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Impact of temperature difference (water-solar collector) on solar-still global efficiency

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Abstract

Different theoretical and experimental studies carried out in the field of solar distillation with green-house effect, have shown that global efficiency of a simple solar still are affected by physical and building parameters, especially by the difference of temperature between the evaporation surface and that of the condensation. Optimising this difference allows us to obtain a solar still with a better efficiency. A mathematical modelling has been carried out aided by some basic and simplified hypotheses, according to overall thermal balances and appropriate heat and mass coefficients, while taking into consideration a stagnant area in the solar still. Resolution of equations, based on method of finite differences, has shown that a better efficiency is obtained at a maximum temperature difference, as well as we can obtain this latter by a low glass thickness, a gradient (angle of inclination) closer to that of the area latitude, in which our solar still is placed, a low thickness of the solution to be distilled and a high wind velocity. Results issued from this study show clearly the importance of a cooled condensation surface and a hotter evaporation surface.

Keywords: Backish-water desalination; Solar distillation; Global efficiency; Evaporation; Condensation; Temperature difference

1. Introduction

Considering the increasing demand on water all over the world and the water resources depletion, sea-water and/or brackish-water desalination are considered, in fact, as a contemplated principle to realise, in order to obtain soft or drinking water. In Algeria, the problem of water supply is being faced, where saline water is available and desalination represents a solution for water resources increase.

Progress in desalination has been made to the point where industrial units have been set up using energy with a high cost price of a produced water cubic meters. In spite of having a low efficiency, solar distillation proved to be a process of soft-water production, economically

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viable, particularly in desert areas, which have an important solar deposit and where rainfall is rare or mostly absent. However, in the case of the south of Algeria, an important groundwater resource, mostly brackish, is available and where solar distillation can be an adequate solution to face the increasing demand on soft water.

The aim of our work is to study the energetic global efficiency of a solar still with a green-house effect, which is dependent on the temperature difference between the brine and the inner side of the glass, on the climate and geometric parameters and on those related to the brine. A theoretical study has been carried out in order to set up equations governing the performance system as well as parameters influencing solar-still efficiency.

By knowing equations governing the inner and the outer heat transfer and through experimental models, we can, by mathematical simulation, set up an adequate solar still and elaborate a mathematical model, being able to meet distilled-water demand and where efficiency can reach acceptable values.

2. Literature review

It seems that Egyptians who discovered first green-house effect. Use of solar energy began in the third century before J. C, by Archimedes and 100 years after J. C, by Heron of Alexandria, in 1615 by Salomon de Gauss, in 1774 by Joseph Priestley and in 1878 a solar still of 5000 m^2 has been set up in the desert of Atacama (Chile), in order to supply in water a mine of sodium nitrate. After 1878, works on solar energy has slow down because of fossil energy availability in a lower cost. Solar energy has been reused from 1902 to 1908, by Schuman who built up solar machines with much horse power to pump water.

In 1913, Boys set up, near Cairo (Egypt), a big machine of 50 horse power with lengthy parabolic cylinders which concentrates solar radiations upon a central pipe with a concentration factor of 4.5, in order to pump water from the Nile River for irrigation purpose.

Solar energy still being used till 1938, from which there was no other progress in solar-energy field, because of its lack of competitiveness compared to energy issued from fossil fuels. From 1950, use of solar energy, began to develop slowly [1]. Among solar energy uses, we can quote heating and air conditioning for respectively building, solar swimming-pools, salt production through salted-water evaporation, drying products issued from agriculture and animals, solar cookers and pumps, food preservation, photovoltaic conversion, solar furnace, electricity production, indirect solar-energy conversion, wind energy, hot-water production and for domestic and industrial use and distilled water [2].

3. Main characteristics of saline water

Water resources the world is mostly saline, of which an excessive salt content renders their use inappropriate for human activities, and where salt elimination is required. Sea water and brackish water can then be distilled.

Sea-water composition is variable; it contains about fifty simple substances, where chlorine represents 55% from the total weight of the dissolved salts. However, sea-water salinity is closer to 35 g/l, but it changes from one sea to another.

Brackish water is defined as saline water not drinkable, where its salinity is lower than that from sea water; this salinity is usually contained between 1 and 33 g/l. Brackish water can be identified by its degree of salinity: waters called slightly brackish have a salinity between 1 and 3 g/l. Moderately brackish waters have a salinity between 3 and 10 g/l. High brackish waters have a salinity beyond 10 g/l. The first two categories are the most widespread, usually found in North Africa, in Middle Eastern countries and in some areas of USA. Chemical