SOLAR WATER HEATER DEVELOPMENT IN NIGERIA

Y A Jimoh, Department of Mechanical Engineering,
College of Science & Technology, Kaduna Polytechnic, PMB 2021, Kaduna, Nigeria

ABSTRACT

Electricity supply is limited and its cost is also increasing steadily. Solar energy is abundant and it may be economically utilised as a supplement to electric power, if appliances such as solar water heaters, air heaters, dryers, air conditioners etc are made available at low cost. So it is important to develop methods and technology for the utilisation of solar energy. A solar water heater has been designed and fabricated for domestic and industrial uses which can be commercialised. While carrying out this project we also aimed at developing awareness and skills in using locally available materials in efficient and economical ways, thus becoming independent of imports.

The typical solar water heater consists of a flat plate solar collector, an insulated hot water storage tank and the piping system. A prototype, 1.1m^2 flat plate solar collector was fabricated from locally available materials (Y A Jimoh 1983). It was tested in a thermosiphon water heating system connected to a 62 litres insulated storage tank.

Performance tests were carried out over a period of one year. The results were quite satisfactory with the net absorbed power being, on average, about 250W per square metre collector area (considering a day of 8 hours from 8.00 am to 16.00 pm). The range varies from 0 to 600W per m^2 depending on the intensity of solar radiation.

The cost of the complete solar water unit at the time of construction (January 1983) was 500 Naira. At present, the cost is estimated to be about 1,000 Naira. Further work to increase the efficiency of the solar water heater involved improvement to both the collector and the insulated storage tank. Progress will be reported in due time.

INTRODUCTION

Researchers at Kaduna Polytechnic, Kaduna, Nigeria have been designing and developing an appropriate and efficient solar collector using locally available materials and skills as far as possible. The solar collector will be used to suppy the newly constructed student canteen with all its hot water. The initial capital investment is expected to be offset by the savings made in the running cost.

This paper describes the design and evaluation of the performance of a prototype collector.

SOLAR COLLECTOR DESIGN

Solar collectors exist in various forms and types but for our solar water heater project flat plate collectors were selected because of their simple geometrical form, which makes for simple construction from locally available materials. They also have comparatively good performance.

The main components of a flat plate solar collector are the absorber, the heat exchanger, insulation, and the frame and cover. These are discussed in the following sections.

The absorber-heat exchanger

Because of cost constraints and the level of technology in Nigeria, the absorber-heat exchanger was fabricated from galvanised mild steel plate and copper pipes. Aluminium sheets and pipes were considered, but aluminium pipes are not available locally.

The final selection of a combination of mild steel plating and copper tubing has sufficient thermal efficiency and is an optimum economic solution. Efficiency can be further improved by double glazing, honey combing, etc.

The absorber-heat exchanger was constructed using 12.5mm copper riser pipes spaced at 125mm. Riser pipes were joined to 25mm copper headers. A 2mm thick galvanised mild steel plate was cut to fit the spaces between the copper pipe and headers. The whole unit was coated in matt black paint.

The insulation

Initially, a combination of chipboard and glass fibre was used as insulation for the collector and the storage tank. It has now been replaced with polyurathane foam which has a very low thermal conductivity (0.026 W/m°k) and is abundantly available locally.

The frame

The collector is enclosed by a galvanised mild steel frame, lagged for long life and durability. The frame is 1230mm by 925mm and includes a glass cover selected for durability against adverse weather conditions, good transmittance, low absorbance, dimensional stability and availability in the local market.

WATER STORAGE TANK AND PIPING

The hot water storage tank used in the tests of performance of the solar water heater was a 62 litre rectangular mild steel tank lagged with 10mm thick glass fibre and enclosed in a chipboard box. This tank remained above 40°C overnight. This is now to be replaced with a 100 litre tank which is double walled with polyurathane foam lagging.

COST

The complete solar water heater installation comprising 1.1m^2 collector, 62 litres hot water tank, piping, frame fitting and wooden supports cost N500 in 1982. The cost can still be considerably reduced if units are mass produced.

PERFORMANCE TEST

During performance tests the collector was connected to a 62 litre storage tank by lagged galvanised steel pipes and fittings in an open circuit thermosiphon system. The collector frame was inclined at an angle of 12° to the horizontal, towards the south as Kaduna is situated at about 12°N latitude.

Thermometers were installed at the entry and the outlet of the collector. Provision was also made for measuring the temperature of water in the tank. Readings taken included: (i) ambient temperature TA in °C; (ii) collector inlet temperature T_1 in °C; (iii) collector outlet temperature T_2 in °C; (iv) the temperature of the water in storage tank T_3 in °C were recorded daily on hourly basis from 8 am to 3 pm.

Table 1 shows typical daily temperature recordings from 8.00 to 18.00 hours and the calculated power output P in watts of the collector.

OBSERVATIONS

With the full capacity of 65 litres of water in the thermosiphon system, the collector outlet temperature was 55°C, collector inlet temperature 49°C and water temperature in the storage tank 50°C on a cloudy, windy day. The highest water temperature was achieved in the storage tank, 78°C, was recorded on April 5th 1983 at 13.00 hours on a day with an ambient temperature of 38°C.

The mean net power output of the collector determined from the heat energy gained by water when the temperature in all parts of the system is almost equal is 265W per square metre collector area. But the power output of the collector varied betwen 0 and 600 W per m^2 during the day depending on the intensity of solar radiation.

The power output can be considerably improved for normal water heater operation where water is taken out and the same quantity is automatically added in domestic and industrial installations. A larger capacity tank will improve the thermal efficiency.

SUGGESTIONS FOR IMPROVEMENT

1. The design is to be modified by eliminating the copper pipes and making a thin box with a copper absorber plate on the top and a steel plate behind a 100mm polyurathane foam lagged hot water storage tank.

2. The frame can be made of seasoned and painted wood. This would extend the life of the unit and improve the insulation of the absorber plate.

3. The use of foam as insulation will reduce cost and weight.

4. The storage tank is to be installed near to the collector to reduce head loss due to friction. Installation of a solar energy powered pump will further improve the thermal efficiency of the unit.

CONCLUSION

Experience gained from this prototype has indicated that efficient solar water heaters for domestic and industrial applications in Nigeria can be successfully developed and produced at less cost than imported ones. Encouragements and incentives should be provided for the development of these types of import substitution projects.

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REFERENCES

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Kreider and Kreith Solar energy handbook. McGraw Hill Book Co. NY.

TABLE 1: Typical daily temperature records and hourly power absorbed

Total capacity of water in the system : 65 litres

Date	Time	T_A	T_1	T_2	T_3	T_4	Power output P-Watts
8.3.84	8.00	27	26	26	48	0	0
	9.00	29.5	41	43	48	0	0
	10.00	31.5	45	50	50	2	152
	11.00	32	49	56	56	6	456
	12.00	36	55	62	61	5	380
	13.00	38	60.5	60	57	6	456
	14.00	39	66	73	72	5	380
	15.00	39	72	76	74	1	76
	16.00	38	72	74	73	-1	-76
	17.00	36	62	69	68	-5	-380
	18.00	34	52	53	65	-3	-228

T_A = Ambient temperature

T_1 = Collector inlet temperature

T_2 = Collector outlet temperature

T_3 = Temperature of hot water in storage tank

T_4 = Hourly difference of T_3