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On effect of wind speed on passive solar still performance based on inner/outer surface temperatures of the glass cover

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ABSTRACT

The thermal performance of a passive single basin solar still was investigated by computer simulation using the climatic conditions of Jeddah (lat. 21° 42′ N, long. 39° 11′ E), Saudi Arabia under the two conditions: (a) the temperatures of the inner T_{gi} and outer T_{go} surfaces of the still cover are equal and (b) the temperatures of the inner T_{gi} and outer T_{go} surfaces of the still cover are not equal. Effect of wind speed V on the daily productivity P_d of the still for these conditions was studied. It was indicated that for the condition $T_{gi} = T_{go}$, there is a critical mass (depth) of basin water beyond which P_d increases as V increases until a typical velocity V_t. For basin water masses less than the critical mass, P_d was found to decrease with increasing V until V_t. After V_t, the change in P_d becomes insignificant. When $T_{gi} \neq T_{go}$, P_d was found to be less dependent on wind speed V for all investigated values of mass of basin water m_w in the range $0 < m_w \leq 100$ kg. The rate of heat transfer by forced convection due to wind should be estimated on the basis of the temperature of the upper surface of the still cover.

1. Introduction

Supplying fresh water is still one of the major problems in arid remote areas in different parts of the world. Solar stills can solve part of the problem in those areas where solar energy is available. Basin type solar stills are simple in design and have low technology; hence, low maintenance expenses are required. Detailed reviews of different designs and factors affecting the performance of active and passive solar stills had been recently reported [1,2]. A review article describing the status of solar distillation in India had also been presented [3]. All methods reported in these review articles aimed to improve the still productivity by reutilizing the latent heat of condensation [4], coupling the still to solar collectors [5] or solar ponds [6,7], using external and/or internal mirrors [8,9], reducing the volumetric heat capacity of the basin using different wick materials [10], using energy storage media [11,12], etc. A new method to calculate the heat and mass transfer coefficients and efficiency of industrial distillation columns containing structured packings was recently proposed [13]. Cost analysis for different solar still configurations was performed by Kabeel et al. [14]. Moreover, most of mathematical models reported in the literature for different designs of active and/or passive solar stills assumed that the temperatures of the inner and outer surfaces of the still cover are equal. This assumption is not accurate since the inner surface of the still cover is in contact with water vapor and the outer surface is in contact with ambient air which results in inaccurate estimation of the temperatures of the still elements, external and internal rates of heat transfer and productivity. Recently, Tiwari et al. [15–18] performed theoretical investigations of active and passive solar stills for the two conditions: (a) inner and outer glass cover temperatures are equal ($T_{gi} = T_{go}$) and (b) inner and outer glass cover temperatures are not equal ($T_{gi} \neq T_{go}$). Some of their results [16–18] had been validated experimentally and their main conclusion was the thermal models of solar stills should be developed based on the assumption that $T_{gi} \neq T_{go}$. On the other hand, the rate of heat transfer by forced convection from the upper surface of the still cover due to wind depends on the temperature difference between the upper surface of the glass cover and ambient air. Therefore, estimation of the rate of heat transfer due to wind on the basis of the temperature difference between the glass cover as a lumped element has an average temperature T_g and ambient air probably gives inaccurate estimation of the still elements temperatures. Therefore, inaccurate estimation of productivity which in practice depends mainly on the temperature difference between the basin water and the inner surface of the still cover. This fact may be one of the main reasons that cause the contradictions that reported in the literature about effect of wind speed on productivity

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