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THE BEST POSITION OF PARTITION DISK RESEARCH ON THE ENERGY SAVING 2ND GENERATION SOLAR WATER HEATING TANK

Chun-Te LEE[1*], Huna-Mei CHU[2]

[1]Department of Leisure and Sports management, Cheng Shiu University
[2]Department of Business Administration, Cheng Shiu University

Abstract

In the recent time, because of global warming caused by the growing environmental disaster, government and non-government agencies around the world are actively involved in the implementation of energy saving and carbon reducing products and plans. Our team has targeted and improved the problem of water getting colder as it is being used. It can, as well, effectively improve the efficiency of the consumption of heat and electricity. And this solves the problem of solar water-heaters. In order to solve the weakness of the first generation water-heating tank. The second generation water-heating tank, which put a partition disk in the tankhas been invented. The partition disk likes partition wall, separating two room inside the tank. There is a aqueduct between the left room and right room. When cold water flows in the tank, it flows in right room first, and flows in left room slowly by aqueduct. This research is willing yo find the best position to set partition disk, and make it bring into maximum affect.

Keywords:green power,Solar Energy,water- heating tank

Introduction

Due to gradual expansion of global warming effects and the ecological and environmental changes, many places around the world began to have unusual the ecological crises; therefore, different government organizations and NGOs are very determined in implementing "carbon reduction". Of all the available renewable energies, the cleanest, most environmentally friendly, and most inexhaustible is solar energy. And sadly, out of the many solar energy related products available in the market there is one that is often ridiculed-the solar water heater. And they question why a product that is supposedly environmentally clean and is using renewable energy not energy saving at all.

Taiwan is a country with quite adequate amount of sunlight; even at the northern highlands solar-powered water heater will still be usable. However, the design of the traditional storage water heater is not ideal. When hot water is being used, the tank refills itself with cold water, and, thus, resulting in the decrease of water temperature inside tank. This will then cause the heater to have an additional heating cycle, thereby, increasing consumption of energy sources.

In trying to resolve the disadvantage of the first generation storage water heater, we designed a smart water heating tank that allows cold and hot water to be completely separated and to be fully utilized. In fact, with this design the amount of hot water that can be utilized is twice more than the traditional design. This new design is patented, and the prototype is already made. If we can commercialize this new storage tank, you can make solar water heaters more energy saving. This energy saving effect is bound to greatly exceed the heat pump water heater. Once we are able to commercialize this design, low price as well as energy-saving quality of the solar water heaters will

Corresponding author: charter@gcloud.csu.edu.tw

be able to beat the heat pump water heater in the market, and let the public enjoy a more energy-efficient water heater.

Industry Overview

Economic development relies on adequate energy supply. We are in great need of a clean, environmentally friendly and inexhaustible source of energy. And the best option for that will be solar energy. Solar energy from the sun is about 3.845×10^{26} J per second. The energy received by the Earth is 1.743×10^{17} J per second. That is approximately equal to 6.1 million tons of coal combustion heat generated, which is 16,700 times more than the global demand [1]. The conversion and application related to solar radiation is based on the density of solar energy.

For solar water heating systems, solar greenhouse system, solar cold rooms and refrigeration systems, solar power, and etc. [2], the primary purpose of lowtemperature applications (<100℃) is for water heating and other warming purposes; for medium temperature applications (100℃ ~ 200℃) it is for industrial heating and air conditioning; in hightemperature applications (> 200℃which focuses on solar power is for smelting and poison decomposition purposes [2][3].

Taiwan (including Penghu, Kinmen and Matsu) is located in the Northern Hemisphere, across the Tropic of Cancer, and is situated in a subtropical area;a very sunny place with an average insolation of about 11,746 kJ / m^2 per day [4].

However, Taiwan's solar water heating is mostly concentrated in the central and southern part of the island and also in northern Taoyuan County. From the annual report of Solar Power systems installation of 2012, Kaohsiung has 4,965 installations, followed by Tainan Number with 3,858 installations, and then Taichung with 3,308 installations, Pingtung County with 1,801 installations, Taoyuan County with 1,605 installations, and part of the outlying islands with 706, the majority in Kinmen County with 612 installations.The number of solar power systems installed in Kaohsiung and Kinmen County has increased rapidly from the past years, and this should be credited to the subsidy offered by local governments [5].

Solar water heating systems using solar collectors (flat plate or vacuum tube), will be able to convert solar radiation to thermal energy in heating water. This has been in the market from as early as 1891, and by 2001 the world's area with installed solar collector was already more than seventy million square meters [6].

The most common water heaters are: gas water heaters, power heaters, heat pump water heaters, and solar water heaters. These four kinds of heaters use heat pump to heat water; the solar water heater is the most energy saving. Both have little differences between them being energy-saving and are determined by the weather and location. In general, we get an average of half a year's worth of sunshine yearly- about 210 days of sunlight (that is more or less four hours of sunshine a day). So, the use of solar water heaters is more energy saving and money efficient [7]. Conversely, when there is less than 180 days of sunshine, the heat pump water heating system is better an option compared to solar water. But if we consider the price of each system, heat pump system is the most expensive.A regular home-sized heat pump system would cost around forty to fifty thousand NTD, while for a solar heating system costing only around thirty thousand NTD. Table 1 is a table comparing various heating sourceswhere 400L of cold water is heated from 23 degrees to 60 degrees using 14800 Kcal:

From the above table we can see that the heat pump water heaters and solar water heaters generally cost roughly the same throughout the year. The solar water heater is prone to hot and cold water mixtures that lowers the temperature of the water. This research, the Smart Solar water heating tank, by our research team addeda movable partition disk that can effectively separate hot and cold water. The partition disk prevents the mixing of hot and cold water, and thus, be able to keep a constant temperature of hot water. The cost will be lower than that of solar water heaters.

Table 1. Comparison of different heating sources. (ex. 400L)

Equipment	Electric Heater	Gas Heater	Heat Pump	Solar Heater
Daily Energy Consumption	19.88°	2.57°	4.78°	Sunny=near 0degree Cloudy=9.52 degrees
Energy Price	NT$4.2/deg	NT$29/deg	NT$4.2/deg	NT$4.2/deg
Daily Expense	NT$83.5	NT$74.5	NT$20.1	Cloudy= close to 0 Cloudy= $40
Annual Expense	NT$30476	NT$27203	NT$7329	40 x (365-210) = NT$7200 Assuming 210 days of sunlight

Source: RECHI PRECISION., LTD

Of all water heating methods that are available, only the solar water heater is environmentally. The most common solar water heating system can be divided into: natural cycle or forced cycle. [8] (Fig. 2, Fig. 3):

Natural cycle of solar water heater

The process inside the solar collector is as follows: after absorbing heat from the sun, the water temperature rises and density lessens and travels to storage tank. Then, cold water inside collects at the bottom towards the solar collector that makes a natural convection cycle as a system to heat up the water. The majority of natural circulation system is used in those commonly found in houses.

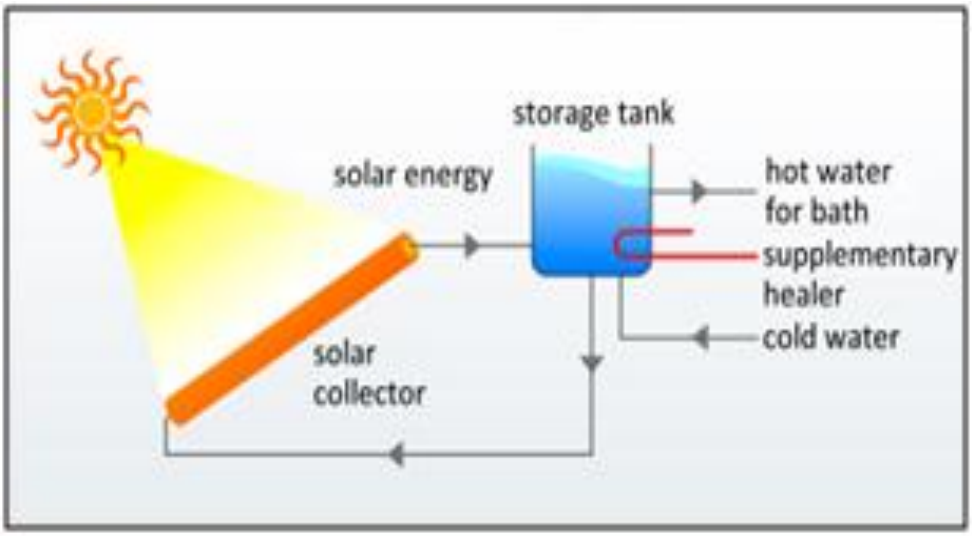

Fig. 1. Natural cycle type of solar water heater [8]

Forced Cycle type of Solar water Heater

By using collector circuit pump, the temperature controller enables storage tank water to flow through the solar collector. The solar heat collected is then brought back to the collector. This is mainly used in large-scale solar heating systems.

According to Khalifa's research [9], studies show that the efficiency of solar water heating system under forced circulation is higher than those under natural circulation by 35-80%. However, when buying a solar water heating system, the additional costs for circulation pump, the manner of operation, and maintenance (such as leakage) and other issues must also be considered.

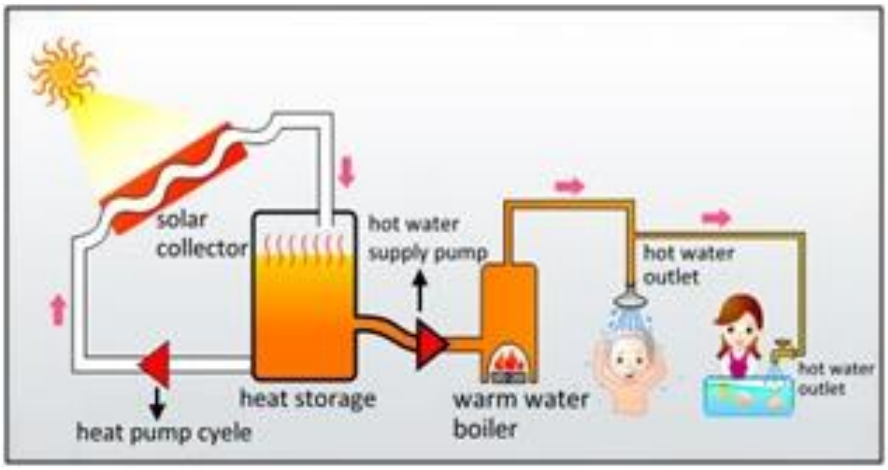

Fig. 2. Forced Cycle type of Solar water Heater

Overview of Previous Products

Why is the use solar water heater not necessarily the most energy-efficient? In addition to having to use electrical energy in heating during cloudy and rainy days, another reason is that when hot water is being used, cold water is added in simultaneously causing the temperature of the stored hot water to drop.And once the temperature is not hot enough, electric heating is then required. Figure 4 is an analysis chart of the conventional storage water tank.

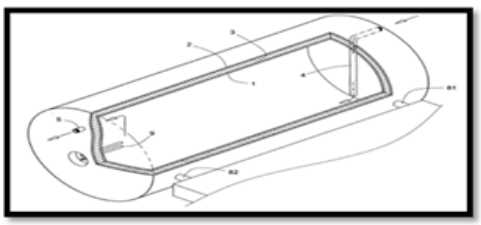

Fig. 3. Analysis of the Traditional Storage Tank [10]

At the end of a traditional storage water tank there is an inlet pipe (4) and outlet pipe (5). When hot water is being used, hot water flows out from the outlet pipe (5), and cold water is being added in through the inlet pipe (4) (there are some parts that will need pressurized motor injection).The cold water added will then be mixed with hot water stored inside that result in dropping of the water temperature.So in order to maintain water temperature within therange of the predetermined temperature, power heater (9) is often installed together to keep the water at the desired temperature.But due to the large capacity of the tank (usually at 400L), the water heater would consume more electrical energy and heating time.So the concern is thatinstead of it being energy saving, it wastes energy.

Second-generation solar water heating tank

To work according to the government's carbon reduction policies, some manufacturers have proposed a solution to improve the aforementioned storage tank issues such as the dropping of temperature and the need for additional consumption of energy. And the solution they have brought

up is to add a partition disk inside the tank that separates the tank into two (hot water on the left and the buffer zone on the right), and having a tubes on the disk to connect the two spaces.This gives the newly added cold water buffering time, and then water flows to the other side of the disk with a relatively lower temperature.Then it guides the direction of flow, and it also slows down the speed of hot and cold water mixing.As shown in Figure 5:

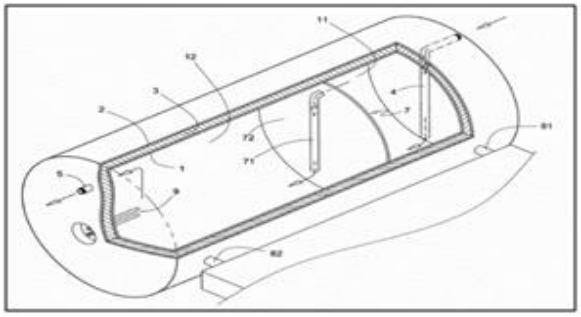

Fig. 4. Analysis of the improved heating tank [10]

Table 2 is a comparison of the advantagesand disadvantages of various solar water heatersin detail.

Table 2. Comparison of the advantages and disadvantages of each type of storage tank (400 liters)

Storage Tank	Traditional	Improved
Advantages	Low manufacturing cost	Slower mixing rate of hot and cold water
Disadvantages	Time and energy consuming	Still needing electric heating
Water available for use	200L of hot water	250L of hot water
No. of hot showers 50L/person	4 people	5 people

Source: Research Findings

Table 2 assumes that hot and cold water is fully mixed and heated to 50 degrees during winter. When the hot water is used up to half (200L), the temperature of the newly added cold water is 20 degrees. So the temperature at this time is reduced to (50 + 20) / 2 = 35 degrees. At this temperature most people will it not hot enough. The amount of hot water of a traditional design with 400L that can be used is only half of the content, which is approximately 200L.The other half of hot water has already been mixed with cold water resulting in a temperature not hot enough for hot baths.

As for theSecond-generation solar water heating tank, the rate of the mixing of hot and cold water couldlowers. And when the temperature is not hot enough, there is still a need to use consume time and energy to heat. Under our calculations, the amount of hot water that can be used is only a little bit over half of its storage content, 250L.

Conclusion

To prove the affectivity of theSecond-generation solar water heating tank, and to test the best position of the partition disk of the 2nd design, we made prototypes to test and determine the best position of the partition disk. At the same time to test the water temperature of the various generations from the 1st - 2nd generation.

The following table shows the actual measurement of the changes of water temperature inside the tank after every shower. Prior assumptions are:

- Storage content is 400 L, Hot water temp. at 60 °C;
- Injected water at 20 °C;
- Every Shower consumes 50 L;
- Every Shower consumes 15 min;
- Basis for water temperature measurement is the water from outlet.

During the actual experiment we used a small 2000ml bucket to simulate the 400L storage tank, and the 50L of water used for shower per person was also reduced to 250ml. During our experiment on the improved design, we divided the tank into 20 equal portions into 1/20, 2/20, 3/20.....10/20 as placements for the partition disk. With this we measured the change in temperature of the water after every shower. The picture below shows the partition disc placed in 4/20:

Table 3. Results of the experiment with the different Water Heater designs.

No. of Baths Storage tank Design	Temp. after 1 Bath	Temp. after 2 Baths	Temp. after 3 Baths	Temp. after 4 Baths	Temp. after 5 Baths	Temp. after 6 Baths
Traditional (w/o P. Disk)	58.5℃	55.3℃	52.0℃	47.5℃	42.3℃	37.2℃
1/20Position (2nd Gen Design)	58.5℃	55.0℃	53.0℃	50.0℃	45.5℃	41.0℃
2/20 Position (2nd Gen Design)	59.0℃	57.0℃	54.5℃	51.2℃	46.3℃	41.5℃
3/20 Position (2nd Gen Design)	58.1℃	56.0℃	52.3℃	48.5℃	44.0℃	39.5℃
4/20 Position (2nd Gen Design)	58.5℃	56.2℃	53.0℃	48.5℃	43.6℃	38.8℃
5/20 Position (2nd Gen Design)	58.7℃	55.0℃	51.0℃	46.2℃	42.0℃	37.0℃
6/20 Position (2nd Gen Design)	59.2℃	56.2℃	51.5℃	46.8℃	42.0℃	37.7℃
7/20 Position (2nd Gen Design)	59.2℃	56.3℃	51.8℃	47.2℃	42.3℃	38.0℃
8/20 Position (2nd Gen Design)	59.1℃	56.5℃	52.0℃	48.0℃	42.5℃	38.2℃
9/20 Position (2nd Gen Design)	59.1℃	55.9℃	51.9℃	47.9℃	42.3℃	38.5℃
10/20 Position (2nd Gen Design)	59.0℃	55.0℃	52.0℃	48.0℃	42.2℃	39.0℃
Moving P. Disk (Smart Design)	59.5℃	58.9℃	58.5℃	58.0℃	57.6℃	57.2℃

Fig. 5. Photos of the Improved Design model

As the result of our experiment shows, the position of the partition disk at 2/20 position is the best with 41.5 ℃ after the sixth bath.The 1st generation design has a result of 37.2 ℃ after the six baths. That gives the 2nd generation design a leverage of 4.3 ℃. This concludes that the partition disk of the 2nd generation design is best at 2/20.

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