Low Cost DIY Solar Energy Hot Water System

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Abstract – This paper describes a low cost hot water system for domestic use. The system is very simple, low in cost, and can be made without any sophisticated equipment and manufacturing tools.

INTRODUCTION

This paper describes a domestic solar energy hot water system that is suitable for domestic use. In domestic homes, electricity for hot water normally use up a large proportion of the electricity energy bill. Thiis portion of expenses will increase when the cost of fuel gets more and more expensive. Solar energy is plentiful and abundant, therefore it is an attractive proposion to tap this energy to heat up water for the homes. However, using photovoltaic cells to generate electricity for heating are very expensive. There are some commercial direct heating solar hot water systems in the market; however, they are still too expensive for the average home. In this paper, we will introduce a DIY solar energy hot water system that is both low cost and easy to make. The system can be divided into three, namely the heat collection unit, the temperature sensing and control, and software design.

THE TEMPERATURE SENSING UNIT

The temperature sensing unit consists of copper tubes bended in a rectangular spiral form. To prevent heat loss, the tubes are enclosed inside a sealed box. The ligning of the box is coated with black paint, and a thick glass is put on top. See Fig. 1 for the details.

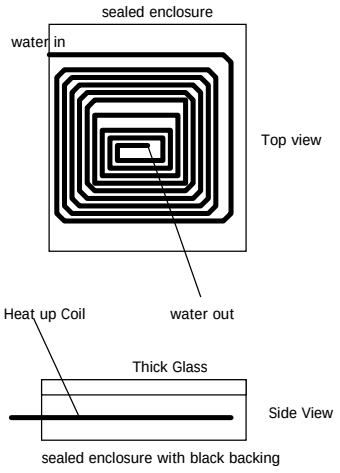

Fig. 1 The Heat collection unit

THE CONTROL UNIT

The control unit consists of a low cost embedded processor. The processor collects the temperature information on the inlet and outlet of the heat collection unit, and controls the flow of water into the heat collection unit. Fig. 2 shows the circuit diagram of the control unit. The heart of the control unit is a low cost 8051 processor. Only very few external components are needed to construct the whole control unit.

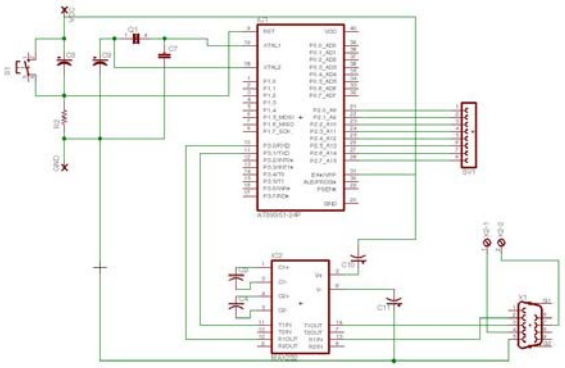

Fig. 2 The embedded control unit

Fig. 3 shows the circuit diagram of the LCD display unit. The unit displays the incoming and outgoing temperature of the DIY hot water system. Fig. 4 shows the temperature sensing circuit. Two semiconductor sensors are used to measure the temperature of the incoming and outgoing water. An 8 bit analogue to digital converter is unused to convert the analogue temperature information back to digital form.

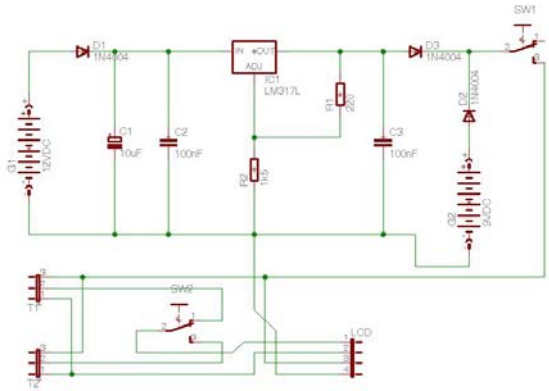

Fig. 3 The LCD display unit

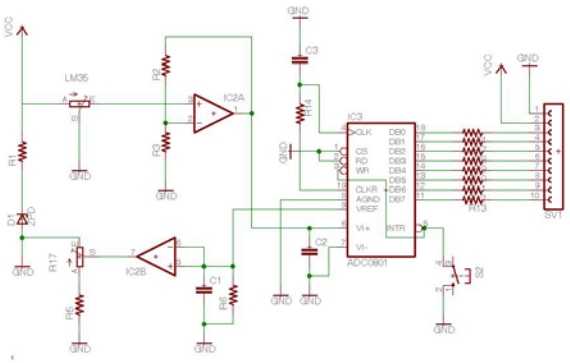

Fig. 4 The temperature sensing unit

Fig. 5 is the solenoid valve control unit. This circuit controls the flow rate of water into the heat collection unit.

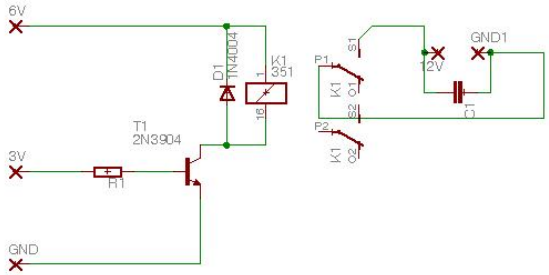

Fig. 5 The solenoid valve control unit

THE CONTROL PROGRAM

The whole program is written in C, and it is downloaded into the 8051 processor. Basically the processor controls all the house keeping tasks of the whole system, including the solenoid valve on/off, time of day management, user preferences, status display to LCD panel, temperature monitoring. The whole program occupies less than 1K byte of machine code.

RESULTS

We tested the system under three type of weather conditions: (i) cloudy day, (ii) cloudy day with sunny intervals, and (iii) cloudless sunny day.

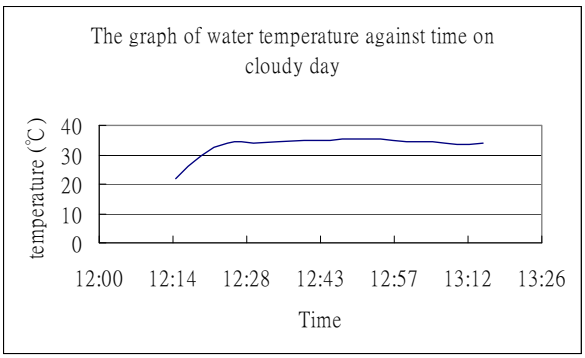

Fig. 6 Temperature rise of water during a cloudy day

All the tests were done during spring time, on the podium of the Hong Kong Polytechnic University. The ambient temperature at that time was 21˚C.

During a cloudy day, the temperature rise of water is very limited, and the maximum temperature of water cannot exceed 38˚C. Therefore, the use of this system during cloudy days is very limited.

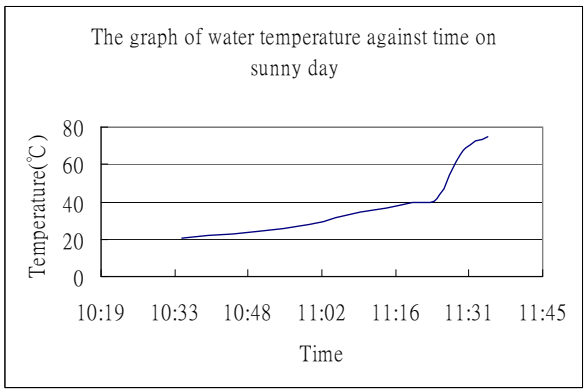

Fig. 7 Temperature rise of water during a cloudy day with sunny intervals

Fig. 7 shows the temperature rise of water during cloudy days with sunny intervals. During the cloudy interval, the performance is similar as before. However, as the sun breaks out from the cloud, the temperature rise of water will increase rapidly. During this sunny interval, the temperature rise of water shoots from below 40˚C to 70˚C in 15 minutes. The amount of heated water is ½L for a surface area of 30cm × 30cm (i.e. approximately 1 square foot).

This is quite an acceptable performance. For household roof-top of 1000 square feet, we can expect 500L of 70˚C hot water heated up within 15 minutes.

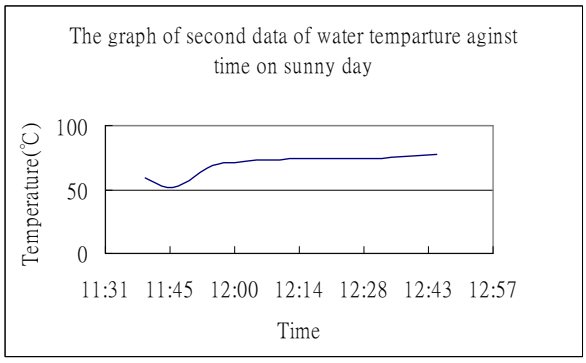

Fig. 8 Temperature rise of water during a sunny day

Fig. 8 shows the performance of the system on a sunny day. In order to find out the maximum achievable The controller is purposely set not to pump the water away when the desired temperature is reached. We found that the maximum temperature is around 75 ˚ C. The temperature will not rise any further, even after a long sunny exposure.

CONCLUSION

This paper describes the design, construction, and testing of a very simple solar energy domestic hot water system. The system is low cost, and can be easily fabricated at home as a DIY project. The result measured on a sunny day is very encouraging: for a solar collection area of 1 square foot, it can heat up ½L of water from 40˚C to 70˚C in 15 minutes, or from 23˚C to 70˚C in 23 minutes. This simple project can promote the use of solar energy in domestic homes.

REFERENCES

[1] Trimby Paul, "Solar water heating: a D-I-Y guide", Machynlleth (Wales), Centre for Alternative Technology Publications, 1995

[2] Zhao JC, "Practical Solar Hot Water System," Shanghai Technical Press 1983 (Chinese).

[3] HL Li, SY Wang, SC Chen, "8051/52 Single Chip Computer User's Guide," ChiShing Digital Press (Chinese)

[4] www.itdg.org/docs/technical_information_service/solar_water_heating.pdf