INITIAL EXPERIMENT RESULTS ON THE RESEARCH PROTOTYPE FRESHWATER DISTILLATION EQUIPMENTHIGH EFFICIENCY

MỘT SỐ KẾT QUẢ BƯỚC ĐẦU CỦA NGHIÊN CỨU CHẾ TẠO THỬ NGHIỆM THIẾT BỊ CHƯNG CẤT NƯỚC NGỌT HIỆU SUẤT CAO

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Abstract - Distilling freshwater using solar energy is a promising way to sustainable development since the energy used is free and clean [1], [2], [3]. In this paper, the freshwater distillation equipment using a parabolic concentrated solar collector has been experimentally studied. The experimental system consists of a parabolic concentrated solar collector with 1.3m diameter and 0.45m depth. The material of reflective surface's parabolic collector is Inox, so that it can reflect solar radiation. The parabolic type's solar collector is adjusted according to the movement of the Sun every 15 minutes so that the reflective surface of parabolic is perpendicular to the solar radiation. At the focal point of the parabolic collector mount the freshwater distillation equipment. Performance of the freshwater distillation equipment using a parabolic concentrated solar collector is tested under the local conditions of Dinhquan, Dongnai province from 13/6/2012 to 30/11/2012. The experiment shows that, the influence of the solar radiation and wind speed on a capacity of the equipment. The capacity of this equipment can range from 6 to 8 L/day of fresh water from 8 AM to 4 PM.

Key words - distillation equipment; solar energy; freshwater distillation; water distillation; parabolic type's solar collector.

Tóm tắt - Chưng cất nước ngọt bằng cách sử dụng năng lượng mặt trời (NLMT) là phương pháp tốt cho sự phát triển bền vững, vì năng lượng được sử dụng miễn phí và than thiện với môi trường [1], [2], [3]. Trong bài báo này, đã nghiên cứu thực nghiệm thiết bị chưng cất nước ngọt sử dụng một bộ thu NLMT kiểu parabol. Hệ thống thử nghiệm gồm một bộ thu kiểu parabol có đường kính 1,3m và chiều sâu 0,45m. Bề mặt phản xạ parabol được làm bằng Inox có thể phản xạ NLMT. Tại tiêu điểm của parabol gắn một thiết bị chưng cất nước. Thiết bị được điều chỉnh quay theo chuyển động của mặt trời 15 phút/lần, sao cho bề mặt phản xạ parapol vuông góc với tia bức xạ mặt trời. Thiết bị chưng cất nước sử dụng bộ thu kiểu parabol được thiết kế và thử nghiệm ở Định Quán, Đồng Nai từ 13/6/12 đến 30/11/12. Thí nghiệm đo ảnh hưởng của bức xạ mặt trời và tốc độ gió đếncông suất của thiết bị. Lượng nước thu được từ 6 đến 8L/ngày trong thời gian từ 8h00 đến 16h00.

Từ khóa - thiết bị chưng cất; chưng cất nước ngọt; chưng cất nước; NLMT; bộ thu NLMT kiểu parabol.

1. Introduction

There have many researches on application of solar energy on freshwater distillation. This enables people in rural areas and isolated islands to use freshwater. Though freshwater distillation use solar energy has long been used, most of these used greenhouse effect, which has many disadvantages such as very low efficiency and unreasonable cost due to energy loss on collector surface.

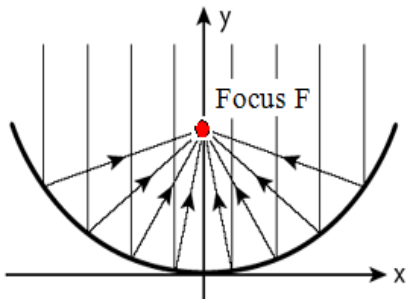
The water distillation technology using parabolic concentrated solar collector can reduce those disadvantages. This collector can focus solar radiation so that the water temperature is very high, thus, the evaporating process occurs very rapidly, resulting a very high efficiency for the distillation process.

In this paper, the freshwater distillation equipment using a parabolic concentrated solar collector has been experimentally studied. The section 2 presents the concentrated parabolic and it's thermal analysis, section 3 describe freshwater distillation equipment used for experiments. The experimental results are shown in section 4. Section 5 summarizes the result.

2. The concentrated parabol and thermal analysis

2.1. Concentrated Parabolic

Figure 1 show the sunlight reflected on the parabolic collector. The sunlight is reflected to a point known as the focus F.



Firgure 1. *The image of the sun at focus F.*

If a black generator is placed at the focus it will absorb the sunlight's energy and boil the water in a generator.

2.2. Thermal analysis

The collector thermal efficiency is defined as the ratio of the useful energy per the energy incident on the concentrator aperture as flows [3], [4]:

$$\eta_c = \frac{Q_u}{A_a I_b} \quad (1)$$

Where:

- A_a is the aperture area of the dish concentrator;
- I_b is the incident solar radiation per unit of concentrator area.

Under steady state condition, the energy balance on a

solar collector can be written as:

$$Q_u = Q_r - Q_l \quad (2)$$

Where: Q_u is the useful heat delivered by solar collector which is equal to the energy absorbed by the heat transfer fluid and can be calculated by:

$$Q_u = \dot{m}c_p\left(T_{out} - T_{in}\right) \quad (3)$$

Q_r is the radiant solar energy falling on the receiver.

$$Q_r = \eta_0 A_a I_b \quad (4)$$

η_0 is the optical efficiency

So the collector thermal efficiency can be written as:

$$\eta_c = \frac{Q_u}{A_a I_b} = \eta_0 - \frac{Q_l}{A_a I_b} \quad (5)$$

Q_l is the total heat loss rate of collector

$$Q_l = U_L A_r \left(T_r - T_a\right) \quad (6)$$

Where: U_L is the overall heat transfer coefficient based on A_r.

According to [..] the actual heat gain is given by [3],[5]:

$$Q_u = F_R A_a \left[S - \frac{U_L}{C}\left(T_{in} - T_a\right)\right] \quad (7)$$

Where:

- $C = \frac{A_a}{A_r}$ is the concentration ratio;
- $A_a = \pi R^2$ is the aperture area of parabolic dish;
- $A_r = \frac{\pi}{4} d^2$ is the receiver aperture area;
- $S = \eta_0 I_b$ is the absorbed flux;
- T_a is the ambient temperature; and
- F_R is the heat removal factor.

$$F_R = \frac{\dot{m}c_p}{A_r U_L}\left[1 - e^{-\left(\frac{A_r U_L F'}{\dot{m}c_p}\right)}\right] \quad (8)$$

From equation (7) and (8) the actual useful heat gain is given as [3],[5]:

$$Q_u = \frac{\dot{m}c_p C}{U_L}\left[S - \frac{U_L}{C}\left(T_{in} - T_a\right)\right]\left[1 - e^{-\left(\frac{A_r U_L F'}{\dot{m}c_p}\right)}\right] \quad (9)$$

Where F' is the collector efficiency factor.

3. The freshwater distillation experimental equipment

Figure 2 shows the freshwater distillation equipment used for experimental in this paper.

The experimental model consists of a parabolic concentrated solar collector, generator, condenser and cooling water system. The volume of generator contents 3 liters of water. There are two models of distillation equipment is presented in figure 3 and figure 4. The specification of the experimental equipment is shown in table 1.

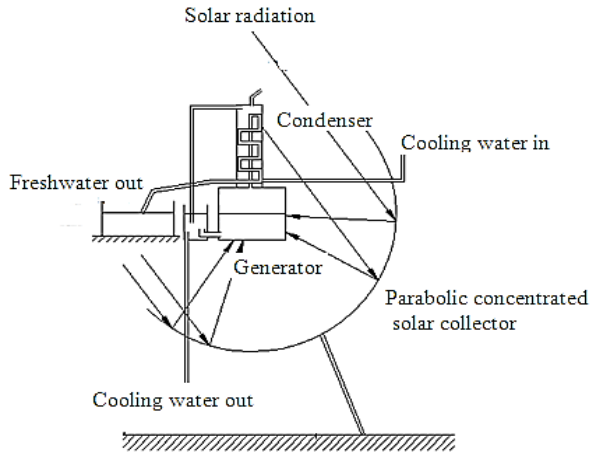


Figure 2. *The experimental model*

Table 1. *The specification of the experimental equipment*

No.	Components	Specification
1	Collector	1,3m Diameter
2	Generator	3 liters
3	Condenser	2 models

Figure 3 and figure 4 shown 2 models of distillation experimental equipments with different types of condensers. In the first model (Figure 3), the water is condensed inside the coils where as the water in the second model (figure 4) is condensed outside the coil.

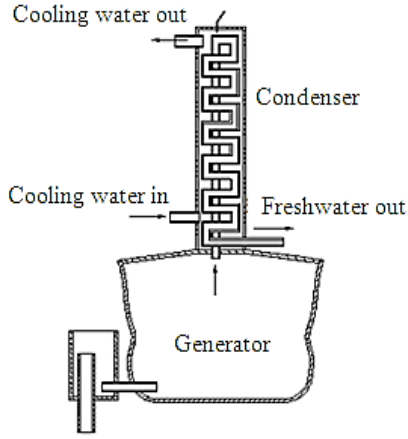


Figure 3(a). *The distillation equipment of first model*

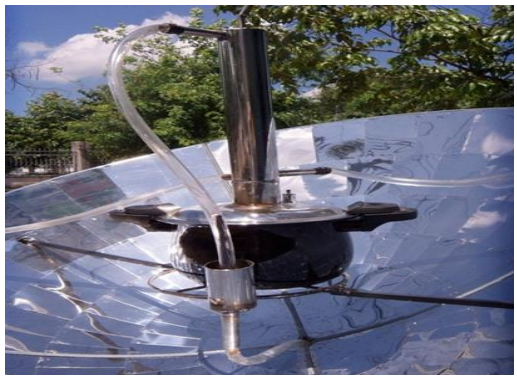


Figure 3 (b). *The distillation equipment of model 1*

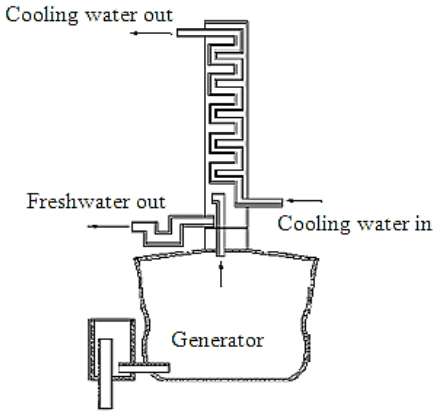


Figure 4 (a). *The distillation equipment of second model*

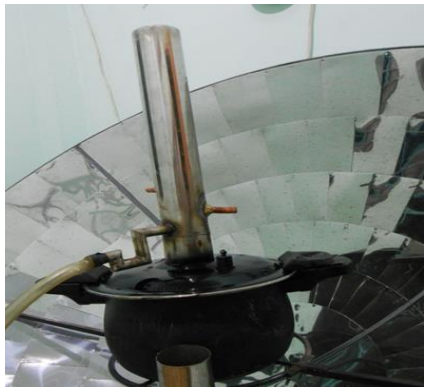


Figure 4 (b). *The distillation equipment of second model*

4. Experiment results

The two models of distillation equipments described in section 3 were used for experiment. Many experiments have been carried out the freshwater distillation equipment under the local conditions of Định Quán, Đồng Nai province during the days from 13/6/2012 to 30/11/2012. An experimental result of each model is the result of an average of 5 days of experiments in the sameconditions.

The experimental results of two models are presented in figure 5 and figure 6.

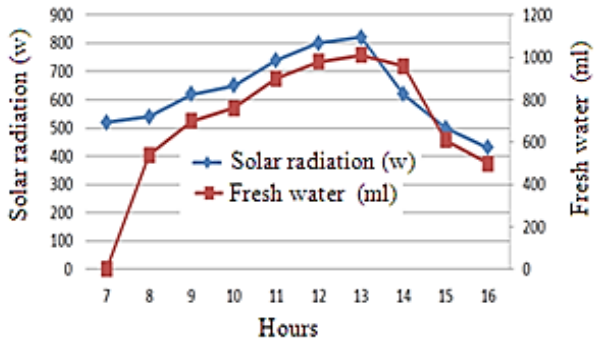


Figure 5. *Experimental results ofthemodel 1*

Experimental results of the first model for the amount of distilled water from 7h00 to 16h00 is 6960ml, meanwhile results of the second models in the same conditions, the amount of distilled water is 8005ml. In the first model, water steam is condensed in the small tubes (coils) and flows down, so it will be bad influence on subsequent condensation so this explains why and the condensing process is less efficient. Meanwhile, in the 2nd model, the water steam is condensed in the large tube and flows down. In this case, the distilled water does not affect the subsequent condensing processes. This explains why the second model gave better efficiency as shown in this experimental data.

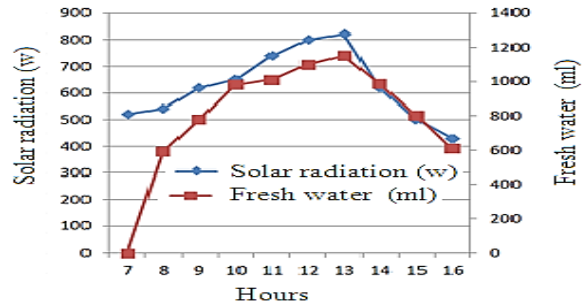


Figure 6. *Experimental results of the model 1*

In comparison with the greenhouse effect technology, this concentrated solar collector gives a much better efficiency. In particular, with a solar radiation above 800 W/m^2 the amount of freshwater obtained with the parabolic concentrated solar collector is 1180 ml/hour (second model) where as the number is 800ml/hours for greenhouse effect technology. Total cost of equipment is only 2,500,000 Vietnam dong.

5. Conclusion

The experimental data shown freshwater distillation technology using parabolic concentrated solar collector can be exploited solar energy for rural areas or isolated island to produce freshwater.

The experiment was carried out during the raining season in the south of Vietnam and gave quite good efficiency. It is expected that, during the dry season where the peak solar radiation is up to 1000 W/m^2, the amount of distilled water will be increased significantly.

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