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Self Sufficient Atmospheric Water Generator using Renewable Energy

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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.**

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.

(Kabeela et.al. 2014) In his paper "Solar-based atmospheric water generator

utilization of a freshwater recovery: A numerical study" has done thermodynamic analysis for a Peltier device which is used to develop a device that uses the principle of latent heat to convert molecules of water vapor into water droplets called the Atmospheric Water Generator.

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.

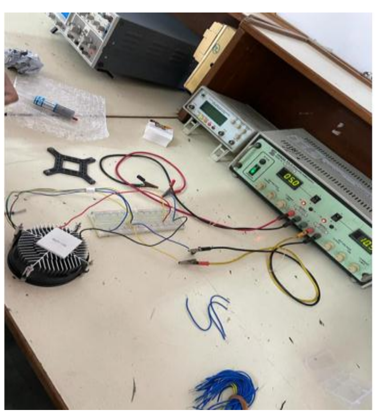
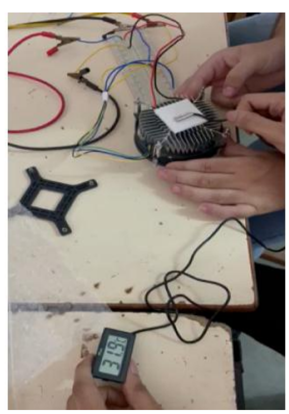
F) Arduino Board:- Microcontroller interface for controlling the movement of the solar panel.

G) IR based Proximity Sensor:- To sense the presence of an object when placed on the cooling pad.

H) Relay:- To perform switching action based on the signal generated by IR Proximity Sensor.

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.

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.

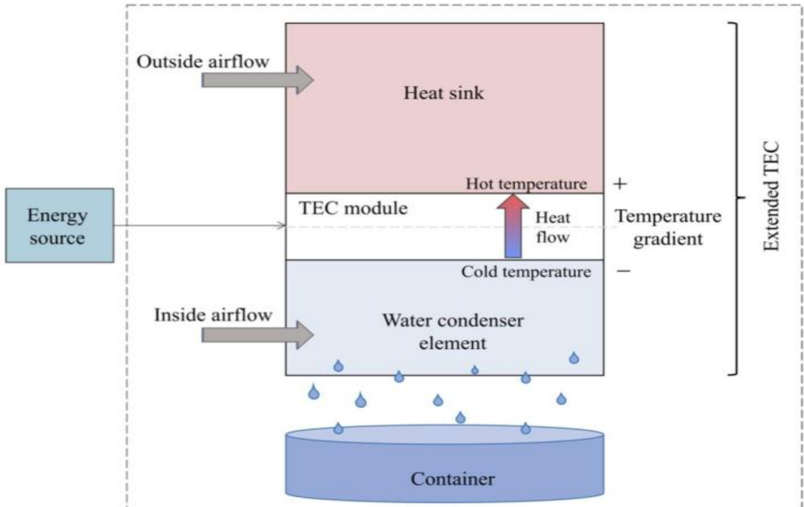


Fig.2 - The internal working of the TEC system showing the movement of heat and water production.

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 design would allow the solar panel to point accurately towards the sun.

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

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.

The Solar panel acts as a source for charging the 12V battery to ensure constant functioning of the AWG. This includes the timespan covering the duration post sun set. During the day, while the battery charge is being consumed for the working of the module, it is simultaneously being charged by the solar panel resulting in minimal loss which allows functioning for later hours of the day. This however is a simultaneous process and compliments the functioning of the cooling system parallely based on independent working principle. The cooling system is based on the working of an IR proximity sensor that triggers cooling of the TEC module when it detects the presence of an object in the field of detection. The entire unit is powered by the battery which in turn is powered with the Solar panel.

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.

Auto-Cooling System

Integrated in this project is an Auto-cooling system that functions on the basis of input fed to an IR proximity sensor, that is; it activates when the proximity sensor detects the presence of an object within its visible field of detection or range upto 80 centimeters. It does so by emitting a beam of infrared light that works similar to an ultrasonic sensor. The auto cooling system is an independently functioning module designed to function only if the IR sensor detects the presence as this results in conservation of charge for desirable efficiency. It incorporates benefits such as instant cooling and coverage of a standard surface area for the same. Plummeting to temperatures below 2 °C, it justifies the task of cooling effectively. Positioned above a fan acting as a heat outlet to offer ventilation and a heat sink working in conjunction respectively , the cooling system is supported by its attributes to prevent any external factors from affecting the output.

V. RESULTS AND DISCUSSIONS

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

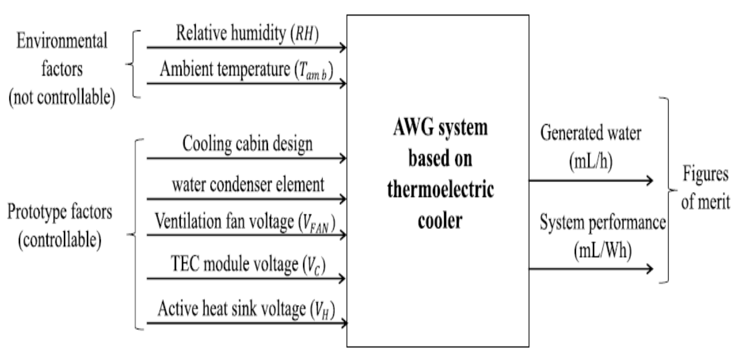


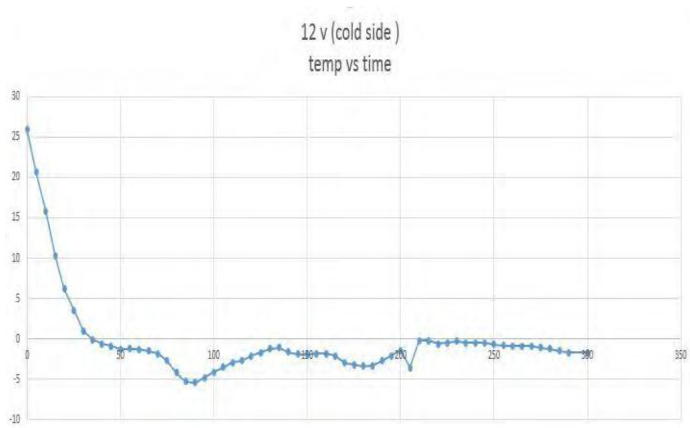
Fig.4 - Factors affecting the AWG system & the figure of merits

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.

After reviewing numerous papers, our first laboratory test was to determine the phenomenon of peltier devices at various voltages. We wanted to look at the temperature vs. voltage graph and see what information we could glean from it for our project. We began by applying voltage in increments of.5v from 5v to 12v. Keeping the voltage constant, we monitor the temperature of the hot and cold sides of the peltier device every five seconds. We showed those numbers on a graph to better understand the phenomena of a peltier device when a constant DC voltage is applied, namely the change in temperature over time (second). We used 16 distinct constant voltages starting at 5V to 12V for our purposes.

PARAMETER TUNING ANALYSIS

In the instance of cold side occurrences, we have noticed a quick rise and decline. The temperature began to diminish with each consistent voltage. When the temperature reached the theoretical dew point, the humid air made contact with the cold side of the Peltier and began to condense into water. After a few seconds, the condensed water on the peltier's surface will begin to absorb temperature from the atmosphere. As a result, the temperature on the cold side will be slightly raised, and the dew formed on the Peltier's surface will have turned into ice within a few seconds. This process is repeated indefinitely, resulting in a graph with far too many ups and downs. We tested our device in a variety of settings throughout our field work. The presence of humidity in the air was not consistent, and the conditions were not even comparable. As a result, the volume of water produced varied. All of the tests were carried out with a single peltier.



As the results are shown below in Fig.4.1

Humidity Rate	Hours	Amount of water produced (ml)
65	4	33
62	3	20
68	5	44
60	2	13
63	5	38
64	1	7
63	4	30
65	3	23
61	2	16

Table 4.5: Amount of water produced in ml based on Humidity and Time

VI. Application

- 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.
- Solar powered AWG can be used by the army in high altitude regions or dry desert regions with acute water shortage.
- Rapid cooling unit used in vehicles and portable refrigeration unit
- minor cooling applications having flexible usage

VII. FUTURE SCOPE & CONCLUSION

A solar-powered AWG system is constructed with a TE cooler, solar panels, a heat exchange unit, and a digital control device. The technology is self-powered and may be utilized to produce water from the surrounding humid air in coastal and hilly places. Our primary motivation was to create a system that could generate clean drinking water from air. Before beginning the practical investigation, we estimated the predicted output from air analytically. At the time, the outcome was very gratifying. Because the energy source is free and the solar system normally requires less care, this system would be a long-term, cost effective solution. The development and production of such equipment is a future commercial possibility.

After tireless review and research we found that the following reasons might be in charge of the low water output of the gadget and the possible solutions are also mentioned-

Lack of Humidity Percentage

The experiments were carried out in Mumbai, which has a varying humidity level. Also, based on our calculations, we discovered that when the humidity is above 50%, the AWG functions better. As a result, we anticipate that the water output from AWG will grow if the device is tested in coastal and hilly regions, as well as in other meteorological situations where and when relative humidity is quite high throughout the year.

Lack of Wiping Mechanism

When the device was first turned on, condensation began to build and water drops formed on the chilly surface of the Peltier device. However, because water is not a good thermal conductor, the thermal conductivity of the area reduced as a result of the accumulation of these water droplets. As a result, the condensation procedure was slowed down. A wiping mechanism should be implemented in the device in the future to raise the condensation rate in order to boost the output.

Poor Quality of Peltier

The peltier mechanism itself is one of the most significant restrictions. We discovered the peltier we were using isn't the most efficient at creating water. While experimenting with locally available peltier devices, we discovered that these devices frequently lose their ability and do not perform completely. The Peltier device comes in a variety of types that are far more effective than TEC (12706). Those can be used to improve performance and outputs in the approaching days. Ceramic is the surface material employed in this local peltier. We can increase the output supply by changing the surface materials, inner materials (often utilized in the fabrication of semiconductor legs), and contact materials.

Energy Output

Another major problem that we faced that can be tied in with scalability is the amount of energy needed. Since the output energy at this scale isn't high it not only limits the amount of time the system can run but also the quality of components used as better quality components often require higher power consumption.

Weight of solar panel

The weight to the power output ratio of the solar panel is below average and hence a very high wattage panel wasn't feasible and a low wattage panel wouldn't provide a satisfactory output. This issue ties in with a problem that we faced while developing the project which was to make the solar panel trackable. But since the weight of the panel and hence the power required to make the panel rotatable turned out to be high, that feature had to be scratched.

1) Because the project is focused on delivering water from the environment while keeping this device portable, large-scale scrubbers are not used for better air filtration. Scrubbers are capable of removing oxides from the air. It can be taken care of if there is a lot of use.

2) The concept of this venture can also be used as a superior alternative in refrigeration science to traditional frameworks.

3) For the time being, we have only used one Peltier device in the AWG prototype. In the future, the prototype could include multiple Peltiers to increase the water output.

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