EasyChair Preprint

№ 7604

Self Sufficient Atmospheric Water Generator Using Renewable Energy

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March 23, 2022

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Abstract— **There is a saying, "water has only two aspects; when mixed with anything it's NEED, and when not it's LIFE".**
This paper sets forth a solution to assist the struggle against the scarcity of freshwater. Atmospheric Water Generators (AWG) are a promising technology solution to the water scarcity in the world. This paper takes into account that the AWG fulfills certain prerequisites of portability, simplicity, flexibility, maximize efficiency & minimize cost.

I. ***Keywords***— Atmospheric Water Generator; Solar energy;Renewable Energy.

I. Introduction

In principle, AWGs extract water molecules from air, causing a phase change from vapor to liquid. This is done by decreasing the temp. of air till dew point temperature and converts atmospheric moisture directly into clean drinking water form by condensing the latent heat of water vapour into water droplets. Under constant atmospheric pressure, the dew point depends only on the Relative Humidity (RH) and the ambient temperature (Tamb). However, their main drawback is the high power consumption. This paper presents the optimization process of an Atmospheric Water Generator (AWG) based on a thermometric cooler that is self-sustained using renewable energy.

In this paper we use a peltier module which is used as a thermo-electric device & it reduces compressor and condenser usages. This leads to reduced spacing, size and weight of the equipment, so we use a peltier device to extract water from atmospheric air.

II. Literature Review

This literature studies the various technologies that are used worldwide in the AWG systems.This paper is set to combine two different technologies of solar tracking and atmospheric water generation.

The paper **Review On Automatic Solar Radiation Tracking System by Prof. Vaibhav J. Babrekar, Madhur S. Kurhekar, Kaustubh K. Mulmule, Durgesh B. Mohade** describes the complete design and construction of a microcontroller based automatic solar panel tracking system. The solar panel is fixed and no automatic tracking of sun light based on its intensity.

Amir Hossein Shourideh , Wael Bou Ajram , Jalal Al Lami , Salem Haggag, Abraham Mansouri in their paper on A comprehensive study of an atmospheric water generator using Peltier effect talk about the various components, design choices of an AWG. It also provides a detailed mathematical approach to the overall functioning of the system.

Ingrid Casallas , Manuel Pérez , Arturo Fajardo and Carlos-Ivan Paez-Rueda in their paper on Experimental Parameter Tuning of a Portable Water Generator System Based on a TEC describe the working of how water is being produced from atmospheric moisture, & it also mentions other methods that gives other parameters more importance based on the needs/outcome.

Nikhil Bhatt, Shubham Lot, Roshan Dalvi, Mehul Kasbe presented a paper on Solar Powered Atmospheric Water Generator By Using Thermo-Electric Couple explaining the working of an AWG with a single heatsink & powered the system using a static Solar Panel.

III. Proposed Model

An AWG generates liquid water from the ambient air humidity . This device is a water harvester, which condenses the water vapour by cooling the air below its dew point. Under constant atmospheric pressure, the dew point depends only on the Relative Humidity (RH) and the ambient temperature.

Construction

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

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

C) Heat Pipe & Exhaust Fan:- Exhaust fan is attached to the heat pipe and it is used for transferring the heat from the hot side of the peltier plate to the atmosphere and it 2is located on the hot side of the peltier module.

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

E) Water Collector :- It is used to collect the water droplets.

F) Arduino Board:- Microcontroller interface for controlling the movement of the solar panel.

G) Light Dependent Resistors:- To act as a sensor to detect light intensity at various angles.

H) Servo Motors:- To rotate the Solar Panel in the most optimum direction.

Thermoelectric cooling uses the Peltier effect to create a heat flux at the junction of two different types of materials. A Peltier is a solid-state active heat pump which transfers heat from one side of the device to the other, with consumption of electrical energy, depending

on the direction of the current.

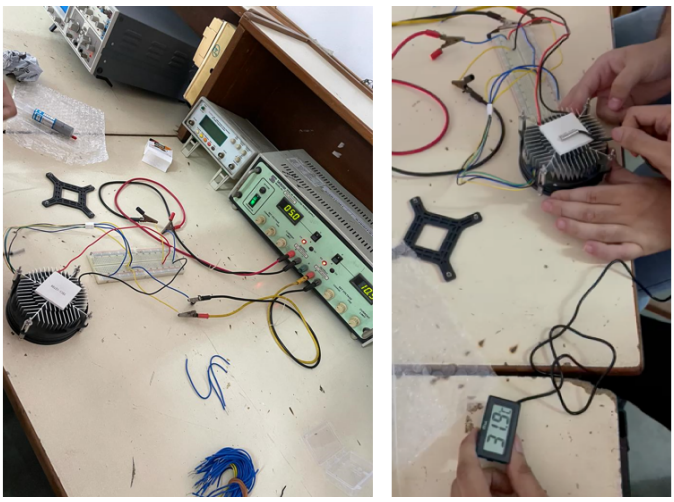

Fig.1 - AWG during the experimental stage of the paper

The AWG device is based on the vapor compression cycle, a Thermoelectric Cooler (TEC), or adsorption/absorption refrigeration. The TEC transforms electric energy into a temperature difference by the thermoelectric cooling effect, which consists of heat transfer from the cool side to the hot one .This heat transfer has been optimized by the use of heat sinks on both sides of the cooler .In this paper, the inside heat sink will be referred to as the water condenser element because the water vapor condensation takes place in this heat sink, and the system composed of the TEC and its heat sinks will be referred to as the extended TEC.

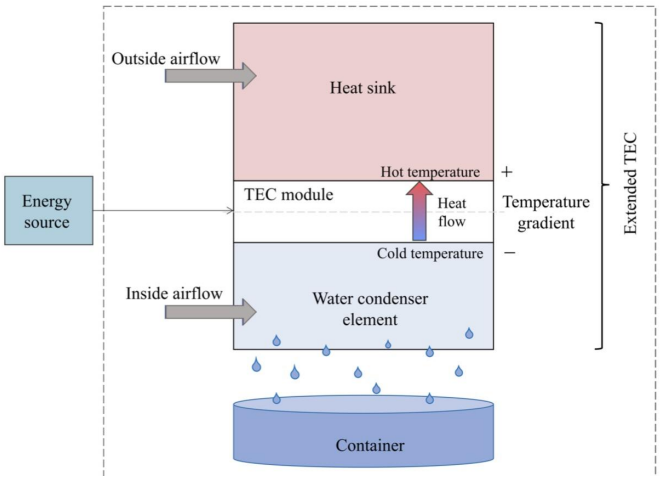

Fig.2 - The internal working of the TEC system showing the movement of heat and water production.

Furthermore, the airflow (inside or outside) could be produced by natural or forced convection. Typically in forced convection, the airflow is forced in both the outside and inside of the AWG. Moreover, the outside and inside airflow is produced by an active heat sink and a semi-closed cooling cabin with inlet and/or outlet fans, respectively.

The position of the sun in the sky varies in accordance with the time of day as the sun across the sky. Any solar powered equipment works best when it is pointed at or near the sun. So, it is obvious that an equipment which is powered by a stationary solar panel provides a less efficient output. An ideal tracker would allow the solar panel to point accurately towards the sun.

There are two broad types of solar trackers:

Single axis - The single axis trackers can either have a horizontal or a vertical axis. The horizontal type is used in tropical regions where the sun gets very high at noon, but the days are short. The vertical type is used in high latitudes where the sun doesn't get very high, but summer days can be very long.

Dual axis - The dual axis trackers have both a horizontal and a vertical axis and thus they have a wide range of tracking, which makes them usable in corners of the world. Dual axis tracking is extremely important in solar tower applications.

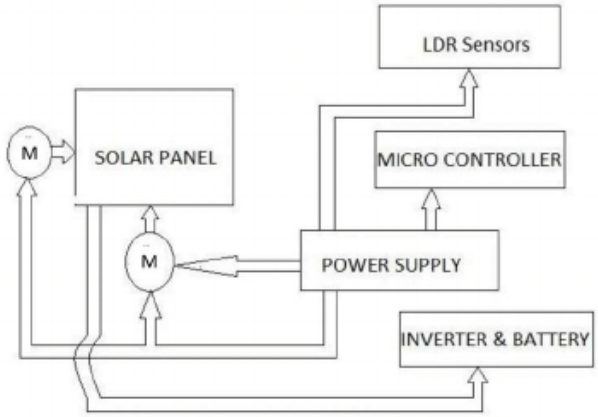

Fig.3 - Block diagram of the solar tracking system connected to a battery

IV. WORKING PRINCIPLE

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.

Solar Panel System

In this setup, the LDRs are placed on the surface of a large curvature. A provision is made such that any immediate two LDRs remain

active at a time. The stepper motor follows the bit pattern of the LDRs, and thus, the solar panel connected on the shaft of the stepper always faces the sun normally. The LDR combination plays a crucial role.

There is a light sensing module attached to the solar panel, which sends digital information about presence and absence of light intensity to the Microcontroller. The motor driver module receives the signals from the micro controller and drives the motor in the specified direction with the specified speed. The motor in turn controls the orientation of the solar panel mounting structure. Thus maintaining constant exposure to sunlight throughout the day.

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

Peltier System

At the same time, the upper side of the peltier module is getting hot. But we have used the heat pipe with an exhaust fan to transfer the 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 gets cooled and at the same time the upper side of the peltier module gets hot and without a heat pipe it is impossible to cool the lower side of the heat pipe. Condensation of the air starts after dew point temperature. As we reach dew point temperature condensation starts and moisture is formed and water is collected in the form of droplets in the container. The amount of water collected in the container is dependent upon the relative humidity present in the atmosphere.

V. RESULTS AND DISCUSSIONS

The amount of water generated by an AWG prototype depends on multiple factors, as shown below.

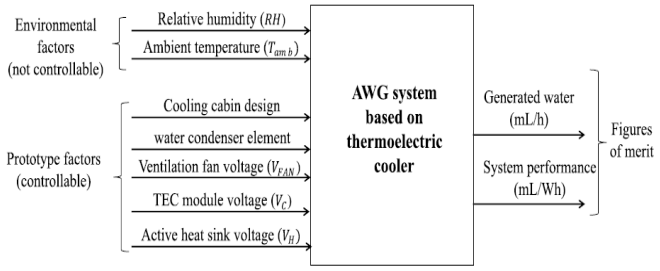

Fig.4 - Factors affecting the AWG system & the figure of merits

On the one hand, the RH and T_{amb} are uncontrolled environmental variables. On the other hand, the cooling cabin and water condenser element dimensions are design variables, which could be optimized.. Therefore, the supply voltages of the TEC, the inlet fan, and the active heat sink (i.e., VC, VFAN, and VH) are the only system parameters that can be optimized in the proposed AWG prototype. The tests were performed with a fixed value of VH (i.e., 12 V) and under quasi-fixed environmental conditions. Therefore, VC establishes the condenser element temperature (Tcold), and VFAN determines the cooling cabin airflow (ACC). The Figure of Merit (FoM) is the quantity used to characterize the performance of a device related to its alternatives.

Consolidating the test conditions and deriving the test results in a tabular format.

Test Conditions (Constant)

Low humidity = 60% which is equivalent to 30°C≤T ≤ 32°C

Test No.	Experimental water generation rate (ml/Hr)	Power Consumption (W)	Theoretical Water Generation rate(ml/Hr)	Error %
1	9.3	62	8.9	4.4%
2	10.1	62	9.6	4%
3	11	64	10	10%

Table 1 - Tests conducted to check the production of water using AWG

Due to the presence of a solar panel that is tracking the sunlight using LDR mounted on servo motors, this paper has been a significant improvement on the previous versions of this system. The system in this paper because of the tracking is able to generate more power which in return is stored in the battery to power the peltier part of the system to produce water.

This leads to the peltier system working for a longer duration hence producing more amount of water.

VI. FUTURE SCOPE & CONCLUSION

It will act as a vital source of drinking water not only in rural areas but also places where drinking water may not be accessible.

Generated water can also be for domestic purposes.

It can also be used by the army in high altitude regions or dry desert regions with acute water shortage.

The goals of this project were purposely kept within what was believed to be attainable within the allotted timeline. As such, many improvements can be made upon this initial design. That being said, it is felt that this design represents a functioning miniature scale model which could be replicated to a much larger scale.

Analysis done in various temperature conditions and humidity can help future developments.

Currently the sources of energy that can be tested for this project are limited due to its scaling, but trying to implement this on a larger scale will open gates to many other sources of energy like geothermal, tidal, etc.

A mobile application can be programmed that will take the values captured by the sensors on the arduino system and provide it in a card form with live time tracking.

By applying this system we have concluded that from a highly humid region we can extract more amount of drinking water from

atmospheric air. The use of this system may result in solutions for drinking water problems in many situations without high infrastructure setup cost and time needed. It could create additional portable drinking water without any external sources like compressor, condenser, etc. The efficiency of the entire system can however be increased by the use of the Arduino based solar tracking system as it has been integrated. This facilitates the rotation of the solar panel in 2 phases of 180 degrees in one plane improving radiation tracking and angular movement. This is a unique and flexible quality for which the tracker could easily be used in conjunction with a solar panel to derive efficient energy.

VII. REFERENCES

[1] Review On Automatic Solar Radiation Tracking System. Prof. Vaibhav J. Babrekar, Madhur S. Kurhekar, Kaustubh K. Mulmule, Durgesh B. Mohade. International Journal of Scientific & Engineering Research,Volume 7, Issue 2, February-2016

[2] Amir Hossein Shourideh , Wael Bou Ajram , Jalal Al Lami , Salem Haggag, Abraham Mansouri in their paper on A comprehensive study of an atmospheric water generator using Peltier effect. Thermal Science and Engineering Progress Volume 6, June 2018

[3] Experimental Parameter Tuning of a Portable Water Generator System Based on a Thermoelectric Cooler. Ingrid Casallas , Manuel Pérez , Arturo Fajardo and Carlos-Ivan Paez-Rueda. MDPI 2021.

[4] Solar Powered Atmospheric Water Generator By Using Thermo-Electric Couple. Nikhil Bhatt, Shubham Lot, Roshan Dalvi, Mehul Kasbe. International Journal of Scientific & Engineering Research, Volume 10, Issue 5, May-2019