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An Experimental Study of Heat and Mass Exchange Processes in Solar Desalination Plants

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ABSTRACT: One of the most pressing issues today is the targeted use of renewable energy. With this in mind, we should get the most out of our solar desalination plant. To do this, we need to experimentally study the processes of heat and mass transfer in solar desalination plants and set ourselves a clear task.

KEYWORDS: sun, water vapor, mass transfer coefficients, evaporation, condensation, radiation, heat, energy.

I.INTRODUCTION

In a solar heat exchanger, water evaporates from mineralized water, creating a water-air mixture inside the device’s heat exchanger. Heat and mass transfer processes that occur during vibration play an important role in determining all the thermal characteristics of a device.

Many scientists have tried to identify the processes occurring in solar heaters, based on theory and practice. Evaporation and condensation of water in a certain number of solar heaters, the choice of device size and the location of the device at an angle relative to the horizon, of course, depend on the heat and mass transfer coefficients of the device. Studies to determine the criteria equations for thermal and mass coefficients are carried out in laboratory models. The main measurements were carried out in a stationary mode [1,2,3].

The following criteria equations for determining heat and mass transfer coefficients for solar heaters are dedicated to solar heaters:

For heat transfer during evaporation and condensation:

$$Nu_{\text{и}} = 2{,}77\varepsilon_{\text{п}}(Ra_{\text{н}})^{0,34} \,,$$

$$Ra_{\text{н}} = 2{,}17x10^{6} \div 4{,}73x10^{8},$$

$$Nu_{\text{к}} = 5{,}16 \cdot 10^{-2}\varepsilon_{\text{пк}}(Ra_{\text{к}})^{0,69}$$

$$Ra_{\text{к}} = 2{,}35x10^{6} \div 7{,}39x10^{8}.$$

For mass transfer during evaporation and condensation:

$$Nu_{\text{и}}' = 0{,}063\varepsilon_{\text{ти}}(Ra_{\text{н}}')^{0,32} \,,$$

$$Ra_{\text{н}}' = 3{,}21x10^{6} \div 9{,}1x10^{8}.,$$

$$Nu_{\text{к}}' = 2{,}78 \cdot 10^{-2}\varepsilon_{\text{пк}}(Ra_{\text{к}}')^{0,50}$$

$$Ra_{\text{к}}' = 3{,}31x10^{6} \div 1{,}5x10^{9}.$$

The free flow of the vapor-air mixture into the desalination plant is based on the difference in the liquid density of the entire liquid wall inside the unit, which is similar to the uneven distribution of temperature and the uneven distribution in a limited double layer [4,5,6].

On their basis, one can apply the integral equations of natural convection of binary laminar layers bounded on vertical surfaces:

a) equation of motion

$$\rho\frac{d}{dx}\int u^2dy = g\int_0^h(\rho-\rho_\infty)dy - \mu\frac{du}{dy}\Big|_\omega, \quad (1.1)$$

b) the diffusion equation

$$\rho\frac{d}{dx}\int_0^h u(m_1-m_{1\infty})dy = J_{1\omega}+\rho_\omega(m_{1\omega}-m_{1\infty}), \quad (1.2)$$

c) energy equation

$$\frac{d}{dx}\int_0^h u(t-t_\infty)dy + \frac{c_{1p}-c_{2p}}{\rho_\infty c_p}\int J_1\frac{\partial t}{\partial y}dy = \frac{q_\omega}{c_p\rho_\infty}+\bar{\rho}(t_\omega-t_\infty), \quad (1.3)$$

(1.1) To solve the system of equations (1.2) and (1.3), it is necessary to give the mixing speed, temperature and mass in the boundary layer:

a) Speed distribution

$$u = u1\frac{y}{\delta}(1-\frac{y}{\delta})^2; \quad (1.4)$$

b) temperature distribution

$$t-t_\infty = (t_\omega-t_\infty)(1-\frac{y}{\delta})^2; \quad (1.5)$$

c) The quantitative distribution of the mass of components

$$m_1 = m_{1\infty} = (m_{1\omega}-m_{1\infty})(1-\frac{y}{\delta_m})^2. \quad (1.6)$$

When calculating the heat from the physical processes occurring in a solar water evaporator, it is necessary to determine the amount of heat required for the evaporation of water and heat fluxes into the environment.

Thus, the heat loss in a solar water heater can be as follows:

$$Q_{T.П} = Q_{T.СТ.} + Q_{T.ДН.} + Q_{T.БС.}.$$

$Q_{T.СТ.}$ – Heat loss from the opaque surface of the evaporator chamber (heat loss due to thermal conductivity and radiation); $Q_{T.ДН.}$ – heat loss through the bottom of the block; $Q_{T.БС.}$ – heat loss from the side walls of the device.

If we consider the average fruiting temperature as 65°C, and the ambient temperature 30°C, then heat loss from a transparent surface $Q_{T.СТ.} = 220\frac{Вт\cdot ч}{м^2}$, heat loss from the bottom of the device and from the side walls $Q_{T.ДН.} + Q_{T.БС.} \cdot = 52\frac{Вт\cdot ч}{м^2}$. So the total heat loss

$$Q_{T.П} = 272\frac{Вт\cdot ч}{м^2}.$$

It is worth noting that the amount of solar radiation in the Bukhara region is $(500-1000\frac{Вт\cdot ч}{м^2})$. Heat loss in the evaporator chamber is 55.8 ÷ 47.4.8%. Similarly, 44.2 (52.2%) of the heat is supplied to desalinated water. Thus, based on scientific articles and literature, it can be concluded that the heat loss on the transparent surface of the desalination plant is 41 (48%) relative to the radiation emanating from the device, and the heat flux at the bottom of the device is 6.9 (8%).

The amount of heat lost from the side walls of the newly proposed unit is 3.4 (4%), and the rest can be charged with additional circuits inside the unit.

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