High level product specifications for very very low cost solar powered portable water distiller

Theertham - NGO or nonprofit organization formed in the state of Texas, USA

Author, CEO, **Vishwa Narayan,** BE(Hons)EEE, MS(EE), Ph.D(EE)

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Introduction

This document defines the high level requirement specifications for a very very low cost solar powered portable water distiller.

The key components of the distiller, named the **quencher** are:

1. input water tank and connectors
2. input water tank filters
3. selective solar energy absorber
4. heat pipe structure that concentrates absorbed solar energy
5. evaporator
6. condenser
7. sludge remover
8. output water tank and connectors
9. solar tracker
10. supports and stand

1. input water tank and connectors

1. capacity 20 litres
2. tank lid
3. items 1 and 2 made of sturdy plastic, extruded epoxy, or some other very sturdy material, to withstand 50 years of rough usage
4. sturdy metal connectors and pipes, from input water tank into evaporator

Output section of input water tank must feed into evaporator via metal connector pipes. Evaporator is expected to be at a maximum of 100 deg C. Operating range is likely 80 to 90 deg C.

2. input water tank filters

input water filters must also be made of very sturdy material, such as very rugged plastic. Perforated filters are removable and washable, and then replaced into input tank section. More than one filter is required, perhaps a series of three or four filters, such that each filter removes smaller and smaller particulates, the smallest particles are of the order of 1 mm in size. The largest particles are of the order of 5 to 10 mm in size. (3 or 4? we'll decide later).

3. Selective solar energy absorber

Solar energy selective absorber is made of metal coated with appropriate coating such that emissivity is as high as possible at sunlight wavelengths of 250 nm to 2.5 microns, and emissivity is as low as possible at wavelengths radiated by objects at 90-100 deg C – the temperature reached once the system attains steady state, i.e., at wavelengths of 10 to 30 microns a **'selective' absorber is very desirable** as it minimizes IR radiative energy loss.

Note:

Almeco-TiNOX makes a good selective absorber. it absorbs most sunlight – '95 % of incident light' and radiates very little in the infra-red – '4 %', so that around '90% of the solar energy can be used as heat.(as opposed to almost 50 % for a non selective black surface absorber), so that around '90% of the solar energy can be used as heat'.

How-ever, this is an expensive solution.

TiNOX is a 'hi-tech' selective absorber made of multiple layers deposited in a semi-conductor like process involving vacuum chambers. This is probably too expensive for our use. But we need to verify the price of this product before eliminating it as a possible solution.

There are other, simpler, selective absorbers. Dr. Md. Golam Mowla Choudhury from the Department of Physics, University of Rajshahi, Bangladesh, in his paper titled 'Selective Surface for efficient Solar Thermal Conversion' describes several of these lower cost solutions.

Specifications for a good selective absorber are:

1. **high sunlight-emissivity at 0.2 – 3 microns (target 80 % or more).**
2. **Low emissivity for greater wavelengths of 3 to 30 microns (target emissivity of 10 % or less)**, with sharp transition between the two spectral regions.
3. stable opto-physical properties over long term (50 years) operation at elevated temperatures up to 100 deg C, repeated thermal cycling, air exposure, and ultra-violet radiation.
4. if it is a coating, good adherence to substrate.
5. coating must be easily applicable
.
6. and finally, absorber must be economical and affordable.

The selective absorber may look like something shown below, as a disc of 1 sqm surface area. The hot surface may be coupled to a custom designed 'heat pipe'. It will heat up to 80-90 deg C at its operating point, due to direct heating from the sun.

Absorbers such as **copper oxide, nickel black, black chrome and cobalt oxide** are listed. while these selective absorbers may not perform as well as TiNOX, they, and others of their ilk, are worth a good look, because they may be simple, relatively easy to make and cost effective.

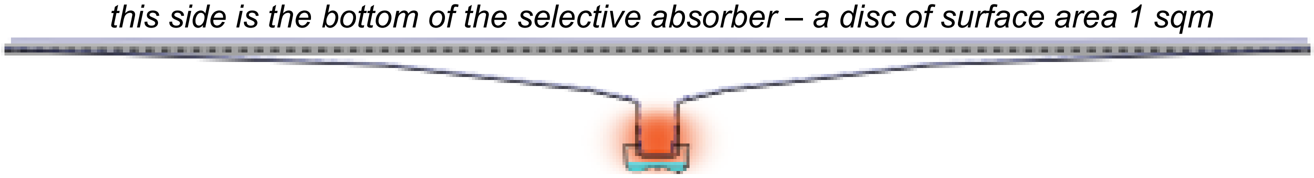
Target is to get to MAGE performance specification, if possible but at low cost will be the ultimate solution.

Note: both surfaces may be of any shape, not the shape shown in the schematic above.

4. heat pipe structure

The heat pipe structure concentrates the solar energy collected by the selective absorber and delivers it to where it is required – at the evaporator.

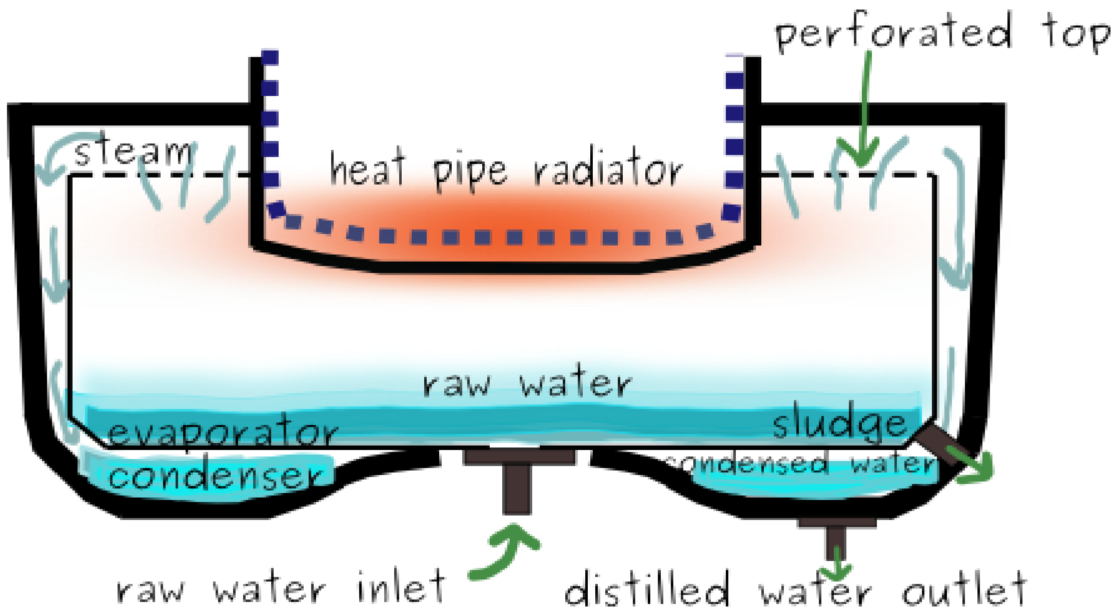
this side is the bottom of the selective absorber – a disc of surface area 1 sqm



this side is the heat dump into the evaporator-condenser-waste remover combination

1. A specially designed or custom heat pipe of the shape shown below, or other shapes, may be considered.
2. Heat pipe structure will transfer the heat to the heat dump end, for use within the evaporator.
3. Once unit attains steady state, heat dump end must be in the 80-90 deg C range.
4. Heat dump end must continuously transfer heat to the evaporator even as the selective absorber tracks the sun, and tilts from east to west each day, and incrementally moves N-S-N over the seasons.

5-6-7. Evaporator-condenser-sludge remover combination



The evaporator-condenser-waster (or sludge) remover is a tightly integrated unit. This is required so that the heat released during condensation may be reused to preheat raw incoming water, which greatly improves the efficiency of the system.

Reuse of latent heat of condensation is essential.

The thermodynamic coupling of the evaporator-condenser may be achieved In multiple ways. Here is one schematic of the evaporator-condenser-waste remover combination.

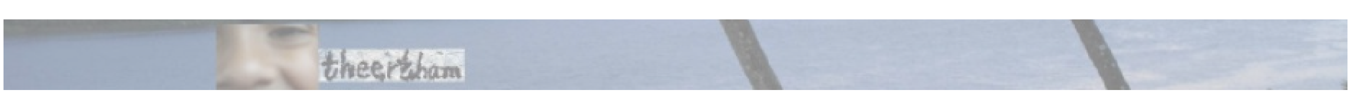
Notes:

1. This need not be the final design.
2. In this design, the outside of the condenser needs to be thermally insulated.
3. The sludge remover may be in the form of a plate, different ideas are solicited.
4. A potential problem with this arrangement is that it will may cause issues as the unit tilts along with the heat absorber, when the sun is close to the horizon in the mornings and evenings. This might still be possible though.

8. output water tank and connectors

Output water tank is very similar to the input tank in that it is of 20 litre capacity, and is made of the same sturdy plastic as the input tank.

It differs from the input tank in that: there are no filters, but there is a spigot or tap instead, to



draw water. The tank may need to withstand temperatures of up to 90 deg C.

Metal connecting pipe and connector from the condenser to the output water tank must also withstand temperatures of 90 deg C.

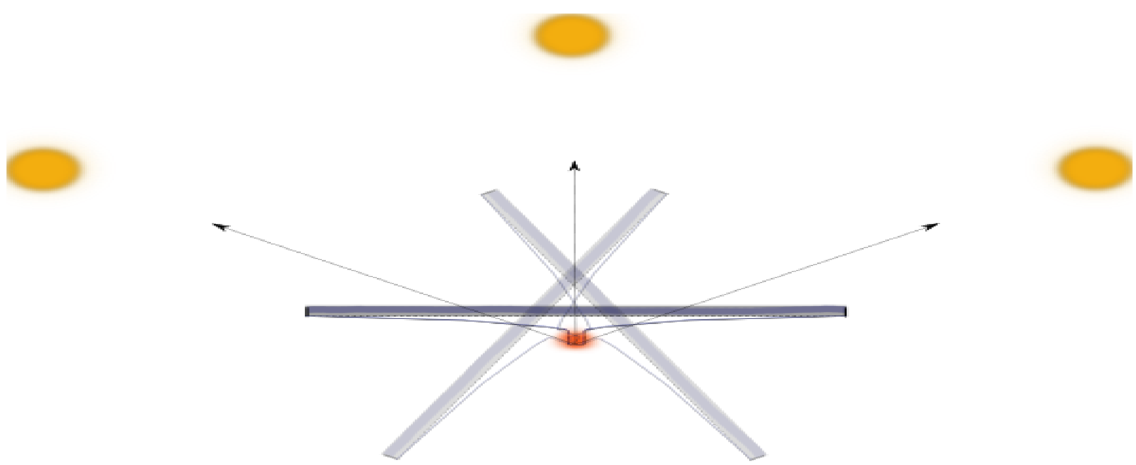
9. Solar tracker

Solar tracker ensures that the solar collector (or selective absorber) continuously points at the sun to within +/- 1 degree. This improves efficiency of the system significantly when compared with a non tracking fixed install absorber, because constant continuous heat transfer to the evaporator is required, even as the unit tracks the sun.

The absorber shall be manually pointed at the sun, alignment being determined from the shadow cast on the ground by the absorber. The absorber is aligned with the sun when the shadow cast by the absorber is the smallest in size. A lever or a button is now engaged, to initiate tracking.

The energy for tracking is provided by a wind-able arrangement, much like a mechanical clock, which is wound before alignment and engagement. Key is taking advantage of the robustness of the ‘time piece’ design. Tracking is required from -60 deg from zenith up to +60 deg for daily East-West movement.

+30 to -30 degree daily incremental adjustment in the axis orthogonal to the E-W axis is also required, to track the North-South movement of the sun over the seasons. This is accomplished by unlocking the mechanism, manually performing the N-S alignment with the sun (by looking at the shadow cast by the absorber, once again), and once again locking the system to the tracker. Tolerance to +/- 1 degree is required.



10. Supports and stand

sturdy mechanical stand, with levelers. Details to be fleshed out later.