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A new maritime lifesaving distiller driven by wind

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Abstract

We proposed a newly designed, maritime lifesaving small distiller consisting of a windmill and a number of horizontal concentric cylindrical partitions in contact with saline-soaked wicks. The wind energy is directly converted to frictional thermal energy in a liquid heat medium forming a thin layer between a rotating shaft directly connected to the windmill and the first cylindrical partition, and the frictional thermal energy is recycled on all cylindrical partitions to increase the productivity of distillate. The proposed distiller can be driven by wind only, without human power or electricity. The blades can be separated or folded when the distiller is stored, and the distiller can have an outside diameter of about 0.15 m and a length of about 0.35 m in storage. The performance of the proposed distiller is analyzed theoretically, and the distiller is predicted to produce 1.5 kg/d or more when a 6 m/s wind blows steadily all day on a sunny or cloudy day, and this amount of fresh water is enough to meet one person's daily requirement.

Keywords: Wind energy; Desalination; Distillation; Multiple-effect; Wind-thermal conversion

1. Introduction

Drinking water is a most important issue when a ship is in distress, and a reverse osmosis (RO) desalinator is currently used for maritime lifesaving desalinators. For example, the Survivor-6 manufactured by the Survivor Corp. [1] is a compact desalinator which has a 20.3 cm length, a 6.4 cm width, a 12.7 cm height and weighs 1.1 kg and can stably produce drinking water since it is driven by human hands. But to get 1.5 kg drinking water, which is the minimum daily requirement for one person, 1.5 h work by hand of 27–50 N force is required, so the operator may suffer from excessive exhaustion, especially for the person who is already fatigued from drifting for an extended time.

Recently, Fukui et al. [2] proposed a new maritime lifesaving multiple-effect solar still that consists of a transparent cover film and a number of plastic partitions. Solar energy absorbed on the first partition causes the evaporation of saline

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water fed to the wick attached to the under surface of the first partition, and the water vapor diffuses through a humid air layer between partitions and condenses on the upper surface of the second partition. Latent heat from condensation causes further evaporation from the wick attached to the under surface of the second partition. In this manner, the evaporation and condensation process is repeated on all partitions and the productivity of distilled water can be drastically increased. They performed a theoretical analysis of the lifesaving multiple-effect solar still, and found that the still, which has six plastic partitions and a 3-mm humid air layer between partitions, is estimated to produce about 15 kg/m^2d of fresh water on a sunny day of 22 MJ/m^2d of solar radiation.

The maritime lifesaving solar still has great potential since the still is simple and compact in size for storage. But the solar still needs a relatively large area to absorb solar radiation, and cannot produce drinking water on cloudy days. On the other hand, high wind speed is steady at sea and the wind energy can be utilized for production of fresh water.

Wind-driven seawater desalination systems have been studied. Carta et al. [3], Miranda et al. [4], Weiner et al. [5] and Kiranoudis et al. [6] have studied wind-driven RO systems, and Karameldin et al. [7] and Witte et al. [8] have studied the wind-driven mechanical vapor compression desalination system (MVC). In the wind-driven RO and MVC systems, wind energy is converted to electricity first, and then this electricity is used to operate pumps or an electric heater. The objective of both wind-driven RO and MVC systems is to supply large amounts of fresh water to a small community, and both systems may not be downsized to a very small distiller which can be used as a lifesaving distiller since both systems have many components such as a generator, pumps and RO and MVC systems.

The technique of direct conversion from wind energy to thermal energy has been studied for room heating and hot-water supply systems because the efficiency of direct wind–thermal conversion is higher than that of wind–electricity conversion since there are much smaller conversion losses and almost all the energy produced by the windmill can be used as thermal energy for direct wind–thermal conversion.

Further, the direct wind–thermal conversion system has a very simple structure; the system needs only a rotating shaft directly connected to the windmill, an outer pipe and a thin layer of liquid heat medium such as silicon oil, and the rotational energy of the shaft can be directly converted to frictional thermal energy in the thin layer of the liquid heat medium. This simple structure may be a great advantage for a direct wind–thermal conversion distiller if the distiller is to be used as a maritime lifesaving distiller, since the maritime lifesaving distiller should be compact in size.

In this paper we proposed a new simple maritime lifesaving distiller, which has a direct wind–thermal conversion structure, and have done numerical simulations to theoretically predict the basic behavior of the heat and mass transfer occurring in the proposed distiller as well as the productivity of the proposed distiller in a steady state. The distiller is designed to be compact for storage, and can produce enough distilled water to meet one person's daily requirement, with wind energy only, without human power or electricity.

2. Maritime lifesaving distiller driven by wind

A schematic diagram of a maritime lifesaving distiller driven by wind is shown in Fig. 1(a). The proposed distiller basically consists of a windmill and a distilling unit. The windmill has a rotor diameter of 0.6 m, and the distilling unit has an outside diameter of 0.12 m at maximum and a length of 0.3 m. The blades can be separated or folded as shown in Fig. 1(b) when the distiller is

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