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Fabrication and Experimental Evaluation of Solar Still with Aluminium Sheet

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ABSTRACT

People are unable to drink since one-fourth of the globe is covered in water, making it slightly unnecessary for them due to the salt that makes up seawater. Several countries face difficulties caused by an absence or shortage of water, especially along coastal areas. It is largely due to the rapid expansion of industry and populations throughout the world. In an area with warm temperatures and scarce water and electricity goods, solar is the most efficient way of solving the water problem. A solar still is an essential tool that makes use of solar energy to transform brine (a mixture of salt water) into water for drinking. This study project will look at the efficacy of using a single-slope solar still with an acrylic casing, which has a thermal conductivity rating of 0.2 W/mk and helps to retain heat within the solar still. V-shaped aluminium sheets are utilised to improve the heat storage material because they have a very high thermal conductivity of 167 W/mk, allowing more heat to be transferred to the seawater. The solar-powered still works by allowing the sun's light to enter and reflecting it through a 3mm-thick glass cover. Heated aluminium fins, which have a high thermal conductivity, generate warmth in the brine water, which starts evaporating the pristine water and condenses on the glass cover until it is gathered in the water collector. The solar still was found to collect nearly 281 ml of water when placed on a day with sunshine between nine in the morning and six in the afternoon.

KEYWORDS: Evaporating, Aluminium sheet, Acrylic, Solar still, Water collector

1. INTRODUCTION

Freshwater serves as crucial for the existence of all living things on our planet, such as animals, plants, and humans. It makes up the majority of Earth's surface, accounting for about seventy per cent of the planet's total area. The majority of water on Earth is found in the oceans as saltwater, while only about three percent (approximately 36 million km^3) exists as freshwater. This freshwater is primarily located in ice caps and glaciers in the Arctic and Antarctica, as well as in groundwater, reservoirs, and rivers. This freshwater is essential for meeting the needs of both humans and animals. However, humans have access to just over one per cent of all fresh water. Despite the scarcity of pure water, it appears to be sufficient to support life and plants on Earth. The hydrological cycle is the main source of fresh water. The natural hydrological cycle includes the generation of vapours above the liquid surface, wind transport of vapours, cooling of the air-vapour combination, condensation, and precipitation. The solar distillation operation generates vast amounts of pure water. Unfortunately, fast industrial expansion and the worldwide population boom have led to a massive increase in the need for water that is fresh, both for home and agricultural reasons, to provide enough food. Furthermore, industrial waste pollutes rivers and lakes, and a considerable volume of sewage discharge exacerbates the situation. Globally, human-caused contamination of natural water sources has become a serious issue, resulting in freshwater shortages. As a consequence, the availability of purified water is turning into a growing concern in many parts of the globe. Tiwari and colleagues used cooling water to lower the temperature within the covering of glass of a single-basin solar powered still on a regular basis. This caused the outermost layer of glass to be somewhat warmer compared to the surrounding air, but the water beneath remained at the same temperature as the air. [1] Lawrence et al. evaluated the effect of heat production on a solar still's efficiency when water runs over its protective glass cover. When liquid is put over the cover, it cools both the liquid and the glass. Reducing the ambient temperature in the basin water reduces evaporation rates somewhat. As the glass temperature dropped, the condensation rate rose, enhancing the still's production. [2] Dr. Shanmugam conducted experiments using a single-slope, single-basin solar still, incorporating a drip system to gradually introduce brine into the basin. The system has been evaluated using rock fragments, black granite stones, concrete stones, and a variety of energy-absorbing materials. The concrete pebbles in the basin, which are weeping with briny water to keep the water depth as low as possible, were found to be compatible with the experiment's findings. From February to October, studies were conducted in the Chennai, Tamil Nadu climate. In comparison to different energy-absorbing resources, the experimental result using absorbing components in concrete pebbles has a high manufacturing rate [3] Ehssan M.R. The researchers Nassif, Mohamad Z. El-Abd, and Yahya A. El-Tawil studied the effectiveness of solar stills. The project's main purpose is to evaluate the design of an essential solar-powered distillation still that works purely on solar power and requires no additional energy suppliers or moving components. The still, which functions as a renewable energy collector, is simply a rectangular basin that contains solid or darkened material. The trials were conducted between the duration of May through August. The collecting materials included black polyamide balls of different sizes, black-painted steel balls about 5 mm in diameter, and dark or black pebbles with an average diameter of 6.4 mm. The study found that employing 4 mm black plastic spheres produced the largest distillate volume of water at a velocity of 4 m^3/m^2 each day, having a typical performance of 49%. Furthermore, it was proved that materials with high melting points result in higher distillation rates and efficiency, especially during the afternoon hours. Under ideal conditions, they still generated around the same production rate when used to desalinate saltwater. [5] Dr. S. Shanmuga Priya and Umair Iqbal Mahadi examined the efficiency of a single-basin solar still using dye and ink as thermal retention materials. They conducted a comparative analysis of distillation using both materials and determined that dye in water exhibited superior performance compared to ink. [5] Pankaj K. Srivastava, S.K. Agrawal, and Abhay Agrawal conducted an investigation comparing the performance of stills using commonly available absorber materials such as cotton and jute fabric. The float porous absorbers type was discovered to provide greater yields with jute fabric over cotton cloth, resulting in an estimated 12% rise in distillate output while running at higher temperatures. [6]

2. EXPERIMENTAL SETUP

2.1 The parts that were used on the solar stills remain as follows:

1. Acrylic box

The acrylic box acts as the solar stills outside the housing. Its major role is to serve as a heat insulation, assisting in the retention of heat produced within the acrylic set, resulting in a rise in the amount of evaporated water, especially when salt or brine water is injected into the solar still.

2. V-shaped aluminium sheet

V-shaped metallic aluminium sheet is utilised as heat storage materials due to their elevated thermal conductivity around 160 W/mk and great corrosion resistance. Its excellent thermal conductivity facilitates for the efficient transmission of warmth to saltwater or brine water, while its resistance to corrosion prevents degradation in such situations.

3. Glass sheet

The acrylic box is topped with the top glass layer to facilitate the passage of more solar energy through the solar still, thereby augmenting the absorption of radiation from the sun by the aluminum fins.

4. K-type Thermocouples

On an hourly basis, the thermocouples detect the internal temperature within the aluminium fillet, liquid, the glass's bottom surface, and the ambient temperature.

5. Temperature indicator

The temperature indicator shows two temperatures dependent on the placement of the thermocouples that are which may be adjusted via the knob in the front.

6. PU tube

The PU pipe functions as both an exit pipe to gather distilled water and an input tube for entering briny or solar water through the solar still.

7. Infrared thermocouple

An infrared thermocouple serves to measure the change in the temperature inside the sheet of glass on an hourly basis.

2.2 FABRICATION

The acrylic box is assembled by securing the acrylic sheet in place using silicone glue and polyfix adhesive, after which the aluminum sheet is inserted. The aluminum sheet was fabricated by affixing a 450mm long V-shaped aluminum sheet onto the surface of a 1.2mm thick aluminum sheet, ensuring that four V-shaped fins are evenly spaced, and then painting it black to improve energy absorption. The drinking water collection is affixed to the bottom edge inside the acrylic box at a 2° angle using silicone glue and polyfix adhesive. The drinking water collector appears to have the shape of an L. Silicon glue and m-seal are used to attach the glass cover to the highest point of an acrylic box at a 24° angle. A diameter of 15mm is bored to accommodate the intake pipe, and an opening of 10mm is created for the output PU tube. In addition, a 4mm hole is made for the thermocouple, which is then inserted in two distinct positions using m-seal. M-seal is used to ensure the solar still remains airtight. Silicone glue and m-seal are applied to all the acrylic box edges to prevent water and water vapor leaks.

3. EXPERIMENTAION

A single-basin solar-powered still consists of a basin and a black-painted aluminum sheet with fins. This still is sealed with a 5mm thick clear glass cover to maintain airtight conditions. The performance of a solar still is influenced by various factors, such as the intensity of sunlight, wind speed, ambient temperature, the temperature differential between the water and the glass, the exposed surface area of the water, the size of the absorbent plate, the temperature of the incoming water, the angle of the glass cover, and the depth of the water. The solar still works by injecting brine or saltwater through a 15mm intake pipe and then sealing it with an airtight lid to prevent water vapor from escaping. The solar still is set up with a tilted glass cover facing south to maximize solar radiation. The solar still is constructed using an acrylic sheet with a thermal conductivity of 0.2 W/mK, aiding in the retention of heat. When solar energy enters the still, it heats the aluminum sheet, which has a thermal conductivity of 167 W/mK. This aluminum sheet then transfers the heat to the brackish or saline water, resulting in its evaporation. The difference in temperature between the water and the glass causes the water vapor to condense on the underside of the glass cover. Due to the temperature differential, water condenses at the bottom surfaces of the glass and slides down the sloped portion. This condensed water accumulates in the drinking water collector, which is positioned at a 2° angle to enable distilled water to exit through the 10mm output PU pipe. The water that was distilled is then gathered in a beaker and measured.

The thermocouple was installed to monitor the variation in temperature of the solar still's aluminium sheet, the water, the glass bottom surface, as well as the ambient temperature, over time. The thermocouple is inserted inside the solar still through a 4mm circular opening covered with M-seal.

Fig 1. Final assembly of single slope solar still

4. Advantages of Solar powered Still

- Solar energy is non-polluting, renewable, and ecologically benign.
- The solar still is affordable and simple to build, making it ideal for large-scale desalination procedures.
- This technique has the ability to turn copious saltwater into drinking water for home use, making

5. RESULTS

Throughout a bright day, the temperatures of aluminum, water, the bottom surface of the glass, and the ambient air were measured hourly from nine in the morning to six in the evening. A graph was created to illustrate the changes over time at different locations. Four graphs are used to show the link among the duration of the time and the outside temperature, aluminium temperatures, temperature of the water, glass bottom temperature at the surface, and amount of water that was distilled collected. Throughout the day, 10 litres of briny or saltwater were put into the solar still, yielding roughly 281 ml of purified water. A substantial volume of purified water is collected around eleven in the morning and 2:00 p.m., when an enormous amount of solar energy flows through the glass, causing the aluminium fins to heat up. The largest quantity of distilled water, 89mL, was acquired between 12:00 a.m. and 1:00 p.m. It is apparent that the amount of purified water obtained is mostly determined by the strength of solar radiation and the substance used to absorb heat.

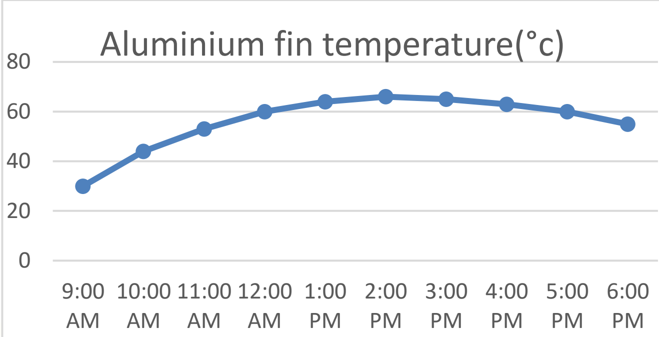

Figure 2 Timing vs. Aluminium Temp Plot

Figure 2 illustrates a graph showing the temperature variation of the aluminium fin, that acts like a heat-absorbing material, as time passes. The data provided stems from an experimental inquiry conducted on an overcast day from nine in the morning and six in the evening. The internal temperature of the aluminum fin reaches its zenith at 2:00 p.m. and subsequently remains relatively consistent, with only slight fluctuations observed from eleven in the morning and two in the afternoon.

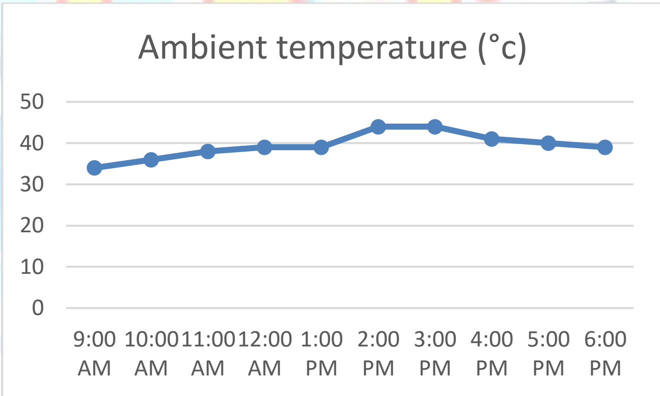

Figure 3. Timing versus. Ambient Temperature Plot

Figure 3 illustrates a graph that depicts the fluctuation of the outside temperature, which functions as a heat-absorbing medium, over time. The graph shows the results of an experimental investigation conducted on an overcast day from nine in the morning and six in the evening. The ambient temperature reaches its peak around 2:00 p.m. and then remains relatively steady, with only minor variations from eleven in the morning and two in the afternoon.

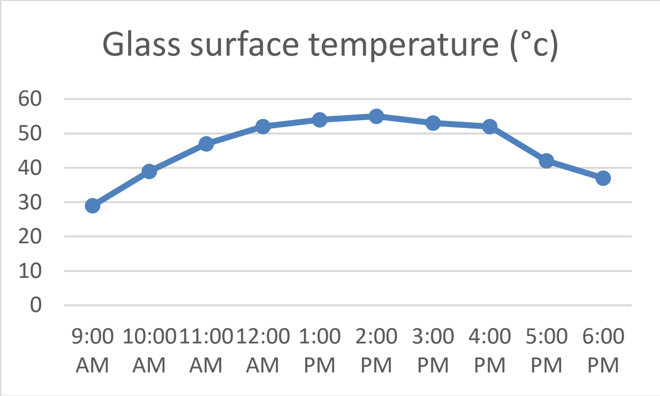

Figure 4. Timing Vs Glass sheet temperature (°c) plot

Figure 4 depicts a graph that demonstrates the fluctuation in heat of the glassy surface, which functions as a heat-absorbing medium, over time. The graph shows the results of an experiment conducted on an overcast day from nine in the morning and six in the evening. The temperature inside the glass sheet peaks around 2:00 p.m. and remains relatively stable with only minor fluctuations from eleven in the morning and two in the afternoon.

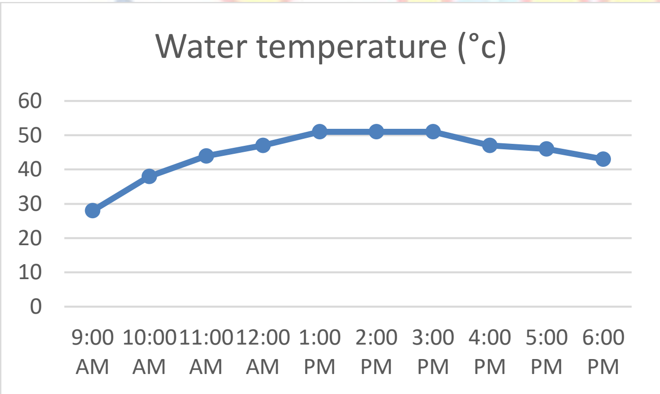

Figure 5. Timing Vs Water Temperature Graph

Figure 5 is a graph showing the temperature change of salt water, which functions as a heat-absorbing medium, over time. The graph illustrates the results of an experiment conducted on an overcast day from nine in the morning and six in the evening. The water temperature peaks around 1:00 p.m. and then remains relatively constant, with only minor fluctuations from eleven in the morning and two in the afternoon.

6. CONCLUSION

After doing the experimental research, we discovered that our solar still produced 281 mL every dayOur main goal of delivering clean water to remote villages and rural areas will be accomplished. Furthermore, such places frequently have power outages and a scarcity of clean water resources. Our idea will overcome these difficulties since it only uses solar energy, which is abundant in nature. We have made our gadget simple to build, maintain, and repair, which is the most crucial characteristic since it makes it accessible to the vast majority of people.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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