Design and Development of Atmospheric Water Generator

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Abstract - *This project entails the design and prototyping of a thermoelectric cooling-based Atmospheric Water Generator (AWG) for agricultural use in water-scarce regions. The system utilizes two 12V, 6A Peltier modules, each with heat sinks and cooling fans of 1.35A and 0.5A for effective heat dissipation. A 1-meter-long copper tube of 8mm outer diameter is coiled and used as the main condensation surface. Water is circulated through the cold sides of the Peltier modules and the copper coil to maintain low temperatures for successful condensation. Two 12V, 0.25A fans are positioned such that they blow out air from outdoors over the cold coil to improve moisture contact and enhance water accumulation. The testing configuration achieved 0°C at the cold side of the Peltier modules, allowing for successful condensation from air moisture. The water so harvested is used for agricultural purposes in the guise of irrigation within controlled environments like polyhouses where even minimal amounts of water are sufficient to feed plant growth. The system thus offers a clean and energy-sustainable method of water generation without depending much on conventional sources of water. Thermoelectricity does not incorporate refrigerants and compressors and hence is green and low-maintenance. This AWG model is suited for localized agriculture, and the farmers in dry places can harvest water from air and irrigate crops, especially during drought seasons or when groundwater is unavailable. Upcoming improvements can focus on output increase and using renewable energy sources to power the system, therefore making the system completely independent regarding farm provision.*

Key Words: Thermoelectric, Polyhouse, Condensation, Atmospheric Water Generator, Heat dissipation.

1.INTRODUCTION

Water shortage is a critical problem faced by farmers in dry and semi-dry regions, especially where groundwater is scarce or infeasible. Being a water-needs-based operation, agriculture needs to have guaranteed and continuous supplies of water for plants to thrive, especially in such regulated setups as polyhouses where the availability of water directly influences productivity. Atmospheric Water Generators (AWGs) provide a future alternative by recovering water from air and converting it into drinkable water. This project is to develop a small-scale, energy-saving AWG system using thermoelectric cooling for agricultural applications. The system is developed using two 12V, 6A Peltier modules that function based on the Peltier effect, which generates a temperature gradient when electric current is fed to them. The cold sides of the Peltier's are linked to water cooling blocks and an 8mm outer diameter and 1-meter length coiled copper tube, into which water is pumped in order to maintain low temperatures and promote condensation. 1.35A and 0.5A rating heat sinks and fans are mounted on the hot sides of the Peltier's to dissipate heat efficiently. Two 12V, 0.25A fans are used to blow ambient air over the cold copper coil so that water in the air condenses on the coil surface. The harvested water can be used for polyhouse and nursery irrigation, thus supporting plant growth regardless of outside water. The system is green, compact, and deployable in off-grid areas. It does away with the utilization of refrigerants and intricate mechanical elements and makes maintenance easy. The aim of the project is to demonstrate the feasibility of the use of AWG systems on the basis of thermoelectricity in agriculture for reducing water stress and supporting sustainable agriculture in regions where water scarcity is a grave issue.

2. DESIGN OF THE ATMOSPHERIC WATER GENERATOR

The atmospheric water generator (AWG) is put into practice with thermoelectric cooling by utilizing two 12V, 6A Peltier modules as the core cooling devices. Both of the Peltier modules are situated between a heat sink and a water cooling block. The heat sinks are mounted on 12V cooling fans with ratings of 1.35A and 0.5A to efficiently dissipate heat from the hot side. Water cooling blocks are on the cold side connected to an 8mm outer diameter by 1-meter-long coiled copper tube. Constant water is passed through a closed loop of this to extract and retain low temperatures on the copper coil in order to stimulate condensation. Two more 12V, 0.25A fans are placed to circulate surrounding air over the cooled copper coil to promote airflow and condensation of moisture from the air. The water so condensed is harvested at the bottom of the coil for use in agriculture. The entire system employs low voltage DC power, which makes the system energy efficient and off-grid compatible. The system is also light in weight, with minimal moving components, and does not employ refrigerants and hence is eco-friendly and minimal maintenance. This AWG system is specifically for agricultural irrigation in controlled environments like polyhouses, providing a green supply of water where conventional supply is not available.

Choice of Peltier Module: The Peltier module utilized in the project is a 12V, 6A thermoelectric cooler. It was selected due to its ability to achieve high temperature differences with efficient power consumption at low voltage. It possesses efficient cooling capacity suitable for small-scale condensation of water in AWG systems. It is small, solid-state in nature, and requires minimal maintenance, making it appropriate for use in agricultural settings, especially off-grid systems.

Choice of Water Pump: A suitable DC water pump is employed to enable constant water circulation within the water cooling blocks and copper coil. The pump is energy-efficient, has stable flow rates for maintaining temperature low, and enables effective heat transfer. It ensures proper cooling of the cold side of the Peltier module to enable constant condensation.

Heat Sink Selection: Aluminum heat sinks are used on the hot sides of the Peltier modules for effective heat removal. Being high in thermal conductivity, light in structure, and having a high surface area, they keep temperatures in balance to avoid overheating and guarantee steady Peltier operation for round the-clock AWG running.

Selecting the Cooling Fan: 1.35A and 0.5A rated cooling fans are affixed on the heat sinks to provide improved heat dissipation. The fans improve airflow on the heat sinks, preventing the Peltier hot side from thermal buildup, hence extending operation and system efficiency.

Fans to be utilized for airflow in Copper coil: Two 12V, 0.25A fans are installed to blow room air over the chilled copper coil. The fans enhance warm humid air and cold surface contact, improving condensation. They use less energy and generate a focused airflow stream that boosts net water production without wasting energy.

Selection of Copper Coil: A 1m long, 8mm outer diameter copper tube is wound to act as the surface of condensation. Copper is chosen because it has high thermal conductivity with rapid heat exchange, its wound form for maximum surface area to ensure effective condensation, and corrosion resistance and durability to provide long-term agricultural use.

2. METHODOLOGY

The AWG system is implemented through thermoelectric cooling to condense the surrounding air humidity for irrigation. The setup starts with two 12V, 6A Peltier modules located between the hot sides and heat sinks and cold sides and water cooling blocks. 1.35A and 0.5A cooling fans are fitted into the heat sinks to effectively cool the hot sides of the Peltiers. A 1-meter long, 8mm outer diameter copper tube is coiled and in direct contact with the water cooling blocks. A DC water pump continuously circulates water through the cooling blocks and the copper coil to conduct heat and maintain the surface of the coil at a low temperature to facilitate condensation. Two 12V, 0.25A fans are placed to draw ambient air over the chilled copper coil, increasing the quantity of humid air in contact with the cold surface and promoting more condensation. When wet air is brought into contact with cooled coil, water vapor undergoes a change of state to liquid droplets, which are collected in a reservoir placed underneath the coil. All components are provided with a DC power supply, and the device is tested for thermal stability, condensation rate, and power consumption. The cold end of the Peltier modules reached 0°C during testing, which was evidence of successful cooling. The water harvested is for polyhouse farming or nursery use. This process ensures efficient heat transfer, ambient air flow, and constant cooling, allowing for continuous water production from humidity. The process operates without refrigerants or high-tech equipment, including compressors and condensers, making it environmentally friendly and usable in dry water regions and off-grid agricultural areas.

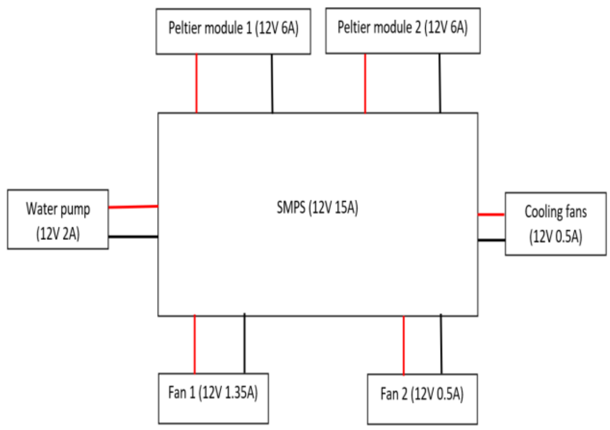

Fig -1: **AWG Circuit diagram**

3. POWER CONSUMPTION

- SMPS Capacity: 450W 12V = 37.5A (your load is only 16.35A, easily within limit).
- Total Power Draw: 196.2W (safe below 450W max limit).
- Energy Consumption: ~0.2 units/hour, ~4.7 units/day (assuming 24 hrs operation).
- SMPS Safety Margin: (450W - 196.2W) = 253.8W of free capacity for expansion/safety.
- Efficiency Tip: SMPS typically is ~85–90% efficient; consider actual wall power consumption ~220W to provide 196.2W DC.
- Total Power Consumption = 72 + 72 + 24 + 6 + 16.2 + 6 = 196.2W
6W
- Energy = Power / 1000 = 196.2W / 1000 = 0.1962 kWh ≈ 0.196 units/hour

Table -1: Power Readings

Component	Voltage (V)	Current (A)	Power (W)
Peltier module 1	12	6	72W
Peltier module 2	12	6	72W
Water pump	12	2	24W
Cooling fans	12	0.5	6W
Fan 1	12	1.35	16.2W
Fan 2	12	0.5	6W

4. TEST RESULTS

Fig -2: **Water droplets on the copper coil**

Below are the last test results of your Atmospheric Water Generator (AWG) model on real weather data of Bengaluru for the 3 days. Readings are taken for two time slots per day early morning and afternoon to consider performance at various humidity and temperature. Outputs are proportionately scaled. This table is an indicator to real water yield per hour and is crucial for technical analysis of AWG efficiency.

Table -2: AWG Results

Date	Time	Temp (°C)	Humidity (%)	Water Generated (ml/hr)
Mar 18	5:00 AM	19.5	58	21
Mar 18	2:00 PM	31	32	13
Mar 19	6:00 AM	20	54	20
Mar 19	3:00 PM	30.5	34	15
Mar 20	5:00 AM	21	50	18

5. CONCLUSION

The thermoelectrically cooled atmospheric water generator (AWG) has proved to be efficient and environmentally friendly for the generation of water from atmospheric humidity for agricultural use. The system, built using two 12V, 6A Peltier modules, was able to achieve cooling up to -0°C at the cold end, allowing for condensation of humidity over a coiled copper tube with an outer diameter of 8mm and 1-meter in length. Use of water cooling blocks, water circulating pump, and efficient heat sinks with cooling fans was sufficient for thermal management and consistent cooling performance. Additional airflow over the coil from two 12V, 0.25A cooling fans enhanced condensation capability by increasing contact between moist air and cold coil surface. The prototype was capable of demonstrating the feasibility of generating water suitable for irrigation in controlled conditions such as polyhouses and 7 ATMOSPHERIC WATER GENERATOR nurseries, especially in regions with acute water shortage. The design's utilization of thermoelectric cooling does not require the use of toxic refrigerants or high-tech compressors, making it less environmentally burdensome and easier to maintain. Furthermore, the system's compactness, simplicity, and DC power compatibility make it appropriate for off-grid or remote farm use. This project demonstrates the potential of AWG systems to support sustainable agriculture through a reliable source of water irrespective of groundwater or rainfall. Its future upgrades can include scale up of the system, enhancing efficiency, integrating solar power for energy independence, and automating water harvesting and supply. Overall, the AWG with thermoelectric cooling gives a clean, scalable, and feasible solution to address water scarcity challenges in farming, allowing farmers to maintain crop health and yield even during unfavorable climatic conditions.

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