ATMOSPHERIC WATER GENERATOR USING PELTIER EFFECT

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Abstract - It is necessary to sustain water resources for irrigation or other purposes in many regions, including India, especially in arid areas. Due to a lack of rainfall, water shortage is a concern in several other parts of the world. The relative humidity in coastal locations is extremely high (around 70-80%). Using a dehumidifier device, the air in coastal locations can be utilized to supply people's water demands. Furthermore, the sun insolation in these places is extremely high all year. A device such as an atmospheric water generator can be implemented for this. It's a condensation device that converts water vapour molecules into water droplets using the principle of latent heat. We utilize a thermoelectric cooler that operates on the Peltier effect to eliminate the latent heat from the water vapour. It's been around for a while, but it's not extremely popular in India and other areas of the globe. It has a significant use in this day and age of technology, since we're all reliant on renewable energy sources.

***Key Words*:** Atmospheric Water Generator, Desalination, Relative humidity, Water condensation, Thermoelectric Peltier, Dew condensation (latent heat)

1.INTRODUCTION

The objective of the study is to build a portable device that can be operated to meet the water needs of an average household. The technology will first condense water in the atmosphere before purifying it and making it drinkable.

2. WORKING

2.1 Principle of Peltier Device

The Peltier thermoelectric device has two sides (A p-type and an n-type semiconductor), and when DC current flows through the device, it brings heat from one side to other, so that one side gets cooler while the opposite one gets hotter. This is called Peltier effect and electron hole theory. A Peltier element with a powerful heat sink/fan combine to form a Peltier cooler. Peltier elements are available in a variety of shapes and sizes. They are typically made up of a larger number of thermocouples that are arranged in a rectangular pattern and packaged between two thin ceramic slabs. This technology is so powerful that it can freeze a large amount of water in a short amount of time.

A conventional cooling system contains three fundamental parts-the evaporator, compressor and condenser. A TEC also has some analogous parts. Energy (heat) is absorbed by electrons at the cold junction, as they pass from a low energy level in the p-type semiconductor element, to a higher energy level in the n-type semiconductor element. It is the power supply that provides the energy to make those electrons to move through the system. The energy required for the electrons to flow through the system is provided by the power supply. As electrons flow from a high energy level element (n-type) to a lower energy level element (p-type), energy is expelled to a heat sink at the hot junction (p-type).

2.2 Working features

Practically TE couples are combined in a module, connected electrically in series and thermally in parallel to obtain a promising output. But it will be inconvenient to use such a device that has less advantageous work done to power ratio. There are modules available in the market according to variety of sizes, shapes, operating voltages-currents and ranges of heat pumping capacity. The present trend, however, is towards a larger number of couples operating at lower currents; before choosing an efficient device, some parameters must be determined. These are:

TC: Temperature at Cold Surface.
TH: Temperature at Hot Surface.
This TH incorporates two major parameters:

1. The efficiency of the device i.e. between the hot surface of the TEC and the ambient environment.
2. The temperature of ambient environment into which the heat is being rejected.

QC: The heat to be absorbed at the Cold Surface.
The object to be cooled is intimately confined with the cold surface of TEC, thus the temperature of that object starts falling until it is as same as the temperature of the cold surface of the TEC.
Now, **ΔT** can be defined as:

$$\Delta T = T_H - T_C$$

If the design is to work as intended, this conflict must be precisely determined. The ratio of QC to P is the heat absorbed at the cold junction, divided by the input power i.e., QC / P is known as COP which is often used to pick out better device.

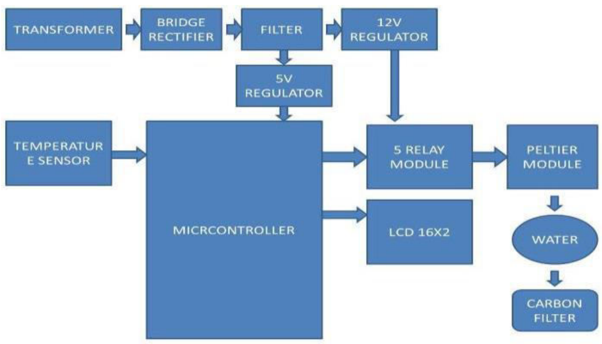


FIGURE 1. Block diagram of Atmospheric water generator

3. CALCULATIONS

Dew Point Temperature Calculation: - This calculation forms an important part of this project as this helps us to determine at temperature the Peltier device must be maintained to condense the humidity present in air at the given atmospheric condition. Dew-point temperature is the temperature at which humidity in the air starts condensing at the same rate at which it is evaporating at a given constant barometric pressure.

A well-known approximation used to calculate the dew point, Tdp, given just the actual ("dry bulb") air temperature, T and relative humidity (in percent), RH, is the "Magnus formula".

$$\gamma(T, RH) = \ln(RH/100) + Bt/c + T$$
$$Tdp = c\gamma(T, RH)/b - \gamma(T, RH)$$
(Where, b = 17.67 & c = 243.50C and T is in 0C)

The formulas above are used to calculate the dew point temperature for various meteorological variables under which the de vice may be operated. Operational parameters are determined and tabulated using Microsoft Excel.

DBT	30	31	32	33	34	35	36
RH	DEW POINT TEMERATURE (Tdp)						
50	18.4	19.3	20.3	21.2	22.1	23	23.9
51	18.7	19.7	20.6	21.5	22.4	23.3	24.2
52	19.1	20.0	20.9	21.8	22.7	23.6	24.6
53	19.7	20.3	21.2	22.1	23.0	24.0	24.9
54	20.0	20.6	21.5	22.4	23.4	24.3	25.2
55	20.2	20.9	21.8	22.7	23.7	24.6	25.5
56	20.5	21.2	22.1	23.0	24.0	24.9	25.8
57	20.8	21.5	22.4	23.3	24.3	25.2	26.1
58	21.1	21.7	22.7	23.6	24.5	25.5	26.4
59	21.4	22	23.0	23.9	24.8	25.8	26.7
60	21.7	22.3	23.2	24.2	25.1	26	27.0

FIGURE 2. Amount of water (in L) present in 1m3 of air

Sample Calculations: -

$$\gamma = \ln(57/100) + 17.67*33/243.5*33 = 1.546$$
$$Tdp = (243.5*1.546)/(17.67-1.546)$$

4. RESULTS

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

Partial Pressure of water (Pw) = □□÷ 100 ×□

Humidity Ratio = 0.622×□□ ÷□□ −□□

(Where Pa is the atmospheric pressure i.e. Pa=1.01325 bar)

Humidity ratio gives the amount of water (in m3) present in 1m3 of air. Also, we know that 1m3 is equal to 1000 liters. Thus, multiplying humidity ratio by 1000 gives the maximum amount of water (in liters) that is present in 1m3 of air.

(For atmospheric temperature 30°C and relative humidity 50%)

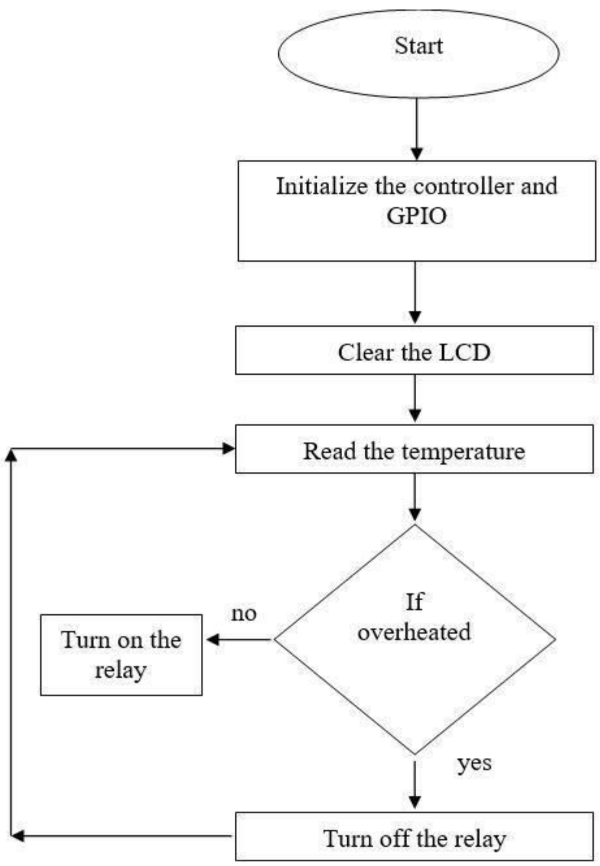
Saturation Pressure of water vapor (Pw) at 30°C is obtained from steam table as 0.04241 bar.

$$Pw = (50 \div 100) \times 0.04241 = 0.021205\text{bar}$$

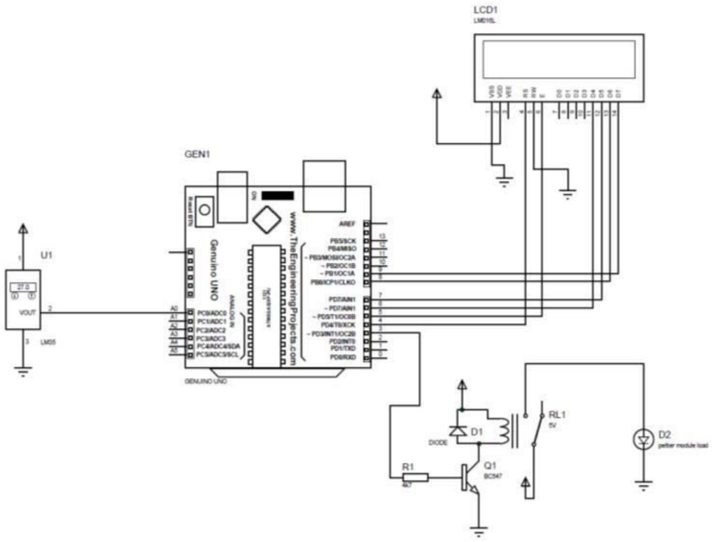
$$\text{Humidity Ratio} = 0.622 \times 0.021205 \div (1.01325 - 0.021205) = 0.013295273$$

Therefore, amount of water (in liters) present in 1m3 of atmospheric air = Humidity ratio × 1000
= 0.013295273× 1000
= 13.2952739 liters

5. FLOWCHART



6. OPERATION



The system was designed and assembled depending on the capacity of the Peltier device, of dimension (4×4 cm^2), and energy needed. The system consisted of a heat sink, extended cold surface, Peltier device and fan, which were housed in a vertical rectangular section duct and used with different air temperatures, airflow rates, and humidity levels. In this work, we identified the precise part number of the Peltier module that can be used and the calculations that we can refer to from it. The TEC1207 module is employed, which is powered by 140 W solar photovoltaic cells. The TEC12706 array is installed on a vertical and inclined plate with the face upward and a heat sink of 0.0945 m2 area for a highly efficient condensation rate

7. CONCLUSIONS

Applying this system in a highly humid region almost 1 L of condensed water can be produced per hour during the day light, this is a promising result; then a more enhanced system can be designed that encounters higher power solar cells and also has the ability to store the excess energy during the day light that is to be used at night; indeed, the economic advantage of this kind of system is a bit obscure due to the relatively high installation cost. This idea can be extended further in future –

1) For large scale implementation, RO and UV water filter can be used for producing such water that meets the standard of WHO and BIS easily.

2) Peltier device has many types of models which are much efficient than TEC1. Those can be used.

3) As the study objective aims at producing water from atmosphere and keeping this device handy, large sized scrubber are not used for better air filtration. Scrubbers can remove all the oxides from the air. For large implementation it can be handled.

4) The concept of this research purpose can also be used as a better alternative in refrigeration science against conventional systems. It can also be observed in this way i.e. the usage of such low power semiconductor devices are indicating towards more prominent evolution of cooling engineering that is going to alter the whole scenario and myths about the power consumption of refrigeration science.

Thus, in near future we will be able to use such devices that are now limited within the project works.

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