Salt Water Desalination

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Abstract

Even though two thirds of our planet is covered by water, a lot of places on Earth are still lacking fresh water. We understand this problem, and our main goal was to create methods salt water desalination with considerably lower energy expense in comparison to already existing methods in order for it to be used for drinking as well as for irrigation. We have made our research and learned that even such highly productive method desalination as it is reverse osmosis, cannot be everywhere used for irrigation in agriculture. Energy expense of reverse osmosis is pretty good for production fresh water for drink and even for some sanitary needs, but it is not efficient for irrigation needs.

In that way we invented and made calculations of energy expense for our two new methods of salt water desalination. Both of these methods are very good for arid regions in general and for overwhelming majority of Arabic countries in particular. It is well known that in warmer latitudes the difference temperature of the upper and lower surfaces of the ocean is about 30C. Therefore namely that natural condition we decided to use for salt water desalination in our one of our methods.

We offered to fill up a basin with the warm sea water and above a basin to establish a moisture trap with a heat exchanger in it and to fill up a heat exchanger with cold water. According to our calculations, if the temperature of vapor-air mixture at the entrance of the moisture trap will be equal 309K with relative humidity equal 90% and the temperature of the cold water into the heat exchanger equal 279K, one can obtain about 480L of a condensate at expend 1kWh energy. It is at heating the cold water into the heat exchanger from 279K to 299K.

The second method that we have discovered also based on using natural conditions. In this method we offered to use cold water for a heat exchanger from an artesian well that located near the coast of ocean. Since the temperature of the subsoil water is approximately the same as the ocean water of the same depth, subsoil water can be used as the cold water for heat exchanger. As a rule under pressure stratums of soils cold subterranean water in artesian well itself rise on the surface of earth. As far as subsoil waters near coasts of oceans are forming by percolation from the deep layers of oceans, one can obtain unlimited quantity cold water for heat exchangers, therefore

during many years one can obtain fresh water without any expenditure of energy. It may only require the initial cost of very simple equipment and its mounting cost.

Expenditure energy for 1Kg fresh water produced by both of our methods in less expensive in comparison with reverse osmosis method desalination. One more and also very important advantage is the simplicity of producing, assembling and exploitation of these plants; they do not require a special training staff.

Both of our methods of salt water desalination can be used for irrigation in agriculture and allow for millions people obtain job in their countries, maintain their families and do not seek a piece of good luck in emigration.

Introduction

We devised three methods for the production of freshwater. It is very well known that ocean (sea) is warm only on the upper layers, since the temperature of water in deep is almost constant and equal to nearly 278 K. In the torrid zones the temperature of water on the surface of ocean often reaches 308 K.

First of all we decided to calculate how much freshwater we can obtain at expend 1 kWh energy. In our calculations we taken the temperature that fed into the basin 4 equal 303 K. The sea water in the basin 4 was heated both by heat exchange with platform 3 and with solar rays. Therefore the temperature of the vapor-air mixture at the entrance of moisture trap 5 we taken equal 309 K with relative humidity equal 90%. With such parameters of the vapor-air mixture the moisture content is g=0.03435 kg/kg of dry air. We taken the heat exchanger 6 as a steel pipe with a round cross section and diameter of 1 M and length of 1 M. At the existing dimensions of the heat exchanger 6 and density of sea water equal ρ=1030kg/M^3 the mass of sea water in the heat exchanger equal M_w~809kg. The specific heat of sea water at given salinity equal C_{pw}=3.93 kJ/kg K. The temperature of sea water in the heat exchanger we took equal T_c=279 K. We took the warmed up sea water into the heat exchanger at ΔT_w=20C, i.e. up to 299 K. In our calculations we used following formulas:

$$Q_w=M_w*C_{pw}*\Delta T_w \quad (kJ) \qquad (1)$$
$$C_p=C_{pa}+gC_{pv} \quad (kJ/kg\ K) \qquad (2)$$
$$Q_i=M_{va}*C_p*\Delta T_i+L_v*M_c \quad (kJ) \qquad (3)$$
$$L_v\sim 2500-2.3*T_s \quad (kJ/kg) \qquad (4)$$
$$M_c=\Delta g*M_{va} \quad (kg) \qquad (5)$$

Q_w=Quantity of heat that necessity for heating M_w of sea-water at ΔT degrees.
C_p=Specific heat of the moisture air with temperature equal 309 K.
C_{pv}=Specific heat of water vapor ~1.96 (kJ/kg K).
M_{va}=Mass of moisture air (kg). T_s=Saturation temperature (C).
L_v=Latent heat of vaporization (kJ/kg). M_c=Mass of condensate (kg).

Take into consideration that in diapason of examined temperature the saturation temperature of moisture air is changes linearly, in formula (4) we took it mean number, *i.e.* at 36 C, T_s=34.031C and at 6C, T_s=4.475 C we have:

T_s=(34.031+4.475)/2=19.253 C.

Knowing all components we can calculate at formulas (1)-(4).

Q_w=809*3.93*20=63584.4 (kJ)~63584 (kJ).
C_p=1.005+0.03434*1.96=1.0723 (kJ/kg K)~1.07(kJ/kg K).

Quantity of the heat (Q_i) that is necessary for cooling of the moisture air up to dew point and then for condensation of vapor we calculated in form of variation rows in which one step of cold sea- water equal one degree. For more convenience tabulation we transformed formula (3) in the following way:

$Q_i = M_{va} * C_p * \Delta T_i + L_v * M_{va} * \Delta g$,

from which we received:

$M_{va} = Q_i / (C_p * \Delta T_i + L_v * \Delta g)$.

Once we know value of C_p and L_v as well that one step for cold sea-water equal one degree we can write:

$Q_i = Q_w/20 = 63584/20 = 3179.22$ kJ and $M_{va} = 3179.22/(\Delta T_i * 1.07 + 2455 * \Delta g)$
in which: $\Delta T_i = 36 - T_{cwi}$ and $\Delta g = 0.03435 - g_i$.

T_{cw}	T_i (C)	g_i(kg/kg dry air)	ΔT_i	ΔT_i*1.07	Δg_i(kg)	$M_{va}(M^3)$	M_c (kg)	Q_i
7	36	0.03435	29	31.03	0.02878	31.5703	0.909	3179.22
8	35	0.03242	28	29.96	0.02838	31.9093	0.906	3179.22
9	34	0.03059	27	28.89	0.02796	32.5967	0.911	3179.22
10	33	0.02885	26	27.82	0.02751	33.3402	0.918	3179.22
11	32	0.02721	25	26.75	0.02703	34.1453	0.923	3179.22
12	31	0.02565	24	25.68	0.02653	35.0091	0.929	3179.22
13	30	0.02418	23	24.61	0.02600	35.9478	0.935	3179.22
14	29	0.02278	22	23.54	0.02543	36.9803	0.940	3179.22
15	28	0.02145	21	22.47	0.02483	38.1075	0.946	3179.22
16	27	0.02020	20	21.40	0.02419	39.3534	0.952	3179.22
17	26	0.01901	19	20.33	0.02351	40.7347	0.958	3179.22
18	25	0.01789	18	19.26	0.02279	42.2716	0.963	3179.22
19	24	0.01683	17	18.19	0.02203	43.9887	0.969	3179.22
20	23	0.01582	16	17.12	0.02123	45.9162	0.975	3179.22
21	22	0.01487	15	16.05	0.02038	48.1096	0.980	3179.22
22	21	0.01389	14	14.98	0.01948	50.6218	0.986	3179.22
23	20	0.01312	13	13.91	0.01853	53.5212	0.992	3179.22
24	19	0.01232	12	12.84	0.01752	56.9226	0.997	3179.22
25	18	0.01156	11	11.77	0.01646	60.6288	1.003	3179.22
26	17	0.01084	10	10.7	0.01534	65.7411	1.008	3179.22
	16	0.01016					Σ=19.1	Σ=63584.4
	15	0.00952						
	14	0.00892						
	13	0.00835						
	12	0.00782						
	11	0.00732						
	10	0.00684						
	9	0.00639						
	8	0.00597						
	7	0.00557						
	6	0.00520						

Then we calculated haw much condensed water can be obtain if we only expend 1 kWh energy. With that end in view we chose an ordinary centrifugal pump with following technical characteristics: electric driver P=11 kW, supplying V=250M^3/h and pressure E=10.5M. If re-count for 1 kWh energy we obtain 22.727 M^3. During this calculation the quantity of cold sea- water was distributing in the following way: 20 M^3 of water for feeding of heat exchanger, the rest for feeding the basin and for washing it out from the brine solution. Under these existing conditions we can obtain the following quantity of condensate: M_c=20*19.1*1030/809=486 kg. We made calculation at the same scheme for a temperature 318 K and a relative humidity 90% and we obtain more then 600 kg condensate at expend 1 kWh energy. The efficiency of such plants may be considerable increased if solar-heat collector will be used.

Second method salt water desalination consist in use a water from an artesian well what located near a coast of an ocean (sea). Water from an artesian well under pressure stratum of soil itself raise on surface of earth. The temperature of artesian well water as a rule the same that the temperature in deep of ocean. Underground water near the coast of ocean as a rule formed at the expense of the deep layers of ocean. As a result one can obtain unlimited quantity "free of charge" cold water for heat exchanger. Accordingly one can obtain unlimited quantity freshwater without expend any energy. Water from artesian well may be used as for heat exchanger as for basin.

The next way production freshwater that we proposed is based at condensation moisture directly from air. On the Earth there are many places with very high temperature and very high relative humidity of air and at the same time an acute shortage of freshwater. And, as it is understand for everyone, if there is enough quantity of cold water one can obtain a freshwater directly from air. For example at a temperature equal 305 K and its relative humidity equal 80% one can obtain about 500 kg of condensate with an expense 1 kWh energy.

Our way production freshwater has some obvious economic and technical advantages. The first of them and one of the most important advantages is very low cost of freshwater in comparison with another. Expenditure energy for 1kg freshwater produced by means of these methods in dozens time lower in comparison with return osmoses and in hundreds time lower then expenditure energy by thermal evaporation. The second and also very important advantages is the simplicity of producing, assembling and exploitation of these plants, they do not require a special training personal.

Certainly we understand that proposed our methods not solve all existing problems connected with shortage of freshwater. But in some regions allocated at the coast of ocean our methods can considerably improve water supply.

In our calculations we took data from USA TODAY and we especially grateful for their page "Calculator for atmospheric moisture". Other formulas were taken from ordinary textbooks at technical thermodynamic.

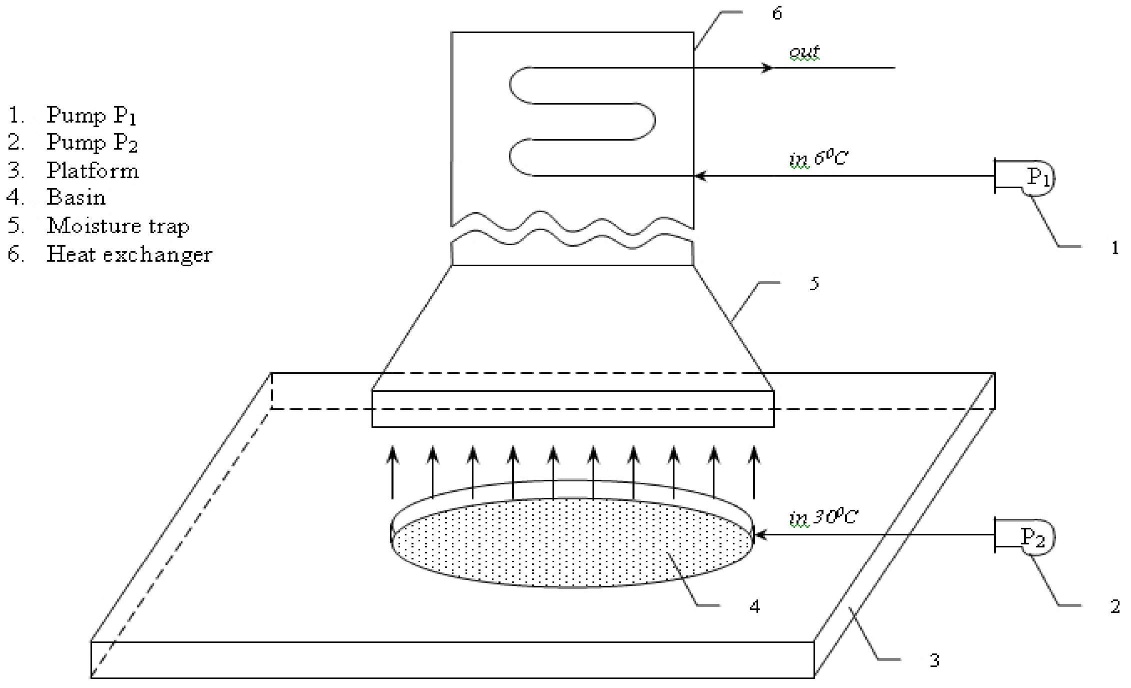

Fig. 1. Scheme of desalinating process.