Solar Powered Atmospheric Water Generator

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Abstract: In many countries, it is difficult to obtain water for drinking, irrigation or other purposes, and especially so in the arid regions and with regions or locations where there is no electricity or fuel sources. The problem of water scarcity is also prevalent in many places around the world due to lack of rainfall. In highly humid areas such as places close to the sea, water can be obtained by condensing the water vapour present in the air. Solar-powered Atmospheric Water Generator is an appliance that employs dehumidification/condensing technology, that extracts water present in the air in the form of vapour by applying Peltier effect of Thermo-Electric Cooling. The system consists of cooling elements, heat exchanger and air circulation unit. A Solar PV unit with adequate current output drives the cooling elements through a controlling circuit. This concept has promising application in this age of technology when renewable energy is poised to grow rapidly. Sun-To-Water and use of MOFs are latest developments in Atmospheric Water Generator sector. Experiments have shown that Solar-energy based AWG are able to produce around 10L of water per day without the use of moving parts, no chlorofluorocarbons use and no consumption of electricity. This paper presents an overview of the AWG technologies and in particular Solar based AWG using Peltier effect.

Index Terms **– Peltier effect, humidification, thermo-electric cooling, PV panels**

I. INTRODUCTION

Absolutely pure water is essential for use in fuel cell power generators, scientific research and many medical and plant uses. Scientists, students and researchers will find our Solar Still Water Purifier ideal for making consistently ultra pure h20 from any water source. The lack of inexpensive, drinkable water for people around the globe is becoming a very serious problem, and recent published stories address the concerns from scientists around the world. to read a recent story published in many newspapers and magazines.

Water is needed in all aspects of life. Difficult to purify, expensive to transport and impossible to substitute, water is an indispensable element of life Nearly 45 crores of people in 29 countries are staying in water-deficit regions. Nearly 70 % of the fresh water is used for irrigating the agricultural fields which has raised water conflict between the urban and rural areas If all this continues, then very soon i.e. by 2032, nearly half of the world's population will be facing water shortage problem. It is predicted that in the 21st century there will be water wars. Atmosphere contains large amount of water in the form of vapour, moisture etc. Within those amounts almost 30% of water is wasted. This amount of water can be used if we are able to extract the water that is present in air in form of moisture. The project is an attempt to make device that is capable of converting atmospheric moisture directly into usable and even drinking water.

The device uses the principle of latent heat to convert water vapour molecules into water droplets. In many countries like India, there are many places which are situated in temperate region; there are desert, rain forest areas and even flooded areas where atmospheric humidity is eminent. But resources of water are limited. In the past few years some projects have already been done to establish the concept of air condensation as well as generation of water with the help of peltier devices, such as harvesting water for young trees using Peltier plates that are powered by photovoltaic solar energy etc. So, this project will be helping to extend the applications of such devices further in the near future. According to previous knowledge, we know that the temperature require to condense water is known as dew point temperature. Here, the goal is to obtain that specific temperature practically or experimentally to condense water with the help of some electronics devices. This project consists of a thermoelectric Peltier (TEC) couple, which is used to create the environment of water condensing temperature or dew point.

The project is an attempt to provide drinking water to the people where there is shortage of pure and fresh drinking water so that we can overcome the problem mentioned above. The idea is to make use of the moisture present in air to produce water, because there is always certain percentage of humidity present in air even if we are in desert.

We can implement it at any place and this will also save the cost of transmission pipelines that we normally use for transmission of water. Hence the project aims to develop a technique of water production that can be practice by any one and at any place affordably and efficiently.

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. Peltier coolers consist of a Peltier element and a powerful heat sink/fan combination. Peltier

elements come in various forms and shapes. Typically, they consist of a larger amount of thermocouples arranged in rectangular form and packaged between two thin ceramic plates. This type of device is so powerful that it can freeze good amount of the water within several minutes.

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. At the hot junction, energy is expelled to a heat sink as electrons move from a high energy level element (n-type) to a lower energy level element.

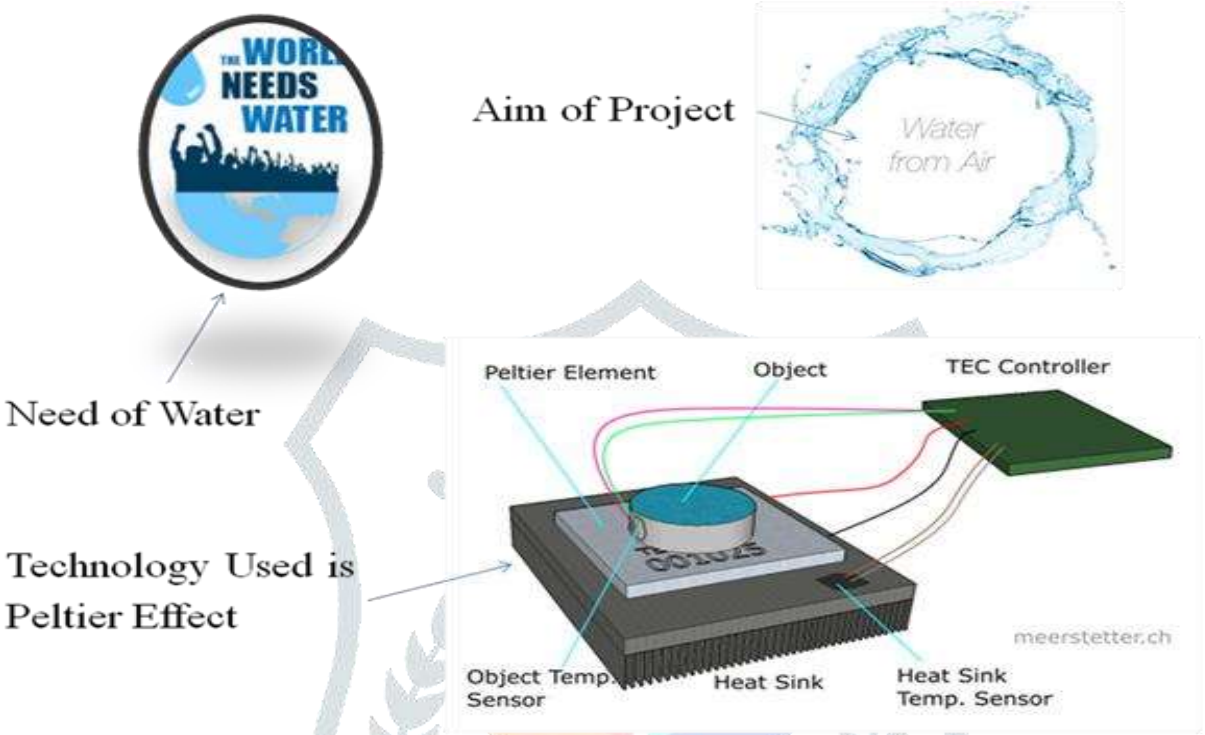

Fig 1 Connections of Peltier model

2 PROBLEM STATEMENT

[1] The initial problem was design and develop a prototype system for extracting clean drinking water from conventional system uses compressor, condenser & evaporator etc. which increases the cost and space required for installation. Atmospheric water generator already exist as product on the market, thus there is a need for this design to differentiate itself through some innovation in order to justify the expenditure of time and money on this project. Our aim is to create a small and self sufficient device able to absorb humid air, separate water molecules from air molecules and store water in liquid form.

[2] India is suffering from one of the world's worst national water crises. In fact , it is considered the center of the global water and sanitation crisis. ... More than 50% of the population has no access to safe drinking water and about 200,000 people die every year for lack of access to safe water.Recently, India achieved 5th global position in solar deployment by surpassing Italy. Solar power capacity has increased by more than 11 times in the last five years from 2.6 GW in 2014 to 30 GW in 2019. Presently, solar tariff in India is very competitive and has achieved grid parity

3 Objectives

The main objectives of this projects are

1. To design and develop a solar operated atmospheric water generator with the help of Peltier model
2. To develop a solar assisted Peltier model to generate peltier effect to extract water particles
3. To extract water from atmospheric humid air and purify the water to make it for drinking water

4 Experimental method

The construction setup of the AWG is as follows, a)Solar Panel
Heat Pipe & Exhaust Fan
Peltier Module (TEC1-12706)
Battery
Stainless Steel Cone
Water Collector

Solar Panel: In the construction solar cell is located at the top of the model which direct converts solar energy into electrical energy by conversion of light or other electro-magnetic radiation into electricity.

Fig.2. Solar panel

Battery: The direct supply of solar cell is to the battery for charging an main purpose of the battery is to provide electric supply for peltier plate and heat pipe exhaust fan.

Heat Pipe & Exhaust Fan: Exhaust fan is attached to heat pipe and it is used for transfer the heat from hot side of peltier plate to the atmosphere and it located on the hot side of peltier module.

Fig.3.Heat sink with Battery

Peltier Module: In construction we have used TEC1-12706 solid state peltier module and it is located below the heat pipe in which hot plate is at upper side and cold plate is at bottom side.

Fig.4.Peltier Module

Sheet Metal Cone: The main purpose of sheet metal cone is to collect the moisture, droplets of water in the container and it's located below the cold side of peltier plate.

Fig.5.Sheet Metal Cone

Water Collector: It is used to collect the water droplets from sheet metal cone.

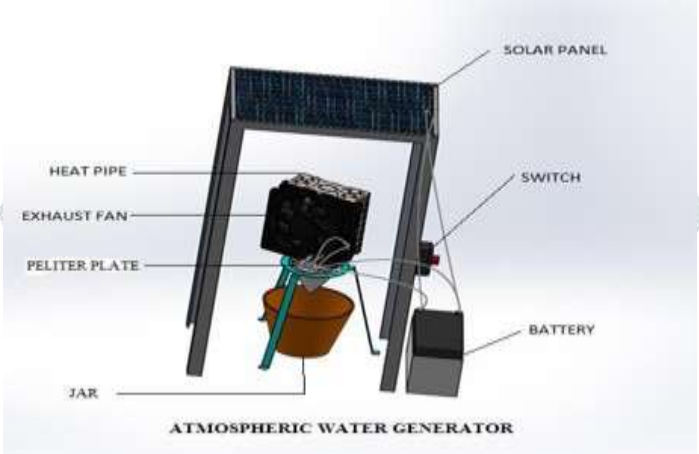

Fig 6D Model of AWG

5 Working and calculations

The main parts used in this project are Peltier module, Heat Pipe with Exhaust fan. The working of the peltier module is based on the peltier effect proposed by Jean-Charles Peltier, a French Physicist in 1834.

As we supply current through battery to thepeltier module,, heat is evolved at upper junction & adsorbed at the lower junction & therefore the upper side get hot & lowers side get cooled. After some time as we reached at dew point temperature the condensation starts or moisture at stainless steel cone is executed. After this moisture is converted into water droplets this can be collected in the container

At the same time, at upper side of the peltier module is get hot. But we have use the heat pipe with exhaust fan to transfer the hot side heat to the atmosphere. At starting we supply electric current to the peltier module and exhaust fan simultaneously. As the bottom side of the peltier module get cooled and at the same time the upper side of peltier module get hot and without heat pipe it is impossible to cool the lower side of heat pipe. Condensation of the air starts after dew point temperature. As we reach dew point temperature condensation starts and moisture is formed on the SS cone and water is collected in the form of droplets in container. The amount of water collected in the container is depend upon the relative humidity present in the atmosphere.

EQUATIONS AND CALCULATION

Assuming Specific humidity =0.012 Kg of water /kg of Dry air.

From 1 Kg of dry air 0.0048 kg of water is extracted.

TABLE I. $F(T, RH) = \ln\left(\frac{RH}{100}\right) X \frac{bT}{C+T}$

TABLE II. Dew Point Temperature = $\frac{C\ X\ F\ (T,RH\ )}{b-F\ (T,RH)}$

Where b = 17.67 & c = 243.5ºC

TABLE III. Relative Humidity, RH= Pw/Ps X 100

TABLE IV. Partial Pressure on Water, $P_w = \frac{RH}{100} X P_a$

TABLE V. Humidity Ratio = 0.622 X $\frac{Pw}{Pa-Pw}$

Sample Calculation:

Relative Humidity in Mumbai = 37%, for DBT at 28ºC

F (T, RH) = $\ln\left(\frac{RH}{100}\right) \text{x} \frac{bT}{C+T}$

$= \ln\left(\frac{37}{100}\right) + \frac{17.67\ X\ 28}{243.5\ X\ 28}$

F (T, RH) = 1.3905

$= \frac{C\ X\ F\ (T,RH)}{b-F\ (T,RH)}$

Dew Point Temperature

T_{dp} = 20.7983 º C

Now With the help of the value of relative humidity ratio, we can calculate amount of water in 1 m³ of air.

Partial Pressure of Water $P_w = \frac{RH}{100} x P_a$

$= \frac{37}{100} \text{x} 0.03864$

=0.01429

Humidity Ratio = 0.622 x $\frac{Pw}{Pa-Pw}$

$= \frac{0.01429}{1.013-0.01429} \text{x}\ 0.622 = 8.9 \text{ x } 10^{-3}$

Amount of Water (in ml) = 8.9 ml

6. RESULTS AND DISCUSSION

OBSERVATION

Sr. No.	Temperature (◦C/ K)	Saturation pressure, Ps (Pa)	Relative humidity, RH (%)	Partial pressure of water, Pw (in Pascal)	Humidity ratio	Amount of water (in Littre)
1	25/298	0.03167	78	0.0247026	1.554×10^{-2}	15.54
2	27/300	0.03565	78	0.027807	1.755×10^{-2}	17.55
3	30/303	0.04005	78	0.031239	1.979×10^{-2}	19.79
4	33/306	0.05031	78	0.0392418	2.506×10^{-2}	25.06
5	35/308	0.05624	78	0.0438672	2.815×10^{-2}	28.15
6	25/298	0.03167	79	0.0250193	1.575×10^{-2}	15.75
7	27/300	0.03565	79	0.0281635	1.778×10^{-2}	17.78
8	30/303	0.04005	79	0.0316395	2.005×10^{-2}	20.05
9	33/306	0.05031	79	0.0397449	2.539×10^{-2}	25.39
10	35/308	0.05624	79	0.0444296	2.852×10^{-2}	28.52
11	25/298	0.03167	80	0.025336	1.59510^{-2}	15.95
12	27/300	0.03565	80	0.02852	1.801×10^{-2}	18.01

The solar cell unit is to be installed in this system, rated as output of 12 V with the maximum output power of 120 W, evidently which is able to supply enough power to keep running two 40 W (3.5 A) Peltier coolers (TEC1) connected in parallel. The Peltier device has a dimension of 4x4x0.8 cm. The maximum temperature difference i.e. ΔT of 87°C. A 3000rpm, 15x15cm (size of TEC1) fan that is capable of producing airflow of 2.54 metre cube per second at most is used for circulation of the air. The heat sinks are made of aluminium and are anodized.

7. Conclusion

This Application of this technology may result in solution for water supply problem in many situations without high infrastructure setup cost and time needed. It could create additional portable water without depleting existing resources. Thus it helps us to tackle the problem of availability of pure drinking water in remote locations, mining sites and instances where water scaling is an issue. These devices surely stand aside in comparison to conventional ways of getting safe water with simple design and endurance capability. By applying devices other than conventional evaporating principle device, we can extract reasonable amount of water from atmosphere. Use of Solar Energy by way of Solar PV or Solar Heating, these devices can not only be energy efficient but also can be used as standalone systems where electricity or other forms of energy is not readily available. Design of devices is relatively simple and can be carried to places like hilly areas, arid regions, flood areas, etc. In the current climatic conditions with global warning threat and the water resources over the world diminishing, these solar integrated devices can be extremely useful. With the advances in technology of these devices leading to more enhanced & efficient systems, such AWG systems hold bright future for generation of the much needed water.

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