Innovative Water Heater Design

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Abstract: - Depletion of fossil fuel reservoirs, their environmental impact and oil crises has made researcher to think about alternate resources of energy. This is why we see tilt towards alternate energy resources often termed as renewable energy resources, as the safe future of the world from energy point of view lies in the usage of renewable energy resources, like solar energy. Solar water heaters generally employ a solar collector and a storage tank. In the present work we eliminate the tubes on the collector that carries additional cost and the transfer of heat duty from the collector to the fluid flowing in the tubes is less than the heat transfer from the collector direct to the channel, which is designed underneath the collector plate. By eliminating the tubes, the present design improves the efficiency by 10% and reduces the cost by 20% as compared with the existing design.

Key-Words: - Water Heater, Solar Energy, Solar Water Heater, Renewable Energy Resources, Solar Radiation, Conventional Energy Resources

1 Introduction

A quite sizeable amount of solar radiation falls on earth surface everyday. Annual 24 hours solar insulation value is about 300 watt/m^2 on earth surface. This solar insulation can either be harnessed as thermal energy or as electricity by silicon photovoltaic cells. Problem even with photo cells, besides high cost is solar energy availability factor, thus a photo cell remain idle for quite long time, thereby increasing energy generation cost [2].

Solar water heaters are used on a common natural phenomenon that cold water in a container left exposed to the sun will be raised in temperature. Solar water heating systems are designed to make convenient use of this phenomenon [3, 11-13].

The climatic conditions in Pakistan are favorable for erecting up solar energy plants. The rate at which the stored fuels or fossil fuels are being consumed in the world today makes it almost inevitable that solar energy will be used to supply the basic human needs for energy sooner or later. The recent drastic increase in prices of combustion fuels: coals, oil and gas makes it even more urgent for man to try and utilize the one source of energy which is free, i.e. the solar energy in the form of Sun light.

Our rapidly changing energy oriented society has promoted us to set up various national and international organizations to look for different type of energy resources and their uses. Pakistan "the Sun burnt country" has abundant supplies of solar energy as it is situated between 24 to 38^o North Latitude. Many systems have been developed around the world in attempts to use this energy. At present the major factor preventing the wide spread use of solar energy is cost economics. Although solar energy is free, the systems using this energy are often very expensive. As the price of conventional energy resources raises more and more, solar applications are becoming economically competitive and so the use of solar energy is increasing with time [10].

Solar energy at the earth's surface does not provide a continuous energy supply. For most locations, this energy source is interrupted by nightfall. Therefore if energy is needed at night, it must either be collected during the day or stored for later use. The amount of solar radiation finally reaching the earth's surface at a particular location depends on the time of the year, the time of the day and the prevailing weather.

On a clear summer day the maximum intensity of solar radiation reaches at earth's surface at sea level is about 1000 w/m^2. This is made up of two components, the radiation in the direct beam from the Sun, and diffuse radiation from the sky. Global irradiance varies through the course of the day because the path length of the solar radiation through the atmosphere changes. For the same reason, there are variations with season and latitude. This variability is an important aspect of solar energy because it influences system design and solar energy economics [4].

The organization of the paper is as follows. Section 2 discusses energy fundamentals for heating water. Section 3 discusses design details. Section 4 discusses cost analysis. Section 5 discusses results. Section 6 concludes the paper.

2 Energy Fundamentals for Heating Water

When radiation energy strikes the surface of an object a proportion is reflected, part is absorbed and part may be transmitted through the object. With a few important exceptions, such as photo voltaic cells, the energy of the absorbed radiation is degraded rapidly to heat.

The balance between the absorbed input energy and the heat loss to the surroundings determines the temperature attained. The heat loss increases with the temperature. It also reduces the proportion of useful heat extractable from the system. Maximum temperatures and maximum power outputs are therefore obtained when a highly absorbent, well-insulated body is exposed to a high intensity of solar radiation [1, 2].

The energy required to raise the temperature of a substance is a physical property known as specific heat of the particular substance. The specific heat of water is 4.2 J/g ^oC. It means that 4.2 Joules of energy are required to raise the temperature of one gram of H_2o through 1 ^oC using larger units:

Energy required = 4.2 x volume (liters) x temp. rise ^oC KJ

The parameters for water heating which are to be considered are:

(i) Volume of water (in litters) required in a given time period
(ii) The temperature of the cold water in ^oC.
(iii) The require delivery temperature in ^oC

Hot water may be used for variety of purposes but we consider only domestic use for example it may be used as for cooking, for bathing, for washing clothes and utensils.

It is convenient to measure energy in KWH for comparison of energy obtained by the heater with electric energy.

1 KWH = 3.6 MJ

Although electricity is efficient at heating water, it is expensive and not available every where.

On a clear sunny day the solar insulation value is about 6 KWH/m^2 [3].

$$CA = \frac{E_D}{S_I * C_E} m^2$$

Where,

C_A = Collector area required,
E_D = Energy demand,
S_I = Solar insulation/m^2 and
C_E = Collector efficiency

The efficiency of device which connects solar energy to heat is the ratio of the useful energy obtained from the device and the amount of solar radiation falling on the device.

i.e. Efficiency of conversion = $\frac{\text{useful energy obtained}}{\text{incident solar energy}}$

To obtain useful energy at high temperatures two approaches are possible.

a. To reduce the heat losses.
b. To increase the radiation incident on the absorbed area.

Methods of reducing the heat losses in a solar collector include the use of special absorbing surfaces glass covers to prevent the wind cooling of the absorber [5].

It also provides insulation from the weather and it behaves like a green house. The principal technique used to achieve high temperatures is to increase the radiation incident on the absorber area.

3 Design Details

The available solar heating device is the fate plate collector, having tubes for the fluid passage ways bonded with the plate or these tubes are integral part of the flat plate collector. We offer a new design for the collector, by eliminating the tubes for the fluid flow, the tubes causes several leakages points in the design and additional cost on the collector. By eliminating the tubes in the collector design the amount of heat transfer to the fluid increases by reducing heat losses as heat absorbed by the collector is transferred to the flowing fluid rapidly in the new design which increases the efficiency of the collector. The flat plate collector absorbs as much as possible of the incident solar energy that falls upon it.

The collection efficiency fall off rapidly with increase in temperature, this can be increased by providing insulation to the collector and the storage tank [7, 8].

Figure 1 shows the construction details of the collector. We use a stainless steel metal sheet for the collector design providing a channel beneath the absorber in which water is flowing randomly from inlet to outlet. Due to random motion/movement of water in the channel, all the heat absorbed by the painted black collector is instantly transferred to the water by conduction. And the hot water then flows in to the storage tank which is situated at top of the collector and heat that is collected by water in the collector is transferred by convection due to natural circulation of water from the collector to the storage tank. The dimensions of the collector are:

Length = 200 cm, Width = 130 cm and Depth = 15 cm

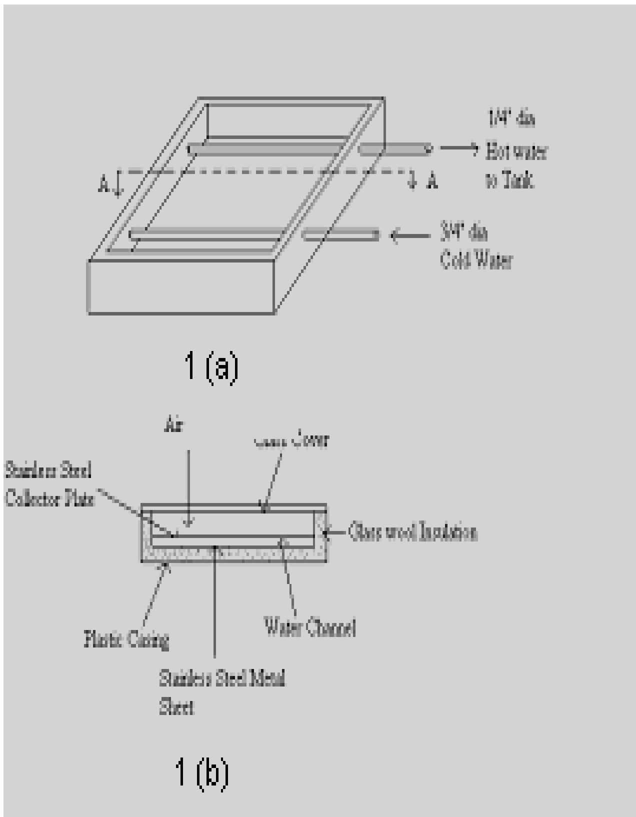

Figure 1 (a) Collector / Absorber Design, (b) X-Section AA

Figure 2 shows the construction detail of the storage tank. The cylindrical tank is also made up of stainless steel sheet for storage of 100 liters of water. Insulation is provided around the tank and to protect the insulation plastic cylindrical tank surrounded the insulation and whole setup is air tight so that heat losses are reduced to a minimum, so that water which is heated at day time can be used either in the evening, night or next morning.

Non-return valve is provided so that hot water can not flow into the collector at night from the storage tank. To heat 100 liters of water per day we use the collector area equal to 2.6 m^2. The storage tank is filled with potable water in the morning. Hot water up to 70 – 80 ^oC is obtainable depending on the sunshine. When using pre-heated water from the unit conventional fuels such as fire wood, kerosene, gas, electricity etc. can be conserved and the use of solar water heating displaces the burning of other fuels and hence is beneficial to the environment [3, 9].

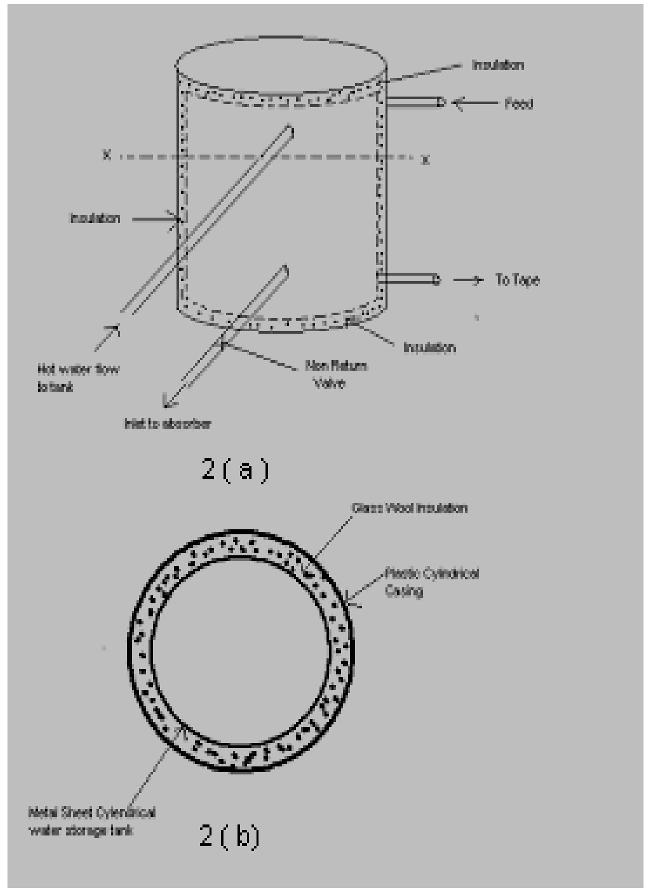

Figure 2 (a) Water Storage Tank, (b) Cross-section XX

4 Cost Analysis

The cost when the unit is manufactured commercially is about 7000 Pak rupees and its expected life is about 20 years. When using electric power for heating 100 liter of water up to 70 ^oC when the inlet temperature of water is 20 ^oC, the energy required is

E = 4.2 x 100 x (70-20)
= 21000 KJ = 21 MJ
As 3.6 / MJ = 1 KWh
=> 21 MJ = 5.6 KWh

It means that this amount of energy must put into the water. Therefore, for heating 100 liters of water thought 50 ^oC requires 1 KW rated electric immersion heated running for nearly 6 hours daily. Which costs about 20 rupees / day or 600/- per month or 7200/- per year. Therefore, the pay back period for the solar water heater is only about one year [1, 10].

5 Results

We have taken the reading of the temperature rise of water in the storage tank during clear sunny days of the months of Nov. to Feb., which are the peak cold weather months in Pakistan and the demand of hot water in these months is increased to 100%.

For showing the performance of our presented solar water heater design, we have randomly selected the data of temperature rise of water from these four months which has been tabulated in Table 1. Figure 3 shows Days Vs Energy Obtained.

Table 1:

Moths	Days	Vol. of H_2o in liters	Temp. rise ΔT ^oC	Energy obtained KJ	Energy obtained MJ
Nov.	1	100	56	23520	23.52
	2	~	57	23940	23.94
Dec	3	~	55	23100	23.10
	4	~	58	24360	24.33
Jan	5	~	62	26040	26.04
	6	~	60	25200	25.20
Feb.	7	~	54	22680	22.68
	8	~	58	24360	24.36

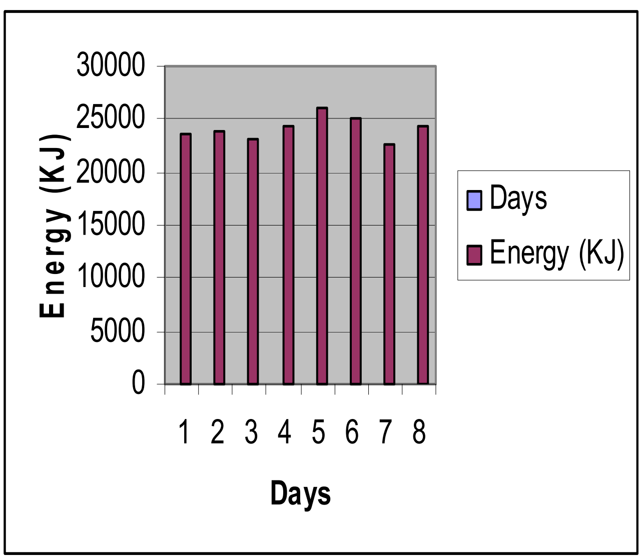

Figure 3: Days Vs Energy Obtained

6 Conclusions

The fossil resources are limited treasure of man – a treasure which is fast disappearing. Renewable energy includes hydropower, solar radiation, wind energy, wave energy and tidal energy. Like other renewable energy systems, solar water heater minimizes the environmental effects. Solar water heater helps to reduce our dependence on foreign fuel. Our proposed solar water heater costs around 7000/- Pak Rupees and it saves about 6 KWh of energy per day and pay back period of the heater is just one year. Its expected life is about 20 years and therefore it saves large amount of energy. In future we are looking for cheap and long life material, we are also working to improve the design for more efficient and economical working.

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