Innovative Food Science and Emerging Technologies 41 (2017) 34–46

Contents lists available at ScienceDirect

Innovative Food Science and Emerging Technologies

journal homepage: www.elsevier.com/locate/ifset

Solar still with latent heat energy storage: A review

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A R T I C L E I N F O

Article history:
Received 20 December 2016
Received in revised form 30 January 2017
Accepted 30 January 2017
Available online 31 January 2017

Keywords:
Latent heat storage
Solar still
Phase change materials
Desalination

A B S T R A C T

The requirement of fresh water is growing exponentially in industrial as well as domestic sector, resulting in more pollution of natural water resources and creating a scarcity of drinking water. Additionally, the number of arid and desert regions on the world map which already face the shortage of rainfalls and ground water. The problem is substantially increased as most of the water bodies like rivers, lakes are saline and brackish which are not suitable for drinking purpose. In recent past, solar desalination has been found to be a sustainable and economical way of generating the fresh water to cater the need of drinking water at large. Much technological advancement in the field of solar stills has been made which can ably produce a large quantity of fresh water depending on the availability of solar radiation. Various desalination schemes have been utilized to utilise water from such available resources to convert the available water in to the drinkable water. Additionally, attention has also been put on developing efficient solar still with latent heat based thermal energy storage systems which can work in the absence of sunlight as well. In the present paper, a short review on solar stills utilizing latent heat storage has been presented. The present study covers the design specifications, efficiency, along with the comparative analysis of solar stills with latent heat storage system, investigated in the last decade. A discussion on the future research outlook in the area of solar stills with latent heat storage has also been given, so as to make it more economically viable for generating sustainable potable water.

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1. Introduction

Extensive use of chemical fertilizers in agriculture and growth of industrial activities has caused the pollutants to leach down to underground subsurface water; hence, the drawing of water through Hand-Pumps is no safer for drinking purposes. Almost 90% of major health hazards in rural areas are caused due to drinking contaminated water. Women and children are generally more affected because they are quite susceptible to water-borne diseases. Out of 40–50 L per capita per day (lpcd) of water needed for domestic consumption, only 2 lpcd is the drinking water. A total quantity of 5–10 lpcd water is desired for

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http://dx.doi.org/10.1016/j.ifset.2017.01.004
1466-8564/

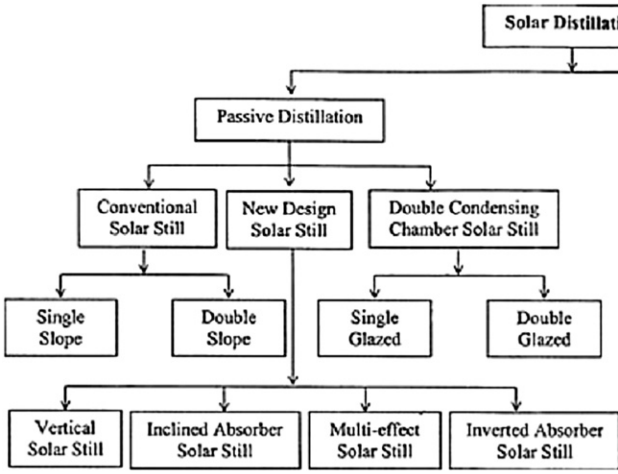

Fig. 1. Classification of solar distillation process(Kuram & Ozcelik, 2014).

cooking and drinking purposes and consequently, it is only this quantity of water that needs to meet the stringent quality standards of potability prescribed by W.H.O. (World Health Organization) or other similar agencies, while the remaining amount of water required for washing and cleaning can be of intermediate quality. Keeping in view of the needy mass, belonging mainly to the lower paying capacity of the society, water supply to remote areas through pipeline could be imprudent and moreover, it may also increase the wasteful use of high-quality water in washing, cleaning, and toiletries. Hence, for cost-effective and sustainable water management system, it is important to supply water at an appropriate level of quality, which is enough available with the least expenditure.

With the growth in population, increasing pollution due to the industrial growth, transportation etc., the fresh water sources which are limited on earth's surface are getting exhausted at a much faster pace (Tiwari, Singh, & Tripathi, 2003). Also in the desert, rocky and arid regions of the world, there is intermittent rainfall leading to acute ground water deficiency. This leaves us with the only feasible solution - to derive fresh or potable water from the globally available brine and saline water resources by desalination (Gopal Nath Tiwari, 2002). The same elementary principle that is involved in the generation of rainfall through the hydrological cycle which happens in nature is applied in all the artificial desalination systems so as to produce fresh water from the salty resources. The elimination or separation of salts from the water cannot be attained automatically but it is done in desalination systems by the assistance of some energy source (Qiblawey & Banat, 2008).

In most of the cases, the direct use of seawater is not possible because it is made up of different types of salts. Distillation is a recognized thermal process for the purification of water and prominently water desalination. Most of the conventional water purification procedures are highly energy consuming and require fossil fuels or electricity for its operation. Solar energy can be used to produce fresh water directly in a solar still or indirectly where the thermal energy from a solar energy system is delivered to solar still. One way to enhance solar energy utilization is to accumulate the energy throughout sunshine hours of higher solar incidence for later use of essential needs. Effective storage technologies are necessary to store energy for twenty-four hour cycles to meet energy demand. Energy storage would permit the power generation for night periods and will provide support for matching the generation and demand peaks. Thermal energy storage (TES) comprises the reversible alteration of enthalpy of a storage material. It is especially thermodynamically eye-catching and economically promising technology. Sensible heat storage is associated with the temperature increase of the storage medium. Solar distillation uses the heat of the sun directly in a simple piece of equipment to purify water. The tool, commonly termed as solar still, contains primarily of a shallow basin with a transparent glass cover. Incident solar radiation heats the water in the basin, causing evaporation. Moisture rises and condenses on the cover and runs down

Table 1
Desirable properties of phase change materials.

Thermodynamic properties	Kinetic properties	Chemical properties	Physical properties	Economic properties
• Large enthalpy of transition with respect to the volume of the storage unit; • High change of enthalpy near temperature of use; • Phase change temperature fitted to application; • The latent heat should be as high as possible to minimize the physical size of the heat storage; • High latent heat of fusion per unit mass, so that a lesser amount of material stores a given amount of energy; • A melting point in the desired operating temperature range; • Fixed and clearly determined phase change temperature (freeze/melt point); • Congruent melting point to avoid segregation; • Lower change of volume during phase change; • High density, so that a smaller container volume holds the material • High thermal conductivity (both liquid and solid phases) would assist the charging and discharging of the energy storage high specific heat that provides additional sensible TES effect and also avoidsubcooling.	• Limited or no undercooling during the freezing process; • Sufficient crystallisation rates.	• No chemical decomposition, so that the latent TES system life is assured; • Non-corrosiveness to construction material; • Long-term chemical stability; • Non-poisonous; Non--toxic; • Non-explosive, non--dangerous; • Non-flammable.	• Limited changes in density to avoid problems with the storage tank; • High density with low--density variation; • Small units size; • Low vapour pressure, • Favourable phase equilibrium.	• Available in large quantities; • Cheap in order to make the system economically feasible