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Experimental Study of the Effect of Distilled Water-Conducting Threads on the Performance of Stepped Solar Still

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ABSTRACT: Academics are interested in solar energy for water purification because it is easily accessible. In this investigation, a stepped solar still was constructed and tested experimentally in Arak. Using the Taguchi design of experiment approach, it was determined how the five input parameters-saline water flow rate, device angle, absorber plate color, number, and spacing of distilled water-conducting threads in each row-affected the amount of freshwater production as the output variable. This research is unique in that it uses plastic threads to create channels on the cover glass surface that lead distilled water to the freshwater tank. In addition, the simultaneous study of the effect of input parameters is one of the innovations of this research. The results showed that when the input saline water flow rate was 50 ml/min, the device angle was 40°, the absorber plate was black, the number of water-conducting threads in each row was 2, and the row spacing was 8 mm, the greatest freshwater output of 1975 ml/m^2 was produced. Also, by using two water-conducting threads in each row and spacing them 8 mm apart, the amount of water produced per unit of surface area was increased.

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1- Introduction

The process of desalination using stepped solar still is one of the older methods of water purification. Due to its economic nature and the use of only solar energy for evaporating saltwater, this method has attracted the attention of various researchers. Balachandran et al. [1] have investigated the increase in the productivity of fresh water in a proposed solar still using new absorbent material. The results showed that the use of more absorbent materials increases the rate of evaporation. In addition, the efficiency of fresh water in the proposed solar still was about 1.5 liters more than the normal solar still. Sakthivel et al. [2] concluded that adding color to the saltwater in the basin has a direct effect on the performance of the solar still device. Nougriaya et al. [3] have studied the factors affecting the output of the stepped solar still. Their research showed that decreasing the depth of salt water due to increasing temperature has increased productivity. The limitation of using the solar still device is the low amount of freshwater production per unit area of the surface. According to the conducted research, it is possible to increase the amount of water produced per unit area by identifying the effective variables and improving them. According to the research done in the past and the identification of the effective parameters, the innovation of current research compared to other research is to create paths on the surface of the glass using thread to conduct the distilled water to the freshwater tank. In addition, another innovation of the current research is the investigation of the effect of simultaneous use of five variables: salt-water inlet flow rate; angle of the device; the color of the absorber plate; number and distance of the conducting threads of distilled water in each row; and the study of their interaction.

2- Methodology

In this study, in order to achieve the optimal number of tests, a set of tests has been designed using the Taguchi design of the experimental approach. It was found how the flow rate of salt water, the angle of the device, the color of the absorber plate, the number of distilled water-conducting threads in each row, and their spacing in each row affected the amount of freshwater produced, which was the output variable.

After determining the level of each parameter in different tests, these tests were conducted from 9 am to 4 pm in Arak city in June and July. In each experiment, the amount of water produced per unit of absorbent surface in each hour of the experiment was recorded.

3- Results and Discussion

After conducting the experiments, the results obtained in different experiments were compared to each other, and the

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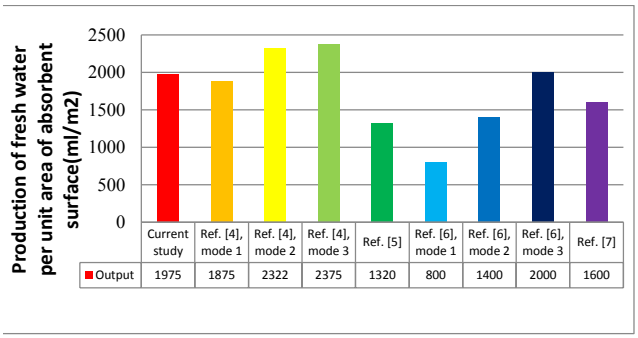

Fig. 1. Comparison of the maximum production of fresh water per unit area of absorbent surface

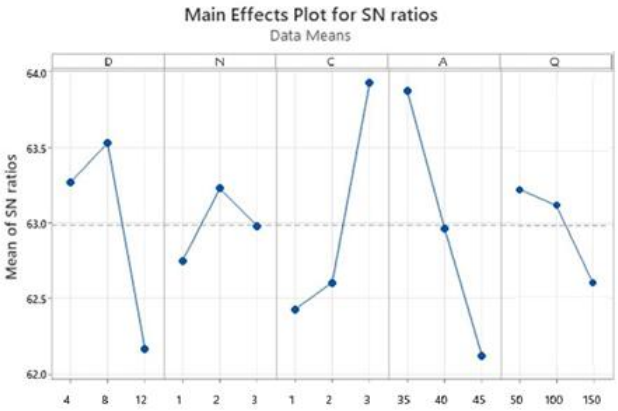

Fig. 2. Normal distribution diagram of the regression equation

effect of each of the above-mentioned five input parameters on the amount of water extraction as an output parameter was studied using different methods such as signal-to-noise analysis and regression analysis.

According to the test results, the maximum amount of water production per unit area was obtained when the inlet flow of salt water was 50 milliliters per minute, the angle of the device was 40 degrees, the color of the absorbing page was black, the number of threads for conducting distilled water in each row was 2, and the distance between the rows was 8. mm. In this case, the output volume obtained was 1975 ml/m^2. The lowest amount of water production per unit area was 1030 ml/m^2 in the case where the inlet flow rate of salt water was 150 milliliters per minute, the angle of the device was 40 degrees, the color of the absorbent plate was silver, the number of distilled water guiding threads in each row was 1, and the distance between the rows was 12 mm.

4- Validation

Fig. 1 shows the highest amount of freshwater production per unit of absorbent surface in the current research, compared to the results of some past research that had conditions closer to the current research. The difference in results between this article and other works is due to factors such as test conditions, test hours, test duration, test location, and so on.

5- Conclusion

The results obtained from the signal-to-noise analysis, according to Fig. 2, and the regression analysis show that the variables of the angle of the device and the color of the absorbent plate had the greatest effect on the amount of freshwater production. Also, the maximum water production volume was obtained when the salt-water inlet flow rate was 50 milliliters per minute, the angle of the device was 35 degrees, the color of the absorbent page was black, the number of distilled water conducting threads in each row was 2, and the distance between the rows of distilled water conducting threads from each other was equal to 8 cm. They were the best levels for each variable.

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