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Original article

Energy, exergy, energy matrices, exergoeconomic and enviroeconomic assessment of modified solar stills

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ABSTRACT

Passive solar stills globally accepted as a well-known system to desalinate unkempt water at a low yield rate without degradation of ecology and environment. Enhancement techniques are available to increase its productivity at higher capital and distillate production costs. Multi-wick solar stills can be a better option to increase productivity and alleviate distillate production cost relatively at lower capital cost. This work is allied to the assessment of the incorporation of hanging wicks in basin-type solar stills on overall performance improvement based on yield, energy, exergy, energy matrices, exergoeconomic, and enviroeconomic methodologies. Four modified solar stills, namely, modified basin type single slope solar still (MBSSSS); modified basin type double slope solar still (MBDSSS); modified basin type single slope multi-wick solar still (MBSSMWSS); and modified basin type double slope multi-wick solar still (MBDSMWSS) are designed and fabricated. Experimental observations are taken throughout the year at the climatic conditions of Prayagraj, India. Results revealed that the annual yield and exergy output; average annual energy and exergy efficiency of MBSSMWSS and MBDSMWSS (with black cotton wick (BCW)) are found as 1172.03 and 2583.99 kg; 100.70 and 97.36 kWh; 23.93% and 28.78%; 2.579% and 2.233%, respectively, in comparison to 861.55 and 1551.48 kg; 72.96 and 66.32 kWh; 15.08% and 17.48%; 1.765% and 1.160%, obtained for MBSSSS and MBDSSS, respectively. Based on energy and exergy, lower energy payback time; higher energy production factor; and higher life cycle conversion efficiency are found as 0.637 and 8.255 years; 1.568 and 0.121; 0.2807 and 0.0262 (life span of 50 years) for MBDSMWSS and MBSSMWSS, respectively, with BCW at lower water depth. Among the modified solar stills, minimum cost of distilled water, least payback period, higher CO_2 reduction benefit and carbon credits (energy basis) are found for MBDSMWSS. The exergoeconomic parameter is found higher for MBSSMWSS.

Introduction

Nowadays, our green planet 'Earth' is no longer greener due to extreme exploitation of its natural resources; dense forestry; flora and fauna; agricultural lands; etc., which leads to severely affects the life of creatures as well as diminishes the ecosystem (or natural habitats) and disturbed the whole natural process of planet Earth. The green earth is often called 'Blue-Planet' due to major availability (approximately 70%) of water on its surface [1,2]. Water is the source of life and it is indispensable in most of its applications. The aggregate surface size/extent of the blue plant is about 510×10^{12} m^2 [3]. The total quantity of water on this planet would be approximately 1.4 billion km^3 with respect to nearly 3000 m mean depth of the sea/ocean [4]. Although, ocean water body consists about 97.2–97.5% of the total water quantity, but due to the high concentration of salt which restricts its consumption in drinking and irrigation purposes. The rest 2.5–2.8% proportion (irregularly allocated) is available as freshwater. About three-fourths of that freshwater is found in the glacier and alpine zones; and the remaining proportion is present in the form of groundwater and surface water. The proportion less than 0.36% of fresh water is available for direct human consumption acquired from rivers; lakes; and groundwater [4] and drinkable (safe, pure, and fresh) water only account for 0.014% of total accessible water on the Earth [5].

Today, water scarcity (or water crises) has become a worldwide issue and almost every country faces the problem of water crises. Water

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