Analysis of the Design Parameters of a Single-Effect Solar Still

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Introduction

Potable water is highly scarce in many areas of rural India, and combined with lack of stable electricity, presents an almost insurmountable challenge for people to source drinking water. The traditional method of digging wells is not viable in the face of dropping water tables, and a suitable, green alternative is needed to supply the bare minimum of 5 l/day water required per person for survival, as shown by the WHO in its study [1].

One simple and time tested solution is using solar energy to evaporate and then re-condense water to purify it. The scope of this work has been limited to passive, single effect solar stills, based on the work of Pednekar et al. (2018) [2], where-in the various design parameters and their effect on the efficiency of the still have been explored.

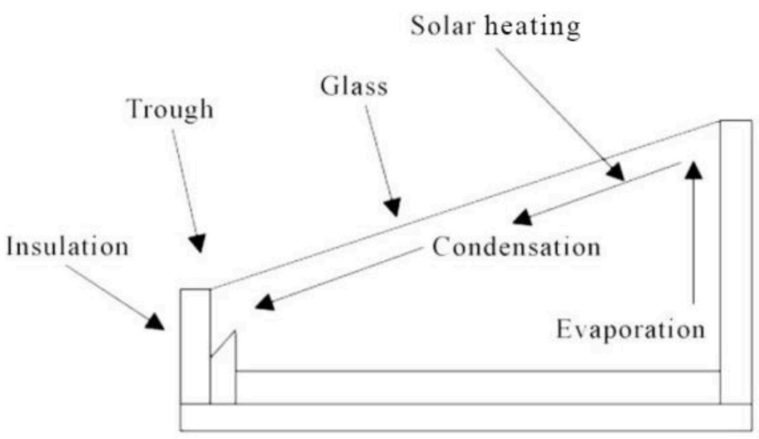

Figure 1: A simple schematic of a single basin solar still [2].

State of the art

The mathematical model of the solar still (fig. 1) was specified by Dunkle [3] and Cooper [4]. The still is modelled as a thermal circuit shown in Figure 2. The light incident on the top cover consists of short wave solar radiation, G_s, and long wave radiations G_L. The amount of energy that passes through the cover is τG_s. Of this, the amount of solar energy that strikes the bottom of the still basin is $\alpha\tau G_s$; this represents the amount of solar radiation absorbed per unit area of the still. The value of $\alpha\tau$ is approximated to 0.8 by Dunkle [3], this value is also used in this work.

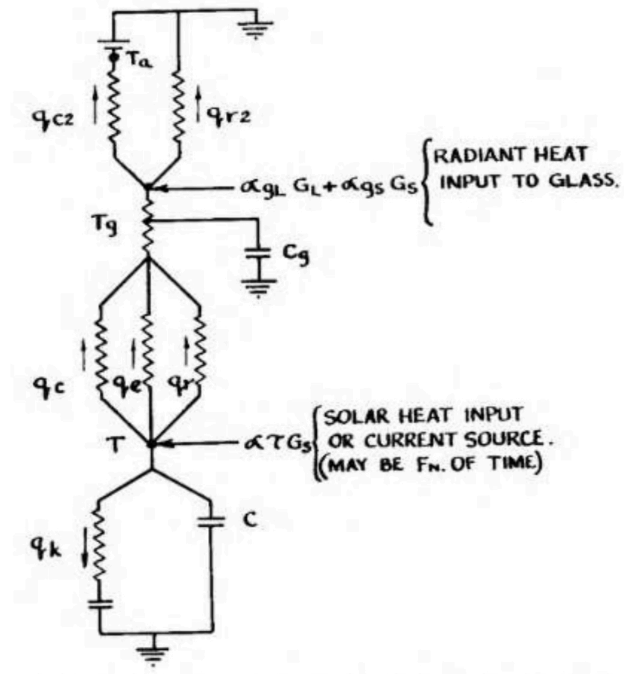

Figure 2: A thermal of a single basin solar still [3].

From this work, the avenues for improving the output of a still are as follows:

- Heat lost from the sides of the still
- Incident solar energy on the bottom of the still
- Heat absorbed by the bottom of the still

These are translated into design parameters as follows:

- Material of the sides of the still
- Material of the bottom of the still
- Insulation on the sides of the still
- Material of the top cover of the still
- Inclination of the still

Some other design considerations are:

- Presence of external condenser
- Presence of a mirror to concentrate the input

Though these parameters have been explored by other researchers previously, there is no consensus reached for a still design that works in various regions of India with consistent output.

Objectives

The objectives of the work are:

- Experimentally validate the impact of the various design parameters
- Modify the design of the still in order to achieve an output of $5 l/m^2$ per day

Expected deliverables

Phase 1: An experimental setup to measure and evaluate the impact of the design parameters

Phase 2: Modified design that can demonstrate an output rate of $5 l/m^2 \ per\ day$

References

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2. Pednekar, A., D. Chatterjee, and S. Bandyopadhyay, Performance evaluation of solar stills. In International Conference on Mechanical Engineering. 2018.
3. Dunkle, R. (1961). Solar water distillation: the roof type still and the multiple effect diffusor. Int. Dev. in Heat Transfer.
4. Cooper, P. (1973). The maximum efficiency of single-effect solar stills. Solar Energy, 15(3), 205–217.