COMBINED BASIN-TYPE SOLAR WATER DESALINATION SYSTEM

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Abstract. *This study summarizes recent enhancement methods for basin-type solar stills aimed at freshwater production in arid regions. Reported improvements include the use of phase-change materials, nanoparticles, porous media, wick structures, modified absorbers, external condensers, and integrated solar collectors, yielding performance gains of 20.5%-128%. Despite these advancements, research on combined systems integrating solar collectors, PCMs, and external condensers remains limited. To address this gap, experimental prototypes of conventional and combined basin-type systems were developed at Karshi State Technical University to analyze temperature distribution, heat and mass transfer, climatic effects, and freshwater productivity.*

Keywords: *basin solar still, desalination, phase-change material, external condenser, solar collector, freshwater productivity, heat and mass transfer.*

Introduction. At present, producing fresh water in regions facing water scarcity using low-cost and simple technologies is of great importance. One of the simplest and easiest-to-operate methods is the single-slope basin solar still (SSBSS), which is characterized by its structural simplicity. Numerous theoretical and experimental studies have been conducted to enhance the productivity of basin-type solar stills. These studies explored methods to improve freshwater yield using phase-change materials (PCMs), nanoparticles, porous materials, high-conductivity fins, and by increasing the evaporation and condensation surface areas.

Materials and methods. Panchal and Shah [1] investigated the productivity of a solar still by placing a black cotton–paper sheet inside the evaporation chamber. When the same material was used to enlarge the absorber surface, efficiency increased by 38.2% [2]. Khare et al. [3] experimentally evaluated the use of multi-strand wicks to increase the evaporation surface, resulting in a productivity increase of up to 20.5%. Ramanathan et al. [4] enhanced solar still performance by using a transparent mineral plate to increase evaporation intensity, where the absorber plate was placed parallel to the transparent cover. Experimental results showed a 25% increase in freshwater yield.

Bhargva and Yadav [5] compared four wicking materials-jute, bamboo-cotton blend, wool, and cotton-to identify the most effective for enhancing evaporation. The bamboo–cotton wick demonstrated the highest efficiency at 34.5%. Agrawal and Rana [6] analyzed the influence of multiple V-shaped floating wicks; the evaporation surface increased by 26%, raising the system efficiency to 56.62%. Elsheikh et al. [7] replaced the conventional absorber plate with a copper-corrugated absorber, resulting in an approximately 128% increase in fresh water productivity. Riffat et al. [8] analyzed a solar still integrated with a solar collector and concluded that the thermosyphon operating mode provided superior performance. Badran et al. [9] reported a 52% increase in productivity when a flat-plate collector was coupled with a single-basin still. El-Bahi and Inan [10] experimentally studied the integration of an external passive condenser, which yielded a daily output of 7 l/m^2 and an efficiency of 75%.

Nijegorodov et al. [11] investigated the influence of an external condenser, in which humid air from the basin chamber was extracted by a small suction fan and condensed externally, doubling the heat efficiency compared to a conventional still. Madhlopa and Johnstone [12] also used an external condenser and achieved 62% higher productivity. Pandey [13] studied the effects of bubbling hot dry air into the saline water and cooling the transparent cover, which together increased efficiency by up to 47%. El-Agouz [14] examined the effect of injecting air bubbles into saline water and analyzed the influence of water temperature, saline water depth, and airflow rate. Results showed that performance increased with water temperature and decreased with airflow rate.

Results and discussion. A review of the available literature shows that research on combined basin-type solar desalination systems integrated with solar collectors, phase-change materials, and external condensers remains insufficient. Considering this, experimental prototypes of both a conventional and a combined basin-type solar desalination system were constructed and commissioned at the educational-research site of the Department of Energy Engineering, Karshi State Technical University (Fig. 1).

Figure 1. General view of the experimental setups (physical model)

The test rig is designed to investigate temperature distribution, heat- and mass-transfer processes, and the influence of local meteorological parameters, as well as to determine freshwater productivity and overall performance.

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