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Showering in the Sun

Authors

Young, William
Haggard, James
Chase, Diana

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Showering in the Sun

William Young, Jr. and James Haggard
Florida Solar Energy Center
1679 Clearlake Road
Cocoa, Florida 32922
young@fsec.ucf.edu

Diana Chase
University of Central Florida
4000 Central Florida Blvd
Orlando, Florida 32782
chase@mail.ucf.edu

ABSTRACT

For thousands of years, man has used energy from the sun to heat water. Today, the typical way of obtaining hot water for a shower is through a residential or commercial thermal system installed on a building. This type of shower is too big and heavy to use outdoors, although camping facilities and parks may have such systems for their patrons. Original outdoor showers that were developed for use in remote locations were bulky and not particularly portable. Today's solar shower is designed to be practical for camping, recreational and marine use. New products are made of plastic for lighter weight and portability, and the tank has been replaced with a bag that performs as both a solar energy collector and storage unit with a hose for dispensing hot water. The solar shower has entered the outdoor market place as a valuable device, reaching into the worlds of campers, backpackers, sailors, archeologists, missionaries and people in developing countries.

There are only a few manufacturers of the camping type of solar showers. There are four basic designs, all of which are very low cost compared to residential hot water systems. All are made of some form of plastic and typically come in sizes from 2 to 8 gallons (9 to 30 liters). Temperatures can reach up to 110 degrees Fahrenheit (43 degrees Celsius) in little more than 3 hours of full sunlight and some even have a built in temperature gauge for easy reading. The performance of each shower is similar, with the major difference being design and quality.

INTRODUCTION

For thousands of years, man has used energy from the sun to warm homes and heat water. As early as 220 BC, the Greeks used copper pipes placed in the sun to collect radiant heat and to store the hot water under marble floors of buildings. The Romans practiced regular bathing, but the practice died out during the Middle Ages. The industrialized world of the 1800s realized the need for personal hygiene, and advances in technology prompted many early thermal water heating system designs to use wood, coal and gas. Early system designs generally consisted of a tank attached to a metal stove used for heating and cooking. In 1891, Clarence Kemp combined his design with other practices and patented the modern solar water heater. Bare metal tanks were installed in a hot box, which was exposed to the sun to increase the tank's ability to collect and retain solar heated water. At first, solar heaters were used for heating water and bathing, until showers became popular in homes.

Now, the typical way of obtaining solar hot water for a shower is through a residential or commercial thermal system installed on a building. This type of shower is too big and heavy for outdoor use, although camping facilities and parks may have such systems. Because of the need for good hygiene in remote locations, the design was reinvented and simplified to be used as a camping, recreational or marine hot water shower. This new design was made of plastic for light weight and portability and the tank was replaced with a bag that performed as both the solar energy collector and storage unit with a hose for dispensing the hot water. The camping shower became a plastic bag for heating water with a hook or loop for mounting and a hose to dispense the water. The shower is placed in the sun and mounted to a structure that will hold the weight of the water and allow a person to stand under it to shower.

Solar showers came on the scene in the 1980s. The solar shower entered the outdoor market place for the recreational, marine, and camping worlds along with other remote applications. Archeologists, missionaries and users in developing countries found the systems valuable. In a remote or camping location where water is available, the solar shower offers a means of personal hygiene. Most people are familiar with the most common solar shower, which consists of a black garden hose looped in a circle and laid in the sun on a flat surface like the roof of your home. Another simple shower that anyone can make is with a black plastic trash bag filled with water and the opening tied with a knot and hung by a cord over your head; once the water is hot, a hole can be punched in it to take the shower. There are other types of solar showers, such as the Hot Water Solar Tube, that uses a household pressurized water line to hook up to a water supply and heats the water in a black multi-tube collector before being dispensed through a shower head mounted usually on an outdoor poolside stand. Another solar shower uses a bucket to collect heat and store the water, while using a low voltage electric pump to dispense the water through a hose.

THE JUNGLE EXPERIENCE

In the summer of 1983, an archaeological survey team from the University of Central Florida (UCF) joined the work started at the ruins of Caracol nearly 120 miles from Belize City, Belize. These were some of the most dense jungles in Central America in which to excavate the city dating back to 300 AD. The construction of the city was overgrown by the jungle, required heavy labor clearing the site and surveying the artifacts. At times, there were as many as 3 professors, 10 students and as many as 50 local workers at the site.

Fig. 1: Village and showers

By 1987, the Florida Solar Energy Center (FSEC) had joined the project to provide photovoltaic power and solar showers to make the work more bearable. The photovoltaic system worked well, but the showers were a problem. As for heating the water to a comfortable temperature, all of the showers did their job. However, the showers were used almost every day in the evening, and lasted only one survey season (2 months) before being replaced. They tried several brands and found similar problems, such as bag tearing, hoses coming off, nozzles dripping and fill caps leaking. This study was started to look at these problems and develop a solution.

SOLAR SHOWER CRITERIA

Reviewing the many designs of solar showers, the camping type was selected for testing and evaluation. Similarities were noted between the various designs available and the criteria for their selection for this project evaluation is listed in Table 1.

Table 1: Shower Characteristics

- Portable
- Collector and storage is one unit
- Collector and storage is in a bag shape
- Can be easily mounted above the head
- Can be carried by one person when filled
- Can be put in a backpack
- Simple filling capability
- Simple water flow control
- Hose to direct water flow
- Materials will not rust
- Made of light materials
- Reusable

The typical design selected was made of plastic with a bag that performs as both the solar energy collector and storage unit with a hose for dispensing the hot water. They are placed in the sun to collect the thermal energy radiating on the bag until the water is sufficiently hot to shower. This project is to evaluate the performance and reliability of the solar showers that meet these criteria for remote use.

THE SEARCH FOR CAMPING SHOWERS

This study focuses on plastic bag type camping showers available from suppliers of military, survival, water sports, camping and the travel industry. A search on the web produced over fifty suppliers of solar showers with just as many from magazines and stores. Typical web sources were E-bay, Backpacker, Ted's Military Surplus, Stearns, Scuba, Camping World, Preparedness Center, Target, Site Outdoors, Sail Net, Travel With Care and PriceTool. They range in price from $7 to $28 depending

on design and size. There are more elaborate and expensive units, but they had options that did not meet the selection criteria.

The next search was with the U.S. Patent Office, where the oldest patent was 4,520,793 in 1985 for a foldable, insulated solar water heater called "Sunshower" originally created by Basic Design. There were older patents, but not of the camping shower design. Newer patents enhanced on this design. A diagram showing the basic design of a solar shower by Stearn is shown in Figure 2.

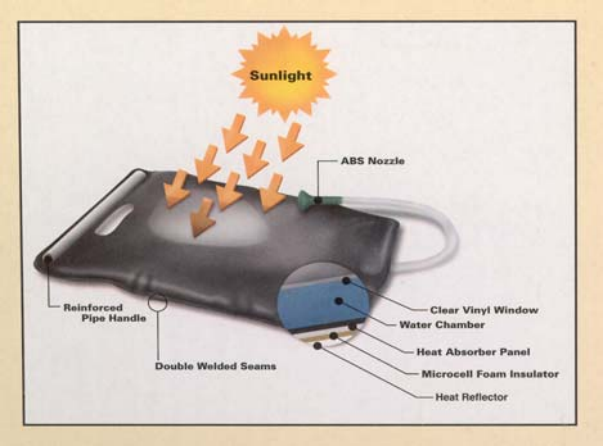

Fig 2: Stearn Inc, solar shower diagram

Some showers appeared to be exactly the same except for the name printed on the bag noting the supplier. It was difficult to determine the actual manufacturer and who was the supplier. Contact with them did not produce any more information, as distributors did not want to reveal their manufacturer. Contact with any organization produced no information except a response of "What model do you want to purchase?"

Table 2: Suppliers and Model List

Product Name	Make/supplier	Size
Sun Shower 2.5	Stearns Outdoor	2.5 gal
Sun Shower 4	Stearns Outdoor	4 gal
Extreme-Fabric Sun Shower	Stearns-Preparedness	4 gal
Solar Shower	Keneico Camping Goods	4 gal
Solar Shower Combo	Stansport	4.5 gal
Sun Shower 5	Stearns Outdoor	5 gal
Camp Shower 5	Coleman	5 gal
Solar Shower 5	Ozark Trail	5 gal
Camp Shower	CW Gear	5 gal
Sun-Heater Shower	Reliance-Preparedness	5 gal
Air/Foot Sun Shower	Stearns-Preparedness	5.5 gal
Sun Shower 8	Stearns Outdoor	8 gal

SOLAR SHOWER DESIGN AND OPERATION

The showers are made in 6 different sizes based on volume of water, starting at 2.5 gallons (9.4 liters) to the largest at 8 gallons (30.2 liters). As shown in Table 2, the selection process identified 12 different showers of 6 different sizes based on our selection criteria.

The showers are designed to heat water to take a comfortable shower to provide good hygiene in an outdoor environment. They are not designed to heat water for human consumption. The showers are foldable and flexible so that they can easily be used by backpackers and other outdoor users. There is an inlet and outlet for water, sometimes the same hole. The showers are light weight when empty and still portable when filled with water. The bag collapses as the water flows out the dispenser hose which has an on/off device or spigot to control the water flow. Because they are gravity fed for showering, the bag is placed at least as high as your head so the nozzle/showerhead will dispense the water creating a shower. Because the showers work over the head, they are mounted to some type of support structure with a handle, hook or cord that will hold the weight of water and allow a person to stand under them to shower. Typically, the showers are hung from a tree, wall, structure, tripod or vehicle where they can get maximum sunlight and water flow.

The bags are all black or mostly black, and some are covered with a copper or silver pigment. Table 3 lists the materials named by the manufacturers used to make the bags. Before use, the bags should be rinsed with 1 tablespoon of baking soda and warn water to remove any HCL generated through heating All bags are made of plastic sheets from 10 to 40 mils thick with double-welded seams, from single sheets or up to 4 ply layered sheets which may include reflective and insolating layers. Some have a clear top that allows the sun to heat from the inside.

Table 3: Bag Material

Polyethylene
Polyvinylchloride (PVC)
Polyester
Polyurethane
Polymeric Foam
Plastic
Vinyl

Dispensing hoses are usually clear and from 2 to 8 feet (0.6 to 2.4 meters) long with nozzles at the end for showerheads made of ABS or PVC. Some have metal clips for water flow control and also mounting. Some

have handles made with PVC, nylon or fiberglass stiffeners for mounting to a structure and grommets for tie down. Some come with nylon carrying or storage bags. A reflector, such as found on solar ovens, can be used to increase heat gain. Privacy enclosures are available.

TESTING AND RESULTS

Testing started late in the fall of 2004 at FSEC, when solar radiation and temperatures were not at their best and certainly would not represent the jungle environment of Central America. Performance and reliability testing was completed on each solar shower listed in Table 2. There were two heating performance tests: one test comparing heating capability of each shower of a typical 5 gallon (18.9 liter) size and one test comparing heating comparing size/volume of water. The showers were not used to take actual showers, but simulated showers through filling and empting the bag through a planned routine to test reliability.

Heating performance testing consisted of attaching a data acquisition system (DAS) with sensors to the showers for bag temperature, ambient temperature and solar radiance. Temperature measurements consisted of four thermal couples attached to each shower bag with one sensor on top, one underneath, one inside the bag itself and adjacent ambient air. The showers were tested on the roof of the FSEC laboratory building where there would be minimal wind. Showers were placed on a wood decking as in the jungle (Figure 3). Water was measured in liters to match the volume metric size of each shower. Data was collected over a week for each test to compare day to day performance with actual solar conditions over a 24 hour period.

Fig. 3: Test setup of showers

The results of the first test comparing each shower found that our data had a similar curve to that of some manufacturers. The maximum temperature reports by the manufacturers were not obtained on all showers and within the three hours. On some test days the ambient temperature started at less then 60 degrees Fahrenheit effecting comparisons. Our results were within 10 percent of their values as shown in Diagram 1. Comparing data of showers with and without a clear window showed that a window did provide a temperature increase of as much as 4 degrees during the day, but lost heat at night. Some temperatures did reach up to 105 degrees Fahrenheit, but took longer then 3 hours of sunlight. The heating performance of each shower is similar with the major differences being reliability and quality.

The second test comparing heat gain based on size of shower was completed with the smallest shower at 2.5 gallons, a typical 5 gallon and the largest 8 gallon shower. The rate at which the showers heated did have an impact on the volume metric size of the shower. The smaller shower heated faster, but also cooled faster. The 4 and 5 gallon sizes followed more closely the manufactures temperature data.

Some showers have a built in temperature gauge where the temperature numbers show when the temperature is reached at ranked numbers. It was observed that the numbers gradually appear until temperature is reached and were within 5 percent of the DAS measurement. The showers were above ambient during peak sun hours and cooled after dark to near ambient.

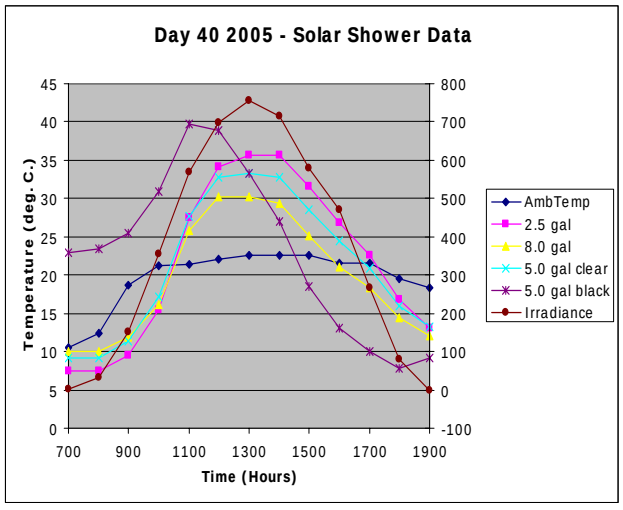

Diagram 1: Size and Temperature Test Data

Reliability of the showers was determined by use of the showers during testing and routinely cycling them with water. The operation of each of the components of each shower was noted in discussion. Overall, the showers

worked as expected and some components performed without flaw on some models. The bags made from plastic sheets with welded seams performed well and appear durable, as none of the bags came apart or were torn from rough handling or stress of the weight of the water. One shower did not have the usual inlet cap, instead one end of the bag was open and the bag was sealed by folding the end several times which was found difficult to seal.

Some problems were consistent across manufacturers and other problems related to a specific model design. The most significant functionality problems were pressure leaks and parts coming off when the showers were full of water, but not with all models. Some showers would leak based on how the shower was carried, positioned or laid on a surface. Some water inlets were a problem, as some were made of soft plastic and deformed when full so as not to maintain a proper water tight seal. Some of the plastic nozzles would leak or drip after a few uses, but this was not a problem with the metal clamp controls. Some of the hoses were connected to a nipple at the bag that was held on by friction and would come loose when the bag was full and moved to often. To prevent water loss during heat testing, some of the inlets were sealed with a sealer, some hoses and nozzles were taped on and additional clamps were applied to hoses to stop leaks.

For the best shower, the unit should be hung from a sling or cantilever where it will get the most sun. The user needs to be fast, as showers do not contain much water. The bird bath method is the best method to use, where you rise, soap and rinse again stopping the water after each step. It is possible to take more then one shower from a bag, except from the 2.5 gallon shower. The 8 gallon bag provides the most showers bases on user skill.

CONCULSION

The overall performance of the showers for heating water was good and approached the manufactures specification most of the time. For this report the testing was done in Florida's winter season; even so, the showers still reached a comfortable temperature most of the time, proving the shower is a summer or fair weather device. Their performance is like a solar oven, not much sun, not much heat. On cold and cloudy days with outdoor temperatures less than 50 degrees Fahrenheit (10 degrees Celsius), the showers were not able to warm to a comfortable temperature consistently. There are ways to improve heating performance, such as blocking the wind and adding a reflector. A reflector, such as found on some solar ovens, can be use to increase heat gain. There are of course, privacy enclosures or tents that improve comfort.

Solar showers are low cost, light weight and portable, but the reliability of operation needs to be improved. Shower bags performed without failure during this testing. Better or harder plastic on the inlets, nozzles with better on/off valves and better hose attachments are physical improvements needed for better quality. This testing is not complete, as the future summer heat of Florida will verify maximum shower temperatures.

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