DEVELOPMENT IN SIMPLE SOLAR STILLS

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Summary

The development of solar stills has demonstrated their application when weather conditions are suitable and the demand is not too large. The problem of the relatively low still productivity and efficiency triggered scientists and engineers to investigate various means of improving the systems' productivity, reliability and thermal efficiency, in order to reduce water production cost.

Based on the presented stills configurations, a combination of the following design and operational parameters should be considered in order to enhance unit efficiency: -

- Higher basin temperature (e.g. lower water level, use of wick, adding black dyes, additional external heating)
- Lower cover temperature (e.g. cover cooling, multi effect, condensation overnight with basin energy storage, additional condenser)
- Large evaporation and condensation surface areas (e.g. stepped basin / condensation surfaces)
- Reduction of still pressure to minimize vapor leakage, eliminate air presence and enhance evaporation / condensation rates (e.g. purge to other condensers, vacuum)
- Minimize heat losses (e.g. good side and bottom insulation)
- Utilization of the shaded area (e.g. additional condenser, combined stills).

1. Introduction

The thermal efficiency of the simple (basin type) solar still (Figure 1), in terms of daily production per m^2 can be increased by various passive methods, e.g. lowering depth of water in the basin; injecting black dye in the water mass; reducing side/bottom heat losses, etc. It could also be improved through active methods of integrating the still with either a solar heater or a solar concentrator, and through the reutilization of waste heat for water production. Several workers have also tried to condense the water vapor externally from the still (in additional condensing surfaces). Others have tried to recapture the latent heat of evaporation through multi (multiple) effect systems (as discussed later). Some of the simple still's modifications are discussed in Section 2.

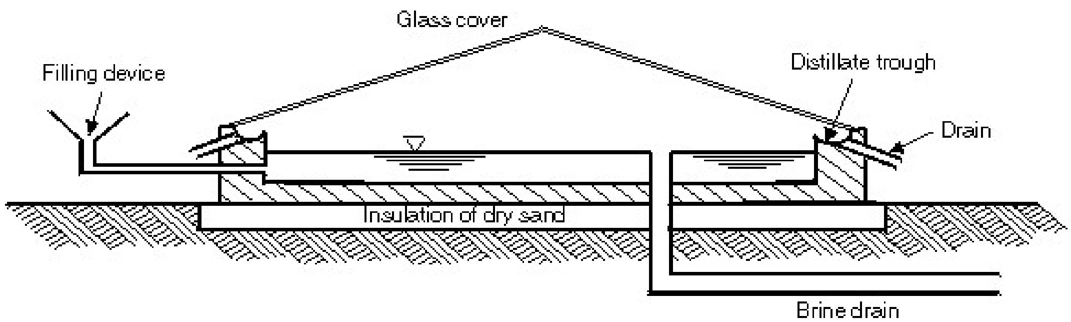


Figure 1. Single effect basin still.

2. Modified Simple (Passive) Stills

2.1. Basin Still

2.1.1. Single Slope versus Double Slope Basin Stills

Two configurations were proposed for basin type stills (also referred to as simple, roof, conventional and greenhouse stills): single slope and double slope. On the basis of motion of the sun, in different seasons and site locations the maximum radiation may be higher for a double slope still and the performance may also be better. On the other hand, a single slope still has less convection and radiation losses and the shaded region may be utilized for additional condensation as will be seen below. On the basis of yearly performance data for Delhi climatic conditions Tiwari and Yadav (1987) concluded that a single slope still gives better performance than a double slope for cold climatic conditions, whereas for summer climatic conditions the double slope gives better performance.

2.1.2. Basin Still with Cover Cooling

Evaporation rate can be increased if the difference in temperature between the basin (heat sources) and the glasses cover (heat sink) increases. This can be achieved by either increasing the basin temperature or decreasing the cover temperature, or both. Two cooling arrangements have been suggested, both using a double glass cover. These two methods are shown in Figure 2 (Elsayed et al. 1986), and termed feed back flow and counter flow. Results have shown that cover cooling produces an increase in the productivity of the still, with the improvement being greater when using the feed back flow than when using the counter flow.

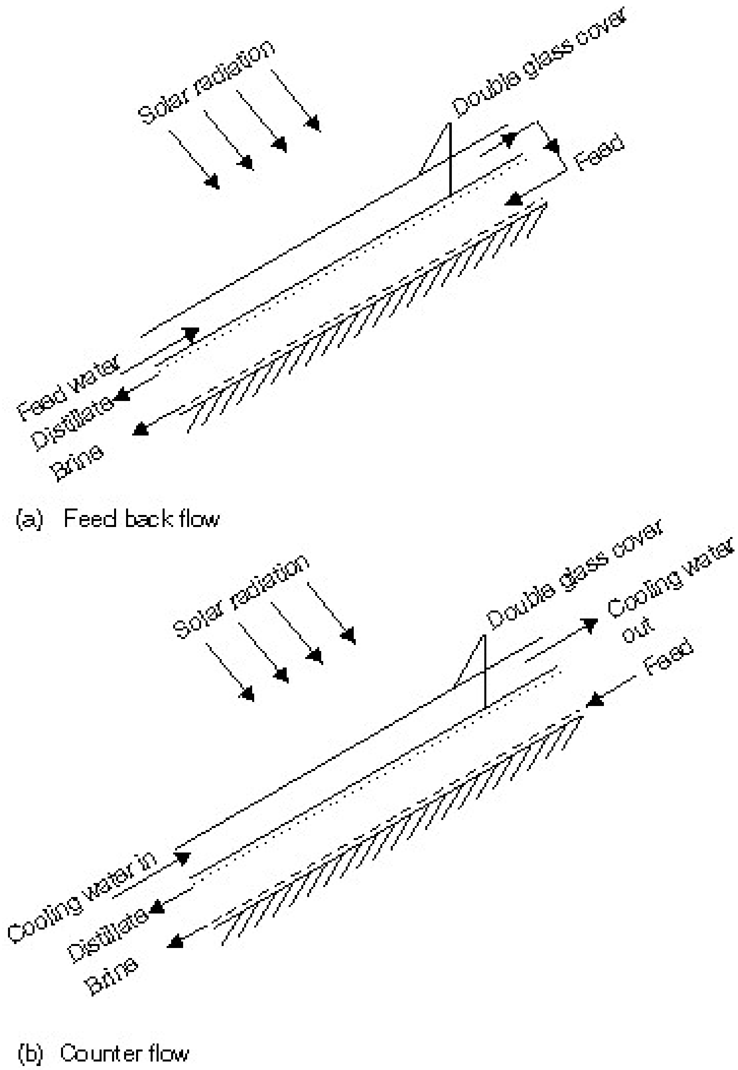


Figure 2. Cooling of glass cover by (a) feed back flow and (b) counter flow.

2.1.3. Basin Still with Treated Cover Surface

One way to improve the yield of a basin still is to increase the wettability of the glass cover. This makes it possible to reduce the slope of the glass cover which, in turn, reduces the distance of the gap between the water surface and the cover. Baladori and Eldin (1973) showed that the use of sodium metasilicate or hydrofluoric acid to treat the inner surface of the glass cover increases its wettability and reduces the minimum permissible cover slope 1.5 degrees from horizontal plan, which increases the yield of the still. The authors recommended that the external surface of the glass cover should not be treated, because the treatment encourages the accumulation of atmospheric dust.

2.1.4. Basin Still with Additional Condenser

Instead of having one continuous basin, Moustafa et al. (1979) suggested the use of a stepped basin as illustrated in Figure 3. To improve the performance of this stepped solar still, a secondary condenser was used on the shaded side of the still. The function of the secondary condenser is to increase the rate of condensation of the evaporated water vapor in the still. The results showed, however, that the use of a secondary condenser reduces both the product rate and the operation efficiency of the still. On the other hand, Fath and Elsherbiny (1992, 1993) proposed the addition of a passive condenser in the shaded region of a single sloped still, shown in Figure 4. Three methods of vapor transfer from the still space to the condenser were addressed: diffusion, purging and natural circulation. The authors indicated that diffusion effect is very small. Purging is a function of the volume ratio between the additional condenser and the still, and the still efficiency increases by 45 per cent. Natural circulation increases the still productivity by up to 75 per cent depending on the circulation flow resistance.

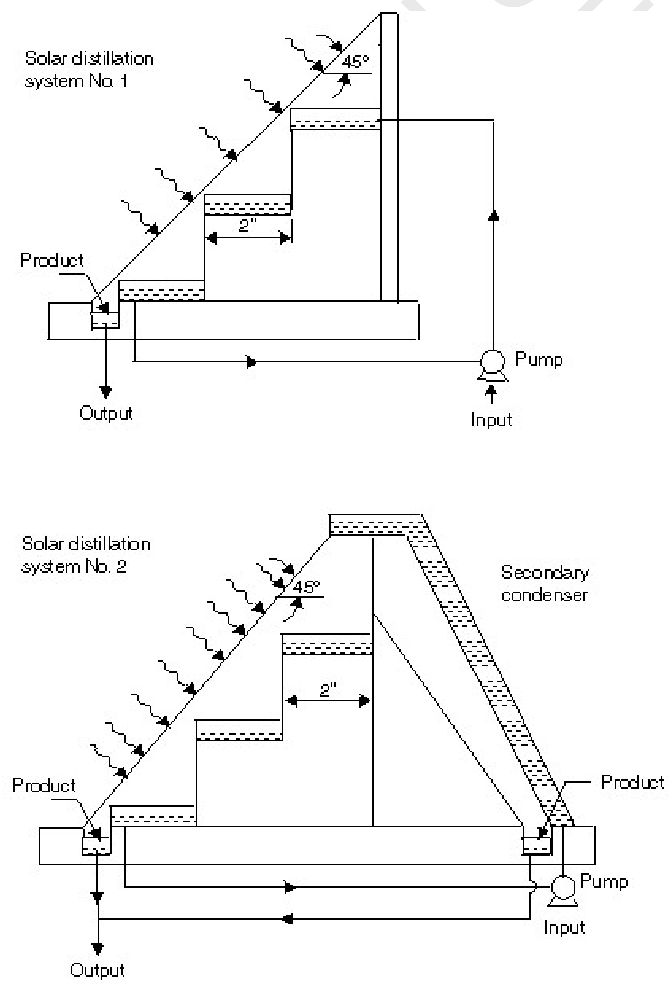


Figure 3. Basin type stepped solar still with and without condenser on the shaded side of the still.

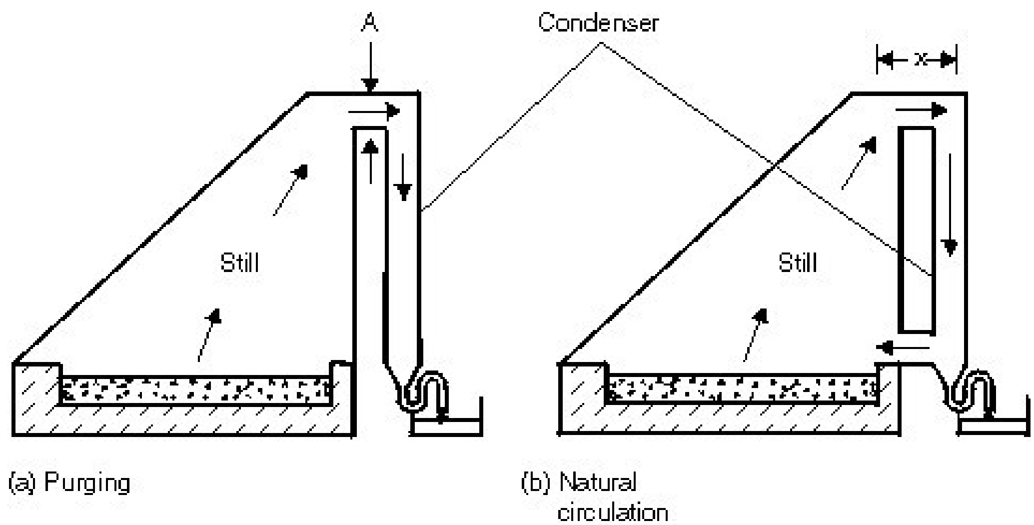


Figure 4. Single sloped still with passive condenser.

2.1.5. Basin Still with Black Dye/Muddy Water

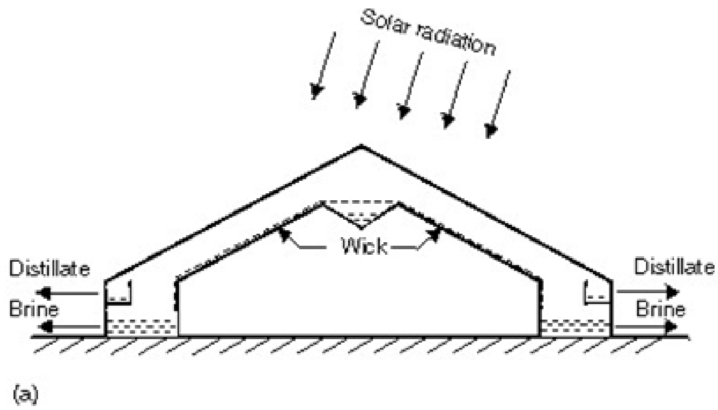
Different investigators have used dye in water to increase basin water temperature. Sodha et al. (1980) and Lawrence et al. (1998) indicated: (i) a significant effect of dye on still performance particularly for large water depth; and (ii) black dye gives better performance than violet and red dyes.

Saline water is transparent and so permits appreciable penetration of solar radiation incident, with the result that the bulk of water is heated up to some intermediate temperature. Muddy water on the other hand is opaque, and so the incident solar radiation gets absorbed mostly around the top layer which gets appreciably heated up. Not much information is available on muddy and polluted water which in some regions of the world may be the only source of water. The results of Onyegegbu (1984) for distillation of muddy pond water indicated (on the daily basics) that the muddy water and clear water samples yield the same distillate output.

2.2. Wick Stills

2.2.1. Single-wick Stills

It has already been established that a reduction in the depth of brine in the basin of the single effect type still improves the productivity of the still, mainly due to the higher basin temperature. This conclusion led Frick and Sommerfeld, see Elsayed (1986), to design a wick-type collector-evaporator still as illustrated in Figure 5(a). The advantage of the wick is to keep the brine as shallow as possible while avoiding dry spots. The results of a still of this type using a plastic cover located at Valparasio, Chile showed a production rate of 3.8 to 4.4 liters m^{-2} per day with an operational efficiency of about 40 to 46 per cent. An improved design for the wick-type collector-evaporator still is shown in Figure 5(b) as carried out by Moustafa et al. (1979). The results of this design indicate a tremendous improvement in the productivity and operational efficiency.



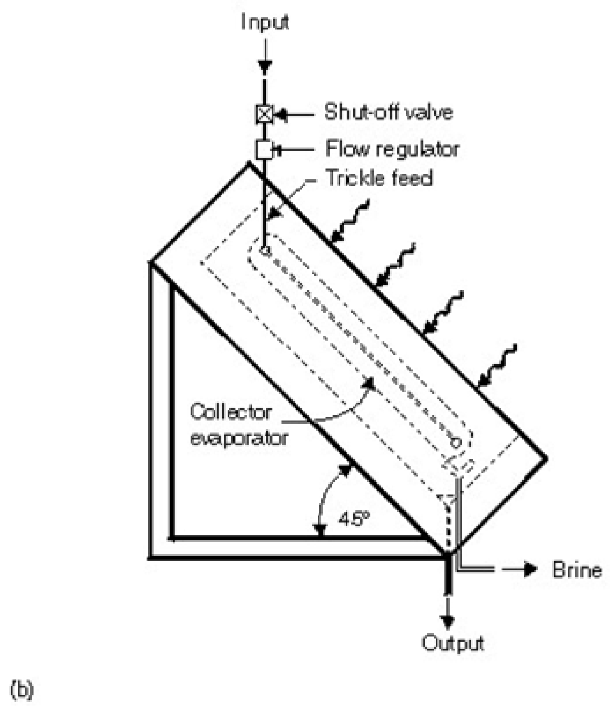


Figure 5. Single-effect single-wick stills: (a) wick type collector-evaporator still; (b) modified wick-type collector-evaporator still.

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