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A SPRAY EVAPORATION TYPE SOLAR STILL.

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ABSTRACT

The single effect basin type solar still has been for long the cheapest way to produce drinkable water from sea water using solar equipment (Howe and Tleimat, 1977). Nevertheless the operating efficiency is low, around 35 %, due mainly to the rejection to the atmosphere of the latent heat of condensation and consequently the production is also low, less than 5 l/m^2 day for a good insolation climate. Furthermore the device presents some operation problems like condensation on the inner side of the glass and algae growth both decreasing the radiation absorption of the basin, and others.

Several attempts have been made to increase production, based mainly on the utilization of several evaporation stages using in each stage the latent heat of condensation rejected by the preceding stage (Férnandez and Chargoy, 1990, Joyce *et al.*, 1993).

Together with the recover of the latent heat one can increase the evaporation area either by utilizing a fabric where the previously heated salt solution circulates (Baumgartner *et al.*, 1991) or by using some kind of high contact surface material like sponges or thorn bushes (AQUASOLAR, 1988).

Another possibility of increasing the evaporation area is just by spraying the salt solution in air and then condensate the moisten air.

The present paper describes the details of construction of a device based on spray evaporation and presents the results obtained in laboratory using water previously heated by electric resistances.

The experimental results where then used to tune a computational model of the chamber [6] to obtain the performance (daily production and energy consumption) of the system when connected to a CPC solar collector. Testing of the device with CPC collectors will be carried on in the summer of 94.

DEVICE DESCRIPTION.

The device consists of two concentric cylindrical chambers that communicate on the top and bottom. The heated solution is introduced on the top of the inner chamber (the evaporation chamber) by a nozzle that sprays the solution in small drops that increase the surface of evaporation and humidifies the air that by free convection circulates through the top to the outer chamber (the condensation chamber) where it condenses around a helical pipe producing the distilled water.

The device is constructed using a commercial type cylindrical 1 m^3 fiber-cement water deposit with a height of 1.2 m and a diameter of 1.1 m, insulated in the outside by a 13 mm thick

"Armstrong" insulation material. The inner chamber has a height of 0.8 m and a diameter of 0.62 m and is shaped by a cylindrical wall formed by a sandwich of polyamide foam 50 mm thick between two sheets of polypropylene. This wall is kept in place inside the deposit by four PVC "legs" that also support the condenser pipe. The condenser pipe is a polypropylene pipe 16 mm diameter with a length of 175 m and a total heat exchange area of 8.8 m^2.

The whole set of inner chamber and condenser is thus constructed with corrosion proof materials and, being very light, can easily be taken out of the water deposit for maintenance.

A cross section of the spray evaporation still is shown in Fig. 1.

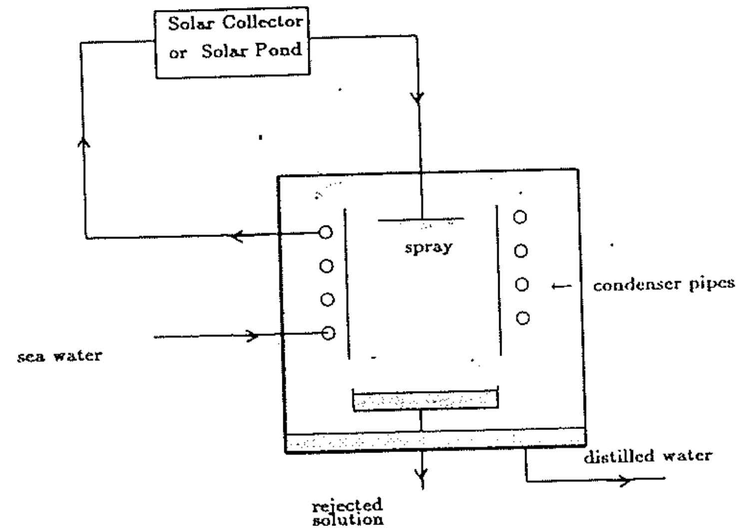

Fig.1 – Spray evaporation solar still.

Several types of commercial nozzles have been used with different drop diameters and different cone angles. Different positions of the nozzle inside the evaporation chamber have also been studied.

RESULTS OBTAINED.

To test the chamber we have used water heated electrically in a circuit that recovers the latent heat rejected to the condenser. To pump the water to the chamber we have used a small PV pump working at 24 V DC with a current of 5 A.

In the first tests the chamber was still without exterior insulation, and the water input flow rate was of 65 kg/h. Distilled water production was measured for different input temperatures till 65°C.

Figure 2 presents the results obtained in terms of the difference between the hot and cold sources of temperature. The dispersion of the productions obtained are due to the fact that the water condenses around the pipe forming drops that fall in the bottom of the deposit in a non uniform way.

It can be seen that productions near 2 kg/h were obtained for temperatures of the hot source of the order of 65 °C (temperature difference around 45 °C). Though the production is good the conversion rate i.e. the rate between the production and input flow rate is low less then 3 %.

Drop diameters play an important role on the production and conversion rate and this means we have to have lower flow rates and still maintain the pressure to obtain small drops. In order to increase the conversion rate we have changed the pump to a piston type pump that pumps with higher pressure for smaller flow rates.

In the last tests we have pumped water at 18 kg/h with a pressure around 4 bar giving drop diameters of the order of 200 μm with a production of 1 kg/h meaning a conversion rate of 5.5 %.

A possible way to produce a very fine drop spray with low terminal speed is to use ultrasonic nozzles, but though they don't need any pressure at all and they have low energy consumption their cost is too high.

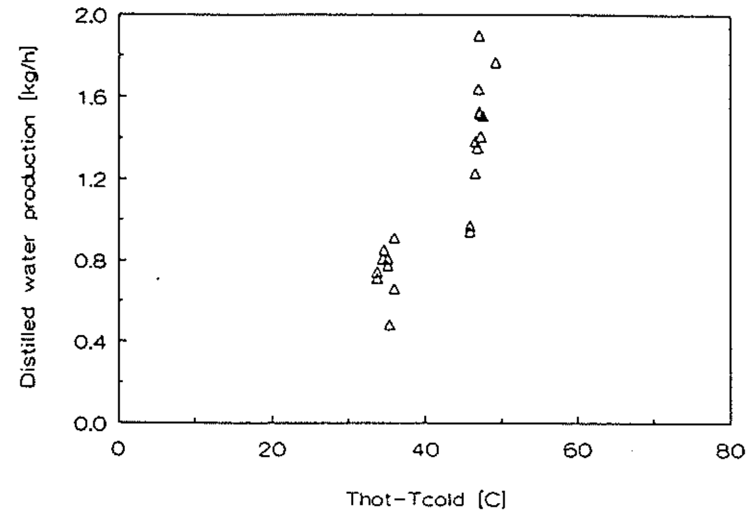

Fig.2 – Results obtained in the first series of tests.

MODELING A CPC/CHAMBER CONNECTION.

The results obtained were used to tune a computational model of the chamber behavior. It can be seen (Moreira, M. 1994) that the production of the chamber versus the temperature difference between hot and cold sources follows parabolic curves depending on the average drop diameter. This can be used together with a clear sky model of the solar radiation [Aguiar, R., and M. Collares-Pereira 1989) to obtain the daily production of the chamber connected to CPC solar collectors (C=1.2, F η_0=0.75, F U=3.5 W/m^2) in a single pass system. The results obtained for Lisbon weather conditions were of 8 kg/m^2 day.

If the chamber is connected to a daily constant heat source like a solar pond the production can reach values of the order of 40 l/day for a temperature of 65 °C.

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