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Improvement of desalination plants of small productivity

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Abstract

New versions of evaporation devices to be used in thermal desalination plants have been considered. The principles of their operation are described. The data showing intensity of heat exchange in these plants and factors for calculating the coefficient of heat transfer have been adduced.

Keywords: Heat exchangers; Thermal efficiency; Peculiarity constructions

In the arid areas of the planet and in the countries of the Middle East and Africa the only sources of water supply are desalination plants. The majority of the states located in these regions do not have enough fresh water sources though they are surrounded by unlimited amounts of seawater. Thermal plants are most technically acceptable for fresh water production. Reverse osmosis desalination plants cannot be used in some countries due to the lack of a large power station. Efficiency of thermal plants has sharply increased due to new technological schemes with high thermodynamic perfection of their power cycle. It has been achieved by the intensification of the heat transfer process, application of the thermal compression increase of the fresh water heating temperature. Great attention has been paid to a proper choice of parameters. New schemes of evaporation, frequency rate with high concentration, and heat regeneration have been used. The plants are distinguished by their design and complex use [1–4].

It is especially important for regions needing agricultural development. Multi-purpose desalination plants as agro complexes with an energy source, and a desalination plant are now being used. They integrally combine water producer and consumer water, including agricultural enterprises. Thin film thermal desalination plants have the greatest economic efficiency compared to MSF and MED [5–8]. However the designs offered by manufacturers can be significantly improved. We have offered some ways to reduce the required surface of heat exchanger, to reduce the heat consumption for generating distillate, to reduce the pumps quantity, pumping over the fresh water between the

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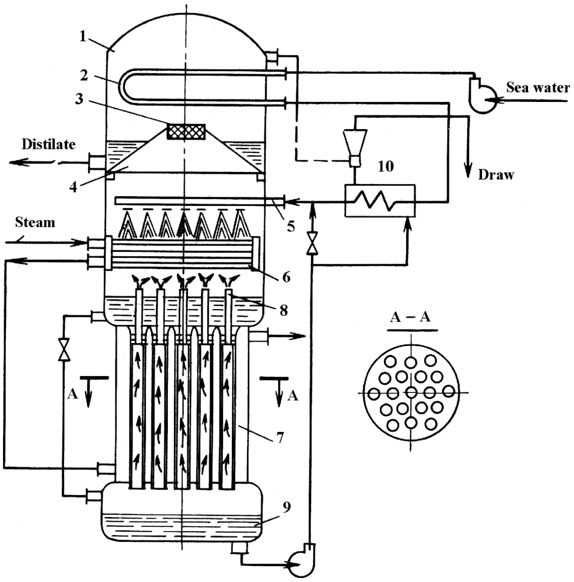

Fig. 1. The basic scheme of the combined desalination plant: (1) case, (2) condenser, (3) separator, (4) chipper, (5) sprinkler, (6,7) horizontal and vertical steps, (8) tubes, (9) receiver, (10) cooler.

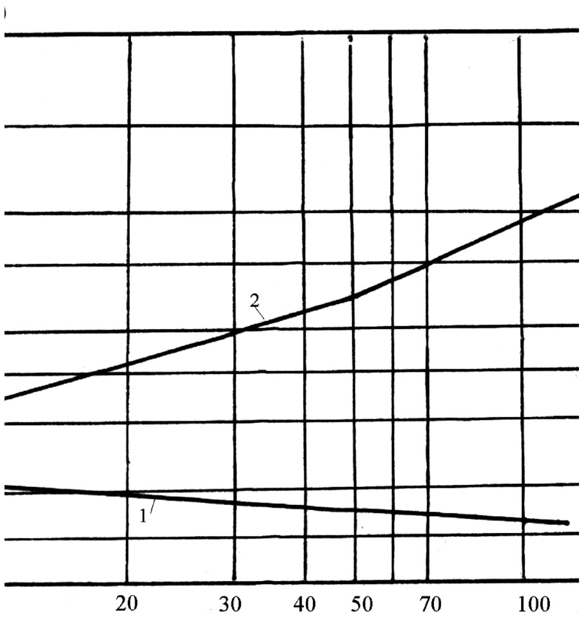

Fig. 2. Dependence of coefficient h_2 on the special thermal flow q (a): $p = 70$ kPa; $b = 3.5\%$; $\Gamma = (18–22)$ 10^5 m^2/s; (1) descending flow, (2) horizontal film flow.

steps. Figure 1 shows the scheme of the combined thin-film installation, which can form both descending, and horizontal film flows. Research on the conditions for descending and horizontally moving film of seawater confirm he possibility of achieving high heat transfer coefficients. Specific thermal flow and pressure influence the intensity of steam formation for both cases of film flow as can be seen on Fig. 2.

The reflex density Γ influences the mode ambiguously. For descending film flow of increase of this value lowers the heat transfer coefficient h_2 while this phenomenon for horizontally moving film (Fig. 3) is not observed. Specially stipulated tubes can provide the formed steam, washing at a high level. Good stability of fresh water film flow in the top and bottom zones of steam formation.

The analysis of the experimental data has shown that steam in the horizontal film step is formed as the advanced boiling while in the vertical step both evaporation and advanced boiling occur [9].

Intensity of heat transfer for the horizontal step of the film flow is described by equation

$$Nu = 0.092 Re^{0.45} Pr^{-0.1} K_p^{0.6} K_d^{0.2},$$

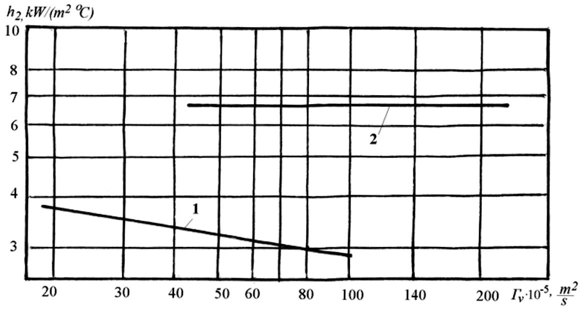

Fig. 3. Dependence of steam formation intensity on reflex density Γ: $p = 70$ kPa; $b = 3.5\%$; $q = 20 \div$ desalter 140 kW/m^2; (1) descending flow; (2) horizontal film flow.