SOLAR DISTILLER IN A PYRAMIDAL COVERING AND ISOLATION WITH COMPOSITE MATERIAL

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ABSTRACT

To demonstrate the thermal calorific and economic viability of the material, compared to the others conventional distiller, here is presented a solar distiller of simple stage, witch has as main differential characteristics the geometry of the covering and the material used to make its coating. The model built has an area of 0.25 m² and pyramidal covering, witch allows the collection of the distillate water in the four faces, different of just two like is found in the conventional distiller, besides promote the absorption of the radiation because of its versatility about the positioning of the sun. Not despite, its built is favored for the low cost associated and the agility in the process because it is made with a mix of gypsum, EPS ground and water, witch also attributes to the distiller thermal properties more favorable to the process of distillation.

Keywords: distiller, solar energy, composite, water.

INTRODUCTION

One of the basics needs for human survival is the ingestion of potable water, in a basis of one to two liters per day. However, in many parts of the planet the only available water is brackish (from one to ten grams of salt per liter) or salt (with more than 10 grams of salt per liter). The seawater is highly salty, with a typical concentration of salts of more than 35g per liter (of which 28 are Sodium chloride or common salt for cooking).

Approximately 97% of water existing on the planet is in the oceans. The 3% remaining, five-sixths are of brackish water, leaving a remaining of only 0.5% of good water. The result is a lack of access to drinking water in a low cost for millions of people, which results in a concentration of population around sources of drinking water already known, poor sanitary conditions and living default. The Brazil has about 11% of its population, or 20 million people without access to drinking water of quality. So, to this water (brackish, salt and even contaminated) becomes suitable for human consumption, it's necessary to remove the content of salt until get a reasonable concentration. In other side, the water completely distilled also is not good for human consumption in a long time, and a minimum concentration of salts is necessary for good health.

The solar distillation uses solar energy directly in a system very simple: the natural process of purification of water through evaporation, condensation and precipitation, is reproduced on a small scale. This equipment, called a solar distiller, is basically in a shallow recipient with a transparent glass, forming a fixed volume. The solar radiation through the glass and heats the water, increasing the rate of evaporation. The water vapor rises, condenses in contact with the glass cooler, and distilled water flows to be captured by a channel, leaving behind the salts, other minerals and the most part of the impurities, including micro-organisms harmful to the health.

THEORY

For much time the distillation has been considered a way to turn salt water in drinking water, in remote places. Already in the fourth century B.C. Aristotle described a method to boil water unfit and then condense it to be ingested. The Arab alchemists had used the solar distillation to produce drinking water in the sixteenth century. In 1593, the navigator "Sir" Richard Hawkins already was using the solar distillation to get drinking water from seawater in his travels to the south seas.

The first modern solar distiller was built in Las Salinas (Chile) in 1872, by Charles Wilson. It consisted of 64 tanks of water (a total of 4.459 m^2) made of wood, painted in black with coverage tilted of glass. This installation was used to supply 20 thousand liters per day of drinking water for animals who worked in the mines. After the opening of the region by the arrival of the railroad, the installation was damaged by the end of its operation in 1912, 40 years after its construction.

The typical losses in a distiller solar of the type flat tank are caused by the reflection of the radiation incident in the glass (about 10% of total energy), absorption in the glass (10%), radiation losses by the coverage of glass to the sky (3.7%), losses by convection of the glass to the environment (12.2%), losses by conduction from the base of the tank to land (16% but with the use of a good thermal insulating may fall to 5%) and other minor losses due to leakage of heat (9.7%). These values were gotten from experiments made in India, Kandpal (2004), wind speed (Bernoulli effect) and the differences of temperature contribute to the leakage of heat. Thus, considering these numbers as reference, from 38% to 43% (the maximum efficiency achieved no more than 60%) of the solar energy received by the distiller is used in the process of mass transfer of evaporation. With a typical value of solar energy incident in a horizontal plane of 4 to 5 kWh/m^2/day, so the typical value of production for these numbers will be only 2 to 2.7 kg/m^2/day of water.

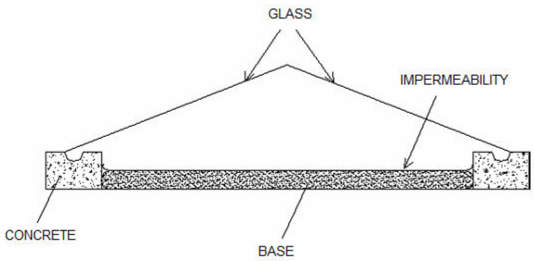

Figure 1. Schedule of a conventional solar distiller of simple stage.

Due to limitations of cost and area, usually the use of solar distillers is still experimental and has not reached a level commercially important, with only small-scale applications. It's estimated that there are only about one hundred distillers solar scattered in about twenty-five countries, with installed capacity of less than twenty thousand liters per day. This figure does not include the small distillers, used only for family use.

In Brazil solar distillers are almost nonexistent, more than twenty years ago there was an agreement between the Technological Center of the Federal University of Paraiba and the government of the state of Paraiba for the construction of a solar distiller in the city of Olivedos / MO. The distiller there was an area of 504 m^2 and could produce an average of 2.520 liters of drinking water per day. After three years of use the distiller was closed because it had not been properly maintained by the local administration. The Solar Energy Laboratory of the Federal University of Paraiba, which had important projects in that area, does not work anymore with this. The prototypes built were dismounted.

There are many variations of conventional settings distillers already used in many parts of the world. They differ among themselves mainly on the materials used, in geometry, the methods to handle and support the transparent coverage and arrangements for admission and discharge of water. Basically all distillers consist in a transparent cover that closes an area located on a little deep tank of salt water. This coverage is tilted to the edges or until the center so that the water which condenses on the surface inside flow by gravity to the channel adjacent to the tank. The materials used to the transparent coverage are plan glasses and laminated plastic. In this work will be given preference for the use of cover glass for two reasons. According LUIZ (1985) the greenhouse effect produced by the glass is more intense than the greenhouse effect produced by the plastic and, moreover, when the steam is condensed on the surface of the glass a continuous pellicle of water is formed, while the vapor condensation on the plastic produces bubbles of water that may produce losses in direct drip of distillate in the tank of salt water. As the drops are, in general, isolated on the surface of the plastic, the use of glass is more efficient because the water flows through the continuous pellicle formed on the glass to be collected in the channels.

EXPERIMENTS

With the objective to test the operation of the proposed distiller, a model with area is 0.25 m^2 was built, to the tank was used an aluminum basin of 0.3 m in diameter and 0.06 m high, coated in its return with a insulation made in composite materials based on gypsum, EPS (expanded polystyrene), cement and water, in the volume proportions of 1.0:1.0:1.0:0.3. The construction of the model followed the stages:

1. Making of a hole in tank of aluminum and placed a PVC pipe for a water supply, sealed with silicone;
2. Construction of the mold;
3. Application of release in all internal parts of the mold;
4. Preparation of the composite with the following proportions 1.0 gypsum + 1.0 EPS + 1.0 cement + 0.3 of water;
5. Putting of the composite in a first layer, where was placed the aluminum tank;
6. Fulfilling the remainder of the structure, molding too the channels and the knees with PVC pipes for collection of distilled water;
7. Drying of the box by direct exposure to solar radiation;
8. Sealing of the channels using isophthalic polyester resin, which is widely used in swimming pools and pipelines;

9. Paintings from the bottom of the tank with non-toxic ink black frosted;

10. Placing the pyramidal coverage of glass of 3 mm thick with inclination of 20° united by silicon, using aluminum paper;

11. Barrier with silicon.

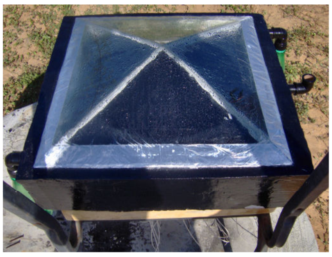

Figure 2. Proposed solar distiller.

The efficiency of the distiller is defined as the relation between the heat transferred by the evaporation the condensation and the radiation that arrive in the distiller, according to Duffie and Beckman (1991).

$$\eta_i = q_e / A.I \qquad (1)$$

Integrating this equation in a period (day, month or year) the performance of the distiller is obtained. From experimental results can be obtained the effective efficiency of the system, which also take into account some losses (drops that fall directly into the tank, leaks in the channels) using the following uation:

$$\eta_i = m_p .h_{fg} / A.I \qquad (2)$$

where "m_p" is the rate of distillate produced by the distiller (measured value) and "h_{fg}" is the latent heat of vaporization, "A" is the area of the tank and "I" is the global solar radiation;

The distiller was fed by water every day until complete a blade of 0.25 m thick, the readings of temperature was made in all the windows of the pyramid as well as from all sides of the insulating material, as well water temperature inside the Distillers and the ambient temperature. The readings of temperature was made with digital thermometer MT - 914, precision ± (1% + 1 ° C), with the type thermocouple K. Water is collected by a few bottles that were set in knees of PVC, linked to the model and then the daily volumes were measured using a measuring cylinder.

RESULTS AND DISCUSSION

From the eq. (2) was calculated the yield of solar distiller proposed. The following parameters were adopted: being mp = 0.25 kg the middle value collected per day, considering 8 hour of test per day then the value will be 0.25 kg/8h = 0. 03125 kg / h, h_{fg} = 539 Kcal/kg, the projection area of the tank was 0.07 m^2, the average global radiation was 620 kcal/m2.h, making the necessary substitutions were found $\eta_i = 0.38$, which is a value that is agreed to the literature.

To check the efficiency of the thermal insulation made of a composite based on gypsum and EPS, graphics were built with the average temperatures of the values of several days of testing, is possible to see that the value of the insulation was very close to the room temperature, thereby proving its efficiency, which can be seen in the fig (3), fig (4) and fig (5).

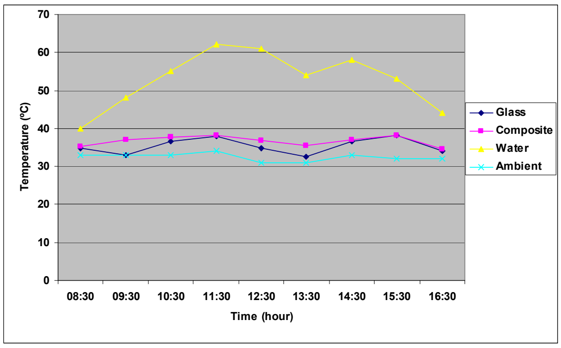

Figure 3. Levels of temperature of the solar distiller proposed for the first day of test.

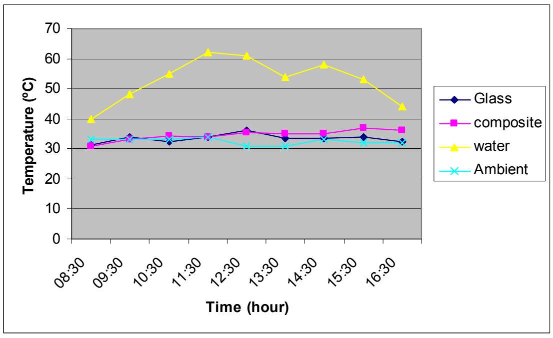

Figure 4. Levels of temperature of the solar distiller proposed for the second day of test.

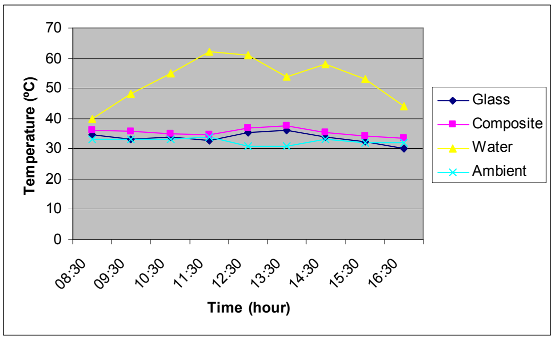

Figure 5. Levels of temperature of the solar distiller proposed for the third day of test.

Another factor that must be taken into consideration is that the pyramidal covered of the distiller receives radiation independent of the position related to the sun and the own equipment. In the several days of test the model was changed of position and the quantity of water collected was always around 0.25 liters, which can be seen in the fig (6) where the levels of temperature were very close.

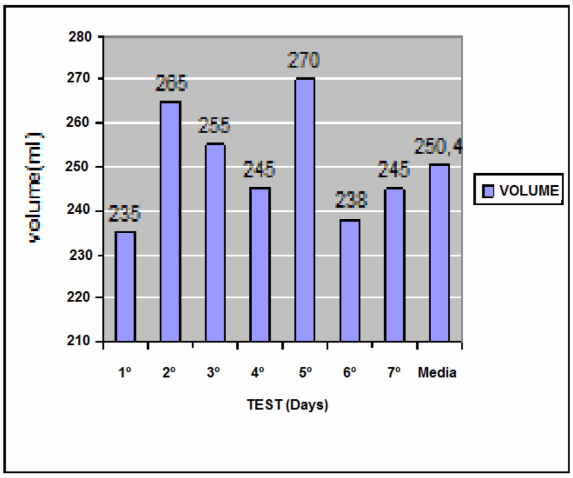

Figure 6. Volume collected in several days of test.

CONCLUSIONS

The model built presented yield of 38%, according to the patterns found in literature, especially in studies made in India by Kandpal (2004). The composite based on gypsum and EPS has proved that it is a good thermal insulating, considering that the levels of temperature were not much above the room temperature in spit of it being painted in black matte. Other positive characteristic is the easy working of the mixture, which shows that can be used in the construction of bigger units.

The use of pyramidal coverage favored the better positioning related to the sun, whereas the model was changed the position several times and the production of distilled water as well as the temperature levels didn't presented significatives changes, like can be seeing in Fig (3), fig (4), fig (5) and fig (6).

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