PCM Heat Storage for Solar Hot Water System

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Motivation

Harnessing the sun's energy via a thermal solar collector (TSC) to heat water is a commonly employed practice with growing popularity. Unfortunately, TSC's are unable to produce enough heat during the night or cloudy weather conditions. Heat storage systems on the market are inadequate for a system relying solely on solar energy. This project utilizes the high latent heat of phase-change materials (PCM) to store thermal energy in a compact and efficient manner to produce a reliable output of hot water.

Background

A phase change material (PCM) is a substance that absorbs and releases high amounts of energy in the form of latent heat when transitioning between states. Energy is absorbed as the PCM melts and is released during solidification. The PCM used in the system is a paraffin wax with a melting point of 55° C.

Objectives

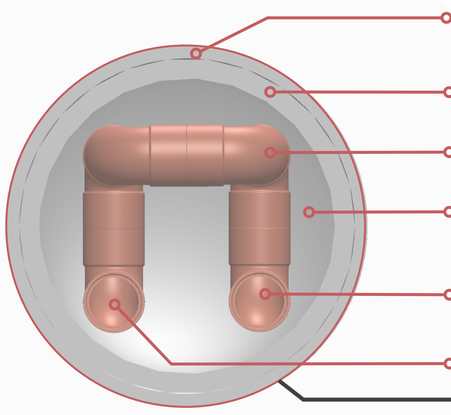
- Design a thermal energy system that utilizes the latent heat properties of PCM to store energy from a TSC source
- The system should be suitable for residential use and incorporate an automated control system
- Manufacture a prototype and execute a real-world analysis

Design Solution

Thermal Storage Unit

The thermal storage unit is designed to be compact and efficient. The unit consists of 6 pipes, each composed of 4 lengths of copper, encapsulated by paraffin wax and enclosed by ABS pipe.

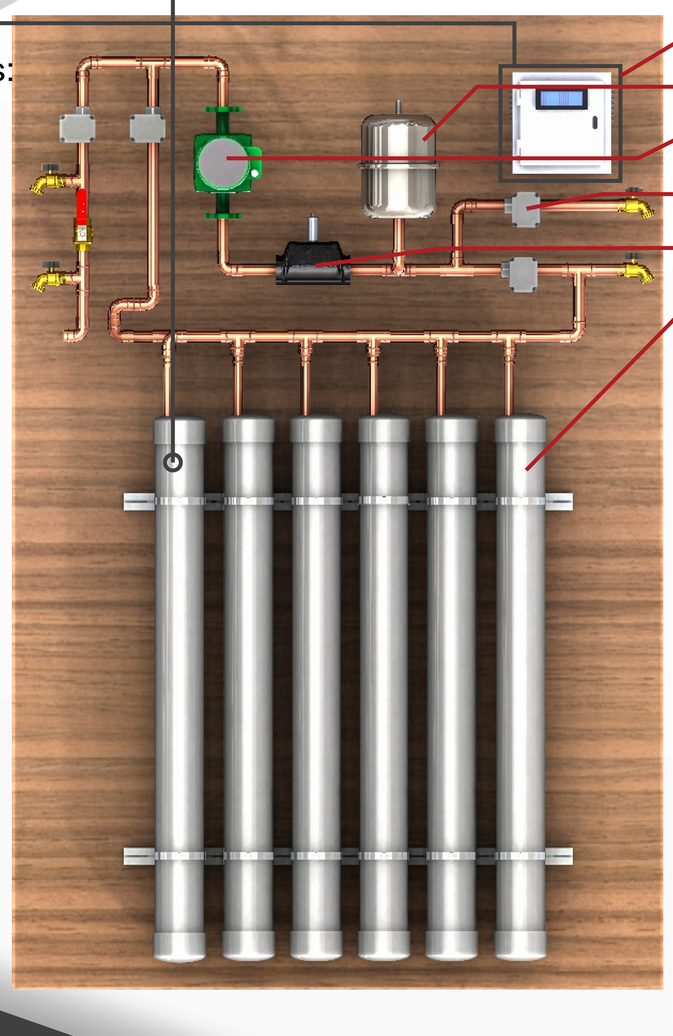
- Copper tubes configured to maximize surface area and enhance heat transfer
- Charge/discharge of system as one loop for compact & cost effective design



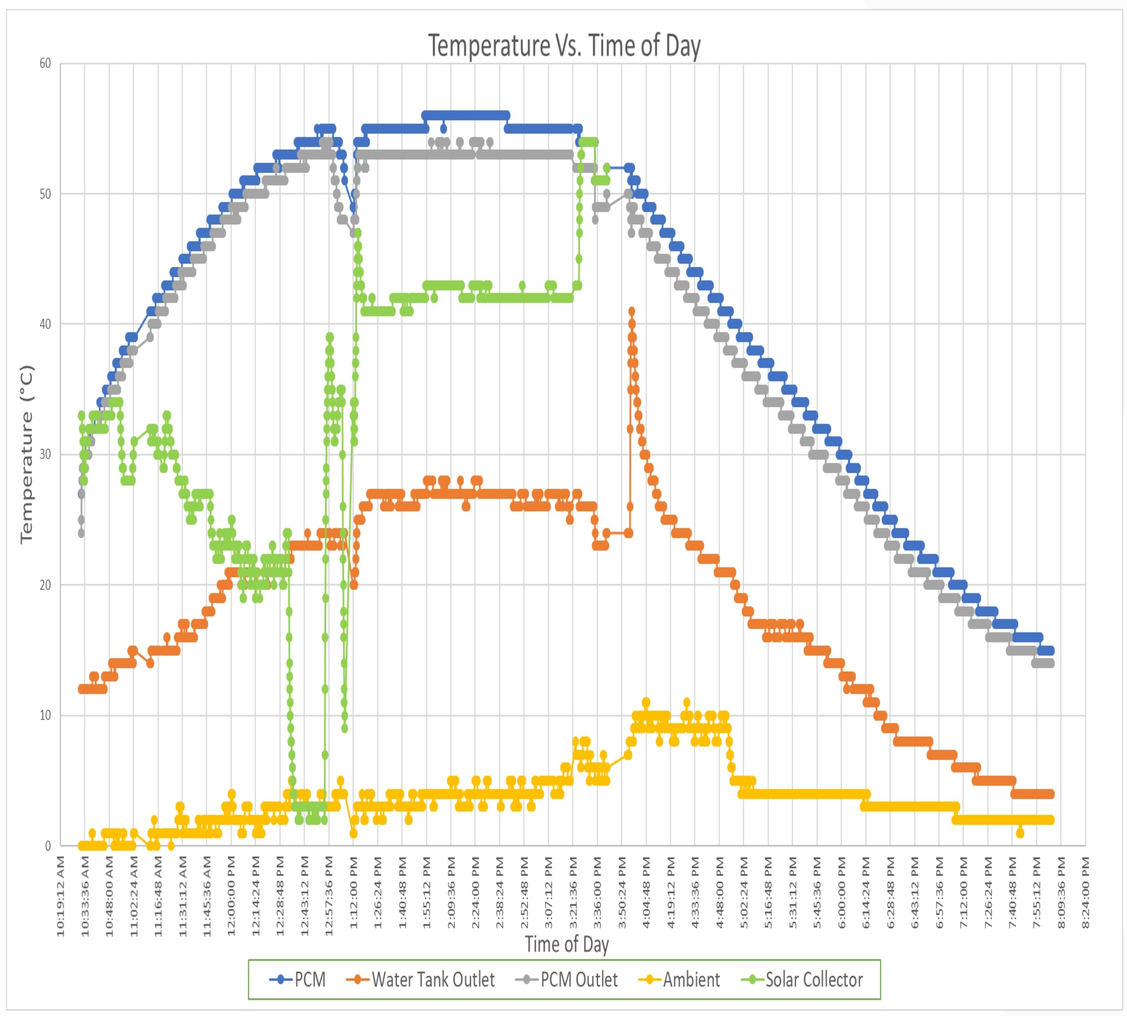
Automation System

The PCM heat storage system is fully automated and includes:

- A micro-controller which governs the embedded system
- 4 motorized ball valves and 5 thermocouples to initiate the charge and discharge cycles and ensure the system does not overheat
- LCD screen and remote controller to display temperatures in the system, charge/discharge cycle and time
- For testing purposes, a real time clock and sd card reader records system temperatures with a date & time stamp



Results



Conclusions

- The daily collector cycle provided sufficient energy to heat and phase change the paraffin wax
- System effectively maintained a 45L tank above 20° C temperature for over four hours after sundown in a 0° C environment
- The design carries an ability to be effectively scaled according to user requirements
- Alternative PCM choices may be considered in future iterations to further improve system performance
- Further testing in various weather conditions will aid in fully defining system performance

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