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Experimental, Theoretical and CFD Validations for Solar Powered Atmospheric Water Generation Using Thermoelectric Technics

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Abstract

The Atmospheric Water Generator (AWG) is an environmental water recovery that easily dehumidifies water vapor moisture from the air. This article presents an experiment to construct an AWG model using solar energy as a source of power. An experimental and numerical study for a device of (AWG) is performed. The experimental work is performed at Basrah city, located in the south of Iraq, during August and September of 2019 and March of 2020. The theoretical results are calculated by EES and the numerical study has been conducted by the (ANSYS19/CFD/ FLUENT) program. The experimental device is tested for different days with different climate conditions. The Maximum water production obtained is 3.4 L/day from all the testing days, for different hours of operation when the relative humidity in the range of (45 – 95 %) and the temperature range from 17 °C to 45 °C. The results shown that, the water production rate is increased with increasing humidity, temperatures, hours of operation, and model size.

Keywords: AWG, TEC, Thermoelectric, Soler Energy, CFD/ANSYS/ FLUENT.

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1. Introduction

Potable water shortages are one of the most pressing issues in the world today. Although water covers more than two-thirds (71 %) of the earth's surface, the amount of water suitable for daily use is still scarce (approximately 2.75 %). Long coastal countries and island countries often face water scarcity with inadequate freshwater supplies, such as rivers and pools. Alternative ways of producing water to meet water requirements needs are urgently needed. The relative humidity is very high in coastal areas, which can be used to dehumidify water [1]. Scrivani and Ugo (2008) [2], investigated a project's aims to explore solar concentrating plants in Mediterranean countries to supply renewable water. Their method used is water extraction from the air by direct cooling of humid air below the dew point. Bogardi et al. (2012) [3], studied the sustainability, fair distribution, and conservation of water resources must occur within integrated water management and governance, but their implementation is problematic. Continuing global climate change, growing population, urbanization, and striving for better living conditions pose a challenge to planetary sustainability. Dash and Anshuman (2015) [4], studied the ability on using dehumidification techniques for supplying potable water for the people in the coastal regions. Since the relative humidity is high in coastal areas (around 70-80 percent) and the sun shines in these places all year. They recommended that dehumidification devices can be used with solar energy as a power source. Kabeel et al. (2016) [5], investigated the technique was intended for Arab Gulf nations and comparable countries by utilizing sun-oriented thermometric generator usage. Cases have been simulated in 3D using CFD programming. It found that the freshwater efficiency of the unit was up to 3.9 L/h/m^2. Liu et al. (2017) [6], designed and experimentally investigated a portable water generator of (7 kg) capacity with two thermoelectric coolers (TECs). They found that, the amount of generated water increased with airflow rates rose, but the condensation rate had the opposite trend. Bharath et al. (2017) [7], studied an atmospheric Water Generator (AWG); this device can convert atmospheric moisture into potable water. The device uses the principle of latent heat to convert water vapor molecules into water droplets with Peltier devices' help. The CFD analysis is carried out to optimize the design by changing Peltier's number and Peltier's location to the desired condensing temperature. Islam et al. (2017) [8], investigated Bangladesh's coastal areas and found the humidity was very high (around 70-80 percent). If enough dehumidifier units are used in an environment individually could meet their water needs. The present study implemented a technique to set up an A.C. concept based on a thermo-electric cooler that used 12 volts D.C. In this cooler, the water has been removed from the air by directly cooling moist air below the dew point. And the possibility of using the sun-powered cooling framework to provide the required cooling force was investigated. The water produced by design must be compatible with the World Health Organization (WHO); the design should not danger to users during regular operation. The flexibility in the energy source and the design should be able to use various energy sources.