Solar pond

A salinity-gradient solar pond is an integral collection and storage device for solar energy. By virtue of having built-in thermal energy storage, it can be used irrespective of time and season. In an ordinary pond or lake, when the sun's rays heat the water, this heated water, being lighter, rises to the surface and loses its heat to the atmosphere. The net result is that the pond water remains at nearly atmospheric temperature. The solar pond technology inhibits this phenomenon by dissolved salt into the bottom layer of this pond, making it too heavy to rise to the surface, even when hot. The salt concentration increases with depth, thereby forming a salinity gradient. The sunlight reaching the bottom of the pond remains entrapped there. The useful thermal energy may then be withdrawn from the solar pond in the form of hot brine or by means of heat exchangers. Power production has been demonstrated on a small scale using heat exchangers but there are no commercial installations.

Salinity-gradient solar ponds were not invented; they were discovered. The phenomenon was first observed in Transylvania, Romania, in the early 1900s. Solar ponds work in winter, even when covered with a sheet of ice and surrounded by drifts of snow. Natural salinity-gradient ponds or lakes form when fresh water flows onto salt brine and mixes to create a salinity gradient. Ours will be a highly engineered version of this natural phenomenon.

Fluids such as water and air rise when heated. The salinity gradient stops this process when large quantities of salt are dissolved in the hot bottom layer of the body of water, making it too dense to rise to the surface and cool.

Generally, there are three main layers. The top layer is cold and has relatively little salt content. The bottom layer is hot -- up to 100°C (212°F) -- and is very salty. Separating these two layers is the important gradient zone. Here salt content increases with depth. Water in the gradient cannot rise because the water above it has less salt content and is therefore lighter. The water below it has a higher salt content and is heavier. Thus, the stable gradient zone suppresses convection and acts as a transparent insulator, permitting sunlight to be trapped in the hot bottom layer from which useful heat may be withdrawn or stored for later use. Brine at 180°F has a sub-atmospheric vapor pressure of about 8 psia. Our expander will be driven by the vapor pressure.

The energy obtained is in the form of low-grade heat of, say, 80 °C compared to an assumed 20 °C ambient temperature. According to the second law of thermodynamics (see Carnot-cycle), the maximum theoretical efficiency of a solar concentrator system is: 1-(273+20)/(273+80)=17%. By comparison, a power plant's heat engine delivering high-grade heat at 800 °C would have a maximum theoretical limit of 73% for converting heat into useful work (and thus would be forced to divest as little as 27% in waste heat to the cold temperature reservoir at 20 °C). The low efficiency of solar ponds is usually justified with the argument that the 'collector', being just a lined pond, might potentially result in a large-scale system that is of lower overall energy cost than a solar concentrating system.

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