached to the heat sink with the help of thermal paste. Heat sink which we will use will be of aluminium
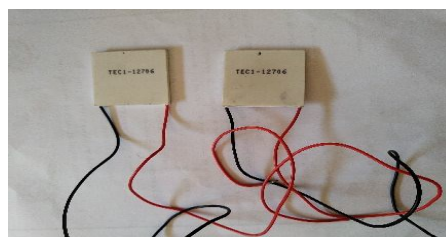


Fig-1- Peltier

The main parts used in making our device are Peltier modules, heat sinks. Solar panel, 12v battery and fan. The cold sink is insulated with glass wool and is covered using sheet metal. The heat sink is one of the crucial parts in the Atmospheric Water Collector (AWC), as the atmospheric air will be in direct contact with the heat sink and the Peltier module. So the heat from the heat from Peltier will be directly transferred to the atmospheric air by means of heat sink.

### B. Heat Sink

A heat sink is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium in this case it is air. The heat sink has a solid metallic surface of high thermal conductivity that may consist fins. The fins are provided in order to increase the surface area of the Peltier module, so that the heat from the heat sink can be efficiently transferred to the air. Thermal grease is used to improve the heat sink's performance by filling air gaps between the heat sink and the Peltier module. A heat sink is usually made out of copper or aluminium. Copper is used because it has higher thermal conductivity and many desirable properties for thermally efficient and durable heat exchangers. First and foremost, copper is an excellent conductor of heat. This means that copper's high thermal conductivity allows heat to pass through it quickly. Aluminium heat sinks are used as a low-cost, lightweight alternative to copper heat sinks, but have a lower thermal conductivity than copper.
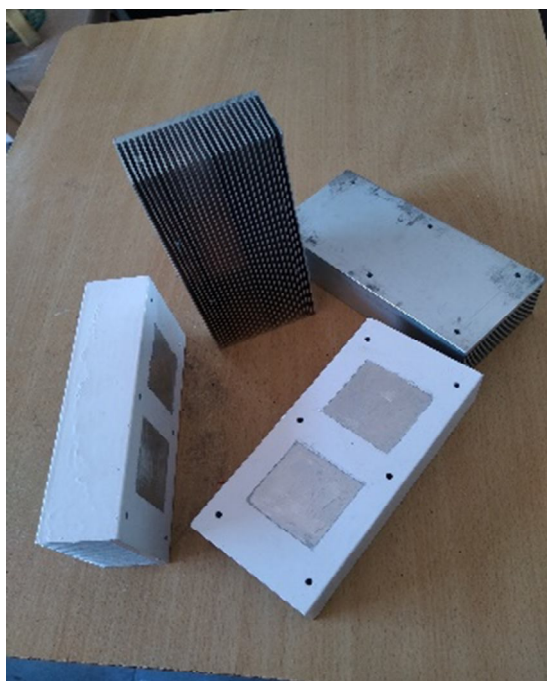


Fig-2- Heat Sink

### C. Photovoltaic Solar Panel

In this project we also making use of solar panel of 100 Watts. Solar panel converts sunlight to current and provides electricity. Solar panels are constructed in a collection of lots of small solar cell which are spread on a large area to provide enough power. The larger concentration of light falls on the cells and more electricity or heat is produced. Solar panel works by converting the light photons to electricity through the solar photo-voltaic (PV) effect. This allows for direct conversion of sunlight into solar power. Solar panels use many layers of semi conducting material most commonly silicon. PV's are measured by kilowatts peak (KWp).
In order to get maximum efficiency the solar panel must be directly facing the sun. i.e. The position of the solar panel should be changed according to the position of the sun.

### D. Battery

Here we use lead acid battery of 12V. It consists of several lead or lead electrodes consisting of several plates connected in parallel which are immersed in a solution of sulphuric acid which converts the chemical energy into electrical power. The lead acid battery is commonly used in substations and power stations and has higher cell voltage compared to other batteries and is also available at lower cost.
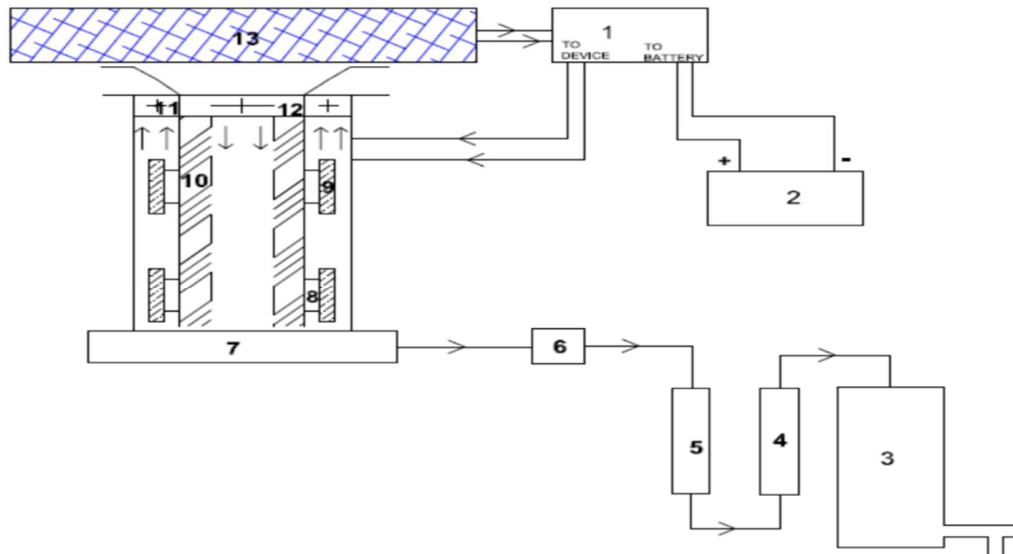
## III. WORKING AND DESIGN



Fig-3-Working of Atmospheric Water Collector

| Sr.No | Components |
|-------|-----------|
| 1 | Solar Charge Controller |
| 2 | Lead Acid Battery |
| 3 | Water Storage Tank |
| 4 | Mineral Water Filter |
| 5 | Porous Stone Filter |
| 6 | Water Pump |
| 7 | Collector Tank |
| 8 | Peltier Module |
| 9 | Heat Sink |
| 10 | Condensing Element |
| 11 | Fan |
| 12 | Inlet Fan |
| 13 | Solar Panel |

Table-1

The above figure is the line diagram of our project. Electric energy is produced when sun light strikes the Photovoltaic PV solar panel (13) electric energy is produced. The solar panel converts the light energy of the sun into electric energy thus producing 100watts power from the solar panel. The solar charge controller (1) consists of three ports one input and two output ports. The PV solar panel is connected to the input of the solar charge controller, from the two output ports one is connected to the battery (2) and the other is connected to the load. The function of the solar charge controller is to distribute the power from the solar panel to the load and to charge the battery when there is sun light. In the absence of sunlight the solar charge controller switches to the battery source in order to supply the required electric energy, the electric energy is used to run Peltier, water pump and fans which is the connected load. Atmospheric air will enter through the inlet fan (12), which will pass over the condensing element (10). The condensing element (10) will be maintained at the dew point temperature with the help of four Peltier module (9). The hot side of the Peltier module will be connected to a heat sink (9) in order to effectively dissipate heat so that the Peltier module does not get damaged, the heat sink will be cooled with the help of a fan (11). The water condensed onto the condensing element will collect in

the collector Tank (7). With the help of a water pump(6) the water from collector tank will be pumped through a Porous Stone Filter (5) and a mineral water filter(4). The filtered water will be then stored in a water storage tank (3). This water will then be used for drinking.

### A.  CAD Design

The CAD model of the atmospheric water generator was made using Siemens solid edge ST5. The various components created are as follows:

1) Peltier Module
2) 120mm fan
3) 80mm fan
4) Heat Sink
5) Condensing Element
6) Collector Tank
7) Air duct

All these components were assembled in order to create a virtual model of the atmospheric water generator. The image below shows the created CAD model
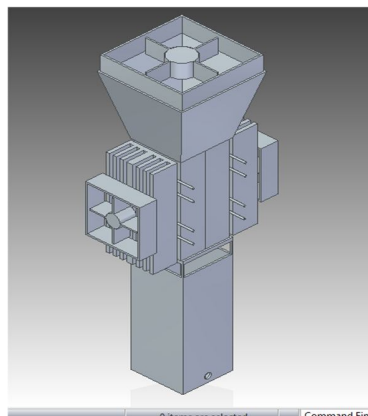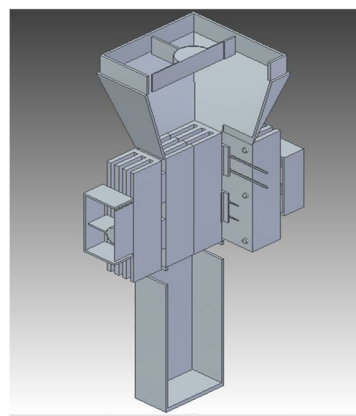


Fig-4-  CAD Model                     Fig-5- Sectional View

### B.  Calculations

1) Dew Point Temperature Calculation

a) *Definitions*

i)   *Dew-Point temperature (TDP)* also known as saturation temperature is the temperature at which water vapor present in the air starts condensing at the same rate at which it is evaporating at a given constant barometric pressure.

ii)  *Dry-Bulb temperature (DBT)* is the temperature of air measured by a thermometer freely exposed to the air and shielded from radiation and moisture. DBT is the temperature that is usually thought of as air temperature, and it is the true thermodynamic temperature.

iii) *Relative Humidity (RH)* is the ratio of the partial pressure of water vapor to the equilibrium vapor pressure of water at the same temperature.

$$T_{dp} = \frac{c \times w(T, RH)}{b - w(T, RH)}$$

$$w(T, RH) = ln\left(\frac{RH}{100}\right) + \left(\frac{bT}{c + T}\right)$$

Where,

b= 17.67

c=243.5°C

T=Dry Bulb Temperature (DBT)

Note: All calculations were done in excel and tabulated.

| Dew point temperatures at 25°C (DBT) | | | |
|---|---|---|---|
| Dry Bulb Temperature (DBT) | Relative Humidity (RH) | w(DTB,RH) | Dew point temp (DPT) |
| 25 | 50 | 0.952104216 | 13.86761705 |
| 25 | 52 | 0.991324929 | 14.47282948 |
| 25 | 54 | 1.029065257 | 15.05789152 |
| 25 | 56 | 1.065432901 | 15.62419002 |
| 25 | 58 | 1.100524221 | 16.1729708 |
| 25 | 60 | 1.134425773 | 16.7053573 |
| 25 | 62 | 1.167215596 | 17.22236627 |
| 25 | 64 | 1.198964294 | 17.72492093 |
| 25 | 66 | 1.229735953 | 18.21386224 |
| 25 | 68 | 1.259588916 | 18.68995843 |
| 25 | 70 | 1.288576453 | 19.15391329 |
| 25 | 72 | 1.31674733 | 19.60637319 |
| 25 | 74 | 1.344146304 | 20.04793324 |
| 25 | 76 | 1.370814551 | 20.4791426 |
| 25 | 78 | 1.396790037 | 20.90050917 |
| 25 | 80 | 1.422107845 | 21.31250362 |

Table-2
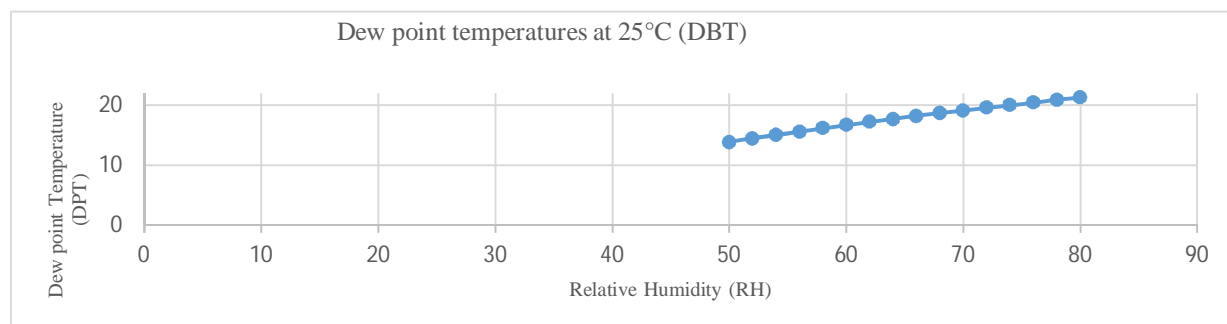


Fig-6

| Dew point temperatures at 30°C (DBT) | | | |
|---|---|---|---|
| Dry Bulb Temperature (DBT) | Relative Humidity (RH) | w(DTB,RH) | Dew point temp (DPT) |
| 30 | 50 | 1.245061229 | 18.45805415 |
| 30 | 52 | 1.284281942 | 19.08507468 |
| 30 | 54 | 1.32202227 | 19.69126874 |
| 30 | 56 | 1.358389914 | 20.27806834 |
| 30 | 58 | 1.393481234 | 20.84676001 |
| 30 | 60 | 1.427382786 | 21.39850393 |
| 30 | 62 | 1.460172609 | 21.93435017 |
| 30 | 64 | 1.491921307 | 22.45525227 |
| 30 | 66 | 1.522692966 | 22.96207884 |
| 30 | 68 | 1.552545929 | 23.45562345 |
| 30 | 70 | 1.581533466 | 23.9366131 |
| 30 | 72 | 1.609704343 | 24.40571555 |
| 30 | 74 | 1.637103317 | 24.86354559 |
| 30 | 76 | 1.663771564 | 25.31067062 |
| 30 | 78 | 1.68974705 | 25.74761539 |
| 30 | 80 | 1.715064858 | 26.17486623 |

Table-3
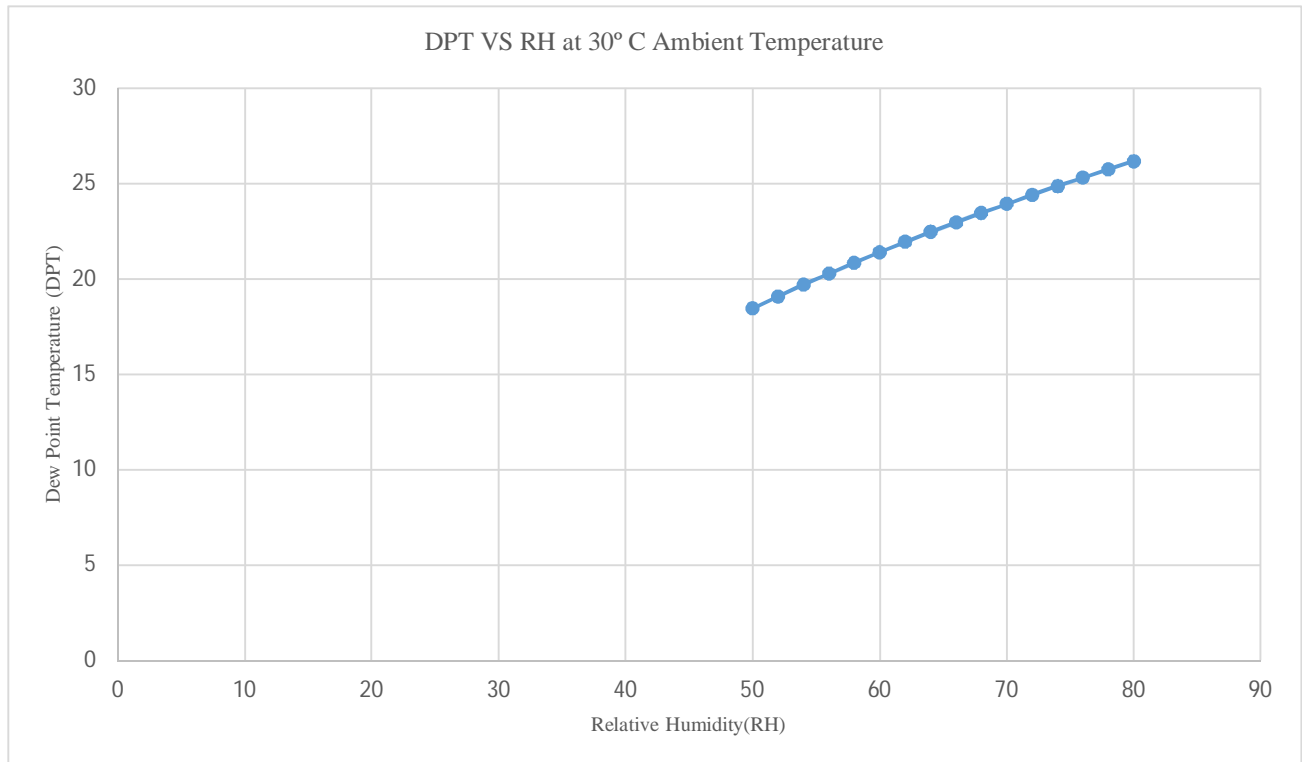
Fig-7

| Dew point temperatures at 35°C (DBT) | | | |
|---|---|---|---|
| Dry Bulb Temperature (DBT) | Relative Humidity (RH) | w(DTB,RH) | Dew point temp (DPT) |
| 35 | 50 | 1.527499139 | 23.04141369 |
| 35 | 52 | 1.566719852 | 23.69059474 |
| 35 | 54 | 1.60446018 | 24.31826495 |
| 35 | 56 | 1.640827824 | 24.92590203 |
| 35 | 58 | 1.675919144 | 25.5148336 |
| 35 | 60 | 1.709820696 | 26.08625702 |
| 35 | 62 | 1.742610519 | 26.64125604 |
| 35 | 64 | 1.774359217 | 27.18081487 |
| 35 | 66 | 1.805130876 | 27.70583008 |
| 35 | 68 | 1.834983839 | 28.21712085 |
| 35 | 70 | 1.863971376 | 28.71543768 |
| 35 | 72 | 1.892142253 | 29.20146993 |
| 35 | 74 | 1.919541227 | 29.67585233 |
| 35 | 76 | 1.946209474 | 30.13917071 |
| 35 | 78 | 1.97218496 | 30.59196688 |
| 35 | 80 | 1.997502768 | 31.03474302 |

Table-4
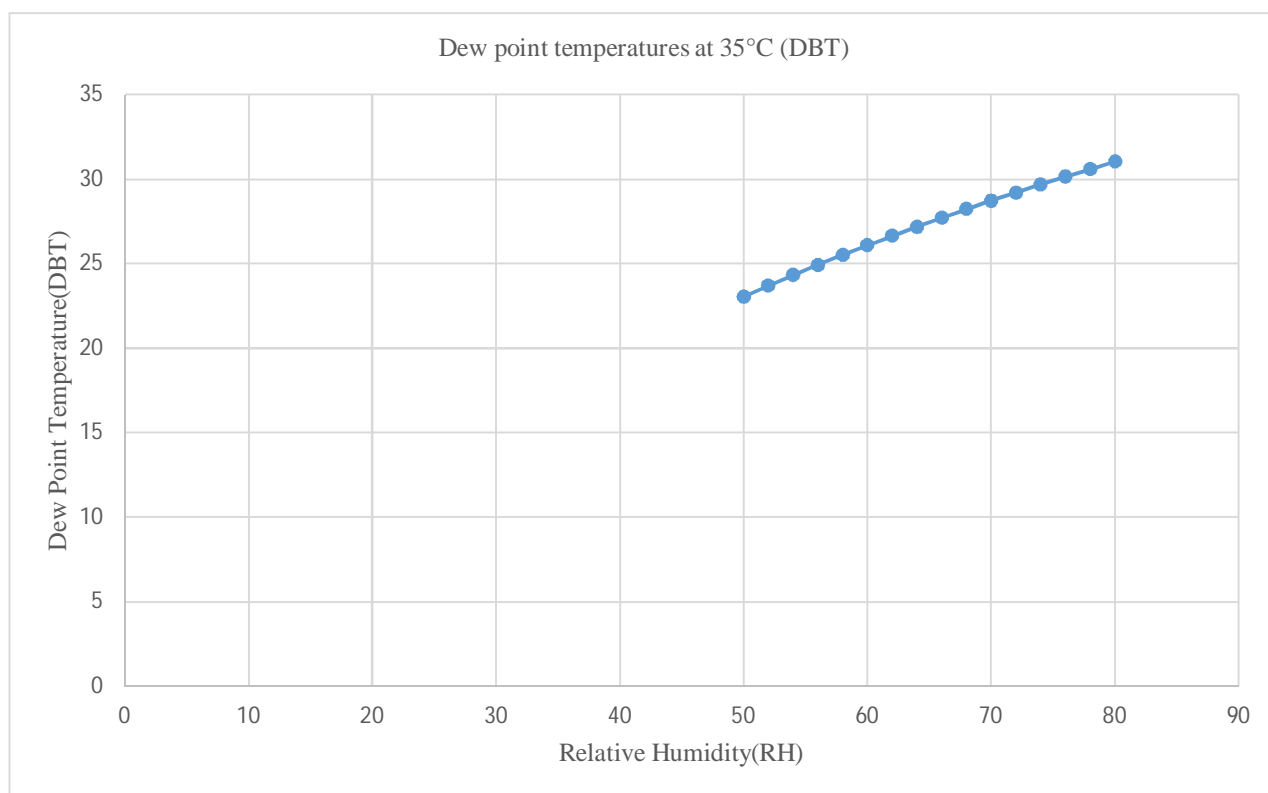
Fig-8

2) Amount of water present in Litres in $1M^3$ of air for different humidity and temperature conditions

a) *Definitions*

i) *Saturation Pressure (Ps)* is the pressure of air at which vapour present in air changes to liquid at a given pressure. The saturation pressure of water at different atmospheric temperature is obtained from the commercially available steam tables. We referred saturated water and steam temperature tables from (steam tables by R.s Khurmi and N. Khurmi)

ii) *Relative Humidity (RH)* is the ratio of partial pressure of water (Pw) to that of saturation pressure (Ps).

iii) *Humidity Ratio* gives the volume of water (in m3) present in 1m3 of air.

Humidity ratio can also be expressed in terms of partial pressure of water (Pw)

$$P_w = \frac{RH}{100} \times P_s$$

$$\text{Humidity ratio} = 0.622 \times \frac{P_w}{P_a - P_w}$$

$$Water\ Quantity = 1000 \times Humidity\ Ratio$$

Humidity ratio gives the amount of water present in $1m^3$ of air. As we know that $1m^3 = 1000$ litres.

Where,

RH= Relative humidity

Ps = Saturation pressure (from steam tables)

Pw = Partial pressure

$P_a$ = Atmospheric pressure (1.013 bar)

Water content at 50% Relative Humidity and corresponding temperatures

| Temperature | Partial Pressure | Saturation Pressure | Humidity Ratio | Water quantity in litres |
|---|---|---|---|---|
| 20 | 0.011685 | 0.02337 | 0.007258525 | 7.25852504 |
| 21 | 0.012425 | 0.02485 | 0.007723909 | 7.723908752 |
| 22 | 0.01321 | 0.02642 | 0.008218346 | 8.218345853 |
| 23 | 0.01404 | 0.02808 | 0.008741972 | 8.741971651 |
| 24 | 0.01491 | 0.02982 | 0.009291767 | 9.291767275 |
| 25 | 0.01583 | 0.03166 | 0.009874204 | 9.874203997 |
| 26 | 0.0168 | 0.0336 | 0.01048946 | 10.48945995 |
| 27 | 0.01782 | 0.03564 | 0.011137724 | 11.13772383 |
| 28 | 0.01889 | 0.03778 | 0.011819195 | 11.81919506 |
| 29 | 0.02002 | 0.04004 | 0.012540474 | 12.54047413 |
| 30 | 0.02121 | 0.04242 | 0.013301828 | 13.30182801 |
| 31 | 0.022455 | 0.04491 | 0.014100329 | 14.10032861 |
| 32 | 0.023765 | 0.04753 | 0.014942688 | 14.94268804 |
| 33 | 0.025145 | 0.05029 | 0.015832475 | 15.83247541 |
| 34 | 0.02659 | 0.05318 | 0.016766841 | 16.76684137 |
| 35 | 0.02811 | 0.05622 | 0.017752663 | 17.75266273 |
| 36 | 0.0297 | 0.0594 | 0.018787145 | 18.78714533 |
| 37 | 0.03137 | 0.06274 | 0.019877286 | 19.87728574 |
| 38 | 0.03312 | 0.06624 | 0.021023636 | 21.02363555 |
| 39 | 0.034955 | 0.06991 | 0.022230071 | 22.23007121 |
| 40 | 0.036875 | 0.07375 | 0.023497247 | 23.49724677 |

Table-5
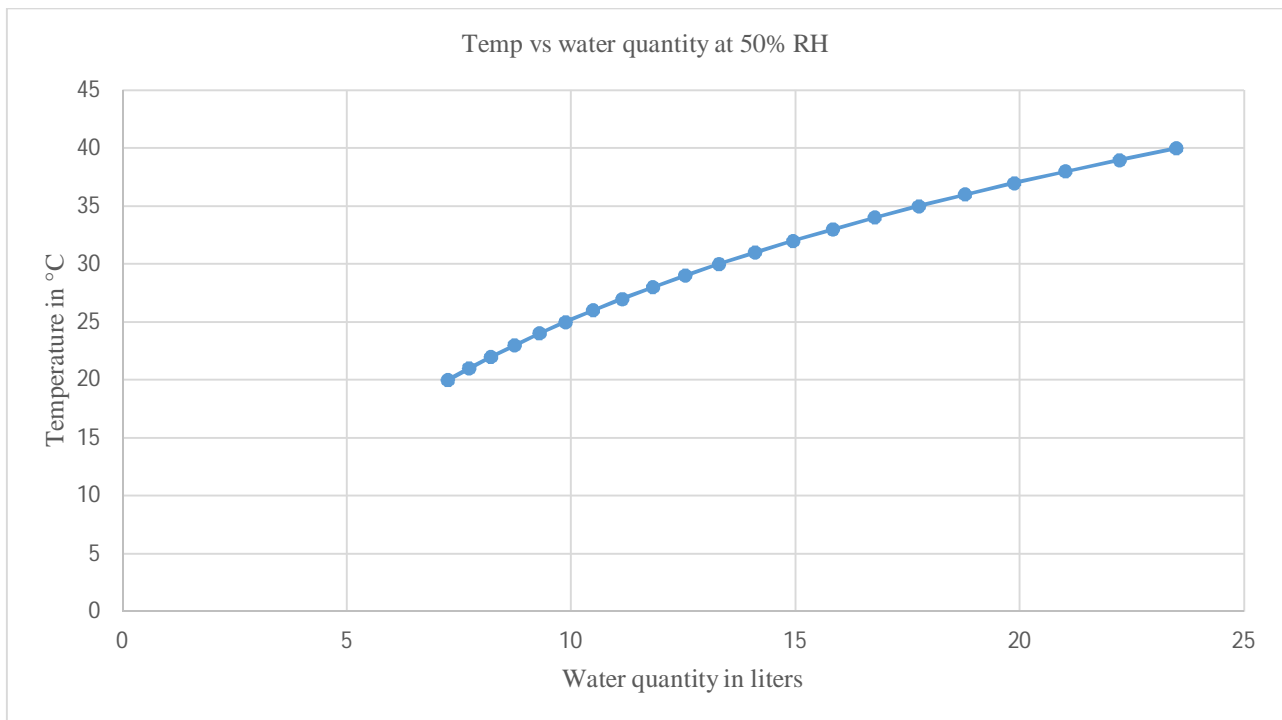


Fig-9

| Water content at 60% Relative Humidity and corresponding temperatures | | | | |
|---|---|---|---|---|
| Temperature | Partial Pressure | Saturation Pressure | Humidity Ratio | Water quantity in litres |
| 20 | 0.014022 | 0.02337 | 0.008730607 | 8.73060668 |
| 21 | 0.01491 | 0.02485 | 0.009291767 | 9.291767275 |
| 22 | 0.015852 | 0.02642 | 0.009888145 | 9.88814499 |
| 23 | 0.016848 | 0.02808 | 0.010519937 | 10.51993672 |
| 24 | 0.017892 | 0.02982 | 0.011183534 | 11.18353385 |
| 25 | 0.018996 | 0.03166 | 0.011886785 | 11.88678516 |
| 26 | 0.02016 | 0.0336 | 0.01262995 | 12.62995045 |
| 27 | 0.021384 | 0.03564 | 0.013413305 | 13.41330515 |
| 28 | 0.022668 | 0.03778 | 0.014237141 | 14.23714068 |
| 29 | 0.024024 | 0.04004 | 0.015109495 | 15.10949507 |
| 30 | 0.025452 | 0.04242 | 0.016030759 | 16.03075901 |
| 31 | 0.026946 | 0.04491 | 0.016997459 | 16.99745856 |
| 32 | 0.028518 | 0.04753 | 0.018017796 | 18.01779616 |
| 33 | 0.030174 | 0.05029 | 0.019096186 | 19.0961859 |
| 34 | 0.031908 | 0.05318 | 0.020229271 | 20.22927106 |
| 35 | 0.033732 | 0.05622 | 0.021425497 | 21.42549741 |
| 36 | 0.03564 | 0.0594 | 0.022681591 | 22.68159123 |
| 37 | 0.037644 | 0.06274 | 0.024006176 | 24.00617621 |
| 38 | 0.039744 | 0.06624 | 0.025400067 | 25.4000674 |
| 39 | 0.041946 | 0.06991 | 0.026868137 | 26.8681371 |
| 40 | 0.04425 | 0.07375 | 0.028411355 | 28.41135484 |

Table-6
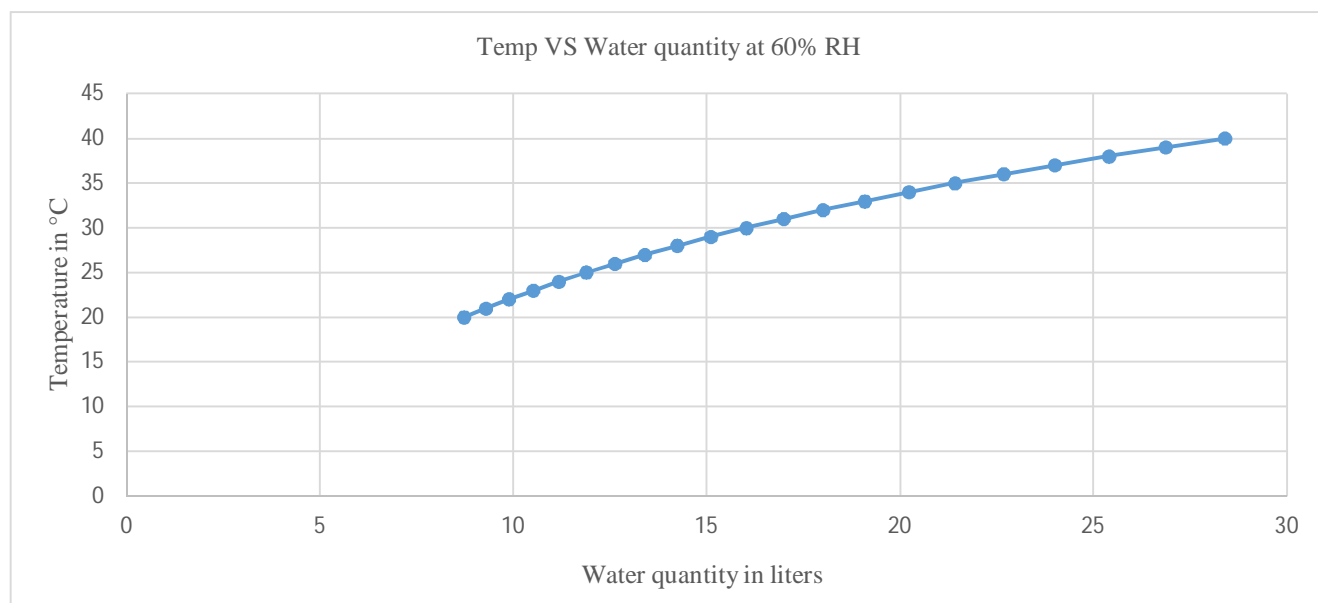
Fig-10

| Water content at 70% Relative Humidity and corresponding temperatures | | | | |
|---|---|---|---|---|
| Temperature | Partial Pressure | Saturation Pressure | Humidity Ratio | Water quantity in litres |
| 20 | 0.016359 | 0.02337 | 0.010209592 | 10.20959202 |
| 21 | 0.017395 | 0.02485 | 0.010867452 | 10.86745245 |
| 22 | 0.018494 | 0.02642 | 0.011566816 | 11.56681609 |
| 23 | 0.019656 | 0.02808 | 0.012307954 | 12.30795374 |
| 24 | 0.020874 | 0.02982 | 0.013086672 | 13.08667246 |
| 25 | 0.022162 | 0.03166 | 0.013912228 | 13.91222783 |
| 26 | 0.02352 | 0.0336 | 0.014784978 | 14.78497797 |
| 27 | 0.024948 | 0.03564 | 0.015705303 | 15.70530296 |
| 28 | 0.026446 | 0.03778 | 0.016673605 | 16.6736053 |
| 29 | 0.028028 | 0.04004 | 0.017699403 | 17.69940262 |
| 30 | 0.029694 | 0.04242 | 0.018783235 | 18.78323533 |
| 31 | 0.031437 | 0.04491 | 0.019921099 | 19.92109931 |
| 32 | 0.033271 | 0.04753 | 0.021122741 | 21.12274108 |
| 33 | 0.035203 | 0.05029 | 0.022393468 | 22.39346817 |
| 34 | 0.037226 | 0.05318 | 0.023729441 | 23.72944145 |
| 35 | 0.039354 | 0.05622 | 0.025140747 | 25.14074725 |
| 36 | 0.04158 | 0.0594 | 0.026623664 | 26.62366433 |
| 37 | 0.043918 | 0.06274 | 0.028188529 | 28.18852894 |
| 38 | 0.046368 | 0.06624 | 0.02983648 | 29.83647965 |
| 39 | 0.048937 | 0.06991 | 0.03157347 | 31.57346978 |
| 40 | 0.051625 | 0.07375 | 0.033400858 | 33.40085815 |

Table-7
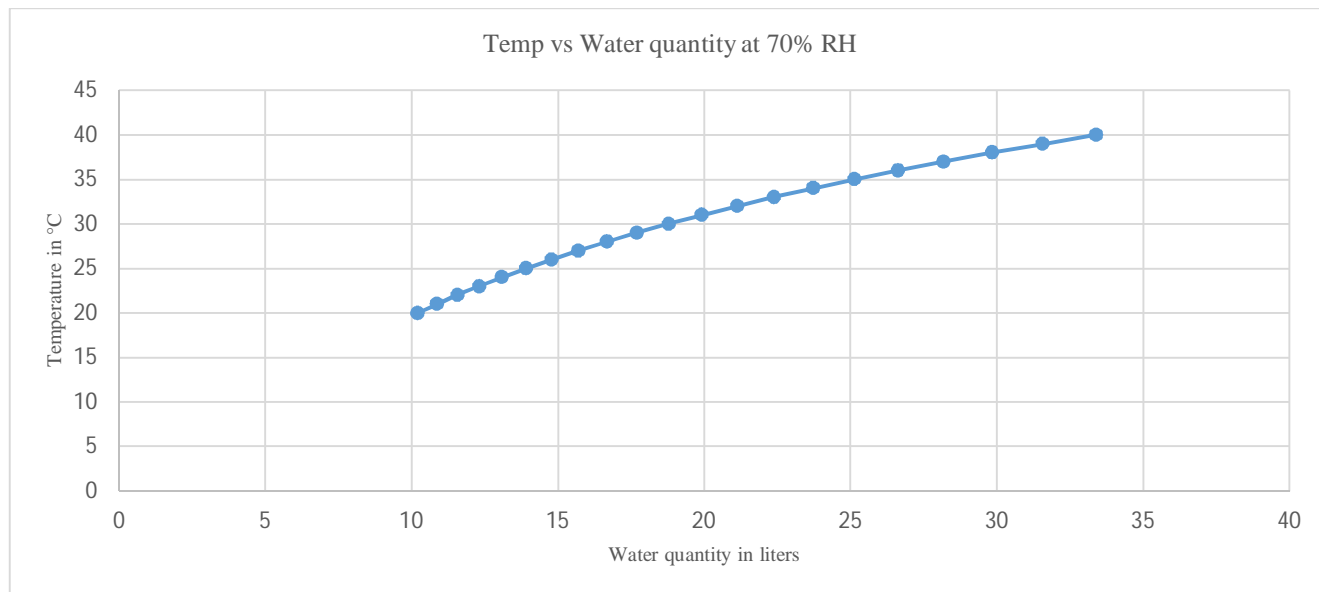


Figure-11

| water content at 80% Relative Humidity and corresponding temperatures | | | | |
|---|---|---|---|---|
| Temperature | Partial Pressure | Saturation Pressure | Humidity Ratio | Water quantity in litres |
| 20 | 0.018696 | 0.02337 | 0.01169553 | 11.69552974 |
| 21 | 0.01988 | 0.02485 | 0.012451023 | 12.45102304 |
| 22 | 0.021136 | 0.02642 | 0.01325443 | 13.25443004 |
| 23 | 0.022464 | 0.02808 | 0.014106108 | 14.10610821 |
| 24 | 0.023856 | 0.02982 | 0.015001286 | 15.00128596 |
| 25 | 0.025328 | 0.03166 | 0.015950656 | 15.95065568 |
| 26 | 0.02688 | 0.0336 | 0.016954691 | 16.95469111 |
| 27 | 0.028512 | 0.03564 | 0.018013896 | 18.01389555 |
| 28 | 0.030224 | 0.03778 | 0.019128802 | 19.12880249 |
| 29 | 0.032032 | 0.04004 | 0.020310453 | 20.31045253 |
| 30 | 0.033936 | 0.04242 | 0.021559563 | 21.55956301 |
| 31 | 0.035928 | 0.04491 | 0.022871616 | 22.87161642 |
| 32 | 0.038024 | 0.04753 | 0.024257959 | 24.25795917 |
| 33 | 0.040232 | 0.05029 | 0.025724843 | 25.72484292 |
| 34 | 0.042544 | 0.05318 | 0.027267973 | 27.26797299 |
| 35 | 0.044976 | 0.05622 | 0.028899151 | 28.89915126 |
| 36 | 0.04752 | 0.0594 | 0.030614244 | 30.61424369 |
| 37 | 0.050192 | 0.06274 | 0.032425389 | 32.42538907 |
| 38 | 0.052992 | 0.06624 | 0.034334114 | 34.33411388 |
| 39 | 0.055928 | 0.06991 | 0.036347543 | 36.34754334 |
| 40 | 0.059 | 0.07375 | 0.038467505 | 38.46750524 |

Table-8
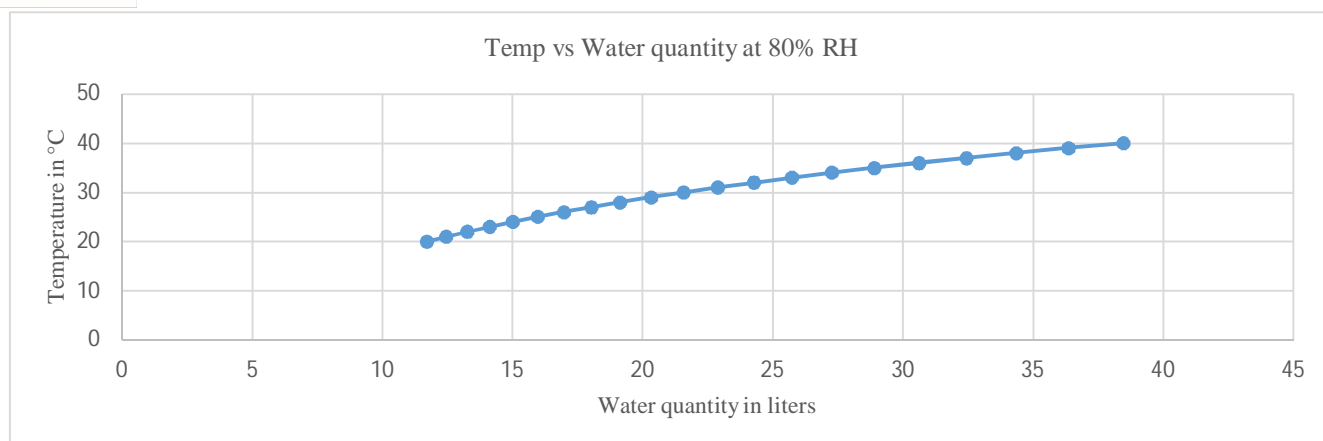
Figure-12

## IV. RESULTS

A. From the Dew point temperatures (i.e. tables 1, 2 and 3) we found that the dew point temperature increases as humidity increases at a given constant temperature.

B. From the water quantity graph (i.e. tables 3, 4, 5, 6, and 7) we found that the water quantity in litres present in air increases as the temperature increases at constant humidity.

## V. CONCLUSION

A. From the above experience we can conclude that the amount of water collected depends upon the dry bulb temperature and the relative humidity of the atmosphere.

B. Total power consumption of the equipment is 90 watt to 270 watt.

C. The casing material should be a poor conductor of heat and should withstand temperature of max 70°C.

D. From the above experiment we know that at higher temperature and higher humidity more water is collected.

E. Good insulation is required between the condenser and heat sink because as the heat sink temp the rate of heat transfer between the condenser and the heat sink increases.

F. Higher capacity solar panel is required for better power supply (actual requirement is 450 watt solar panel considering losses and 150 Ah battery.)

G. Larger heat sink is required at the hot side of the Peltier or a high speed fan to cool the heat sink i.e. larger than the condenser heat sink.

## VI. ACKNOWLEDGEMENT

We would like to express our gratitude towards shri. Mohan vs assistant professor in mechanical engineering department, GSIT for guiding us with his valuable time and profound experience and Mr Ajoy D Silva for his valuable time who helped us with the electronics part. We would also like to thank the management for giving us to use college facilities and for providing other valuable resources.

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