SOLAR WATER HEATER SYSTEM CONTROLLER

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ABSTRACT: *A solar water heater is a solar energy system that uses the sun to heat domestic hot water. Just like a solar electric system, it uses panels to collect solar energy. To ensure the transfer of the solar heat to the water storage tank the solar water heaters uses fluids, like water or glycol, and a recirculation pump. Is very important to have a control of the temperature of the fluid to maintain safety the entire system and ensure a proper transfer of the heat from the sun to the useful water. In this paper is described an automatic controller that monitors the temperatures into a solar water heater systems and controls the recirculation pumps.*

Keywords: solar, water heater, energy, automatic controller

General information

According to [1], a Solar Water Heating System (SWHS) has as its main component a collector. The function of the collector is to capture the sun's energy falling on it in the form of heat to the fluid in the collector. There are two main types of solar water heating systems: active and passive [2].

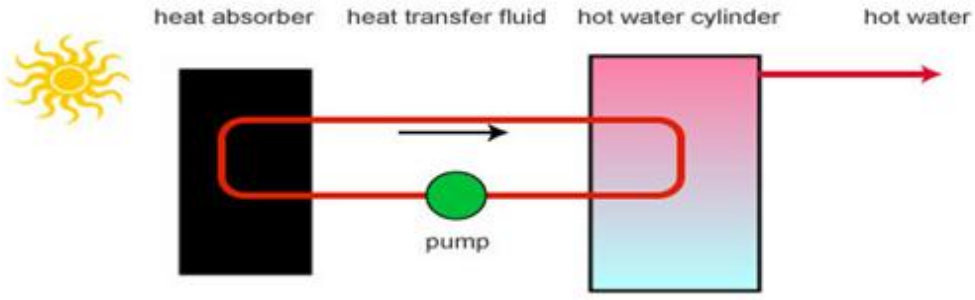

Fig.1. General overview of a solar water heater

Types of solar water heating systems

Active SWHS uses a pump to circulate the water between the tank and the collectors (fig.2).
Active systems can be either direct circulation or indirect circulation. Direct circulation systems circulate domestic water through the collectors and to the storage tank. These are best-suited for mild climates where temperatures seldom drop below freezing. Indirect circulation systems circulate a non-freezing heat transfer fluid through the collectors and then through a heat exchanger in the storage tank. These are preferred in cold climates where the pipes in a direct circulation system might freeze.
Passive SWHS relies on natural convection to circulate the water (fig.3).
Passive systems are usually less expensive but less efficient. They can be either integral collector/storage systems or thermosyphon systems. The integral collector/storage type is typically used to preheat water for a conventional water heater, and is best-suited to climates where temperatures seldom fall below freezing. Thermosyphon systems rely on natural

convection to circulate the water, so the tank must be located higher than the collector panels - the heated water from the panels flows upward to the tank and the cooler water returns to the collector for heating [2].

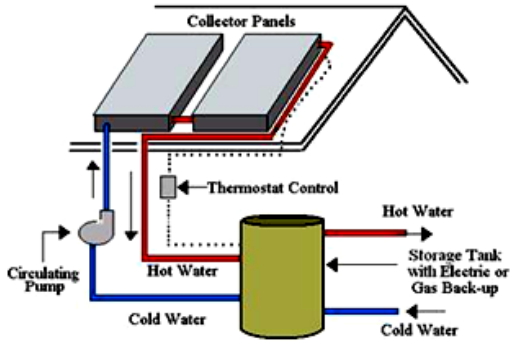

Fig.2. Active SWHS

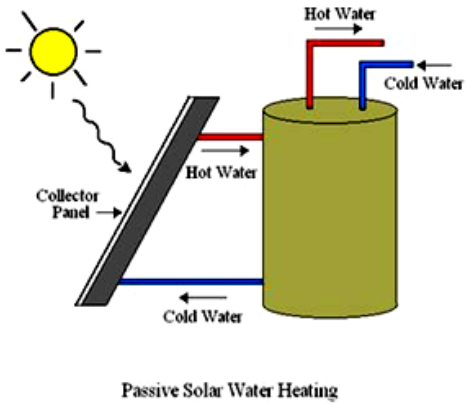

Fig.3. Passive SWHS

Components

The primary components of any solar water heating system are one or more collectors to trap the sun's energy and a well-insulated storage tank.

There are three common types of collectors - flat-plate collector panels, integrated collector/storage systems, and evacuated tube collectors.

Flat-plate collector panels have a dark absorber plate behind a glass or polymer cover. Water circulates through dark-colored pipes running through the collector. As sunlight passes through the clear cover, its heat is absorbed by the absorber plate and piping and transferred to the water. The collector panels are usually mounted on the roof, facing south. They can also be mounted on a south-facing wall or on a stand on the ground (as when used to heat a swimming pool).

Integral collector/storage systems, also known as "batch" systems, have one or more black tanks or tubes inside an insulated box with a clear glass or plastic cover. They are often used to preheat water before it enters a conventional storage-type water heater. They can also be combined with a tankless or on-demand water heater.

Evacuated tube collectors consist of parallel rows of transparent tubes containing metal absorber tubes that absorb the sun's heat. This type is used mainly in commercial applications.

Storage tanks are typically large-capacity (80 gal. or greater) conventional water heaters (either electric or gas). The larger capacity allows for more "free" hot water during periods of overcast weather. When the solar collectors are unable to provide enough hot water, the back-up heating elements or burners make up the difference. A single-tank system uses the existing water heater for both storage and back-up, while a two-tank system pre-heats the water before it enters the main water heater tank.

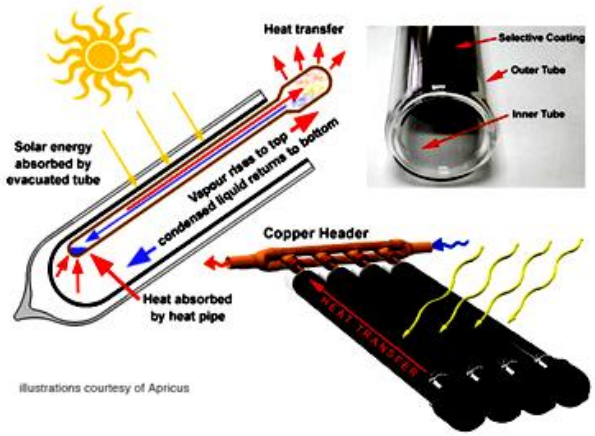

Fig.4. Evacuated-tube collectors

CONTROLLER FOR SOLAR WATER HEATING SYSTEM

In this type of vacuum collector, the absorber strip is located in an evacuated and pressure proof glass tube. The heat transfer fluid flows through the absorber directly in a U-tube or in counter-current in a tube-in-tube system. Several single tubes, serially interconnected, or tubes connected to each other via manifold, make up the solar collector. A heat pipe collector incorporates a special fluid which begins to vaporize even at low temperatures. The steam rises in the individual heat pipes and warms up the carrier fluid in the main pipe by means of a heat exchanger. The condensed liquid then flows back into the base of the heat pipe.

The pipes must be angled at a specific degree above horizontal so that the process of vaporizing and condensing functions. There are two types of collector connection to the solar circulation system. Either the heat exchanger extends directly into the manifold ("wet connection") or it is connected to the manifold by a heat-conducting material ("dry connection"). A "dry connection" allows to exchange individual tubes without emptying the entire system of its fluid. Evacuated tubes offer the advantage that they work efficiently with high absorber temperatures and with low radiation. (fig.5).

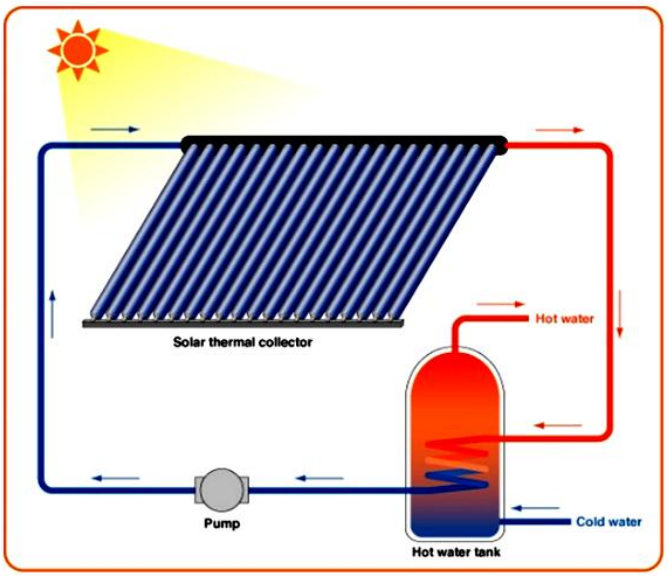

Fig.5. Used SWHS

The control system

The proposed control system for a flat solar water heater panel is presented in figure 6. It consist into a microcontroller based module with 4 temperature sensors and a digital controlled output for controlling the recirculation pump.

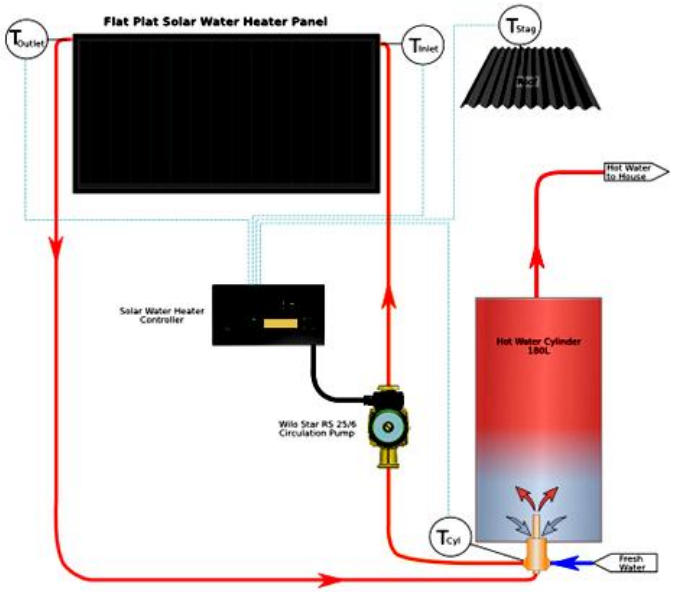

Fig.6. Proposed controller installation SWHS

The microcontroller based module uses an Arduino Nano board and a 16x2 LCD display to view the data from the system. Also the module offer the possibility to send the data to the PC through the serial port. The electronic principle schematic is presented in figure 7. To be able to change the parameters thresholds and the working limits the module has 4 functional buttons which are configured into the software to allow parameters changing.

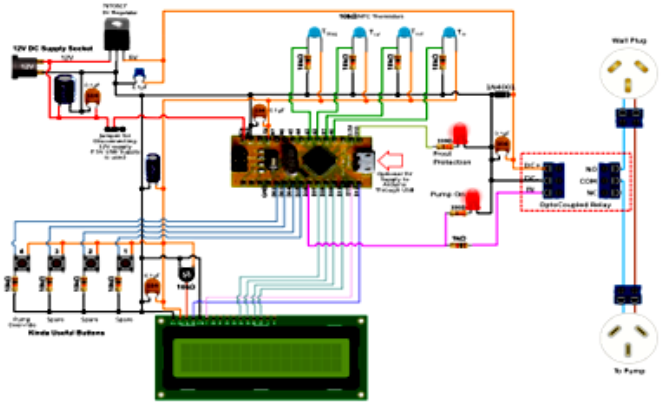

Fig.7. Controller schematic

The presented schematic of the controller has for the output control a relay (fig.8) controlled by the output lines of the Arduino board.

Being modular, the system can be extended with other digital controlled outputs, depending on how many pumps are required for the system.

Form the software point of view the controller has on embedded software located on the Arduino board and a monitoring software on the PC. Mainly, the software on the board has all necessary implementation to work independent by PC and it only provides monitoring data to the PC.

Another variant of the current implementation was made with an Arduino Uno board with and LCD display shield. The sensors part and the output part remained the same. This implementation is presented in figure 9 and was designed to control 2 recirculation pumps, being a cascade tank system.

Fig.8. Relay

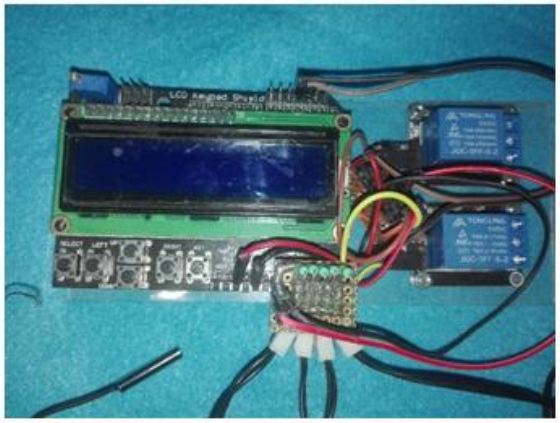

Fig.9. Controller with Arduino Uno

CONCLUSIONS

The presented solution for a solar water heat system controlled can be considered a fast and easy solution if you have small programming knowledge and few electronics skills. The solution was tested for many monts with excellent results and no defective components. Due to the modular design it can be easily extended and improved.

The improvement can consist in adding and EEPROM memory to store configuration parameters and important measured values. Also, to reduce the noise caused by the mechanical relay instead it can be use a solid state relay.

Improvements can be added developing a PC based application which can allow to change the configuration parameters to allow a more flexible controller.

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