iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** V **Month of publication:** May 2019

DOI: https://doi.org/10.22214/ijraset.2019.5329

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

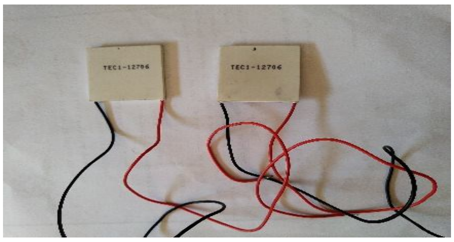

Fig-1- Peltier

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.

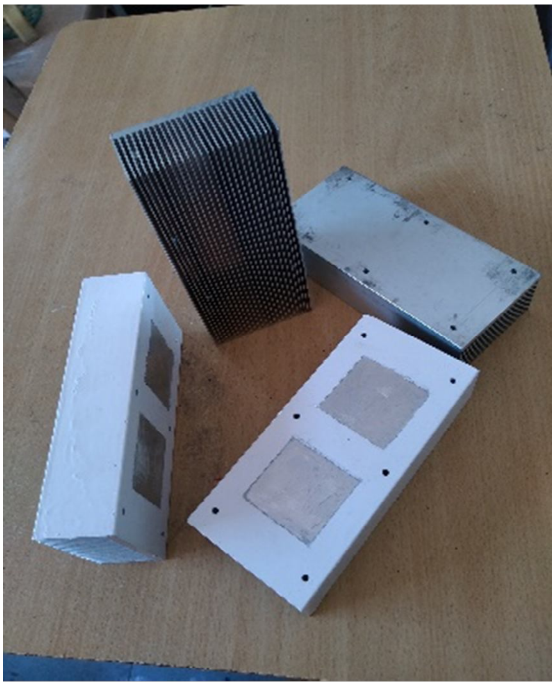

Fig-2- Heat Sink

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.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

III. WORKING AND DESIGN

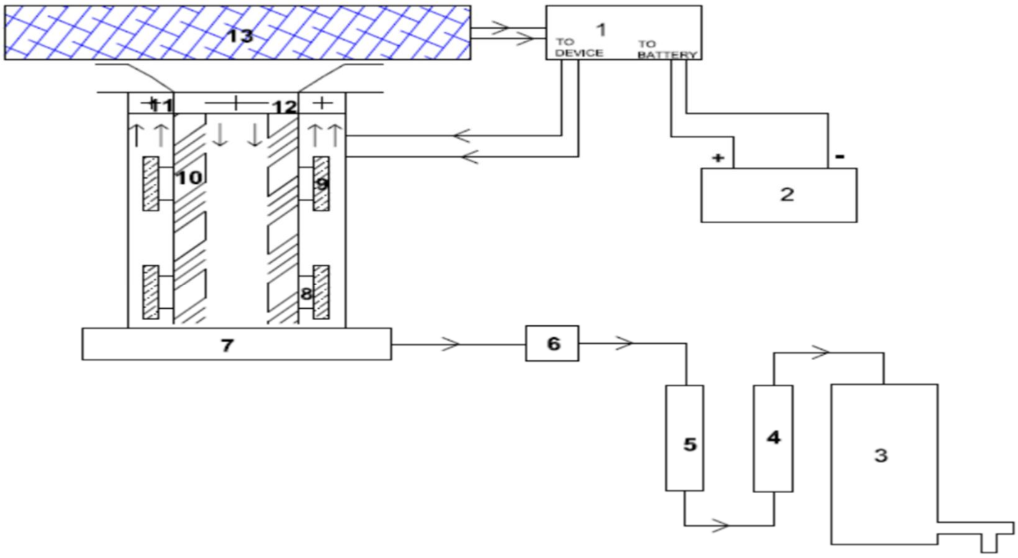

Fig-3-Working of Atmospheric Water Collector

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

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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

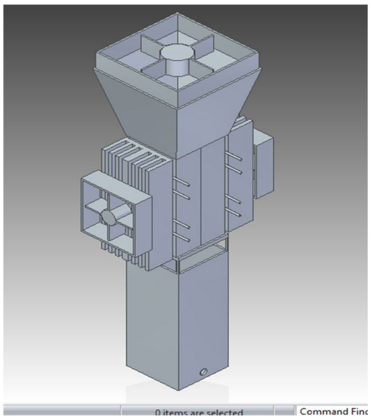

Fig-4- CAD Model

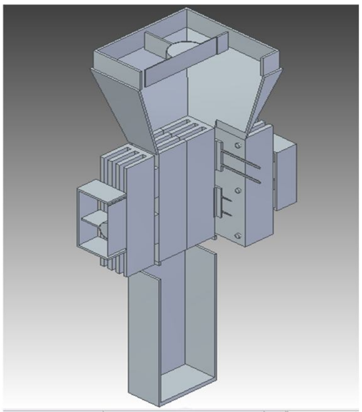

Fig-5- Sectional View

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

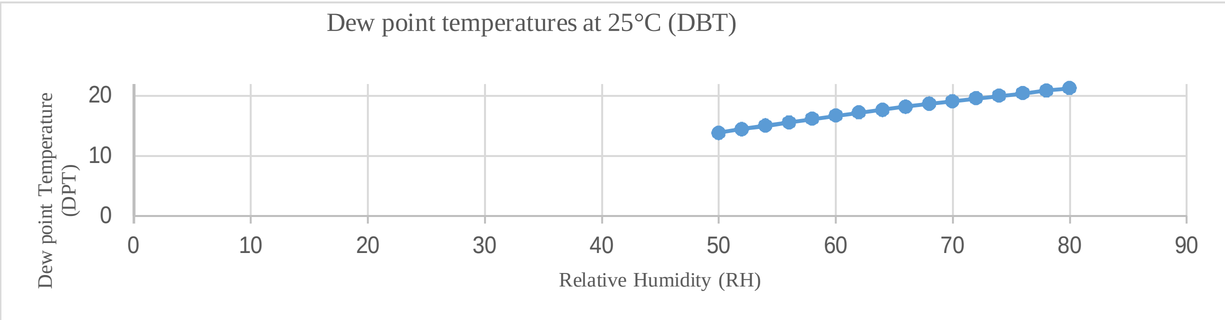

Fig-6

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

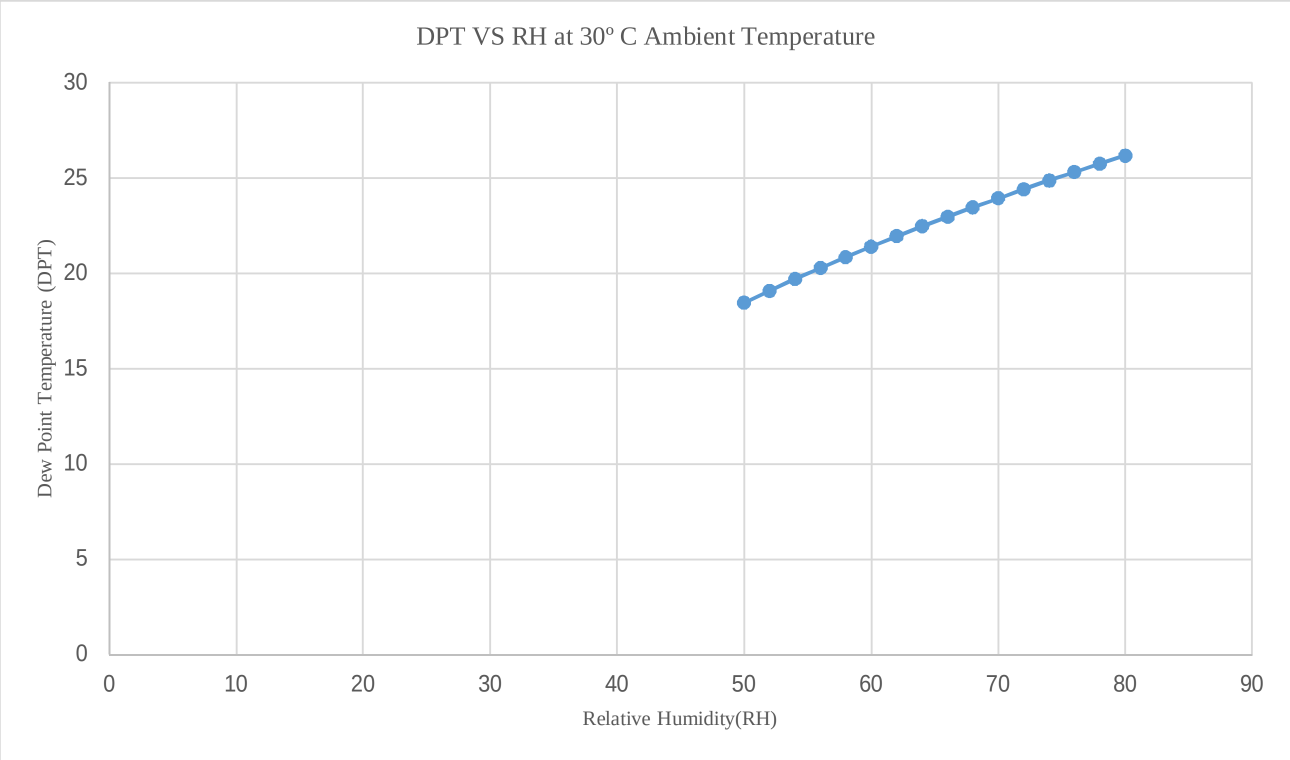

Fig-7

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

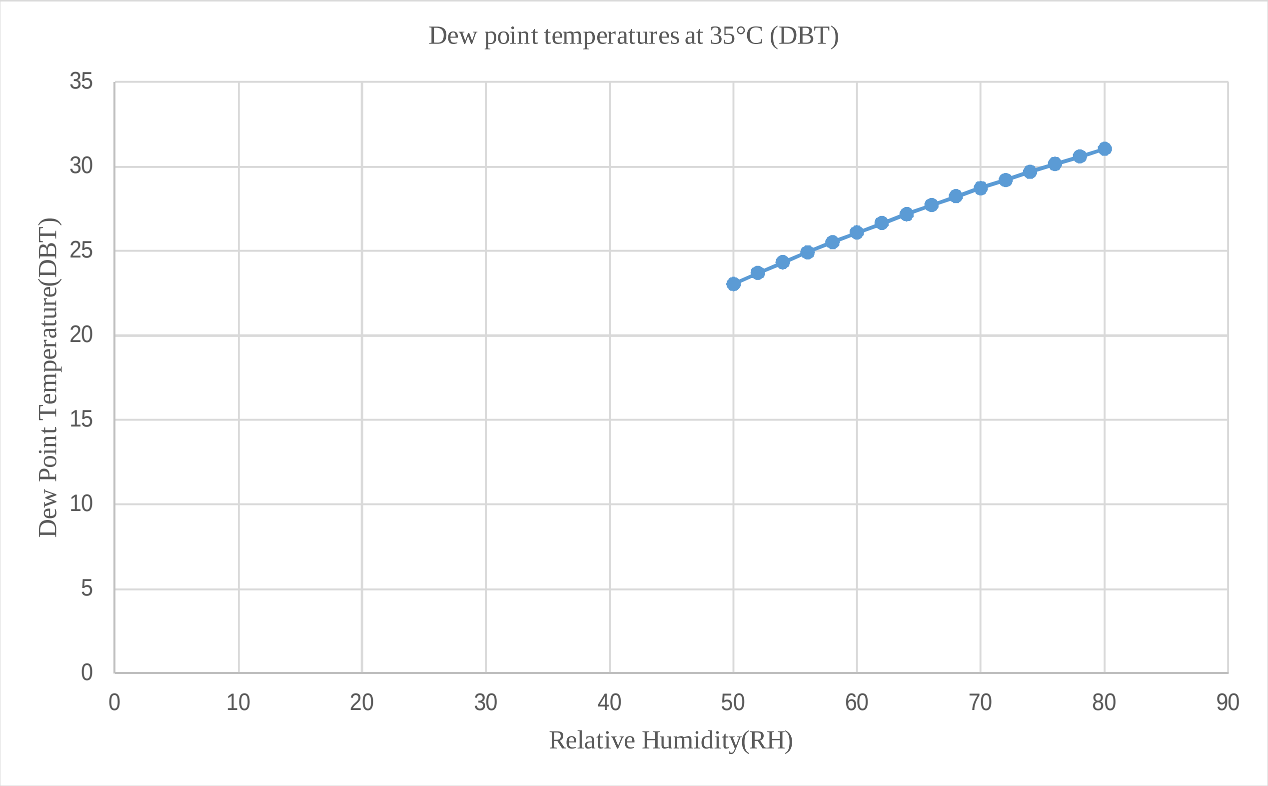

Fig-8

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

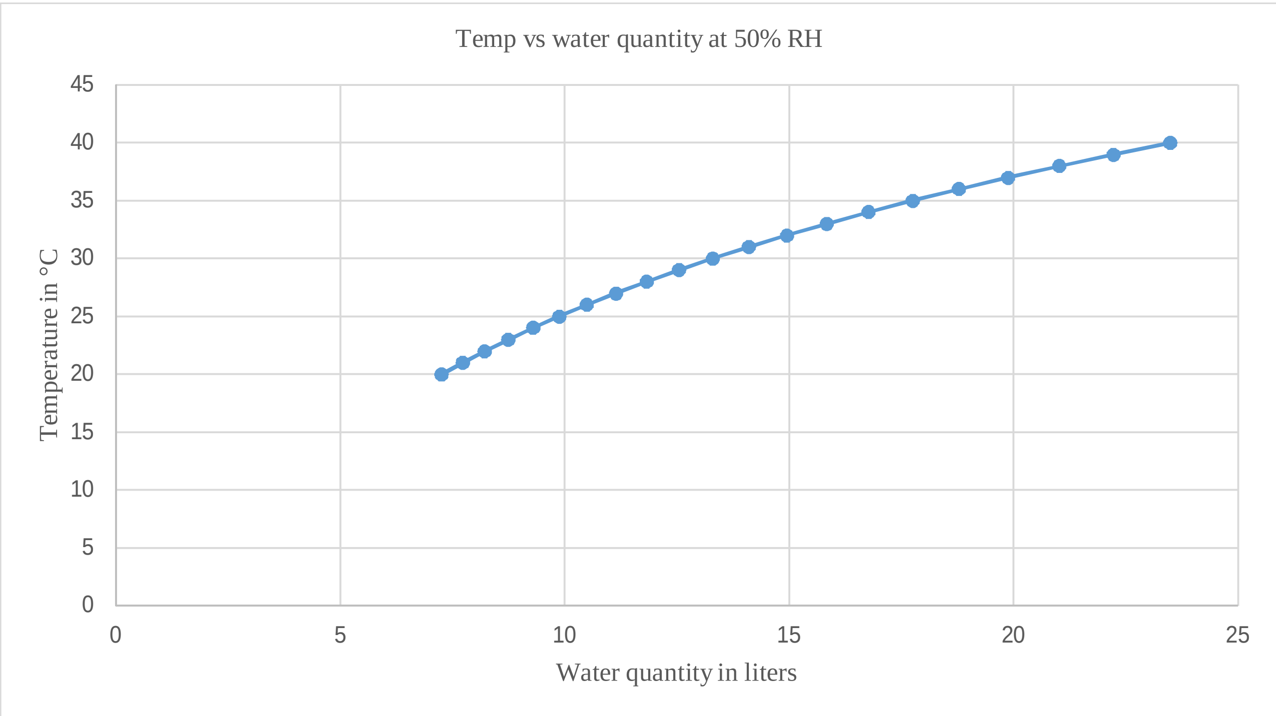

Fig-9

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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

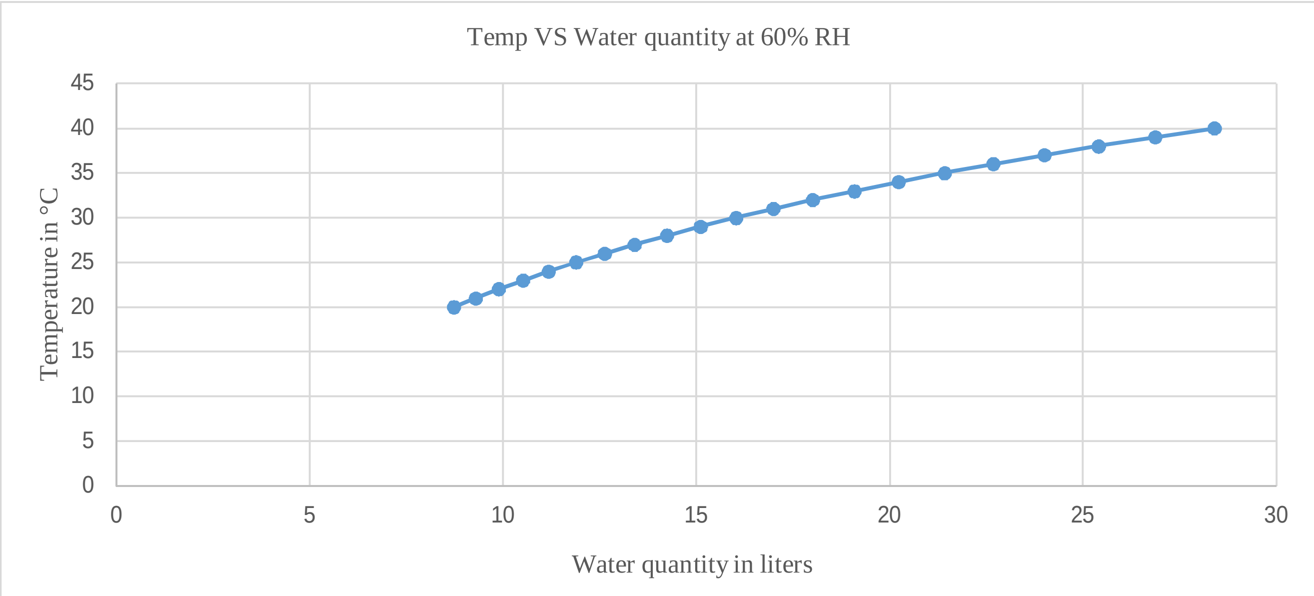

Fig-10

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

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Table-7

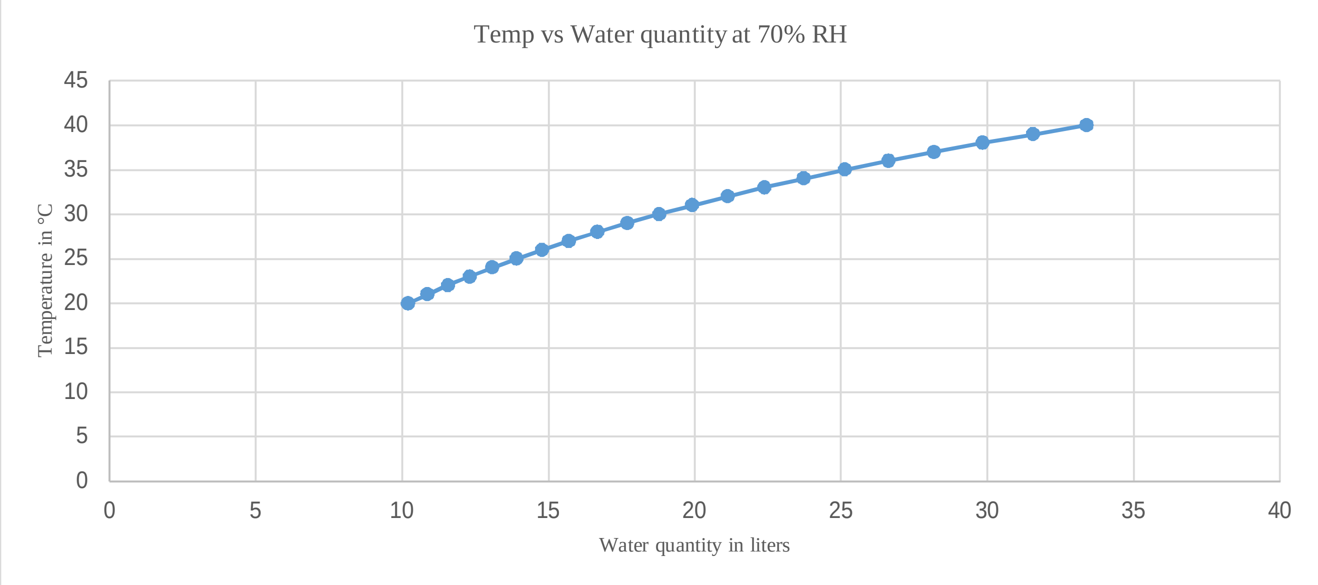

Figure-11

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

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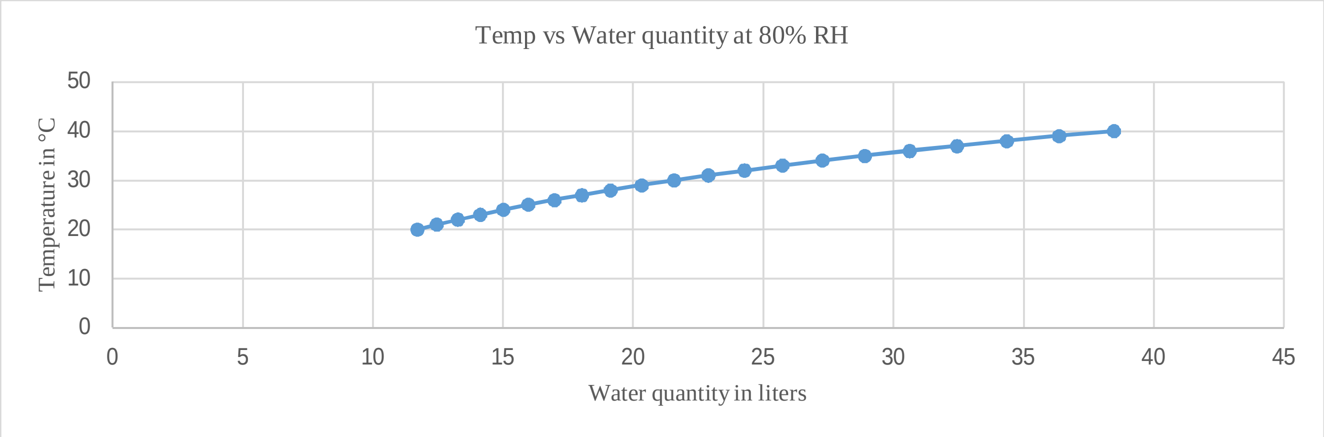


Figure-12

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.

REFERENCES

[1] Aditya Nandy, Sharmi Saha, Souradeep Ganguly and Sharmistha Chattopadhyay, “Atmospheric water generator with the concept of peltier effect” International journal of advanced computer research, ISSN: 2277-7970, Volume 4, 15 june 2014.

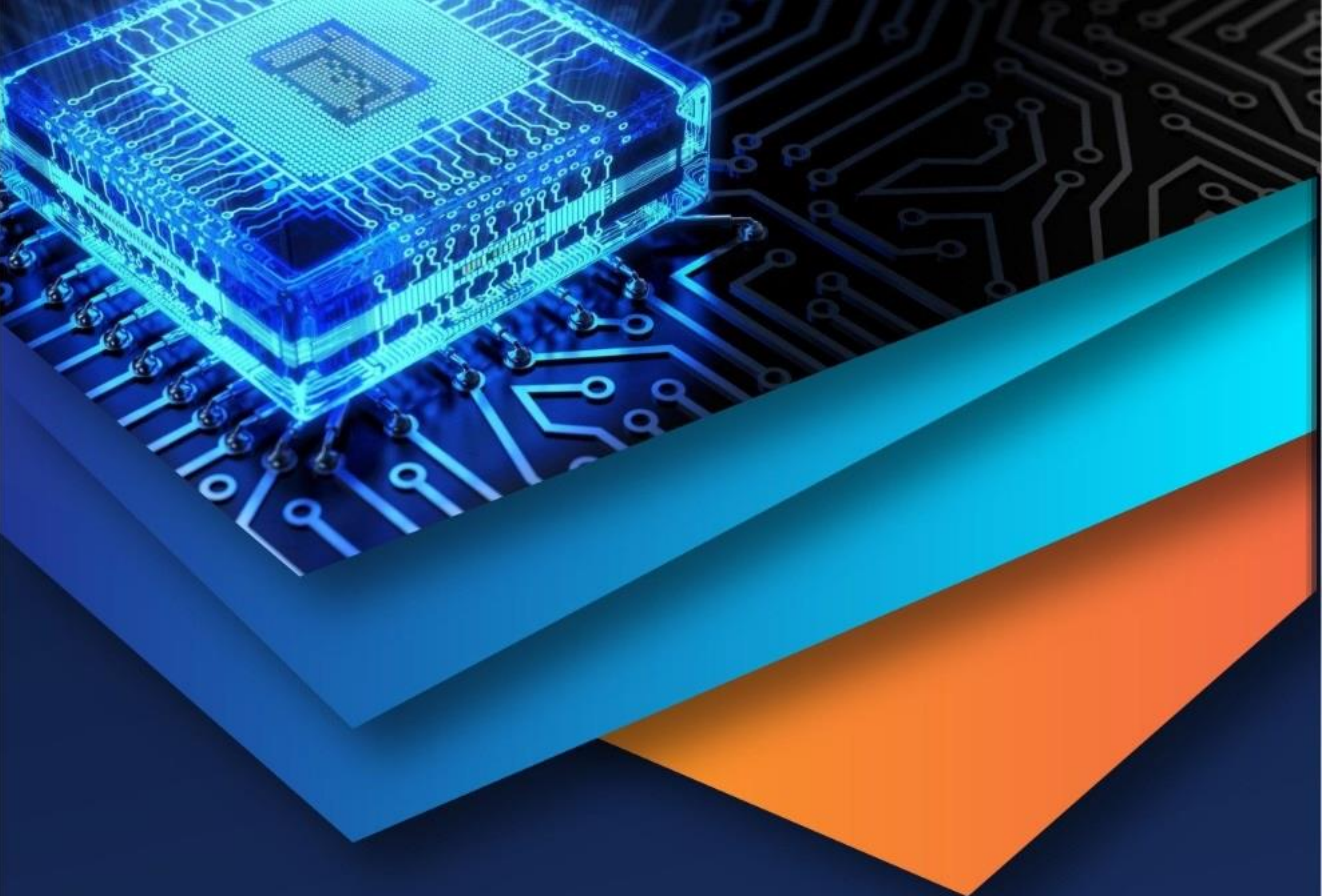
[2] Atul Ekad, Tejas Pawar, Nitish Yeole, Ajinkya Taksale, and Aanand Gajjar, “Solar powered atmospheric water generator and overview on AWG technologies”, ISSN:2319-8753, Volume 7, 01 january 2018.

[3] Rohan Gupta, Jogesh Gupta, Ajay Gupta, Uday Mahadik and Abhay Bendekar, “Water through air using peltier elements” International journal of science technology and engineering, ISSN: 2349-784X, Volume 2, 09 march 2016

[4] https://www.google.com and https://wikipedia.org

[5] Sagar Prajapat, Saransh vijayvargiya and Mayank Rautela, “Generation of water using thermoelectric cooler”, International journal of engineering research and technology, ISSN: 2278-0181, volume 5, 09 September 2016.

[6] A.Bharath and K. Bhargav, “Design optimization of atmospheric water generator” International journal for research in applied science and engineering technology, ISSN: 2321-9653, volume 5, 12 December 2017.



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