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Bubble Wrap: The Key to a New Floating Solar Thermal System

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ABSTRACT
Solar Thermal Energy (STE) is a form of energy and a technology for harnessing solar energy to generate thermal energy or electrical energy for industries and to desalinate water and to treat waste water, among other things. Here we demonstrate a floating solar receiver which is capable of generating 1000C steam under ambient air conditions without optical concentration. Here the high temperatures are achieved by using thermal concentration and heat localization. This reduces the convective, conductive and radiative heat losses. This demonstration of a low-cost and scalable solar vapour generator holds the promise of significantly for expanding the application domain and reducing the cost of solar thermal systems.

KEYWORDS: *Introduction, Construction, Operation, Advantages, Applications, Conclusion*

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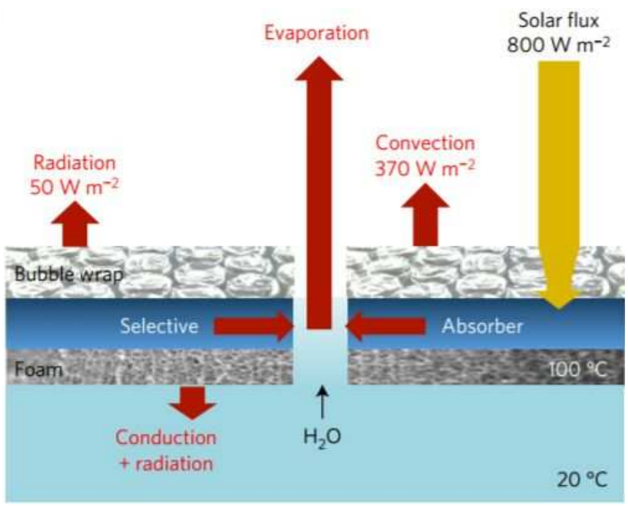
INRODUCTION

Solar thermal technologies, converts the sunlight to thermal energy are being developed for many applications such as power generation, desalination and other industrial processes. Steam and vapour generation is often desired in these applications. But the dilute solar flux (1,000Wm^{-2}) does not provide enough power per unit area of the absorber to reach the required high temperatures .Optical concentrators, such as parabolic troughs, heliostats and lenses, can concentrate the ambient solar flux tens or even thousands of times to achieve high temperatures. These optical concentrators cost a major fraction of capital of solar thermal systems. Under the normal level of sunlight, water can be boiled through the new system which generates steam without optical concentrations. It is a multilayered structure, solar receiver, that floats on water. A new approach for producing low cost Solar Thermal Panels devices has been demonstrated.

Construction:

Achieving steam generation using the ambient solar flux (1,000Wm^{-2}), or one sun, requires significant reduction of the heat losses from the receiver. The middle layer of the solar receiver consists of a copper sheet covered in a blend of ceramic and metal. It efficiently absorbs solar energy, and is also a good conductor of heat. The bottom layer consists of foam that helps the entire structure float. The top layer is made of transparent bubble wrap that lets sunlight reach the absorptive layer. This layer minimizes the convective losses. The solar transmittance of the bubble wrap was measured to be 80%. It reduces the convective heat losses.

A wick made of fabric tunnels through the foam, helping draw water upward, and a sheet of cotton fabric between the foam and the absorptive layer helps spread this water out. Water inside the solar receiver is heated by the absorptive layer. A slot that runs through both the bubble wrap and the absorptive layer allows steam escape.



Energy balance and heat transfer in the developed one-sun, ambient steam generator (OAS).

The overall design of the structure concentrates thermal energy within it. The foam keeps the absorptive layer from losing heat to the cooler underlying water, while the bubble wrap prevents the absorptive layer from losing heat to the air. It is transparent enough to allow solar energy to pass through to an absorber; however, the large air pockets allow bubble wrap to trap the absorbed heat, leading to higher efficiencies. The bubble wrap can be likened to a greenhouse.

Operation:

A solar simulator was used to supply solar flux (1,000Wm^{-2}), and a balance was used to measure the real-time mass loss of the receiver and water supply. The selective absorber temperature and vapour temperature were measured (Fig. a) as a function of the thermal concentration the ratio of the total illumination area to the evaporation area. The vapour temperature closely tracks the selective absorber temperature. The maximum steam temperature reached was 98^{0}C.

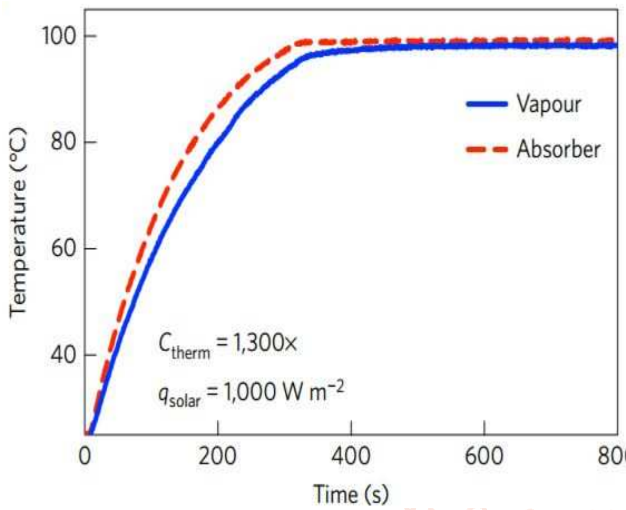


Fig. a: Vapour and selective absorber temperatures versus time at a thermal concentration of 1,300x.

This was achieved when ~0.1% of the surface is devoted to evaporation. The steam temperature .was directly measured by the thermocouple using a small vapour chamber. The kink near t = 300 s clearly indicates boiling limiting further temperature rise of the solar receiver, despite the measured vapour temperature not exactly reaching 100^0 C due to the rapid cooling of vapour.

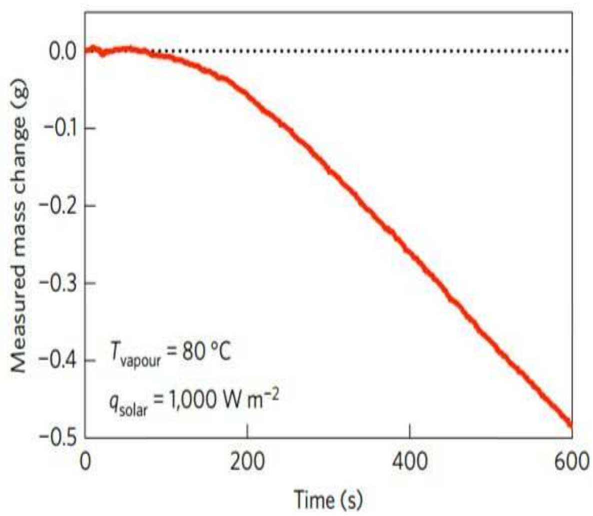


Figure b: Mass change over time, when the produced vapour temperature is 80 ^{0}C.

Figure b shows the mass change as a function of time while generating 80^{0}C vapour. These figures show the receiver reached steady-state operation in roughly5 min, clearly demonstrating continuous steam generation under1 sun illumination.

Advantages:

- When compared to blackbody absorber, a spectrally selective absorber has high solar absorptance and low thermal emittance.
- It is a non economical system.
- Produces steam at both low and high temperatures.
- Spectrally selective absorber emits very little radiative heat.

Applications:

- Applications of this solar receiver includes desalination and wastewater treatment.
- For desalination, there is a need to tweak the system to maximize production of lower-temperature water vapor and then develop a way to condense the vapor for collection.
- For wastewater treatment needs the vapor to be dissipated into the atmosphere, leaving behind smaller but more manageable quantities of concentrated waste.
- Spectrally selective absorbers are widely used in domestic solar hot water systems and allow evacuated solar hot water tubes to be heated to over 100^{0}C under stagnation conditions.

Conclusion:

- Thus bubble wrap system is an efficient and non economical system that traps solar energy and provides steam at low temperatures.

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