Atmospheric Water Harvesting Device

Marcel DeBiasi, Cale Hunter, Adam Kvas, Christian Nunez, Nathan Yokich

LAB FUND

Objective

Our objective is to design, prototype and analyze an Atmospheric Water Harvesting Device (AWH) with the use of Thermoelectric Modules. The goal is to provide a clean drinking water solution for water scarce locations around the world.

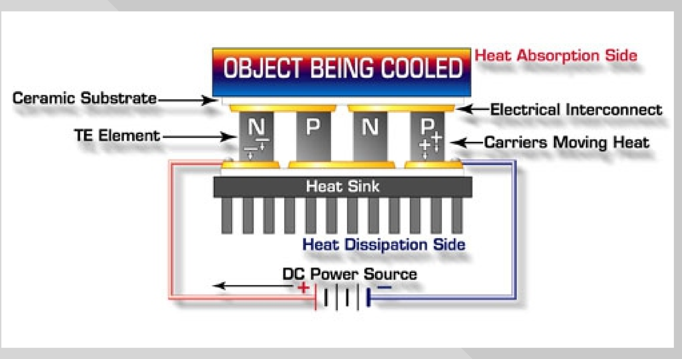
Background

The global concern for fresh drinking water continues to rise as evidence for issues such as climate change and depletion of ground water resources becomes more prominent. According to the FSI index (Magnitude of water resources in a country), the UN predicts that 48 countries will struggle with water scarcity or stress by 2025 [1].

Airborne moisture is a plentiful source of freshwater with an estimated 12 800 trillion liters of water available in the atmosphere [1]. Essentially, an AWH works by cooling down a surface below the dew point temperature of air to create condensation.

Cooling the surface requires the use of Thermoelectric Modules displayed in the schematic below.

With the use of DC power, photovoltaic cells can be easily implemented into the design, providing a clean energy solution.



Thermoelectric Module Schematic [2]

Design Methodology

The AWH is designed to maximize water production by optimizing the following:

(1) Hot and cold fins material and size
(2) Intake fans
(3) Heat sink fans to increase convection
(4) Plexiglas enclosure to increase heat removal around both fins and improve aesthetics
(5) LifeStraw filter for safe drinking water
(6) Arduino control system

- The appropriate number of Thermoelectric Modules

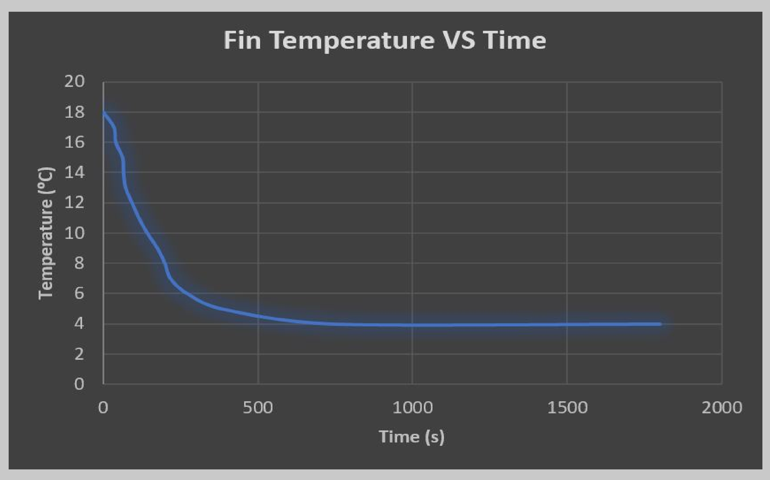
3D Solidworks model of the design

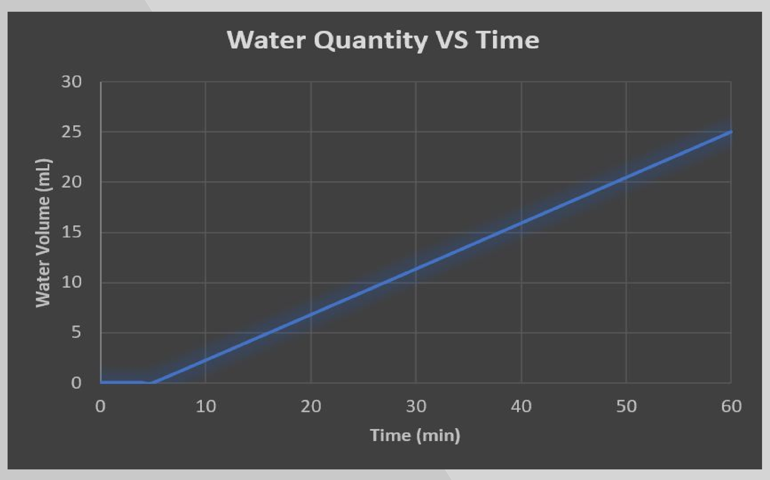
References

[1] F. Bagheri, "Performance investigation of atmospheric water harvesting systems," December 2018. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2212371717300744?via%3Dihub. [Accessed 1 November 2018].

[2] Ferrotec, "Thermoelectric Modules," [Online]. Available: https://thermal.ferrotec.com/technology/. [Accessed 22 3 19].

Results and Discussion





The AWH was tested in simulated conditions of high humidity with relative humidity between 35-60%. Its performance is directly related to the dew point temperature of the atmosphere. In an atmosphere with a higher dew point temperature, the Atmospheric Water Harvester will begin to work with higher efficiency and improve water production as a result. The tested results were as follows:

- With a maximized finned surface, it took 750 seconds (12.5 minutes) to reach its lowest temperature of 4ºc
- In the first hour of running the Atmospheric Water Harvester produced 25 mL of water
- The water it produces was suitable for consumption with 99.9% of contaminants removed from the initially collected water

Design Calculations

The atmospheric dew point temperature is calculated using the following formula in the AWH'S code:

RH - Relative Humidity (%)
T - Atmospheric Temperature (ºc)

$$T_{db} = \frac{243.12\left(\ln\left(\frac{RH}{100}\right) + \frac{17.62T}{243.12+T}\right)}{17.62 - (\ln\left(\frac{RH}{100}\right) + \frac{17.62T}{243.12+T}}$$

The designed finned surface area was calculated using an energy balance equation and isolating for

h - Convective Heat Transfer Coefficient (W/m²)
Qc - Absorbed Heat at Cold Surface (W)
Ta - Atmospheric Temperature (ºC)
Tfin - Temperature of the Fins (ºC)

$$A_{fin} = \frac{Q_c}{h(T_a - T_{fin})}$$

Conclusion and Recommendations

After a variety of tests were conducted on the AWH, the system demonstrated favourable results. There are several technical and design characteristics that can be improved upon such as:

- Using fins with a higher thermal conductivity
- Increasing the surface area of the fins
- Decreasing surface tension on the fins
- Use of photovoltaic cells

The Atmospheric Water Harvesting System displays potential benefits in other applications such as using the excess heat from the hot side fins to provide heat to water or air, thus removing the need to use external resources to heat the fluids.

Faculty Advisor: | Shohel Mahmud. PhD., Peng.
Special Thanks to: Mike Speagle, Elyse Hill, Andrew Gadsden, SOE Machine Shop and Jim Hayden

UNIVERSITY of GUELPH

ENGINEERING

Mechanical

Water Resources