LOW COST SOLAR HOT WATER SYSTEM

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Abstract — ***Solar Hot Water systems are extensively used in some of the more developed countries in the world. They have been subject to much research and are now extremely efficient units. With all of these improvements the cost has escalated to result in units which cannot be afforded in the lesser developed countries. It was because of the high cost that we in Central Philippine University decided to develop a low cost unit, which although not so efficient would be affordable and simple to construct. It should also be designed in a way that it could be used for educational purposes.***

INTRODUCTION

The use of hot water in a piped system within houses in the Philippines is not very common at present. In more developed countries it is widely used. The cost of running these systems is increasing dramatically as more equipment is used in the home that use hot water. The two most common items are the washing machine and the dishwashing machine. It has been proven that the use of hot water for washing dishes, etc. results in much cleaner dishes. There has also been a considerable increase in the use of Spa Baths, these use a tremendous amount of hot water.

Even in countries like Australia, where people are considered reasonably wealthy, it became necessary to develop Solar hot water systems. These are normally used in conjunction with a normal energy consuming unit. Either electrical or gas heated system. The units therefore use solar heating within the daylight hours and the other energy system during the night.

The modern efficient unit uses Ultra Violet stabilized polycarbonate instead of glass and copper for the heat exchanger. This material is also used for the housing together with some reinforcing. This keeps the unit light weight and impact resistant.

Stainless steel for the water tank, insulated with fibreglass. The heating from artificial means is normally controlled by sophisticated electronics. This heats the water when the usage demand is high and maintains the heat during the night hours.

The use of hot water in the Philippines is not as common as in a country like Australia. A fuel saving could be made if the hot water is used for cooking. When cooking a noodle dish for example we turn the gas on high until the water is boiling and then turn the gas down to simmer for three minutes.

Most of the energy is used to bring the water to the boil, if the initial water temperature is raised with solar heating less energy is used.
When bathing, or washing the dishes, the result is cleaner if warm or hot water is used, most of these types of things are normally done with cold water in the Philippines. Therefore this would not produce any cost savings. The benefit in these cases would be improved hygiene.
There are many advantages in using Solar Energy. This is a non polluting energy source, which is provided free. This energy does not have to be imported and therefore assists in the economics of the country concerned. This fuel does not have to be transported.

TYPE SELECTION

There are two main types of unit using the convection method. One is using a pressure system, the second is gravitational (or open) system.
The second system was selected to keep the cost low. A pressure system requires a pressure vessel together with a relief valve.
The gravitational system requires an open tank with a float valve to maintain the water tank level.
These two types use convection to circulate the water, no pump is therefore required, sometimes referred to as passive type.
Other types are available, however these are normally using very large collectors and a pump. This type is normally used to heat swimming pools, sometimes reffered to as active type.

OBJECTIVES

The objectives were to:

1. Manufacture a unit at minimal cost.
2. Produce the unit so that it can be used as a teaching aid.
3. Position the unit so that it can be examined safely by students.
4. Use all locally available products.

LOCATION

The location had to comply with a few criteria:

1. A suitable water supply preferably from an overhead tank.
2. Be able to be fitted where it can easily be viewed, safely.
3. In a predominantly sunny position.
4. Easy installation, with low cost.
5. Close to College of Engineering.

The ideal location for such a unit is directly on the roof of a building. However for this unit it would be impractical, as students could not climb onto a roof to see how it works. A suitable site was located at the power plant area, this suited most of the criteria.

METHODOLOGY

A tank was constructed with a capacity of 120 Litres, this was fitted with a float valve and other pipe connections.

A marine plywood box was made to house the tank leaving suitable space for insulation.

The heat exchanger consists of two main parts, the collector, manufactured from copper tubing in the form of a grid. The housing which consists of a marine plywood boxing with a glass front.

The copper tubing is painted with a dull black paint to absorb as much heat as possible. Dull black paint is around 95% efficient for heat transfer, (white semi gloss is only 30% efficient). These figures are supplied by the U.S. Department of Energy. The housing is lined with aluminum foil to reflect the heat back to the collector.
The housing should have a ventilation area at its lowest point. This will limit the heat loss and allow for expansion of the internal air.
Reference to Heating and Design by Robert Henderson Emerick, indicates that near to the equator the heat exchanger should be angled at 5 to 10 degrees and as much as 60 degrees nearer to the polar regions. These figures are correct in theory, but an accumulation of dirt on the glass would severely restrict the efficiency of the unit.
The mounting of the heat exchanger is such that it should be at an angle so that when it rains the glass will effectively be washed with the water running down. It should not be too sharp an angle so that the water will flow at a reasonable rate to allow suitable heat absorption. The angle selected was around 40 degrees.

Therefore it is a compromise as to the angle selected. As these units would probably used domestically they should for practical reasons follow the angle of the roof of the dwelling. Presuming that it would be exposed to the sun during daylight hours.

The ideal location for the tank is immediately above the heat exchanger. However for practical purposes this was mounted a short distance away. The greater the distance between the heat exchanger and the tank results in greater heat losses. Plastic piping was used for these connections to minimize heat loss.

PROBLEMS

The only problem encountered was for the supply of a float valve. This did not seem to be available in Iloilo.

This was overcome with the use of a standard ball valve, modified by welding some bar to the handle and fitting a float to this.

TESTING

It was decided to test the unit with the lid of the tank not insulated and later with the insulation fitted. This would enable the efficiency of the insulation to be established.
Water usage during the testing was approximately 16 litres per day.

The temperature was measured twice daily, close to 8:30 am and 4:00 pm.

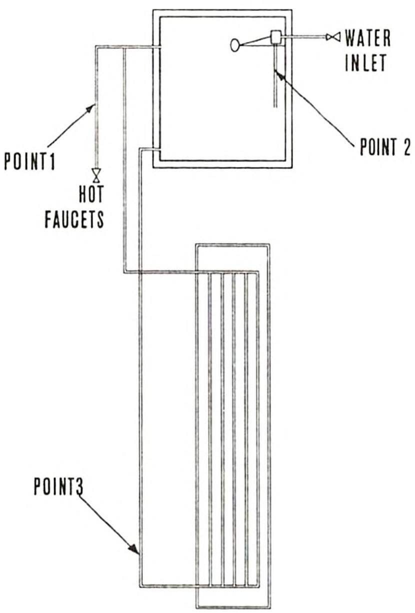
The diagram illustrates the test points, it also gives an indication of the various parts of the system..

TEST RESULTS

The test points where the readings were taken are at POINT 1 the hot water outlet and POINT 2 the cold water inlet.

The maximum gain with uninsulated lid was 25 degrees C and the minimum was 9 degrees C. The average gain in temperature over the temperature of the inlet water was 18.75 degrees Celsius.

DIAGRAM



These readings were taken morning and evening, the system had no insulation on the lid of the hot water tank. This was a piece of plywood laid on top of the tank. The purpose of this is to evaluate the quality of polystyrene foam as an insulation medium. The second and final results were with the lid insulated.

A typical warm sunny day will give result as below:

AMBIENT	OUTLET	INLET	GAIN
31	48	24	24

The second set of test results with the lid insulated were as follows:

Maximum gain was 28 degrees C.

Minimum gain was 16 degrees C.

The average gain was 23.1 degrees C.

A typical warm sunny day will give result as below:

AMBIENT	OUTLET	INLET	GAIN
31	53	25	28

The recovery rate when 8 litres of hot water is drained for the system is as low as 25 minutes on a hot sunny day, and as long as 70 minutes on a dull cloudy day. Even on days with heavy rain for the whole day a temperature increase of 16 degrees C is reasonable considering the cost of this unit is around 1/10 of the cost of an imported unit.

CONCLUSIONS

The Styrofoam used was a high density type used for the packaging of computer monitors. This type is suitable for impact cushioning but a low density foam would probably insulate the tank better. This foam should probably be cumbled to enclose more air pockets for improved insulation. The overseas Solar Water Heaters use fibre glass insulation which is obviously superior but is costly in the Philippines.

Although this unit would be considered low in efficiency. If it is related to the cost of the unit, it is far more efficient than commercially available units. When they are rated against cost of the unit. It therefore has potential for manufacture in the Philippines.

A point of consideration is that when this system is used for bathing it should be combined with cold water. Temperatures above 40 degrees C become uncomfortable.

Therefore proper mixer units would be required for showers, the alternative would be the inclusion of non return valves. It would be a disaster if faucets are turned on and the cold water pressure is higher than the hot water pressure. The result could be for the cold water to enter the hot water tank through the outlet, resulting in overflow of the hot water tank.

The manufacturing process would be very simple, suitable for individual units or on a semi-automated system of manufacture. Very little specialized training would be required for individual manufacture.

Installation of the Solar Hot Water system should be simple for most homes, however the pipework to the faucet outlets may be more difficult. This should not be too long and preferably should be insulated or as a minimum requirement should be plastic suitable for the temperature of the hot water.

The level of sophistication used in the modern overseas units is not required at present in the Philippine environment.

The climatic conditions in the Philippines makes this type of unit suitable for present day needs.

RECOMMENDATIONS FOR FUTURE IMPROVEMENTS

The initial work has now been completed. There is a need however for further improvements. The heat exchanger is an obvious area for future development. The use of plastic pipe sliced lengthwise in half and the inside covered with aluminum foil would reflect the heat to the copper pipe. This could result in considerable improvement in efficiency.

The effect would be similar to a parabolic mirror, ensuring that the maximum amount of heat is reflected to the copper piping.

A top and bottom manifold could simply be constructed, instead of using Tee pieces and elbows in the copper pipe for the collector. This would probably involve less cost and would be simple to manufacture with the use of a jig. The individual pipes would not have to be cut so accurately.

The Styrofoam insulation for the water tank should be low density, which will improve the heat retention for the tank, or other forms of locally available insulation could be considered.

Consideration could be given to the materials used in the construction of the unit. Also care would have to be taken in the size of the water tank.

For every litre of water the weight increases by 2.2 lbs plus the weight of the tank and housing.

Due to the lack of experience of fitting up and installing units of this type in the Philippines a great deal of guidance should be given to any potential manufacturer. There are many pitfalls. An example of this is some form of indemnity that should a unit be installed and a neighbour builds a two story building next door, creating shade on the unit. The system will no longer work efficiently.

REFERENCES

SOLAR HEATING AND COOLING by Jan F Kreider and Frank Kreith.

HEATING AND DESIGN PRACTICE by Robert Henderson Emerick.