UNIVERSITI PUTRA MALAYSIA

DESIGN OF PORTABLE SHELL TUBE HEAT EXCHANGER FOR SOLAR POWERED WATER DISTILLER

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By

AYDIN KHIABANI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, In Fulfillment of the Requirements for the Degree of Master of Science

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DEDICATION

To my family whose support and understanding helped make this possible

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in Fulfillment of the requirement for the degree of Master of Science

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AYDIN KHIABANI

October 2011

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Based on the United Nation records, around 20% of world populations suffer lack of potable water and a third of the Earth's population live in the water stressed area such as Sahara in Africa and South East Asia. Therefore, the importance of solar powered water distillation systems, especially portable devices seems necessary.

The current portable solar distillers are designed based on effective evaporation or distillation method and are usually used for distilling salt water or a liquid phased material. Moreover, they are able to produce 4 liters in eight hours which is far too slow for anyone to wait. On the other hand, larger size water distillers should be installed for more amounts of produced water and they not only are not portable, but also very huge and usually very heavy for carrying and installing in every place.

For enhancing of high condensation and evaporation efficiency, various methods mostly involve conventional heat transfer. Moreover the devices which are composed

of a glass heat exchanger, served as a condenser for vapor condensing were produced in black paint solar absorber. There is a tank for supply water and a tank for storage of produced distilled water.

In this study, a portable shell and tube condenser for solar powered water distiller which is for army personnel or camping groups to enter ecotourism Islands or jungle trekking and preparing their necessity fresh water at hand. This Portable design with considering some performance parameters such as: limited length (L<1m), light weight (W<10kg) and higher efficiency (>40 L/day) has been designed by using of mathematical module, validating and rating of the results via experimental test and implicit numerical analysis.

Rating results showed that accumulated mass water significantly depended on the inlet vapor temperature and volume, heat exchanger material, coolant water temperature and volume. Thus, Stainless Steel 304 and Pyrex glass in the same thermo dynamical condition (vapor temperature, vapor volume, coolant temperature and coolant volume) are considered as preliminary supposition for material in mathematical module. Finally, because of small amounts of vapor in this device, different quality of vapor has negligible effect on physical and mechanical performance of portable shell and tube condensers. These inexpensive shell and tube heat exchangers permitted to produce 40 liter/day distilled water from vapor with 378K inlet temperature in atmosphere pressure. If inlet pressure increase, vapor temperature will decline and thereupon, heat exchanger's efficiency tangibility will be increased.

Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

REKABENTUK PEMINDA HABA KELOMPANG TIUB MUDAHALIH UNTUK PENYULING AIR BERTENAGA SURIA

Oleh

AYDIN KHIABANI

Oktober 2011

Pengerusi: Nor Mariah Bt Adam, PhD PE

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Berdasarkan rekod Bangsa-Bangsa Bersatu (UN), sekitar 20% penduduk dunia mengalami masalah bekalan air bersih dan sepertiga penduduk dunia tinggal di kawasan kekurangan air seperti di Gurun Sahara, Afrika dan di Asia Tenggara. Oleh itu penyelidikan tentang mendapat sumber air bersih menggunakan tenaga suria adalah sangat penting.

Penyuling air bolehalih menggunakan tenaga suria yang sediada direkabentuk berdasarkan penyejatan atau proses penyulingan yang berkesan, dan selalunya digunakan untuk menyuling air masin atau bahan yang berada pada fasa cecair. Peralatan tersebut mampu menghasilkan sebanyak 4 liter air bersih dalam tempoh 8 jam yang mana terlalu lama untuk sesiapa menunggu. Untuk meningkatkan hasil pengeluaran, saiz pemuling harua menjadi besar dan berat, dan tidak mudah alih.

Langkah untuk meningkatkan kadar pemeluwapan dan penyejatan yang tinggi melibatkan kaedah lazim bagi meningkatkan pemindahan haba. Peralatan tersebut terdiri daripada pemindah haba kaca yang berfungsi sebagai pemeluwap yang dicatkan warna hitam untuk menyerap tenaga suria supaya memeluwap wap. jatan. Sistem juga mempunyai tangki untuk menampung sumber air tidak bersih dan satu lagi tangki untuk menadah air bersih.

Dalam kajian ini sebuah pemeluwap kelompang dan tiub mudahalih menggunakan tenaga suria untuk kegunaan askar atau kumpulan perkhemahan memasuki pulau eko-pelancongan atau pun berjalan di dalam hutan, membantu menyediakan bekalan air bersih sendiri. Rekabentuk mudahalih ini dengan mengambilkira parameter prestasi seperti had panjang (L<1m), ringan (W<10 kg) dan berkecekapan tinggi (> 40 L/day) telah direkabentuk menggunakan kaedah matematik, mengesahkan dan mengkadarkan keputusan melalui eksperimen dan analisis berangka.

Keputusan kajian menunjukkan jisim air bersih yang terkumpul bergantung kepada suhu dan isipadu wap masukan, bahan pemindah haba, suhu dan isipadu air penyejuk. Maka keluli tahan karat 304 dan kaca Pyrex didedahakan pada keadaan termal dinamik yang sama (suhu wap, isipadu wap, suhu dan isipadu air penyejuk) untuk diambilkira sebagai keadaan awal kaedah matematik. Seterusnya amaun dan kualiti wap yang berbeza di dalam peranti boleh diabaikan dan tidak memberi kesan terhadap prestasi fizikal dan meknikal pemeluwap bolehalih kelompang dan tiub.

Pemindah haba kelompang dan tiub yang murah ini boleh menghasilkan 40 liter air bersih sehari daripada wap dengan suhu masukan 378K sehari pada tekanan atmosfera. Jika tekanan masukan meningkat, suhu wap akan menurun dan seterusnya kecekapan pemindah haba akan meningkat.

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I certify that an Examination Committee has met on 11 October 2011 voce to conduct the final examination of Aydin Khiabani on his Master of Science thesis entitled "DESIGN OF PORTABLE SHELL TUBE HEAT EXCHANGER FOR SOLAR POWERED WATER DISTILLER " in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student be awarded the relevant degree.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the supervisory committee were as follow:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that if has not been previously, and is not concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.

AYDIN KHIABANI

Date: 11 Octber 2011

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